MASTER

Finishing screens TV-Glass factory Philips, Chupei, Taiwan, R.O.C.

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REPORT

FINISHING SCREENS

TV-GLASS FACTORY PHILIPS

CHUPEI, TAIWAN R.O.C

Bert Jan Post,
August 1990.

ABSTRACT

Philips TV-Glass is a producer of glass parts to be used in television and monitor tubes. This report deals with the extension requirements of the finishing capacity for certain parts in the production process and describes alternative solutions.

ABBREVIATIONS

CC	= Colour Conus
CMT	= Colour Monitor Tube
CRT	= Cathode Radiation Tube (factory)
FS	= Flat Square
MC	= Mono Conus
MS	= Mono Screen
PIM	= Pinning Insertion Machine
SC	= Screen Colour
SEFU	= Sealing Edge Finishing Unit

FOREWORD

At the end of the study for Industrial Engineer, every student has to carry out a research project. Philips TV-Glass in Chupei offered me the opportunity to come to Taiwan to execute my Practical Training in their factory. It took the full six months to find my way in the factory, to investigate the problem and to make some proposals.

Before I left, the calculations were finished and were presented to the management team. A computer program to calculate the needed figures for these graphs was sent to Taiwan afterwards. This report is the compulsory report to show the Technical University the investigation and the results. And for Philips TV-Glass Chupei this report is a more systematic way of presenting the results, as an addition on the data left behind.

Let me take this opportunity to thank Messrs. G. Lock, Y.T. Sung and S.M. Tzaan of Philips TV-Glass Taiwan and Messrs. A.D.M van de Ven and J. Ruules of the Technical University Eindhoven for their support and advice during and after the Practical Training in Taiwan.

Bert Jan Post.

SUMMARY

Philips TV-Glass Chupei, Taiwan R.O.C. is one of the four TV-Glass factories of Philips, which are suppliers of glass parts to (Philips) tube factories. In a TV-Glass factory two main glass parts are pressed: screens (the front-side of a tube) and cones (the back-side of a tube). After pressing, these glass parts need one or more finishing processes. Screens can be produced to be used in mono(chrome) tubes or colour tubes.

In the TV-glass factory Chupei the pressing capacity has been extended in 1988/1989 to enable the factory to produce more attractive glass parts, especially colour screens. Extension of the finishing capacity was also required for these parts. Before the extension of the pressing and finishing capacity, the factory had produced only mono and colour cones and mono screens. For the future expectations exist that:

- the production will shift from products to be used in mono tubes towards parts to be used in colour tubes;
- the total production volume will increase.

The aim of an executed study was to develop alternatives for the expected increasing demand for finishing of the screens. The alternatives should be based upon the market demand (which determines the production volume), the technical realizable solutions and lay-out restrictions. The availability of labour for the solutions should been taken into account.

The production volume of the TV-glass factory is based mainly on the production volumes of the tube factories in Taiwan, which are located on the same plant as the glass factory. Based on the expected production volumes of the mono and colour tube factories for the coming years, the glass factory can supply a lot more glass parts in the coming years. But to keep (or even get for some glass parts) a competitive price optimization of the production is necessary.

Finishing of screens comprises for mono screens only one step: polishing. This is processing the outside surface of the screen in order to achieve the required visual quality. For colour screens an additional process is required: pinning. Pinning is the process of melting three or four pins in the inner-side of a colour screen. These pins are necessary for locating a colour mask during tube production.

Mono screens have always been polished on a large number of machines, which executed the required processes simultaneously. The consequence is a very difficult to predict quality level for each screen. In February 1990 a new polishing line was ready to start polishing colour screens. This line comprises 5 machines and all screens are processed by all these 5 machines. This results in a constant output level. The investigation about optimization of this new polishing concept comprises two main parts: how many products can be processes simultaneously and how many polishing machines should be used in one line.

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Conclusions related to the polishing capacity are:
- More then one glasstype can be used to press colour and mono screens. The results of polishing will vary strongly between the glasstypes used for the screens.
- More products can be handled in the same time by putting more products on one carrier. Process conditions are estimated and have to be confirmed by trials. Critical factor will be the transport between the modules, especially when on one line a number of different screens have to be processed.
- The number of modules as used in the existing situation seems to be the most efficient way to polish most of the screens.

A new production line for colour screen pinning is also just released. Before screens can be pinned, they have to be heatened up to avoid tension in the glass after the pinning process. After pinning, the screens have to cooled down controlled, for the same reason. The new lines comprises one pre-heating oven, two pinning insertion machines and one cooling-down oven. Such a line is called a "cold pinning line". Another possibility is to pin screens "hot". When this will be done the pinning insertion machines are located directly after the press. This saves the heating-up and cooling-down of cold pinning, because the screens are on required temperature for pinning and cooling down will be done anyway.
Due to two reasons "hot" pinning is not an attractive possibility to pin colour screens:
- the existing concept of the press production: in one tank different glass types will be melted to be used for the different products produced. When products will be produced of a different glass type then can be used for colour screens, the pinning insertion machines will be idle.
- space restrictions in the building of the press: too less pinning insertion machines to pin the whole press production can be installed.

Based on the alternative solutions for pinning and polishing has been concluded that no space problems exists for these solutions. All combinations of solutions can be placed in the existing buildings. In some cases regrouping is necessary.

The expected personnel problem could become very serious. The work environment on the work floor in the Glass factory in Chupei is relative bad. And due to an increasing education level, the number of people to employ in the simple jobs is decreasing in Taiwan. This forces the glass factory to mechanize the simple jobs, to reduce the needed number of people employed.

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0. Introduction

This report is the result of a research project, which has been carried out to finish the degree course in Industrial Engineering at the Eindhoven University of Technology.

The factory where the project has been executed, is located in Taiwan R.O.C., an island straddling the Tropic of Cancer about 200 kilometers off the eastern shores of the Chinese mainland. With a population of 20 million people, a land area comparable with the Netherlands and about two-third of the island covered with mountains (where only half a million aborigines are living), the remaining area is one of the most densely populated areas on earth.

Taiwan is known as one of the four "Asian dragons" (Taiwan, Korea, Hongkong and Singapore), who have succeeded in a rapid economical development the last decades.

Taiwan is also very often mentioned as an ecological warning. It is seen as the prototype of an developing nation, which has developed so rapidly that it could not handle this development in environmental terms. Air and water pollution are the consequences of this unregulated development.

The project has been executed at one of the four TV-Glass factories of Philips, which are suppliers of glass parts to (Philips) tube factories. In a TV-Glass factory glass parts are pressed. After pressing, the glass parts need one or more finishing processes. In the glass factory Chupei (Taiwan, R.O.C.) the pressing capacity has been extended in 1988/1989 to enable the factory to produce more attractive glass parts. Extension of the finishing capacity was also required for these parts. And for the future expectations exist that:

1. the production will shift from products to be used in mono tubes towards parts to be used in colour tubes;
2. the total production volume will increase.

The aim of this study was to develop alternatives for the expected increasing demand for finishing of certain glass parts: the screens. These alternatives should be based upon the market demand (determines the production volume and kinds of glass parts to produce), the technical realizable solutions and lay-out restrictions.

Chapter one contains a view in general on the TV-Glass group of Philips and more specific on the TV-Glass factory in Chupei, Taiwan R.O.C.. Chapter two continues with the background (including a little bit history), the aim and the approach of the project. Chapter three deals with Taiwan as location place for a factory and contains some remarks about the labour force.
In chapter four is described the world-wide situation of the TV-glass market and the capacities of the existing factories.
The chapters five to seven handle about the TV-Glass factory in Chupei: chapter five contains considerations about the total volume of products which TV-Glass Chupei can produce; chapter six deals with the first finishing process: the so-called pinning and

chapter seven is about the other finishing process: the so-called polishing.
Chapter eight combines the findings of the chapters seven and eight in conclusions concerning both finishing steps with keeping in mind the market situation (chapter four) and the maximum pressing volumes (chapter five). The last chapter of this report contains some (general) recommendations.

The appendices belonging to this report are added in a separated volume.

1. Philips Industrial Group TV

1.1 Introduction

The Philips Industrial Group TV is part of the Main Supply Group Glass. This group comprises 1 factory for optical glass, 4 factories where TV-Glass parts are made, 23 factories producing glass for lamps and one factory which makes optical fibers. Fig. 1.1 shows the organization.

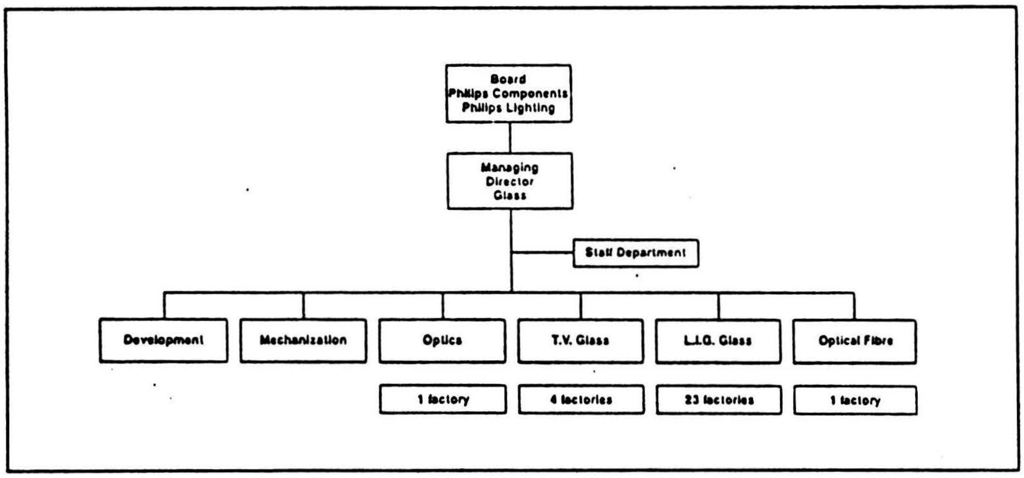


Fig. 1.1: Main Supply Group Glass.

The Philips Industrial Group TV comprehends 4 TV-Glass factories around the world and a central department in Eindhoven (NL). The four TV-Glass factories are located in Aachen (B.R.D.), Cupuava (Brasil), Chupei (Taiwan R.O.C.) an Simonstone (U.K.).
Each factory has one or more furnaces and one or more pressing-lines to produce glass parts for picture tubes. Those glass parts are produced for colour as well for monochrome picture tubes. The two types of glass parts are cones and screens.
Table 1.2 shows the furnace and pressing capacities of the different factories and the types of glass parts being produced.

Factory	Number of furnaces	Furnace capacity ton/day	Number of presses	Products
Aachen	3	120	1	Colour screens
		180	2	Colour screens
		180	2	Colour cones
Simonstone	1	110	1	Colour screens
Cupuava	1	115	2	Colour screens
				Colour cones
				Mono screens
				Mono cones
Chupei	1	180	3	Colour screens
				Colour cones
				Mono screens
				Mono cones

Table 1.2: Capacities of glass factories.

1.2 Products

Products produced by TV-Glass factories are screens and cones for colour and monochrome picture tubes. In the colour screens three pins (FS types four) are inserted for locating the colour mask, which is an iron plate, containing a large number of very small holes. The purpose of these little holes is to deflect the three light beams (yellow, red and blue) in such a way that the beams arrive on the right phosphor layer on the screen. Monochrome screens don't need those pins, because they will not have a mask. All cones are joined with a neck and are inserted with an anode. Colour tube parts are supplied as cones and screens to the colour tube factory. Mono tube parts are supplied as the so-called bulb, a joined screen and conus, to the mono tube factory.

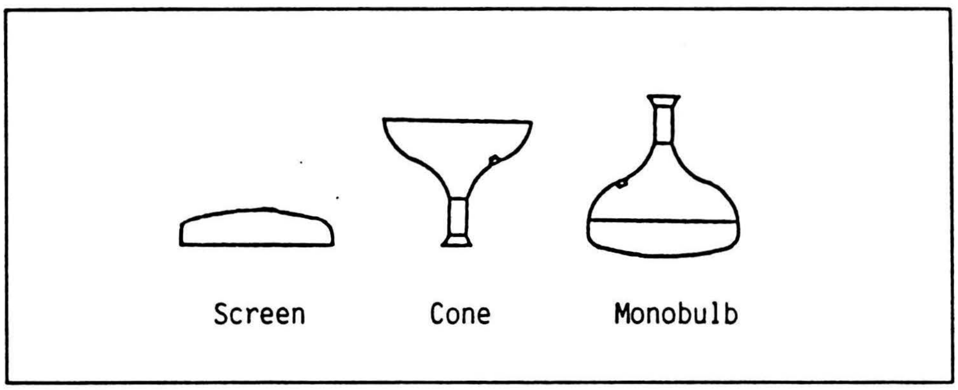


Fig. 1.3: The products.

Products can be classified on the following distinctions:
- screen versus conus;
- colour versus monochrome;
- screen size;
- monitor versus television (consumer);
- flat square versus conventional;
- glass characteristics (X-ray absorption value, transmittance).

1.3 Processes

The manufacturing process of glass parts for picture tubes comprises basically three stages:

1. Glass making: a complex continuous chemical and physical process at temperatures up to 1600° in a melting furnace (mixing and melting).
2. Glass parts forming: a mechanical/physical process on a press giving the product its definite main dimensions (pressing and annealing).
3. Glass parts finishing: mechanical/physical processes in which the glass parts get their final dimensions and surfaces and are ready for use in the tube factory (joining, pinning and polishing).

products. The rest of their needed products (up to 20%) should be obtained from external glass factories. In this way fluctuation in demands for tubes would not disturb the production of the glass factories and enable the glass factories to produce at a stable output volume. But at present, the output volume of the Glass-factories is increasing, due to higher speed of the presses (up to the maximum capacity of the furnace) and higher yields factory-wide. A higher output volume is necessary to stay in a good competitive situation. This situation enables (and forces) the Glass-factories to supply the tube factories of Philips with 100% of the glass parts needed.

1.5 The Glass factory in Chupei.

The TV-Glass factory in Chupei is part of Philips Taiwan Ltd. The national Philips organization comprises several plants and factories. The TV-Glass factory is located on the Philips plant in Chupei. An organization chart of this plant is given below.

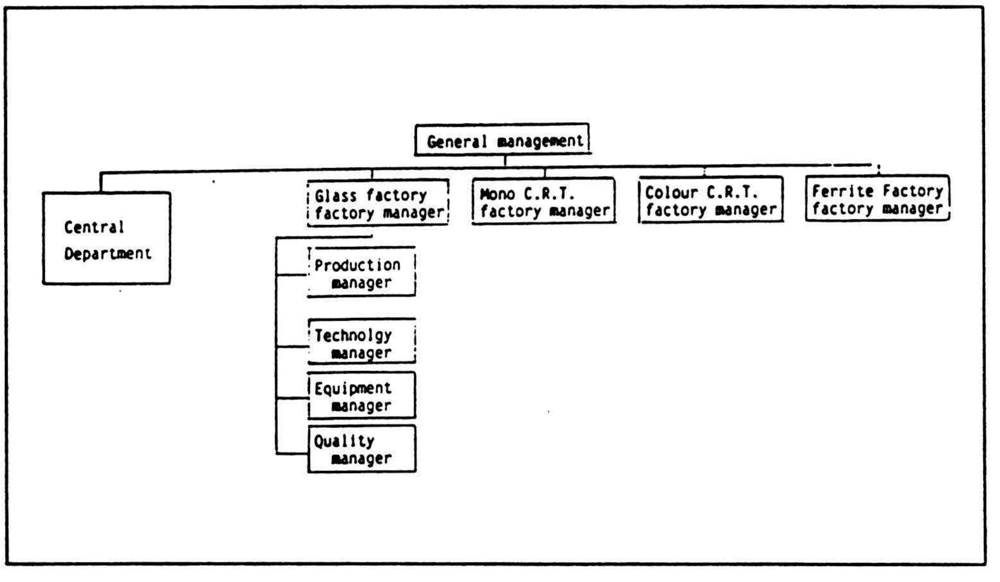


Fig. 1.5: Organization chart Philips plant Chupei, Taiwan R.O.C..

The C.R.T. (tube) factories produce tubes to be used in mono monitors and colour televisions and monitors. The ferrite factory delivers ferrite to the C.R.T. factory.The number of people employed in these factories is (about):

- central departments: 280;
- TV-Glass factory: 650;
- Mono C.R.T. factory: 800;
- Colour C.R.T. factory: 1350;
- Ferrite factory: 40.

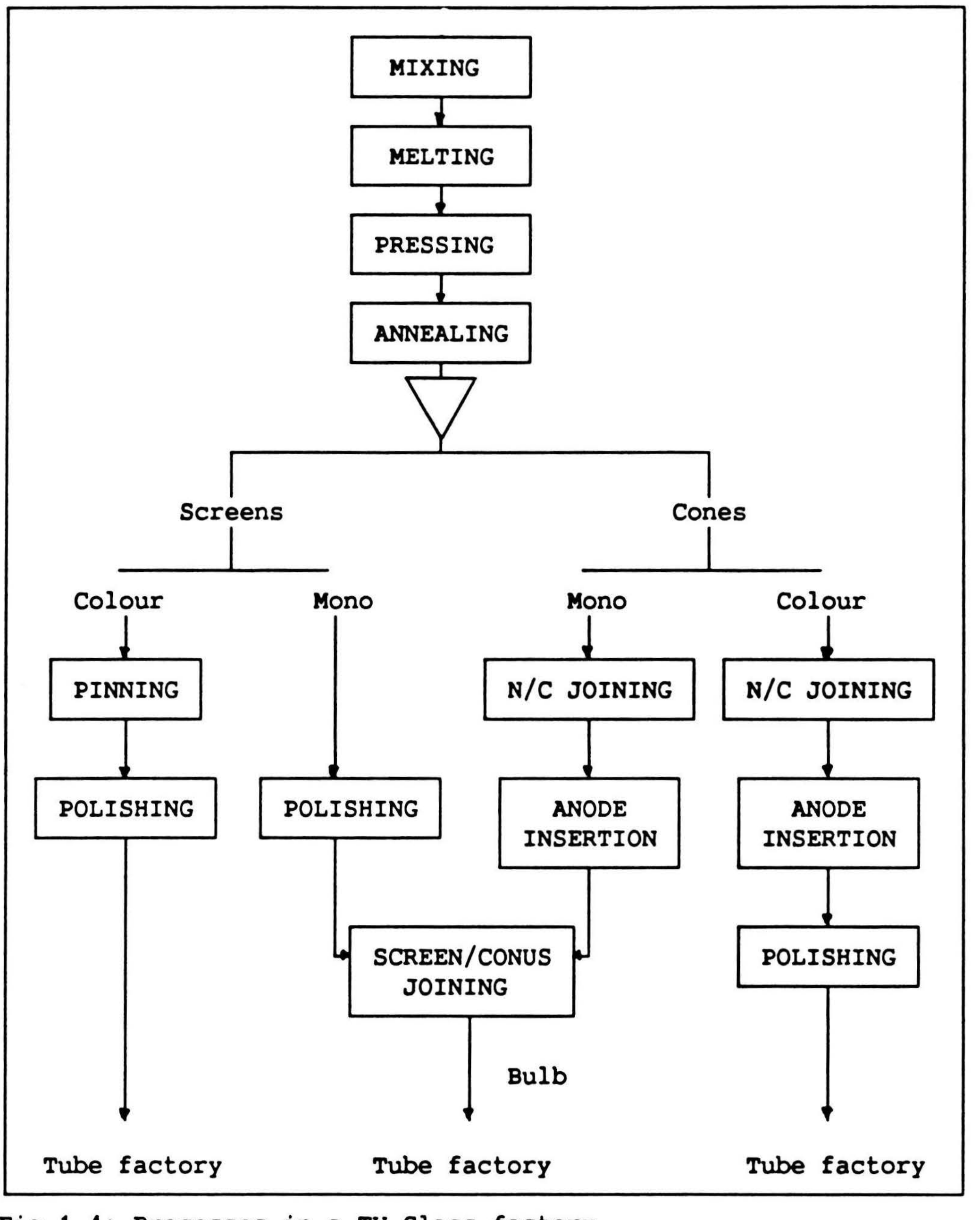


Fig.1.4: Processes in a TV-Glass factory.

Before pinning and anode insertion the products have to be pre-heated. After the process the products have to be annealed to reduce the stress in the glass parts. Another possible place for pinning and anode insertion is between pressing and annealing in stage 1, the so-called hot pinning c.q. hot anode insertion.

1.4 Customers

The customers of the TV-Glass factories are the tube factories of Philips Components. Those factories are located in Aachen (B.R.D.), Dreux (France), Barcelona (Spain), Lebring (Austria), Sao Jose dos Campos (Brasil) and Chupei (Taiwan R.O.C.). The objective (policy) of the glass factories has always been to supply the tube factories with at least 80% of their needed

As shown in section 1.1 the Glass Factory Chupei is equipped with one furnace (max. 180 tons/day) with three presses. This furnace is a so-called flexitank, which means that the furnace is in use for melting different glasstypes, as required by the different products produced.

Trials are and will be carried out to investigate the possibilities of making different glass parts of one glasstype. This should decrease the glass change time in the furnace, which is idle time for the furnace and the presses. Until present, the Glass Factory had produced colour cones and monobulb (which are the joined mono screens and cones). Starting in 1990 colour screens will also be produced. Figure 1.6 shows the produced quantities of the last years.

	1987	1988	1989
Monobulb	3365	3443	2619
Colour cones	2045	2524	2410
Colour screens	-	-	-

Fig. 1.6: Quantities produced (thousand pcs.)

Monobulb is made in the sizes 12" until 20", all for use in a monitor tube. Colour cones are made in the same range of sizes, but these are to be used for consumer tubes (for televisions) as well as for use in monitor tubes. Customers of the Glass Factory Chupei are the colour C.R.T. factories (for colour cones and in the future colour screens) and mono C.R.T. factories (for monobulb). These factories are located on the same plant as the glass factory. Incidentally glass parts are also delivered to other C.R.T. factories in Europe.

2. The investigation area

2.1 Background

In the middle 80's market developments have been established: the expected demand for monitor tubes (especially colour) and the expected demand for the 51" Flat Square colour screen was increasing in the Far East.

In preparation to this expected increasing demand, in 1987 the decision has been taken to combine the planned overhaul of the furnace (needed about every six years in a glass factory), planned in 1988, with a total capacity increase (from 120 to 180 tons/day) to enable also colour screen production (up to the 51" Flat Square screen). Two million colour screens/year should be delivered (finished) on top of existing monobulb capacity and colour cone capacity.

Two other, more strategic reasons for this decision were:
- breaking the monopoly position of the local competitor; this competitor was the only supplier of colour screens in Taiwan and the Philips C.R.T. factory was dependent on this non-Philips supplier for colour screens;
- the potential market of mainland China.

In the second half of 1987 the budget for the so-called flexitankproject (overhaul and capacity increase) has been approved. The project also included three new hydraulic presses (with higher speeds and yields), two cold pinning lines and two new polishing lines (processes are explained in the chapters 6 and 7). With this equipment Chupei would have capacity to produce a large number of different colour screens.

The new pinning and polishing lines would be located in a new building. Regrouping of equipment in the existing buildings would be necessary to create enough space for the new pinning and polishing lines. In the existing buildings the finishing processes for colour screens and the joining processes for monobulb were located.

After the decision for investment, development of production equipment started. But during this preparation and development, it became clear that the hightoned expectations would be difficult to realize.

Changing expectations

Due to the strong increase of tube production from 1986 until 1988 (see table 2.1) most of the tubes, where the glass factory should supply glass for, were no more rentable to make for the tube factories . The only remaining type was the 14" screen in two versions: for use in monitor tubes and for use in televisions.

	1986	1987	1988	1989
Japan	30.1	32.5	35.0	28.0
Korea	10.5	15.0	21.0	24.0
Rest Asia	5.8	7.0	9.0	12.7
Total Asia	46.4	54.5	65.0	64.7

Sources: [2], [6] and [11] in appendix 2.

Table 2.1: Production of colour CRT's in Asia.

So only the 14" screen remained and it was decided to build only one colour-screen pinning and polishing line, instead of the two pinning and polishing lines which would be needed for finishing 2.0 million screens of different sizes. The maximum capacity of one line is 1.8 million per year, if only 14" screens has to be produced. Appendix 1 contains the redefined lay-out of the whole S-building, which also reflects the current situation.

Money and place has been reserved for an eventual future extension to a two-line finishing system. The construction of only one pinning and one polishing line had a big advantage: regrouping of the existing buildings was no more necessary. The new pinning and polishing lines could be located altogether in the new building. Thus, the same processes as described in section 2.1 are located in the already existing buildings.

But again disappointing market developments took place: in the beginning of 1989 the market demand for 14" consumer colour tube became so low that glass making ceased to be rentable. And the development of the required glasstypes (a Philips Eindhoven activity) for 14" colour monitor tube had been delayed: for the medium resolution screens a little, for high resolution screens a year.

The consequences are a lower supply opportunity towards the colour tube factory in 1990 and very low utilization of the new pinning/polishing lines in 1990, which are available since the end of 1989.

This low utilization of the new polishing line for polishing colour screens brought the opportunity of using this modern line for polishing mono screens. This would give the opportunity of a better yield and a more constant (and probably better) quality. Finally it gives an opportunity to reduce the personnel problems related to the present situation of polishing mono screens (for a more extensive explanation of mono screen polishing see 7.2.1: B/W polishing process). The process conditions for polishing monoscreens on the new line will be assessed in 1990.

2.2 Future expectations.

In addition to the opportunity of polishing mono screens on the new line, there are three other opportunities that could be related to an eventual extension of the colour finishing capacity.

1. Making colour cones "as pressed": the pressing quality is so high that cone finishing (=polishing of the edge of the cone) is no longer required. When this opportunity comes true building S2 (where the colour cones finishing capacities are located at the moment) will be available for extension of the finishing capacity without any regrouping effort.
2. Making colour screens "as pressed": here again, due to the high pressing quality, edge grinding and polishing are no longer required. For edge grinding and polishing two SEFU's (Sealing Edge Finishing Units) are located in the current polishing line. When it is possible to produce screens "as pressed", those two units can be removed from the line, thus creating space for installing two more polishing modules in the line.
3. Universal glass: one glasstype can be used for producing colour screens and mono parts. When it's possible to use one glasstype for colour screens and monobulb at the same time, two of the three presses can produce mono parts and one press can produce colour screens. So, only one hot pinning installation (for explanation of hot pinning, see chapter six) is needed for pinning the colour screens. This opportunity will become very important when the demand for colour screens becomes higher then about 1.8 million screens, which is the maximum capacity of the just installed cold pinning line. So, universal glass may prevent the need for a second cold pinning line and may give the opportunity for a rentable hot pinning device.

The above described opportunities have a direct influence on the extension possibilities of the finishing capacities. Extension requirements are dependent on the market demand for colour screens. And for the near future the situation will probably improve for the TV-Glass factory. After the depressing change in supply-opportunities as described in 2.1, the colour C.R.T. factory is now looking at an improving market, especially for the 14" monitor tube. This could create a supply-opportunity for the TV-Glass factory, which would give the opportunity to realize a higher utilization of the furnace and the presses. This is very important, because the furnace and the presses are representing 62% of the total investment in fixed assets. But, increasing supplies require an extension of the existing finishing capacity.

In order to anticipate on the possible situations and their opportunities, investigations have to be carried out to know in which way opportunities should be handled, to get the best expected results.

This investigation deals with the possibilities of finishing all monochrome and colour screens (i.e. pinning and polishing) in the future.

2.3 Objective of the investigation.

The investigation comprises two subjects: polishing of all screens produced (colour an mono) and pinning, which is only necessary for colour screens.

The objective of the investigation is to answer the following questions:

1. A. How is it possible to polish all colour and mono screens in the future: which smart utilization of the possible 14/16 modules for colour and mono screen polishing and the available mono screen polishing capacity (the Philiflows)?
   B. Under which conditions can this be done?
   C. What are the financial consequences?

2. A. How can the total amount of colour screens be pinned?
   B. Under which conditions can this be done?
   C. What are the financial consequences?

Based on the investigation alternative solutions/lay-outs have to be generated. These solutions should include:

A. An optimized lay-out of the S-3 building (and if possible the whole S-building).
B. The conditions related to the alternatives (need of personnel, etc).
C. A financial analysis of the alternatives (based on cash-flow).

2.4 Project execution.

Going down from a global way of problem approach, at first the world-wide situation of the TV-Glass market has been investigated. Next the volumes to press in Chupei has been established (= factory level). After this has been investigated the extension of the pinning and polishing capacity as required for these volume (= department level). Fig. 2.2 shows the assessment items in detail.

To get a good understanding of the production environment of the TV-Glass factory in Chupei a small investigation has been carried out about Taiwan as a location for TV-Glass production. The investigation comprises the costs of production from TV-Glass parts to monitors in Taiwan and the costs and availability of labour.

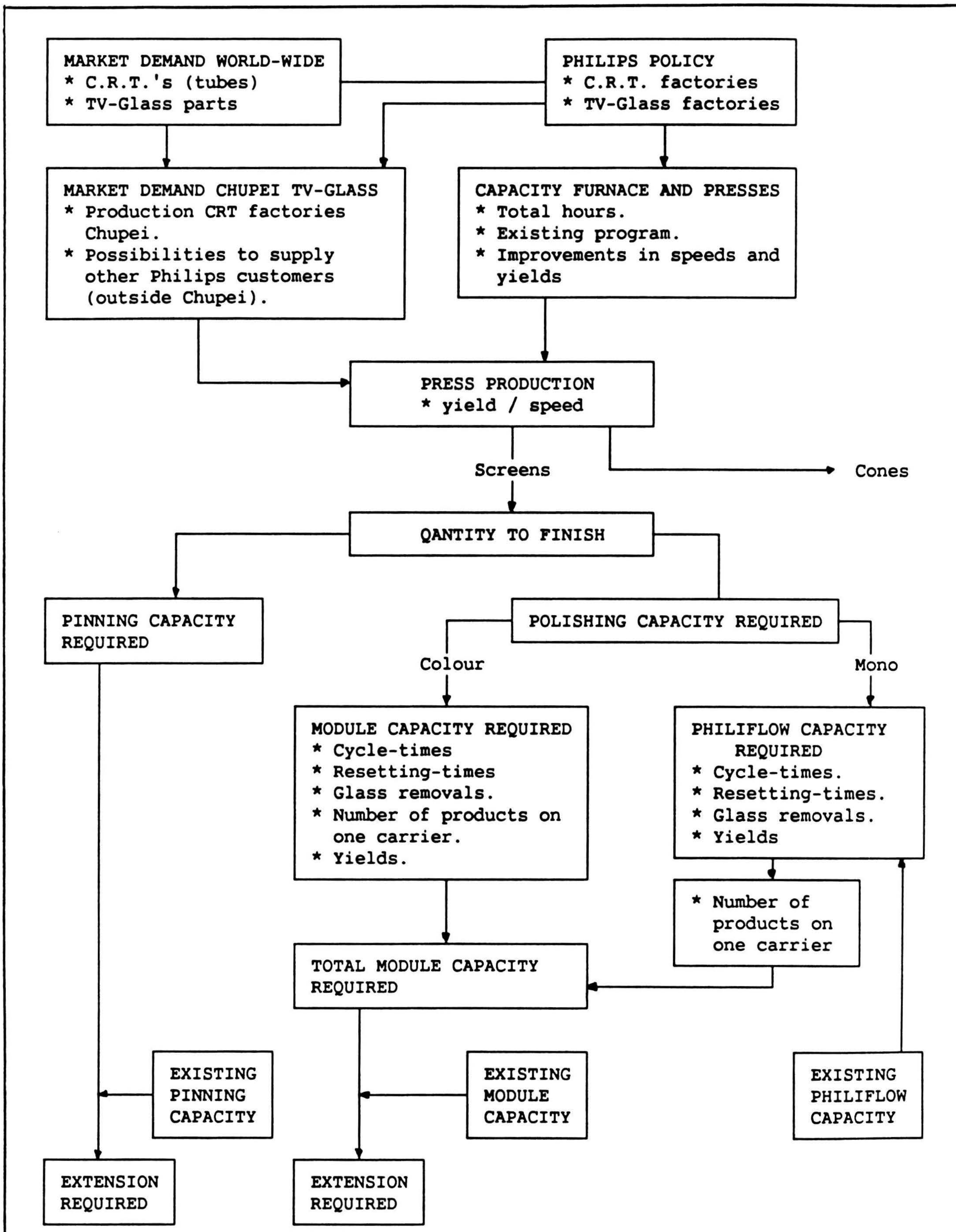


Fig. 2.2: Assessment items.

3. Taiwan as location for TV-Glass production

3.1 Introduction.

Taiwan has succeeded in transforming an essentially agricultural economy into an industrial one during the last thirty years. The driving force behind this development is U.S. economic aid and international trade. The changes in Taiwan can be summarized as follows:

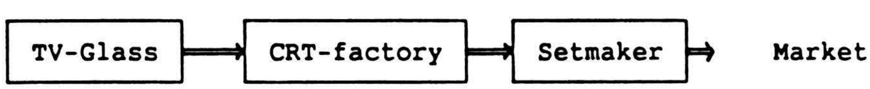
- 1950 - 1965 : an U.S. aid program helped to get the island on his feet. In these years the agricultural sector grew and industrial policy focussing on private investments and import substitution industries was carried out by the government.
- From the early 1960s: Taiwan started to export products from her light industry.
- In the 1970s: improvement in the islands infrastructure and development of capital-intensive industry such as steel and petrochemicals brought the island further prosperity.

Other nations were following the same path to development. In the early 1980s the government of Taiwan was forced to shift its focus towards the more capital intensive and higher added value industries. This was necessary because Taiwan was loosing her comparative advantage in the low cost labour-intensive industry.

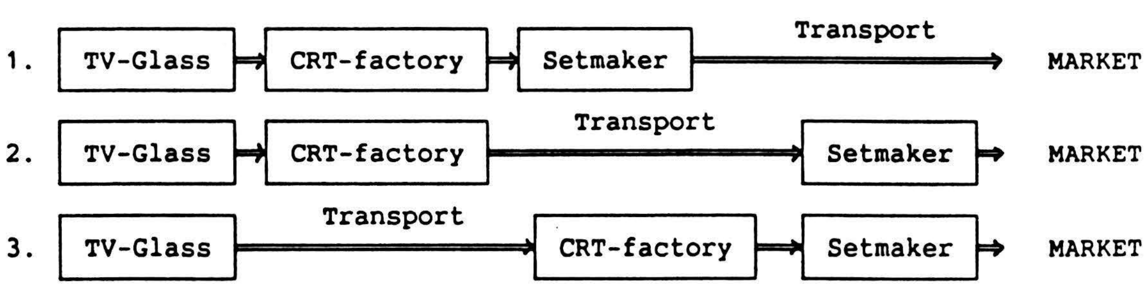
The TV-Glass factory in Chupei is still a factory where a large amount of people is being employed. This is the same for the C.R.T. factories and setmaker, which are also located in Taiwan. In section 3.2 the labour costs (as part of the total production costs) will be evaluated and in section 3.3 is included a paragraph about the availability of a group of labour (the operators).

3.2 Global competitiveness of Philips Taiwan TV-Glass factory.

The TV-Glass competitiveness is dependent on the competitiveness of CRT Taiwan. The competitiveness of CRT Taiwan depends on competitiveness of setmakers in Taiwan or elsewhere:



Finally the competitor has to be faced at the end-users market. Therefore the total factory network has to be taken into account, from sand to client. A possible configuration for markets, main streams of volumes is as follows:



The question to be answered is to assess the optimal location for one of the factories: when is the sum of production and transportcosts (including pipeline for quantity Q/y) minimal over the total network.

Main variables in Asia compared to Europe and USA: labour costs, efficiency and transport.

To remain within the scope of the project, the only variables which have been explored are the relative production costs of the TV-Glass factory, the C.R.T. factories (mono and colour) and the setmaker. Also the supply countries of the different factories are mentioned.

The capacities and deliveries of the four factories are:

* TV-Glass:

Product	Capacity	Delivery from
Monobulb	2.4 M	100% CRT Chupei
Colour screens	1.5 M	100% CRT Chupei
Colour cones	3.2 M	70% CRT Chupei
		30% Europe

* Colour CRT factory:

Product	Capacity	Delivery from
Colour tubes	2.4M	35% Setmaker Chungli
		43% Taiwan third party
		12% Rest Asia
		10% USA

* Mono CRT factory:

Product	Capacity	Delivery from
Mono tubes	4.2 M	20% Setmaker Chungli
		36% Taiwan third party
		16% Rest Asia
		23% Europe
		5% USA

* Setmaker:

Product	Capacity	Delivery
Monitors	2.0 M	55% Europe
		40% USA
		5% Far East

Table 3.1 contains the results of the investigation of the relative production costs. Between brackets the relative production costs are mentioned including the parts which are delivered from TV-Glass to the C.R.T. factories and from the C.R.T. factories to the setmakers.

	TV-Glass	C.R.T. mono	C.R.T. colour	Setmaker
Material	28.7	24.8 [74.3]	64.2 [73.6]	79.7 [88.7]
Energy	8.9	5.4 [1.8]	3.5 [2.6]	0.5 [0.3]
Labour	25.4	49.9 [17.1]	18.6 [13.7]	15.1 [8.4]
Machinery	14.3	6.9 [2.3]	5.1 [3.8]	2.6 [1.4]
Maintenance	4.4	5.6 [1.9]	3.2 [2.3]	0.5 [0.3]
Financial costs	17.0	7.5 [2.6]	5.3 [3.9]	1.7 [0.9]
Waist costs	1.4			

Table 3.1: Relative production costs.

The absolute labour costs can be compared with the costs of labour when this factory network would be located in an other country. A comparison has been made with countries where also a TV-Glass factory is located. Brasil is not included in this comparison, because of the currency problems of the last year, which makes it very hard to compare financial costs with other countries. The comparison is based on the existing number of people employed in Taiwan and the costs of labour in Taiwan, Germany and the U.K.. Table 3.2 gives the result.

	TV-Glass	Mono CRT	Colour CRT	Setmaker
Taiwan	25.4	49.9	18.6	15.1
Germany	70.1	78.8	131.3	158.5
U.K.	37.1	40.5	70.0	83.5

Table 3.2: Comparison absolute labour costs.

The advantage of production in Taiwan in the total production network is clear. But the comparison includes only the costs of labour, based op the number of people employed in Taiwan.

3.3 Availability of labour in Taiwan: operators.

The increasing prosperity in Taiwan has led to changes in the availability of labour. At present, Philips Chupei faces a shortage of operators, especially in the colour CRT factory. The TV-Glass factory has almost enough operators. The only problem area is the Philiflow mono screen finishing area.

This problem is not a special Philips problem. Low wages and easy ways to make "big" money are leading to a shortage of low-skilled labour island wide. The wage of an unskilled operator is about 15,000 NT$ per month (about Dfl. 11,000 guilders) and even a street vendor can earn up to 5 times this salary. The risk of running a private business scares a lot of people and so still a number of operators is available.

On the other hand, there are also some employees who don't have to work (financially speaking), but still work as an operator to 'kill the time'. Some people have become very rich by lucky investments or by selling land which they had used for agricultural purpose. But staying at home and not earning a salary accepted. To keep their reputation high, they have a simple job, nevertheless they don't need the money (example: the personal driver of general manager changes the company Ford after work for his own brand new Mercedes after work).

Another changing field is the increasing education level. Nowadays, more and more people are graduating from high school and they don't want to work as an operator. And for the youngsters who are looking for a low-skilled job, enough positions are available. The electronic and semi-conductor industries are still offering low-skilled jobs and the working environment is rather good. Well air-conditioned rooms and male and female operators (good for the necessary social contacts). Many low-skilled people also prefer to work in a service-oriented company instead of a production factory, caused by the better working environment and more interesting work.

With regards to the Philips situation, especially in the TV-Glass factory the working environment can often be characterized as hot or wet or hot and wet. In the past time Philips was known as a respectable foreign company, but today so many foreign factories have settled in the Hsinchu area, that this relative advantage has vanished. Also in the old time, Philips was known as a rather good payer. Nowadays the monthly payment is still higher then other factories, but the annual package (including bonuses and stock incentives) is equal or even lower than other companies. But one advantage still exists: shift-production. This gives the operators the opportunity to run a second (maybe more profitable) business when they are off duty. It is not abnormal that people use their spare time for doing a second business instead of recreation or entertainment. This second business can provide them with enough money to buy their own house and to give their children good education.

Due to all the forgoing the glass factory is employing at present many old operators (40% above 50 years), who only have a low education and no other choice then the job offered by Philips.

This will probably lead to a problem situation, because some operators will retire in the coming five years (the retirement age is 60 years). This and the island-wide shortage of unskilled labour combined with the hot/wet working environment of the TV-Glass factory can bring the TV-Glass factory in a situation, where it will have problems to get enough labour. The first place where this will occur, is in the worst working place in the TV-Glass factory: the Philiflow area: a tremendous wet and in summertime hot place where the workload is rather heavy. Nowadays, the first signs are there: last year 15 new people were hired to work in this area, only 2 are still working in this place. This forces Philips to reduce the number of people to employ and replace them by mechanizated/automated devices (maybe such as the just installed modular polishing line).

Another solution for the personnel problem in the Philiflow area is to adjust the salaries. But this is not done easy in the total Philips Chupei organization. Salary adjustments only in the Philiflow area will resolve in complaints of other operators, who also would like to see an increase in their salaries.

Reducing the headcount is also preferable because of the increase of the wage costs at an average annual rate of about 8%. To remain in a good (international) competitive situation the total wage costs have to be reduced.

For this reason the Glass factory is at present very busy with mechanizing simple jobs. These projects should lower the headcount in the long term to reduce the cost of production. In the short time these mechanizing projects enable the Glass factory to place people who become idle due to these projects in their own department in other departments where they are needed. In this way, the personnel problem can probably be solved partly and temporary.

4. Market demand and Philips policy

4.1 Market demand and capacities.

The market demand for TV-Glass parts is dependent totally on the production of CRT's. CRT factories are the only customers of TV-Glass factories. And the market demand for CRT's is dependent on the production of televisions and monitors.

Market demand TV's and monitors

↓

Production TV's and monitors
= market demand CRT

↓

Production CRT
= market demand TV-glass parts

↓

Production TV-glass parts

Fig. 4.1: TV-Glass and CRT dependence.

The trends world-wide can be summarized as follows (for a more comprehensive survey see appendix 2):

* Market demand in the free market countries (Asia, W-Europe and N-America) of mono TV's is decreasing, demands for mono monitors and colour TV's and monitors is increasing.
* An overcapacity exists world-wide for C.R.T. factories related to their demand, and this overcapacity is located in Asia.
* The same situation exists for TV-Glass factory: on world-level an overcapacity and this overcapacity is located in Asia.

The CRT demand and the CRT capacity are shown in figure 4.2.

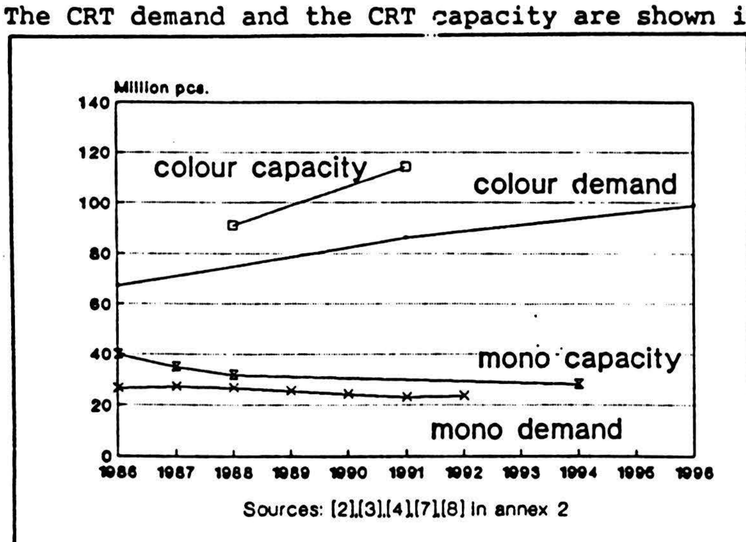
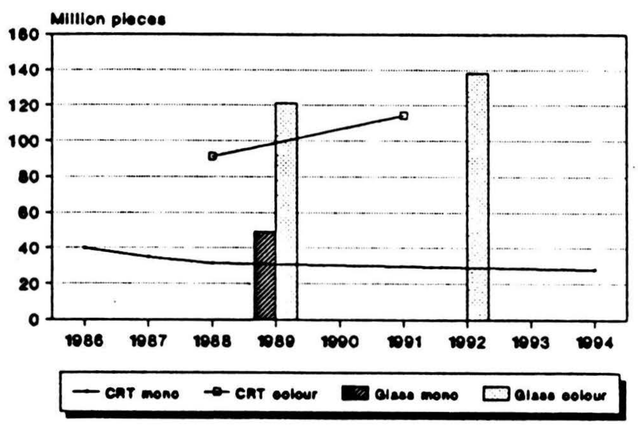


Fig. 4.2: CRT demand and capacity world-wide.

The capacity to produce mono CRT's is decreasing world-wide, due to the strong decrease of needed CRT's for mono T.V.'s and the modestly increasing need of CRT's for mono monitors. The capacity of monochrome CRT's is almost entirely concentrated in Korea en Taiwan (see also appendix 2). From fig. 4.2 can be concluded that a overcapacity exist for CRT production world-wide.

Also interesting is a comparison of the capacity of CRT factories and capacities of TV-Glass factories world-wide. Fig. 4.3 shows these expected capacities in the coming years.



Sources: [7], [8] and [9] in annex 2.

Fig. 4.3: Capacity CRT versus capacity TV-Glass world-wide.

Here also exists an overcapacity of TV-Glass capacities world-wide over CRT production capacities world-wide. So, TV-Glass factories have world-wide an overcapacity over CRT factories, which have an overcapacity over the CRT demand. This could lead possibly to lower prices on the world-market in the future. This means that stronger competition will occur. Prices going down is already a fact today. This makes optimization of production necessary to reduce the cost of production of TV-glass parts.

4.2 Philips policy.

The two CRT factories in Chupei will be treated differently. The mono CRT factory will not extend his capacity anymore. The maximum capacity of 4.2 M will be occupied by the most rentable mono CRT's.

The colour CRT factory may specialize in one or a few types to produce. Probably in 14" monitor CRT's, combined with 51 FS consumer CRT's. To realize the production of 14" CRT's more efficient, the CRT factories may extend its capacity to produce 14" monitor CRT's from 1.8 M to 2.4 M (in 1992) or even to 3.2 M (in 1993).

For the TV-Glass factory in Chupei the situation after installation of a new flexitank last year is a little difficult. Factory Standard Prices are high compared with prices of non-Philips suppliers. With increasing speeds and yields factory-wide, the situation can improve. But the installation of a flexitank of 180 tons/day has created a more structural problem. A flexitank (in use for more glass types) is always less efficient then a dedicated tank (in use for only one glass type). This is leading to, combined with an overcapacity of the furnace (the presses are the bottle-neck in the present situation) and many product changes on the presses, a high factory standard price compared with competitors.

Policy?

Possible solutions are:

- production of more bigger glass parts (more efficient use of the furnace;
- specialize in a few products to produce: less press-changes required;
- less glasstypes in use: less time wasted by glasstype change;
- decrease the costs of finishing by mechanization or automation of these processes.

Is dit gerekend met klassieke kostprijs of met

activity based cost price

5. Production volume TV-Glass Chupei

5.1 Scenario's

5.1.1 Production of mono CRT

Total production of the mono CRT factory in the coming years will be (at most) 4.2M pcs. per year. From non-Philips suppliers the CRT will buy about 0.88M pcs. per year. Remain to deliver at maximum by TV-Glass 3.52 M pcs. per year (for calculation, see appendix 1). If TV-Glass wants to deliver these 3.52M screens, high-glossing must be improved. This is necessary for etchable screens. Etching is a process of plunging the screen in an acid to reduce the reflection of a high-glossed screen. After etching every little scratch (which is sometimes impossible to observe visually) can be seen on the outer surface of the screen. To avoid this problem of high-glossing to a quality which can't be observed visually by the inspectors, Philips is trying to replace the etching process by a coating process, during which minimal scratches are allowed. If high-glossing will not reach the required high standard for etching the number of screens to deliver will decrease with about 0.5 M to 3.0 M pcs per year.

5.1.2 Production of colour CRT

In 1990 the total production of the colour CRT factory will be 2.3M pcs. per year. About 1.8M 14" monitor tubes and about 0.55M consumer tubes will be produced. Plans exists to produce all consumer tubes from 1990 on of the 51 FS type. Three alternative production scenario's for the colour CRT factory can be distinguished:

1. No change in production volumes: 1.8M 14" monitor tubes and 0.55M 51 FS tubes for the coming 5 years.
2. Extension of the production of 14" monitor tubes to 2.4M starting in 1992, while the amount of consumer tubes (only 51 FS) to be produced remains on a volume of 0.55M.
3. One extension in 1992 for 14" monitor tubes (to 2.4M) and another extension in 1993 to 3.2M, while again the amount of consumer tubes (type 51 FS) remains at a level of 0.55M.

5.1.3 Possibilities to supply other Philips customers (outside Chupei).

In 1990 TV-Glass Chupei will supply 0.5M CMT colour cones to Aachen and 0.5M consumer colour cones to Barcelona. But no plans exists (till now) to make these supplies structural. Starting in 1991 TV-Glass Chupei will probably start supply 36 FS screens and cones to the CRT factory in Lebring (Austria).

5.1.4 Possibilities to supply to non-Philips customers.

After installation of the flexitank, Philips has only supplied to customers inside the Philips organization. But in the current situation of expected underoccupation of the presses, the management is looking for possibilities to deliver glass parts where ever possible, to increase the output volume of the glass factory.

The first six scenario's are based on the supply opportunities to the C.R.T. factories in Chupei. The A-scenario's are based on the supply opportunities for 14"CMT screens and in the B-scenario's the possible supply of 51 FS screens is added. Summarized the scenario's are:

Maximum colour screens to supply to the colour C.R.T. factory (M. pcs/year):

Scenario	screen	1991	1992	1993	1994
F1A	14"CMT	1.42	1.89	1.89	1.89
F1B	14"CMT	1.42	1.89	1.89	1.89
	51 FS		0.58	0.58	0.58
F2A	14"CMT	1.42	2.52	2.52	2.52
F2B	14"CMT	1.42	2.52	2.52	2.52
	51 FS		0.58	0.58	0.58
F3A	14"CMT	1.42	2.52	3.36	3.36
F3B	14"CMT	1.42	2.52	3.36	3.36
	51 FS		0.58	0.58	0.58

Table 5.1: scenario's and supplies.

The possible maximum amount of monobulb to supply is for all the scenario's the same: 3.52M monobulbs/year. For these six scenario's is the press occupation of the press calculated in 5.2.

5.2 Occupation of the presses.

Parameters affecting the total amount of glass parts to press are:

1. The net amount of products required: production of CRT-factories in Chupei, utilization factor CRT-factories, purchases CRT-factories, sales IG-TV, interregional supplies IG-TV, stock-movements and the yields of the finishing and joining processes.
2. Those affecting total available pressing hours: pressing days, number of presses, number of glasstype changes, number of type changes and time needed for revision or pressing trials.
3. Those concerning how the pressing time will be used: yield and speeds (different for almost all glass-parts).

These parameters, included the improvement plans, combined with the six alternative scenario's of section 5.1 give a certain (under)occupations of the presses per year. These (under)occupations are given in table 5.2.

Table 5.2 is based on the following assumptions:

* No delays in press production will happen due to transmission requirements (which may be dependent of the success of transmission input in feeders or producing the required transmission by a coating process).
* From 1992 full supply by TV-Glass towards CRT for 14" screens: scenario F1A 1.8M, scenario F2A 2.4M and scenario F3A 3.2M pcs.

per year.
* The B scenario's are adding 0.58M 0.51 FS colour screens to the mentioned amount of screens to supply in the A scenario's.
* Full supply of all colour cones to the colour CRT.
* Stock movements in 1991 and 1992 as planned: reduction of mono parts in stock, building up a little stock of colour screens in 1990, which should decrease in 1991.
* For reference: maximum press capacity per year: 23.000 hours.

	1991	1992	1993	1994
F1A	5346	4518	3756	4606
F1B	5346	1901	1442	2551
F2A	5346	2386	1817	2845
F2B	5346	[- 227]	[- 493]	788
F3A	5346	2386	[- 774]	487
F3B	5346	[- 227]	[-3084]	-1568

Table 5.2: Underoccupation of the presses for six scenario's: hours. (Overoccupation is a negative figure).

5.3 Changing situation.

Due to the market situation Philips TV-Glass has to find ways to decrease the costs per part to get a better competitive situation.
The chosen way is to increase output of the factory by speeding up the presses to come to a better utilization of the furnace. This, combined with mechanization and optimization of the finishing processes should lead to a better competitive situation.

Also some new supply opportunities are expected to occur in the future: about 1.0M 36 FS screens and cones to export to Europe and there is an opportunity to export about 1.0M 51 FS screens and cones to the USA.

This gives the following possible (but very optimistic) colour screens and cones deliveries to be made by the Glass factory: This scenario can be added to the already existing six scenario's (F1A to F3B), and will be called N1.

	1991	1992	1993	1994
14"	1.8	2.4	2.4	3.6
36 FS	0.6	1.1	1.1	?
51 FS	0.8	1.0	1.2	1.2
	---	---	---	---
Total	3.2	4.5	4.6	4.7

Table 5.4: Scenario N1.

The last scenario which will be considered is based on the production schedule as made in May 1990 for the years 1991 and 1992. In this plan is the occupation of the presses 100% and the screens to deliver as given in table 4.5. This last scenario will be called N2.

	1991	1992
14"/36FS	2.1	2.9
51FS	-	-
mono	3.06	2.7

Table 5.5: scenario N2.

Totally 8 scenario's will be considered. The first six (F1A - F3B) are based upon the expected production quantities of the tube factories in Chupei, N1 is an optimistic scenario for a;; possible deliveries all around the world and N2 is based on the last data and can be considered as the basic production schedule for 1991 and 1992.

6. Pinning

6.1 Pinning process.

Pinning is a process of melting three or four pins in the inner-side of a colour screen. This is necessary for locating the colour mask, which is an iron plate containing a large number of very small holes. The purpose of these little holes is to deflect the three light beams (yellow, red and blue) in such a way that the beams will come on the right phosphor layer on the screen. Pinning is only possible when the temperature of the glass is on a high level (about 500°C). This high temperature is required to avoid tension in the glass after pin insertion.

During the process of manufacturing colour screens, pinning can be done on two places: the so-called hot and cold pinning.

Pinning is called hot pinning when the pinning is done between the press and the annealing-lehr. At this place the temperature of the screen still very high and pinning can take place without further heat. Annealing can take place in the regular annealing oven which is always necessary after pressing products.

PRESSING ==> PINNING ==> ANNEALING

Fig. 6.1: Hot pinning.

Pinning is called cold pinning when the PIM is placed after the annealing-lehr of pressing. This means that the colour screens have to be heatened up before pinning can take place and have to be annealed after the pinning process.

PRE-HEATING ==> PINNING ==> ANNEALING

Fig. 6.2: Cold pinning.

At first sight the most logical pinning process is hot pinning, because no second heating and annealing is required. The reason however why the choice was made for cold pinning is because of the melting process of glass. At one time only one glasstype can be melted in the furnace. And till now, different glasstypes are required for colour cones, monobulb and colour screens. For this reason all three presses have to press or colour cones or monobulb or colour screens.

So the choice between hot and cold pinning was for the Philips Glass Factory in Chupei a choice between:
- hot pinning with a very low utilization;
- cold pinning with a very high utilization.

When it is possible to make colour screens and monobulb with the same glasstype there is a chance that hot pinning could be rentable.

6.2 Existing situation.

The existing cold pinning line comprises:
- one pre-heating oven;
- two Pin Insertion Machines (PIM's);
- one annealing-lehr (= the annealing oven).

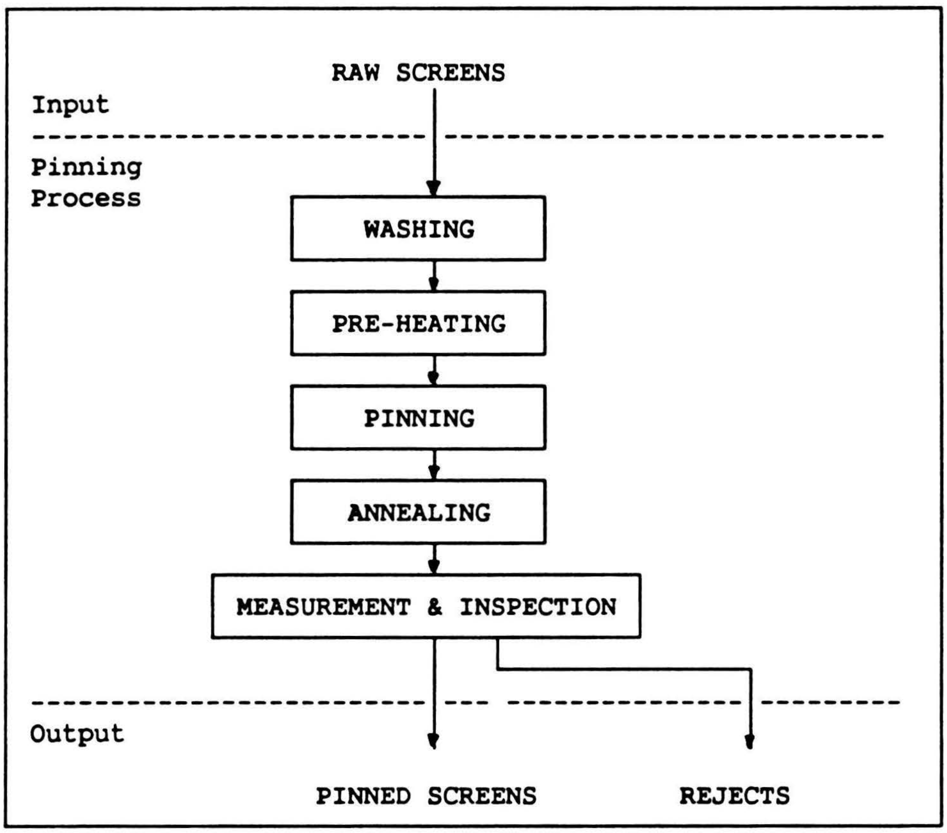


Fig. 6.1: Existing cold pinning process.

Products are manually loaded into the pre-heating oven and are pinned after about 25 minutes pre-heating. After insertion of the three pins the products are annealed in about 80 minutes.

Coming from the annealing-lehr, products are measured (100%) on sagittal height (= innerside of the screen) and feedback for process control is delivered to the controlsystem. After measuring the sagittal height, the products will be visually inspected on quality of pin insertion. After this the products are placed on the conveyer and brought to the polishing line or eventually are packed.

The capacity of the existing cold pinning line is:

Capacity 2 PIM's	: 240 pcs/hr.
Production hours per year (4 shifts)	: 8664
Machine efficiency / allowance factor	: 0.924

Maximum input per year of the cold pinning capacity =
240 * 8664 * 0.924 = 1.92M pcs.

The output varies with the different yields of the screens in the process.

6.3 Pinning capacity required.

The net requirement of the CRT factory for glass parts is the amount of CRT's to deliver times 1.05 (which is the utilization factor of the CRT factories). The quantity for TV-Glass to pin is the net requirement of the CRT factory divided by the yield of pinning * yield of polishing (after the pinning process the screens will be polished and the rejects after polishing are also a loose of pinning capacity).

These quantity to be pinned can be matched with the capacity of a Pinning Insertion Machine. But before the required extension can be calculated, the number of screens which can be pinned by the existing capacity (two PIM's) should be subtracted.

The remaining quantity can be cold pinned or warm pinned. The warm pinning possibility needs another calculation then the cold pinning possibility. For cold pinning the remaining quantity can be divided by the capacity of one PIM and the outcome is the number of PIM's which is required for producing all the pinned screens.

However, warm pinning capacity can only be used when the right glasstype for producing colour screens is in the furnace (warm pinning is located between the press and the annealing lehr). So, the time required for other glasstypes then the glasstype which should be used for producing colour screens, is idle time for the warm pinning installation.

In the case of use of universal glass, which means that mono parts and colour screens will be pressed of one glass type, the idle time of the warm pinning installation is of course much lower then the situation when two different glasstypes are in use for producing mono parts and colour screens.

Another waste of the warm polishing capacity (compared with cold pinning) is the number of rejects of pressing and time required for glass changes and type changes. All pressed screens should be pinned, because it's impossible to inspect the screens between pressing and warm pinning (the screens are quite hot). In this way 15% - 30% of the warm pinning capacity will be used for pinning screens that will be rejected, due to pressing. And during glasschanges and type changed there is no production or a high level of rejects.

On the next page forgoing is presented in a figure.

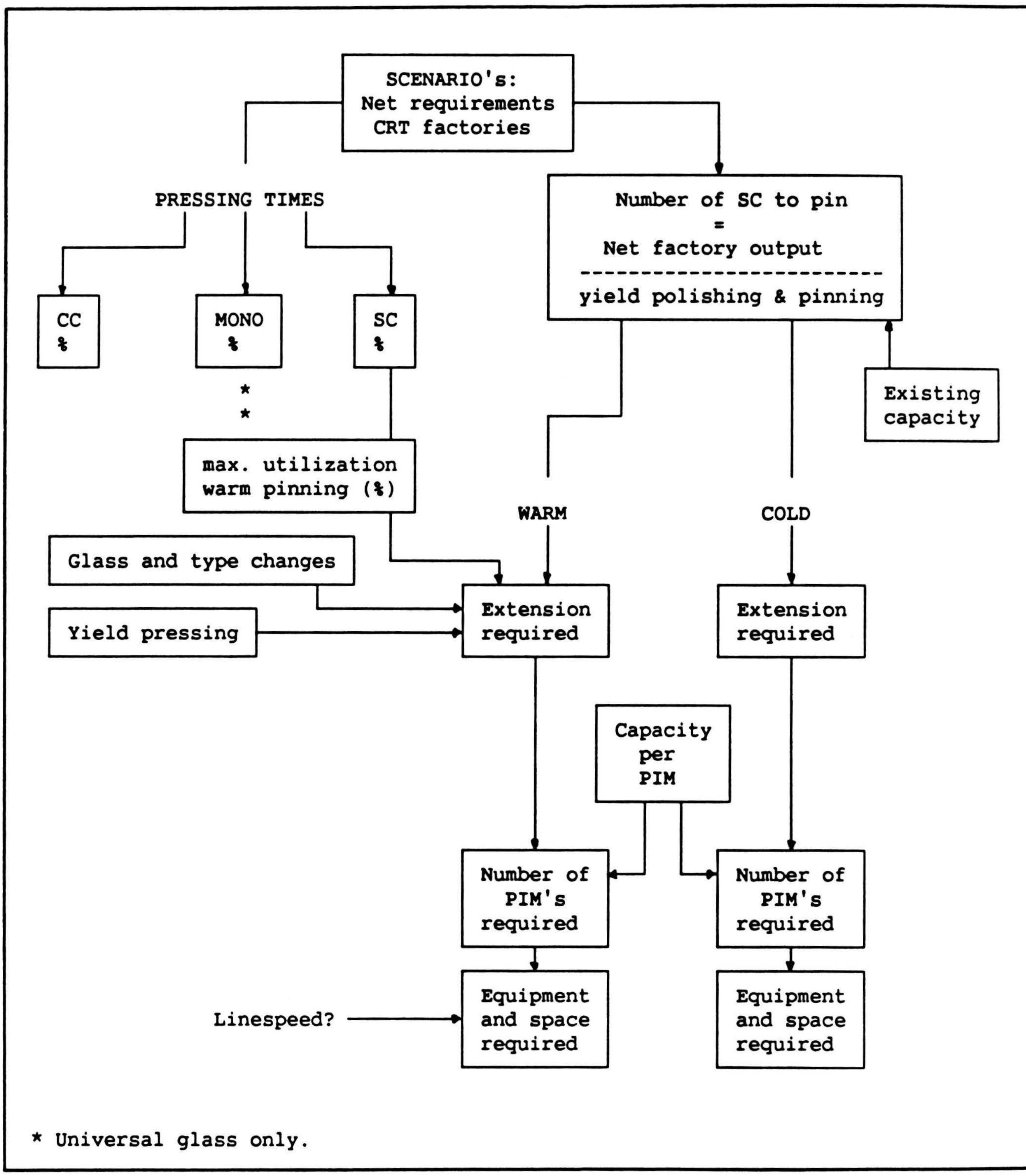


Fig. 6.2: Pinning capacity required.

The required pinning production is the required output divided by 0.93 (average yield over pinning and polishing) for 14"CMT and 0.96 for 51 FS.

	1991	1992	1993	1994	1995
F1A	1.53	2.03	2.03	2.03	2.03
F1B		2.63	2.63	2.63	2.63
F2A	1.53	2.71	2.71	2.71	2.71
F2B		3.31	3.31	3.31	3.31
F3A	1.53	2.71	3.61	3.61	3.61
F3B		3.31	4.21	4.21	4.21
N1	3,41	4.81	5.01		
N2	2.26	3.12			

Table 6.5: Required total input of screens to pin.

The additional capacity required can be calculated by subtracting the existing capacity of the total required capacity. Table 6.6. shows the additional capacity required.

	1991	1992	1993	1994	1995
F1A	-0.39	0.11	0.11	0.11	0.11
F1B		0.71	0.71	0.71	0.71
F2A	-0.39	0.79	0.79	0.79	0.79
F2B		1.39	1.39	1.39	1.39
F3A	-0.39	0.79	1.69	1.69	1.69
F3B		1.39	2.29	2.29	2.29
N1	1.49	2.89	3.09		
N2	0.34	1.20			

Table 6.6: Number of screens to be pinned on capacity extension.

The number of screens to be pinned on capacity extension, the utilization percentages for glasstypes and pressing yields give the required number of PIM's for the warm pinning situation.

6.4 Alternative solutions.

Three alternatives can be distinguished:
- Increase of existing capacity: herefore more PIM's should be placed and the capacity of the pre-heating oven and annealing lehr should be adjusted to the maximum capacity of the pinning process.
- Installing a second cold pinning line: this capacity will only be not sufficient for the scenario's F3B, starting in 1993.
- Installing a warm pinning device in the A-building. The maximum number of PIM's to install in the pressing area is 5: two PIM's on press TA1 and three PIM's on press TA2.

6.4.1 Extension of existing capacity.

When the number of PIM's can be increased to four, the maximum capacity of the cold pinning line could be about 3.0M screens to pin. However, due to the more complicated transport which will be required, the expectation is that the maximum capacity will be about 3.0M screens when only 14"CMT will be produced and that the maximum capacity will decrease when 51 FS has to be pinned. In the case of 51 FS screens the pre-heating lehr will be the bottle-neck, because the amount of glass to heat up in one 51 FS screen is two times the amount of glass which should be heatened up if a 14" CMT will be pre-heated.

6.4.2 A new cold pinning line.

The capacity per cold PIM is 960K. The number of PIM's required to cover the demand for pinning capacity is given in table 6.4. A choice should have to be made how many PIM's a new cold pinning line should comprise, taken into account the required extension.

	1991	1992	1993	1994	1995
F1A	-0.41	0.12	0.12	0.12	0.12
F1B		0.74	0.74	0.74	0.74
F2A	-0.41	0.82	0.82	0.82	0.82
F2B		1.44	1.44	1.44	1.44
F3A	-0.41	0.82	1.76	1.76	1.76
F3B		1.44	2.39	2.39	2.39
N1	1.55	3.01	3.64		
N2	0.35	1.25			

Table 6.7: Required number of PIM's: cold pinning.

6.4.3 Warm pinning.

Three restrictions exists when the required extension will be done by placing warm PIM's:

1. The maximum number of warm PIM's to install. This is for the existing situation in the press area five: three at one press line (TA2) and two at another (TA1), according to the hot pinning study of mr. Y.T. Sung (TRB-FT-90019).

2. Ratio warm/cold pinning fixes the amount to be warm pinned, because the cold pinning capacity is fixed. Dependent on the linespeed and the number of PIM's installed on a line a certain amount of products will pass the warm PIM's unpinned. These screens need to be cold pinned.

Example: - speed of the press is 10 cuts/min.;
- 3 PIM's on this pressing line: 360 pcs./hour can be warm pinned;
- 360/600 = 60% will be warm pinned;
- this 40% may not exceed 1.92M (the maximum cold pinning capacity).

But this situation can exist only if other products can be pressed on other presses, in other words: when universal glass is in use. When universal glass is not in use, the maximum number of screens to press is given in figure 6.8. for different press speeds. The higher the press speed, the higher the percentage of screens which will pass the warm pinning device not pinned. Figure 6.8 represents the maximum number of warm PIM's (total five on three presses) and three different press speeds:
1: 14": 10 cuts/min. and 51 FS 6 cuts/min.;
2: 14": 12 cuts/min. and 51 FS 6.5 cuts/min.;
3: 14": 14 cuts/min. and 51 FS 7 cuts/min.

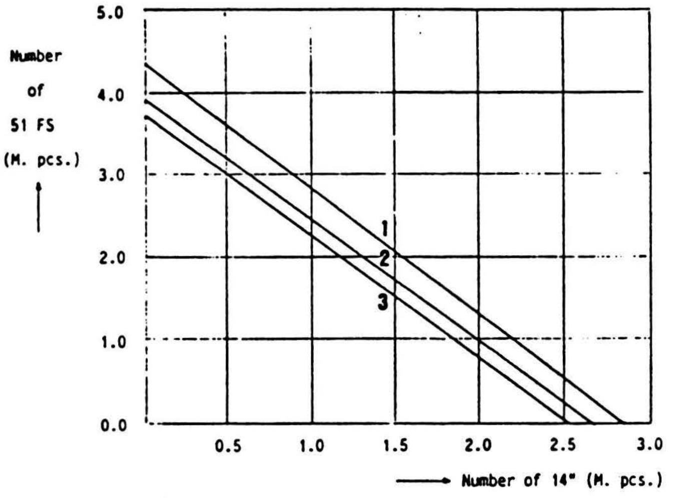


Fig. 6.8: Maximum number of screens to produce with warm pinning.

3. The total number of warm PIM's should be related to the maximum capacity of warm PIM's and the press-hours necessary for each glass part type.

The capacity per warm PIM varies. This is caused by different utilization factors and yields of the presses. The capacity per warm PIM can be counted by:

Speed	: 120 pcs/hr;
Utilization due to two glasstypes	: 65% - 80%
Utilization due to glass- and typechanges	: 90%
Yield pressing and warm pinning 14"	: 75% - 85%
Yield pressing and warm pinning 51 FS	: 65% - 75%

Capacity per warm PIM:

	Glasstype utilization = 65%	Glasstype utilization = 80%
14" yield = 75%	456K	561K
yield = 85%	499K	636K
51 FS yield = 65%	395K	487K
yield = 75%	456K	561K

A method to define the number of warm PIM's required in a specific production situation is:

1. Definite market demands;
2. Estimate the factory yield of colour cones (for the different types) and the factory yields of colour screens.
3. Do the same for the linespeed of the presses, also for colour cones and colour screens.
4. Calculate the required time for colour cones production. The total time available minus the time required for production of colour cones and time required for glass and type-changes gives the time available for colour screen and mono production. The relative time for colour screen and mono production is the glasstype utilization factor.
5. Calculate how many warm PIM's are required.
6. Define over how many pressing lines they should be divided. Restrictions of space should be taken into account. Check if it's possible to divide over more then one line: will more then one line be in use for mono production? If yes and if the warm PIM's should be divided over more then one line, the utilization will decrease.
7. Use the linespeeds (cuts/min) for colour screen production and the planned number of warm PIM's per line to check wether or not the cold pinning capacity will become a bottle-neck.

In appendix 3 this method is used to determine the warm pinning capacity required for scenario N1 as an illustration, as well for two glasstypes in use for colour screens and mono as for universal glass in use for colour screens and mono.

6.5 Comparison alternative solutions.

In this section the alternatives will be compared first qualitative, next financial.

The major difference between the two cold and the one warm pinning alternatives is that in the case of warm pinning, screens have to be stored pinned. When pinned screens will be stored, after a certain time rust will occur on the pins. A small trial in the specific conditions in Taiwan (very high humidity) confirmed the bad expectations: after one month outdoor storage, 4 out of 12 screens showed pins with rust. Indoor was a little better: after two months the first rust occurred on one pin.

But indoor storage is impossible (lack of space) and outdoor storage seems impossible due to the fast rust occurrence. This makes warm pinning almost impossible to apply in Chupei.

The advantage of extension of the current capacity above a new cold pinning line is that regrouping is not necessary. But the capacity extension of the existing line with two PIM's will give a lower additional capacity then when a new cold pinning line with two PIM's will be built. Especially, when big screens (for example 51 FS) have to be pinned.

The financial consequences of the alternatives are accounted in appendix 4. The comparison is given below.

Table 6.9 is based on:
* operating 1 line 4 shifts per year,
* figures are given in 1000 NT$;
* extension cold pinning: 2 Pinning Insertion Machines are added in the exising cold pinning line.
* new cold pinning line: same as the already existing one,
* warm pinning: 3 PIM's on one pressing line and 2 PIM's on another: in total 5 PIM's in use for hot pinning;
* consumption expenditures are for polishing sheet and abrasive consumption and for pinning consumption of pins.

	extension cold pinning	new cold pinning	warm pinning
Total investment	73,865	94,496	100,556
Variable expenditures:			
- Wages/social costs	1,216	5,312	2,880
- Indirect material	325	649	116
- Utilities	3,509	14,036	2,531
- Repair and maintenance	2,955	3,780	4,022
Total 1 line 4 shifts	8,005	23,777	9,531
Total consumption expenditures per screen (NT$)	6.395	6.395	7.993
Capacity	± 1.2M	1.86M	dependent on glasstypes in use

Table 6.9: Comparison of pinning extension alternatives.

The extension of the existing capacity is financially the most attractive: lowest investment, low variable expenditures and also no waist of pins. The higher consumption expenditures for warm pinning is due to the press rejects, which will be pinned and will rejected after pinning due to press faults.

7. Polishing

7.1 Polishing process.

Making glass parts start with mixing of the required chemicals, minerals and cullet. After mixing the materials will be put in the furnace, where controlled melting of the materials takes place. After melting the glass has to be supplied to the press moulds. The glass will be supplied to the presses through feeders. At the end of each feeder the glass will be given the accurate weight and shape, as required for the per producttype. The glass-drop (the so-called gob), which comes out the feeder is cut off by two shearblades, after which the gob falls into the mould.

After pressing a mark does exist on the outer side of the screen. This is caused by cutting the gob through the shearblades. The shearblades have to be cooled to stand the high temperature of the glass. So the (relative) cold shearblades cut the hot glass gob. The glass gob is cooled down a bit locally. This irregular temperature in the gob causes a mark in the outer surface of the screen. This is called the shearmark. In each screen there are two shearmark: one caused by the cut off of the previous gob, which is a minor shearmark and is called the "old shearmark. And one caused by the cut off of the gob, which has been used for pressing this screen. The last one is the major "new shearmark".

Processing of the outer surface of the screen is necessarily in order to achieve the required visual finish. The first thing to be done is to remove the shearmark. This is done by pre-grinding. After pre-grinding the shearmark is removed, but the surface roughness has increased strongly (the screen has become frosted). To achieve the required roughness the screen has to be polished and in some cases to be glossed (if high-glance is required). To improve the grinding, polishing and glossing processes an abrasive slurry is used.

So, to remove the shearmark pre-grinding is necessary an to remove the high surface roughness (caused by grinding) polishing and glossing is required.

For colour screens edge grinding and edge polishing is required to obtain a flat and smooth edge. For some colour screentypes it is also possible to achieve the required edge quality during pressing. This is the so-called "as pressed" quality.

7.2 Existing polishing situation.

7.2.1 Black/white screens polishing.

Mono screens have always to be grinded, polished and glossed. Sometimes they have to be high-glossed either. Till now, these processes take place on the so-called "Philiflows". These are old an simple machines, on which either grinding, polishing, glossing or high-glossing can take place. Only the sheet material and polishing agent (so-called slurry) has to be changed.

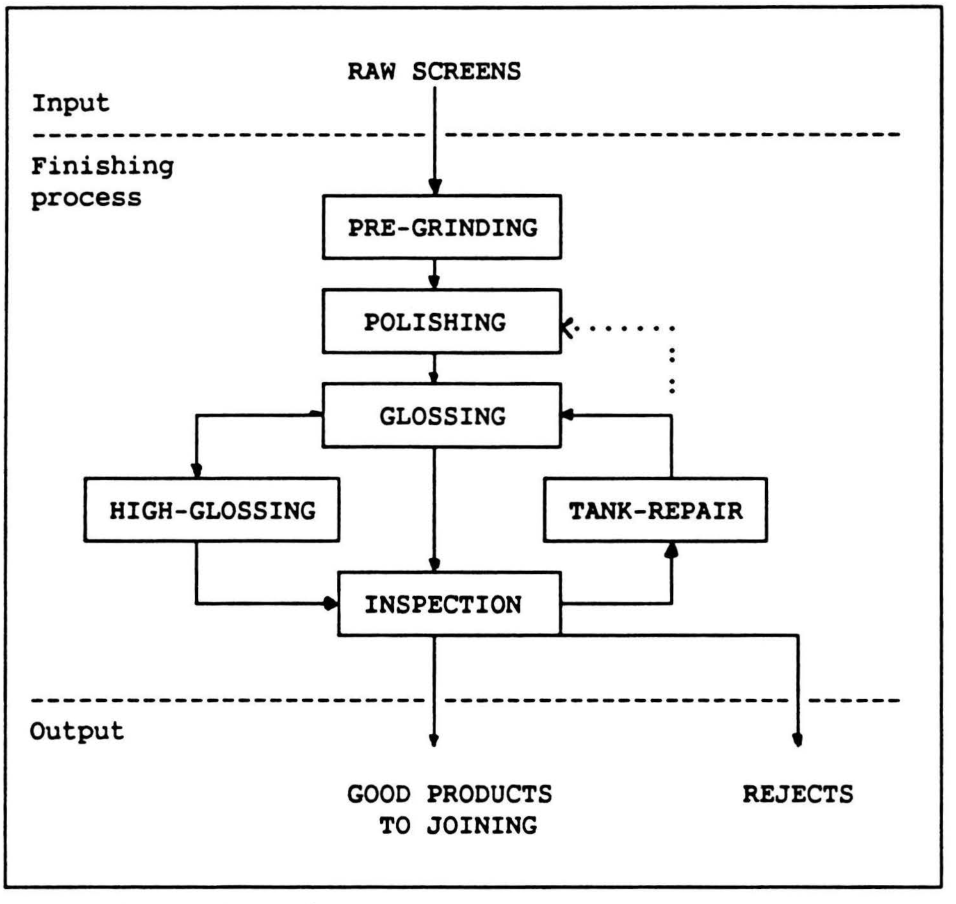


Fig. 7.1: The Black/White polishing process.

Raw screens are delivered packed. They will be put on the raw screen conveyor, which take them to the pre-grinding machines. (for a drawn lay-out see Appendix 6). After pre-grinding the products are placed on the polishing conveyor, which take them to the polishing machines. After polishing the products will be put on the polishing conveyor again and will be taken to the glossing machines. After glossing the products will be put on the inspection conveyor, from which some types of products (12FS, 14F, 15FS and 20) will be taken off to be high-glossed. After the high-gloss area products are washed, dried and inspected. After inspection good products will be placed on the joining conveyor, which take them to the joining department. If necessary, they will be put on the repair conveyor. The repair conveyor takes the products to the tank-repair, which is a big turning table, where the products can be partly polished.

1 of 7

If a product has to be polished all over again it will be put on the polishing conveyor. Otherwise the product needs to be glossed after the tank-repair. After being repaired the product will come to the inspection area again.

Products are divided in two types: Tivi and Bivi. Tivi screens are small screens: 12" and 14"; Bivi screens are the more bigger screens: 15", 17" and 20".

The cycle-time of pre-grinding depends on the shearmark. All products are processed one-fold. The required processing time for polishing is for Bivi screens 360 (for 328 glass) seconds and for Tivi screens two times 360 second, between which the products have to turned and the direction of the polishing head will be changed. This long time makes the polishing the bottle-neck. For universal glass the polishing should be extended to 480 seconds for Bivi and 960 seconds for Tivi screens.

<u>* Capacity of Philiflow area.</u>

86 Philiflow machines are located in the B/W finishing area. Eighteen are in use for pre-grinding, 54 for polishing, 8 for glossing and 6 for high-glossing. The maximum number of products on one machine depends on the size of the products and the process: for the bottle-neck process is this 3 screens per machine for 12" and 14", two for 15" and one for 17" and 20" screens. One man can operate (at maximum) either 6 pre-grinding, 18 polishing, 2 glossing or 3 high-glossing machines. So, the machines are divided in three lines, each with 17 polishing machines. These machines define the maximum input capacity per line per hour, for example for the major products 12" and 14":
- for 328 glass: 3600/720 * 17 * 3 = 255;
- for 423 glass: 3600/960 * 17 * 3 = 191.

Three lines are available, but due to the high number of people they need to operate them and the worse working situation (see below), the maximum capacity of the Philiflow area is 2 lines, which mean a maximum of about 2.4M mono screens to polish per year. Extending this capacity (in the long run) seems impossible (see 3.2).

<u>* The work place.</u>

Operators have to execute the following actions:
- open the machine;
- take the polishing head of the screen(s);
- take screen(s) of the conveyor;
- place the screen(s) in the machine;
- put the polishing head on the screen(s);
- close the machine;
- put the machines on.

Due to the number of the machines they are operating and the many manual actions which the operators have to execute, their task means a lot of physical effort:
- the total weight to lift in one hour rises till 5500 kg. (pre-grinding);
- the distance to walk in one hour rises till 2.9 km (polishing);
- due to the height of the conveyors the operators have to reach most of the time above their head to take off or put on a screen on the conveyor.

Due to the open slurry system and rinsing in the B/W finishing area, the humidity is very high. This, added with the obligation to wear rubber shoes, rubber gloves and an apron, makes the job of operator at the Philiflows a very uncomfortable, and in summertime a very hot and sweaty one.

7.2.2 Colour screen polishing.

Processed needed to obtain desired surface and edge quality are: edge grinding, screen pre-grinding, screen polishing (3x), screen glossing and edge polishing.

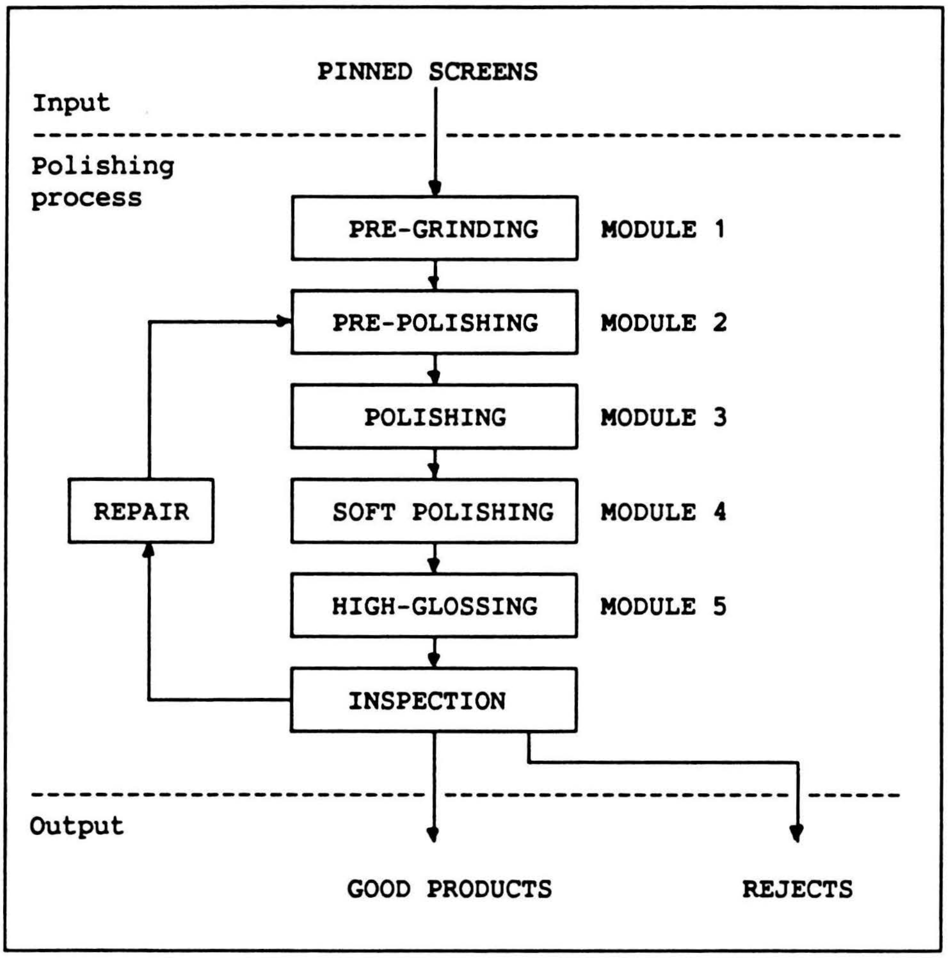


Fig. 7.2: Colour screen polishing process.

These processes will be executed on the new polishing line which comprises two SEFU's (Sealing Edge Finishing Units) and five modules for grinding, polishing and glossing. One module will be in use for pre-grinding, a one-fold process with high glass removal. Three modules will be in use for polishing, a two-fold process with low glass removal and one module will be in use for glossing. At this process is no glass removal, only an improvement of the gloss-value. All seven machines are located in one line and the expected capacity will be 270 pcs/h (14" SC).

Products can be delivered in two way's: directly from the pinning line or packed from an intermediate store, but in the last case they have to be loaded manually on the conveyor between the pinning and polishing line.

The cycle time for all modules is based on the required speed of the line of 270 pcs/h.

The cycle-time is 3600/270 = 13.3 sec. Time needed for positioning of the screen is, which is idle time in the cycle-time:

- indextime table : 1.5 sec.
- screen upwards : 1.5 sec.
- screen downward : 2 sec.

total : 5 sec.

This idle-time will always remain the same, even when the cycle-time changes.

Remains an effective polishing time (contact-time screen/polishing head) of:

- 13.3 - 5 = 8.3 sec. for pre-grinding and high-glossing (one-fold);
- (2 * 13.3) - 5 = 21.6 sec. for polishing (two-fold).

The required total glass removal (during pre-grinding and polishing) depends on the depth of the shearmark. Furthermore, there is a certain glass removal required during polishing to "repair" the roughness of the screen, caused by pre-grinding.

7.3 Capacity extension possibilities.

The modular finishing capacity can be extended in two ways:

- adaptions in a module to reach a higher utilization of the module: more products can be handled by the module in the same time;
- changing the number of modules in one line.

7.3.1 Adaptions in the module.

Placing more products on a carrier (or turntable) gives the opportunity to increase the number of screens to process in a certain time. In the current situation the number of screens on a carrier is during pre-grinding one, during polishing two and during high-glossing one again. Changing the pre-grinding module to two-fold processing and polishing to three-fold processing gives the opportunity to increase the linespeed. Two-fold pre-grinding is not possible for 51 FS SC and 20" mono (surfaces of the screens are too big). Three-fold polishing is only possible for 12" and 14" screens. For 14" CMT screens the carrier should be extended to 800 mm and this means a machine adaption. Wether 14" F mono can be processed on a 700 mm carrier, is dependent on the space that the clamps require on the carrier. It could become necessary by a given linespeed (and so a given process time) to change high-glossing from one-fold to two-fold.

Two-fold pre-grinding and three-fold polishing are new production concepts. In order to calculate the consequences, assumptions should be made for the glassremoval during these processes:

- The glassremoval of two-fold pre-grinding: will the glassremoval per screen stay the same or will the glassremoval per screen decrease till a lower level. Calculations has been

carried out for the same glassremoval and for a glassremoval of 80% of the original value.
- The glassremoval of three-fold polishing: the glassremoval during two-fold polishing is known, but if it is possible to make such adaptions in the process that the glassremoval per screen will stay the same is unknown. For this reason calculations has been made for:
  - the same glassremoval per screen;
  - the same glassremoval per module: instead of polishing two screens, three screens have to be polished; the glassremoval will be two third of the original glassremoval per screen.

These estimations give the following alternatives:
- 1/2 : one-fold pre-grinding and two-fold polishing;
- 2L/2 : two-fold pre-grinding (80%) and two-fold polishing;
- 2H/2 : two fold pre-grinding (100%) and two-fold polishing;
- 2L/3L : two fold pre-grinding (80%) and three-fold polishing (67%);
- 2L/3H : two-fold pre-grinding (80%) and three-fold polishing (100%);
- 2H/3L : two-fold pre-grinding (100%) and three-fold polishing (67%);
- 2H/3H : two-fold pre-grinding (100%) and three-fold polishing (100%).

7.3.2 Change the number of modules.

In the current situation 5 modules are in use in the modular line:
- one for pre-grinding;
- three for polishing: to reduce in a few steps the roughness of the screens to the required level. With the help of different sheets in the three polishing steps the outside roughness is decreased to the required level;
- one for high-glossing: necessary to give the screens a high gloss value.

The capacity of the pre-grinding module can be extended by two-fold pre-grinding and three-fold polishing without changing the current steps to decrease the surface roughness. But it is also possible to influence the capacity of a modular line by a different polishing concept. It is possible to reduce the outside roughness after pre-grinding in two steps. This means decreasing the outside roughness with two modules in use for polishing instead of the existing situation where three modules are in use for polishing. Another possibility is to increase the numbers of modules in use for polishing up to 4 or 5 in combination with two-fold pre-grinding (one-fold pre-grinding is already the bottle-neck when 3 modules are in use for polishing, so it doesn't make sense to increase the non-bottleneck capacity). The consequences for linespeeds are calculated in appendix 5. These linespeeds are used to determine the capacity of the modular line in a certain situation in appendix 6. Calculations include also the possible different glasstypes and the before described configurations (2-fold pre-grinding and three-fold polishing).

The estimated glass-removals for 2, 4 and 5 modules in use for polishing are based on the existing situation of 3 modules in use for polishing. These glass-removals are used to calculate the linespeed in a best, a worst and an intermediate case. These intermediate case used to determine the maximum capacity of a modular line, which shows the graphs for the formulated configurations in fig. 5.3.

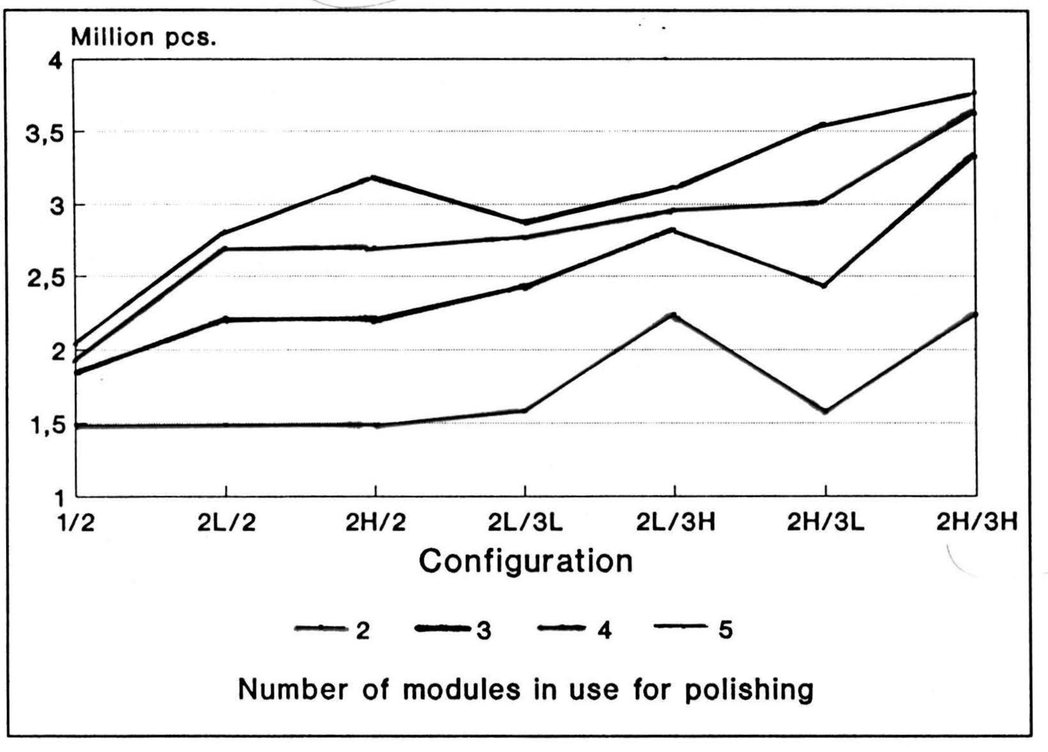


Fig. 7.3: Maximum capacity modular line: 14" CMT.

The graphs in fig. 5.3 are only for 14"CMT screens in case of use of universal glass. All other screens and other glasstypes which can be used are calculated in appendix 6. In this appendix also a few more graphs are added about other screens and glasstypes.

In appendix 6 is also given the output per module, in case of producing a glasspart in a certain configuration of a certain glasstype. This output per module gives a machine efficiency, which can be used to compare the alternatives. In fig. 5.3 are these machine efficiencies given for the case of 2, 3, 4 and 5 modules polishing 14"CMT screens of 423 glass.

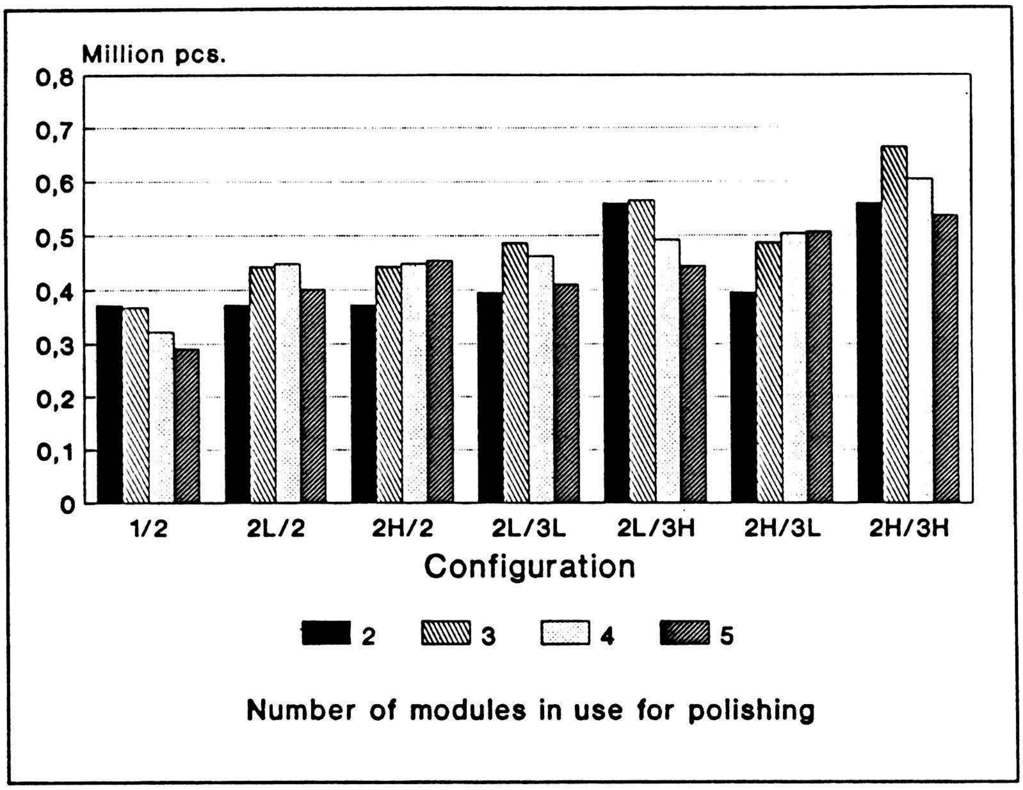


Fig. 7.4: Output per module: 14" CMT.

7.4 Capacity extension alternatives.

Before the alternatives are described the 'borrow and share' opportunity should be mentioned. This opportunity might reduce the number of high-gloss modules in all alternatives or creates the opportunity for a satinized line to produce high-gloss products too:

- the borrow opportunity: when a high-gloss line doesn't need his high-gloss module (51 FS?), a satinized line can use the high-gloss module to produce high-gloss products.
- the share opportunity: depending on linespeeds, number of products on a carrier and required process time for high-glossing, it could be possible to load the high-gloss module from two sides and process the products of two lines in one module. This is theoretical also possible when two different products are polished on the two lines.

Based on the current situation and the opportunity of polishing with a number of modules, 6 extension alternatives can be distinguished:

1. Place 5 modules on the other side of the slurry systems: the same concept as the current line.

2. Place 2 times 5 modules: also the same processing concept, but one line cannot be in a row, because lack of space (maximum in a row is nine).

3. Place one time 5 modules (current concept) and place one or

two times 3 modules (one pre-grinding and two for polishing) to produce satinized screens.

4. Change the current concept of 3-steps polishing to the concept of 2-steps polishing for all lines. The result can be three or four times 4 modules (one pre-grinding, two polishing and one high-glossing).

5. Extend the existing capacity by placing one polishing module more in the modular line.

6. Extend the existing capacity by placing two polishing modules more in the existing.

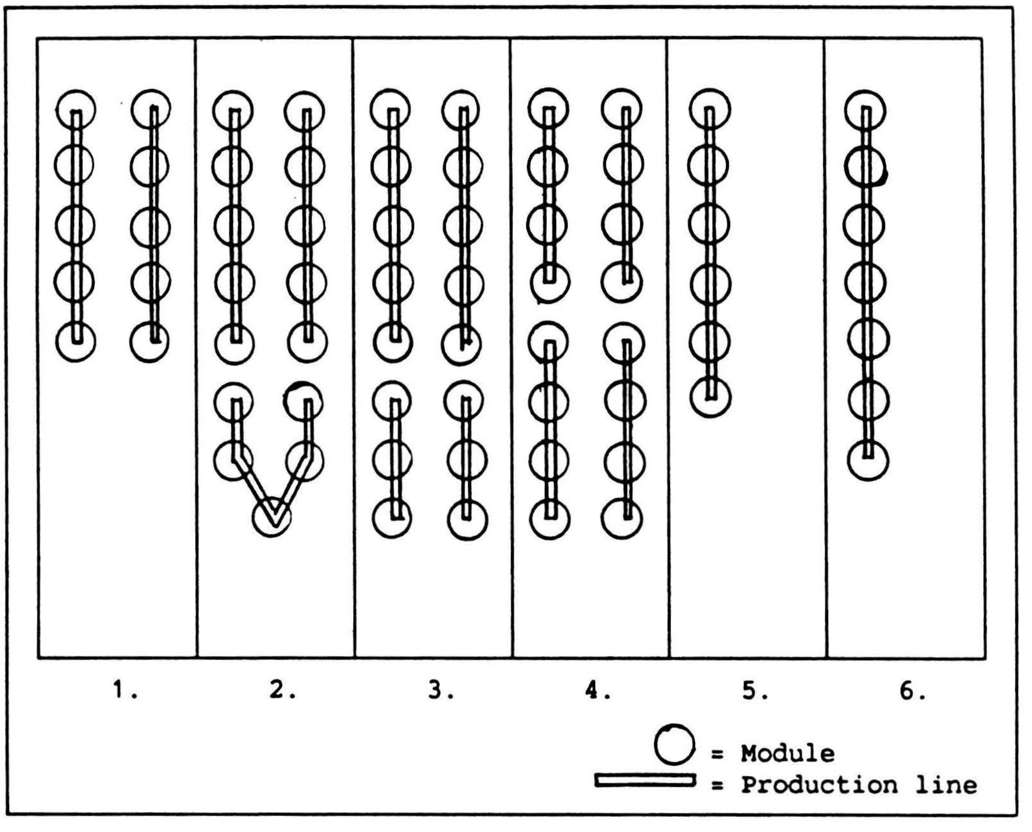


Fig. 7.5: Six extension alternatives.

7.5 Comparison of the alternatives.

Consequences for the slurry systems.

The existing slurry systems are built for 2 pre-grinding modules, 6 polishing modules and 2 high-gloss modules. In case of exceeding these numbers of modules, the slurry system should probably be extended. This will be the case for extension alternatives 2, 3 and 4.

Transport.

The longitudinal transport which is in use in the existing modular line can be used in all alternatives. A problem which has to be solved is the use of this transport system when on one line three-fold and two-fold polishing (dependent on the screensizes) will take place. But this is a general problem, not a alternative dependent one.

Regrouping.

The only problem case is an extension with two times 5 modules. In all other cases the available space for two lines (see also the master layout of Y.T. Sung in appendix 7) is sufficient to place the required number of modules. In alternative 2, 3 and 4, when it might be necessary to extend the slurry systems, the space for slurry systems should be extended and so far no space is reserved for this purpose.

Financial.

The financial consequences are calculated in appendix 5, which contains the estimated investment costs for the alternatives and the pay-back time for a mono investment in a modular line.

Speeds and capacities.

As mentioned before, appendix 6 contains the linespeeds and capacities for the different line-concepts: 2 to 5 modules in use for polishing and one- to three-fold processing. Appendix 8 contains a comparison of the alternatives in relation to the supply scenario's (F1A - F3B and N1).

7.6 Financial analysis.

The financial result of the glass-factory is dependent of the cost of production and the market prices. The cost per product can decrease when a higher utilization of the existing capacity can be realized.

Cost of production are allocated to the different products produced. After adding a few allowances a Factory Standard Price (FSP) for each product is calculated. This is the internal supply price to Philips factories. For being an attractive supplier these FSP's should be comparable with the market prices of outside Philips suppliers.

Nowadays, due to the mainly small glassparts which are produced, the utilization of the furnace is low. By increasing the press speed and/or by producing bigger products the utilization of the furnace can increase. Pressing more products requires an increase of finishing and joining capacities. When the utilization of the (extended) capacities will be at least as high as before the extension, the result of making more products and/or bigger products will be a lower FSP, caused by a higher utilization of the largest investments in the glass factory: the furnace and the presses, which are representing 62% of the total investment in fixed assets.

Market prices are very difficult to predict. Nowadays, it can be generally said that the most attractive glass parts are colour screens, followed by colour cones and the less attractive to produce are monobulb, especially the small ones. The expectation is that this will continue in the future. Also is expected that the low-end products (monobulb, small glass parts to be used in colour televisions) can be produced cheaper in low-labour-costs countries as Thailand and the Fillipines. This forces the glass factory to produce more sophisticated products, which are probably to difficult to produce for the new companies in the before mentioned countries. This means for the future that:

- colour parts are preferred above mono parts;
- monitor parts are preferred above consumer parts;
- screens are preferred above cones;
- big parts are preferred above small parts (also for high utilization of furnace);
- high-end products (fir instance high-resolution) are preferred above low end products.

So, the FSP can be lowered by high utilization of the furnace and pressing capacity and the expectation is that more sophisticated products will be the most attractive ones to produce in the future, due to the upcoming competitors in lower cost countries.

The question which will be the most attractive products in the future can not be answered, but it is evident that increasing the capacity of the presses will result in a better competitive position (it means a better utilization of the furnace capacity). Increase of the finishing capacity will be unavoidable, so additional investments in finishing capacities should be made to make it possible to supply these products to customers. And when the capacity of these capacities will have a higher output then in the existing situation will this have a positive influence on the FSP.

So, the question here to answer isn't wether or not it is profitable to extend the polishing capacity for colour production. When colour screens will be pressed they should be polished on the modular line anyway, so for all colour screens should be sufficient capacity on the modular line(s). But there is a choice to make for mono screens. They can be polished on the Philiflows as well on the modular line. The idle time of the modular line(s) can be filled with mono screens. But will it be profitable to do a special investment for polishing monoscreens on the modular line? This is the question which will be answered in section 7.7.

7.7 Polishing mono screens on Philiflow or modular line.

A comparison of expenditures for polishing on the modular line should include (see also appendix 4):

1. The cost per shift on Philiflow and modular line: manpower costs, utilities costs, indirect material and repair and maintenance required.
2. The expenditures per product: consumption of abrasive and sheets.

3. The linespeeds and number of repairs of Philiflows and modular line.
4. The rejects which are caused by handling during polishing on the Philiflow and which will not exist on the modular line (bruise and broken screens).
5. The rejects from CRT which are caused by handling during polishing on the Philiflows:
   - CRT-rejects due to inside scratches and inside bruise: these rejects are compensated rejects by the TV-Glass factory to the CRT.
   - CRT-rejects caused by outside bruise will not be compensated by the TV-Glass factory. But the outgoing sampling of the TV-Glass factory shows a level of bulb with bruise of about 3500 PPM. Estimated is that 70% of these bulbs will be a reject one due to the bruise. And although this will not be compensated by the TV-Glass factory it is a loose for the CRT factory caused by the polishing on the Philiflows.

The financial consequences of number 1, 2 and 3 together are calculated in appendix 1. The rejects caused by bruise on the Philiflows are about 4% of the total number of screens processed. Saving in the amount of broken screens will be about 0.1% of the total polished screens. This means that polishing on the modular line saves 4.1% of the press-capacity which is needed to press the mono screens. Under assumption that the presses are a bottle-neck capacity, it can be calculated that the savings in press hours per million mono screens to polish are:

1M * 4.1% / speed = 600 / yield = 0.85 = 80.4 press hours.
80.4 * 20.000 NT$ (cost per press hour) = 1.61M NT$ per year.

The costs of rejects from CRT caused by handling faults on the Philiflows are as follows:
- The compensated rejects due to bruise of the CRT is about 2500 PPM. FSP monobulb = 250NT$, material can be re-used and should be subtracted: costs per bulb: 250-30 = 220 NT$. Per million produced monobulb: 2500 * 220 = 0.55M NT$.
- The non-compensated rejects are to calculate as follows: the outgoing sampling shows that the level of monobulb with outside bruise is 3500 PPM. 70% of these will be result in a reject tube. So, 2450 PPM of the delivered monobulb will be a rejected tube in the CRT due to polishing faults on the Philiflows. Costs in case of market demand is bigger then production: 2450 * FSP tube = 2450 * 550 = 1.35M NT$.

Total savings per million screens to polish:

- due to bruise and broken	: 1.61M
- due to less compensated rejects	: 0.55M
- due to less reject in CRT	: 1.35M

Total	3.51M NTS

In appendix 4, section 4.4 are the investments and the pay-back times calculated when different glasstypes are in use and for different configurations for two situations: a line with five modules (as the existing one) and for a line with only three modules: one for pre-grinding and two for polishing.

Pay-back times for a line with 5 modules (1 pre-grinding, 3 polishing and 1 high-glossing); investment costs 112M NT$:

Config.	glass type	pay-back time (years)	
1/2	423	5.4 - 6.6	1/2: one-fold pre-grinding
	328	8.4 -10.3	two-fold polishing
2/2	423	4.0	2/2: two-fold pre-grinding
	328	5.3	two-fold polishing
2/3	423	3.3 - 3.7	2/3: two-fold pre-grinding
	328	4.7 - 5.3	three-fold polishing

Pay-back times for a line with 3 module modules (1 pre-grinding and two polishing); a high-gloss module should be borrowed from an "colour-5-module" line; investment costs 73M NT$.

Config.	glass type	pay-back time (years)	
1/2	423	3.8 - 5.5	1/2: one-fold pre-grinding
	328	4.8 - 6.5	two-fold polishing
2/3H	423	2.4	2/3H: two-fold pre-grinding
	328	3.1	three-fold polishing (100%)

A few remarks about these pay-back times:

- when the presses are not a bottle-neck (no alternative production when polishing has less rejects and less products have to be pressed to reach the required ouput) the pay-back times are longer;
- without three-fold polishing all pay-back-times are above 3.3 years;
- the pay-back times are in all situations higher for mono-glass (328) compared to universal glass (423).
- Pay-back times for 3 modular line are based on the possibility to produce high-gloss products too. These are the most attractive, because the difference between polishing on the modular line and Philiflows is the biggest for high-gloss products.

Taken into account that the maximum pay-back time for an investment should be about two years, all solutions have a too high pay-back time.

8. Conclusions

The question to answer was in which way, under which conditions and at what price the colour and mono screens can be finished (polished and for colour screens also pinned) in the TV-Glass factory in the future. Before conclusions will be drawn about polishing and pinning some remarks are made about the market situation and the production volume. After the conclusions about polishing and pinning some remarks are made about choices which should be made in a short time.

The market situation:
- World-wide exists an overcapacity of TV-Glass.
- The same for the C.R.T. factories.
- Philips TV-Glass Chupei has a relative difficult position in a this market with their expensive flexitank concept. Competitors can supply for a lower price. And in a market where an production overcapacity exist they probably have to, to fill their capacities.
- The TV-Glass factory in Chupei has to use the available capacity (especially the furnace and the presses) in an optimal way to realize a low cost price. This is necessary to get an competitive position. When only little products will be produced, the total production volume should increase.

8.1 Polishing.

1A. Possibilities to polish all screens.

The solutions are various: using 2 to 5 modules for polishing, one- and two-fold pre-grinding and two- and three-fold polishing. For a number of scenario's the consequences (based on estimations which should be proven) were shown for different glasstypes in the foregoing chapters and in the appendices.

Based on the output per module (= machine efficiency when a certain number of modules is in use for polishing) the line with 3 modules in use for polishing is the best alternative: for all configurations the highest or almost highest output per module. (see fig. 7.4 and graphs of appendix 6). Only for monochrome screens made of 328 glass 2 modules in use for polishing is an attractive alternative.

When the number of screens to polish will increase only a little (up to 2.2M), the current line can handle this production volume by implementing two-fold pre-grinding. However, in this situation is no capacity available on the modular line to polish mono screens. And the maximum amount to polish on the Philiflows is 2.4M, due to the resticted amount of labour available.

Three-fold polishing is a very important step in the further development of the polishing process. The critical factors for a succesfull implementation are:
1. the carriers and the clamps to be used: it is possible to place three 12 mono, 14" mono or 14"CMT screens on one carrier, but the carrier which will be used must be 800 mm (instead of the existing one of 700 mm);

2. the transport required, especially when on one line one- or two-fold polishing also is required for big screens.

1B. Conditions related to solutions.

- Lay-out and space available: according to the master lay-out of appendix 7, two rows of modules can be installed with in the middle their slurry systems. So space is no problem, only when 3 times 5 modules will be installed their could be a problem, because 2 times 5 modules in one row is impossible.
- When more then 2 pre-grinding modules, 6 polishing modules and 2 high-glossing modules will be installed, the slurry system can become a critical factor. These systems have been built for a maximum of modules as mentioned before.

1C. Financial consequences.

- Investments costs are calculated in appendix 4, chapter 4.1. When the output volume of the factory will increase, additional investments have to be made. Depending on the chosen solution from 20 NT$ (extension of the existing line with one polising module) to 263M. NT$ (four lines with in total sixteen modules in use).
- The pay-back times for mono are only reasonable when three-fold polishing is successful and when 423 glass will be used for pressing, especially in the case of two modules polishing, under the restriction that the high-gloss module of the existing line can be used to produce high-gloss products.

8.2 Pinning

2A. Possibilities to pin all screens.

Three solutions can be distinguished:
1. Extension existing capacity with two modules.
2. Building of a new cold pinning line.
3. Warm pinning: till a maximum of 5 PIM's, due to lay-out restrictions.

2B. Conditions related to solutions.

Extension current capacity:
- The conveyance between the pre-heating-lehr, PIM's and annealing-lehr has to be solved.

Warm pinning:
- Without a good rust prevention solution, warm pinning is impossible in Taiwan due to the fast rust occurance on the pins during outdoor storage.
- When more then one glasstype is required for mono and colour screens, warm pinning is not an attractive solution to extend the capacity, due to two reasons:
  - a very low utilization of the Pinning Insertion Machines: the machines are idle when mono or colour cones are pressed;
  - the maximum number of Pinning Insertion Machines to install is five, due to lay-out restrictions and when screens on three presses have to be pressed, a high number of screens

will pass the PIM's unpinned and the bottle-neck cold pinning will be filled very soon.
- This last mentioned bottle-neck problem will become stronger when the press speeds will increase: more products will be produced in the same time and the maximum number of screens which can be pinned will stay the same.

2C. Financial consequences.

Extension of the current capacity is the most attractive alternative. The second best alternative is warm pinning, but only when universal glass will be a succes warm pinning can be an attractive choice.

8.3 About choices on the short term.

Four opportunities are described in chapter two. The current state of art about these opportunities is :
1. Polishing mono on the modular line: the first trials are hopeful as far as glass removals are concerned (even higher then expected), but still some process problems have to be solved.
2. Making colour cones "as pressed": the first trials in spring '90 made it clear that in before colour cones can be produced "as pressed" some work has to be done: S2 is not available at this moment for extension because it is not more necessary for colour cone finishing.
3. Colour screens "as pressed": the first screens pressing trial has shown already that colour screens can be produced "as pressed": the SEFU's are no more necessary.
4. Universal glass: a lot of problems still have to be solved. Wether of not it will a success is dependent also on the (theoretical) possibility of adding the transmission of a glasstype into the feeders of the furnace. In this way, products which need to be made of different transmissions can be made from one glasstype. Otherwise, due to the market demand the advantage of universal glass is rather low because of different transmission demands for colour screens and mono screens.

Consequences for the space available in the S-building are: even in the worst case (no universal glass, no "as pressed" cones) it is possible to install all the necessary equipment (including a new cold pinning line and the existing colour cone finishing) in the S-building as shown in appendix 7.

Most realistic is that in 1991 (according to scenario N2) 2.1M colour screens and 3.09M monobulb has to be supplied to customers. To supply these quantities a few options can be considered:
1. Pin and polish about 0.3M in 1990 with the existing capacity and the remaining 1.8M can be finished without any adaption in the finishing capacity in 1991. The advantage of this solution is that the decision about how to invest in an extension can be postponed one year. Expected is that medio 1991 more is known about the supply opportunities for the coming years. The disadvantage of this solution is that the 3.09M monobulb

to deliver should be finished on the Philiflows. And without more personnel the maximum capacity of the Philiflows (in two lines) is about 2.4M. The only solution for this personnel problem is the idle people of other area's where mechanization projects are completed successful.

2. Two-fold pre-grinding will create enough capacity to polish the 2.1M colour screens to supply, but the pinning capacity is not sufficient to pin this quantity in one year.
3. It is expected that before 1992 an investment should be made to extend the pinning and polishing capacity. For 1991 this is not necessary, because part of the production of 1991 can be done in 1990. However, advancing the investment has two advantages in 1991:
   - The amount of mono screens to polish in 1991 is higher then the existing capacity of the Philiflows. An advanced extension gives the opportunity of polishing a part of the mono screens on the modular line.
   - Extra capacity in 1991 gives the opportunities to do trials with 3-fold polishing and different number of modules in use om a polishing production line.

9. Recommendations

1. Start as soon as possible with trials about three-fold polishing: it is very important to know what the glass-removals will be of three-fold polishing, so that a choice between the alternative extension solution can be made.
2. The same for 2, 4 and 5 modules in use to polish screens.
3. Trials which will be executed, should not only include measurements and process observations in the current (fixed) cycle-time, but the factor cycle-time must be used to try to increase the speed of the line when the glassremoval will become higher then necessary for reaching the required outside roughness.

4. After a decision about a new investment in pinning and polishing capacity, it can (and possibly will) happen that the capacities of pinning and polishing are not linked anymore, especially when mono screens have to be polished on the modular line. This might be a good project for a student to determine an optimal product-flow from the storage after pressing to the tube factory; including the product-flow from one finishing capacity to another.

APPENDICES

FINISHING SCREENS

TV-GLASS FACTORY PHILIPS

CHUPEI, TAIWAN R.O.C

Bert Jan Post,
August 1990.

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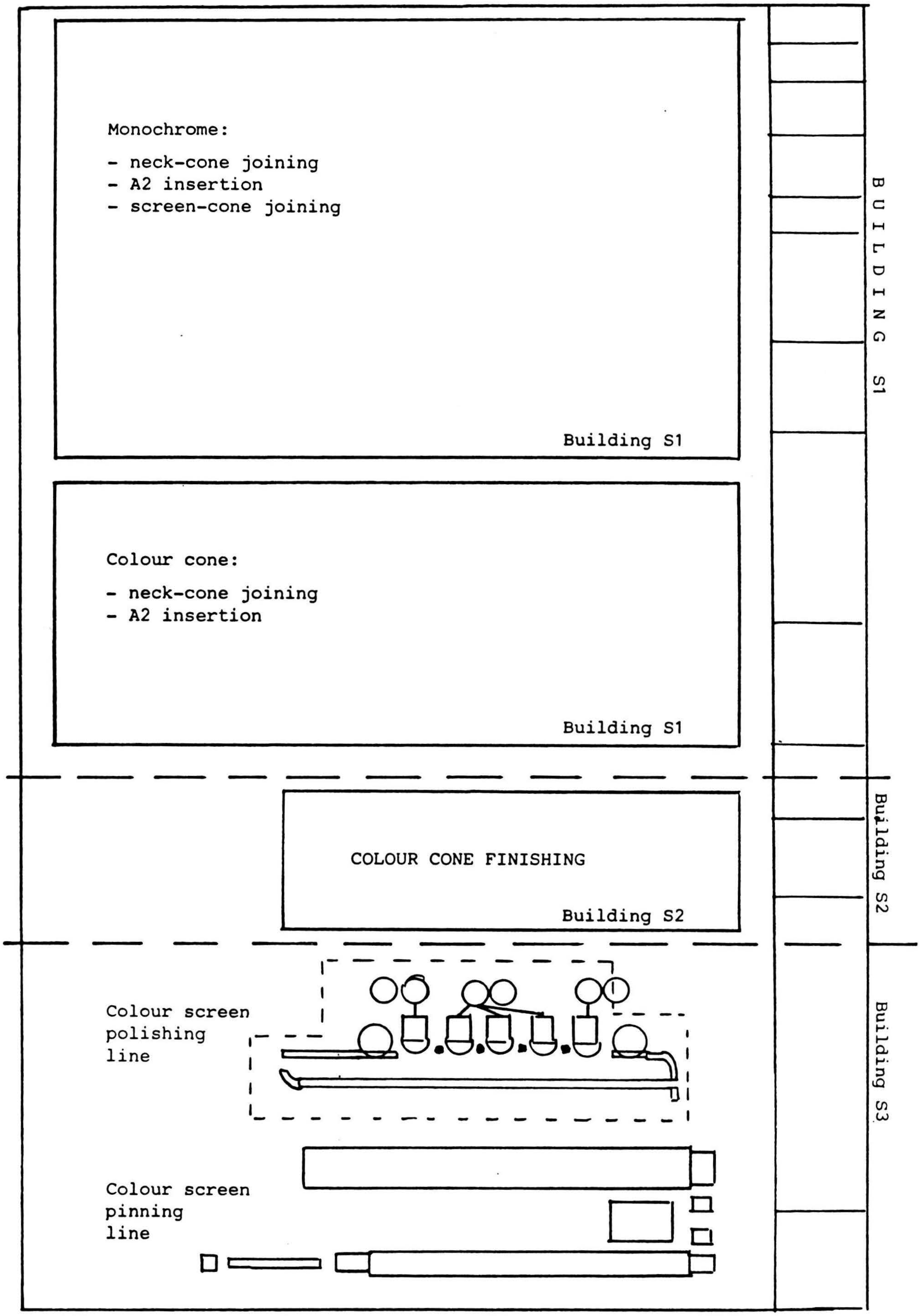
APPENDIX 1: REDEFINED LAY-OUT OF WHOLE S-BUILDING.



APPENDIX 2: MARKET SITUATION TV-GLASS.

Calculations and figures are only concerning Far East, N-America and W-Europe unless a remark has been made.

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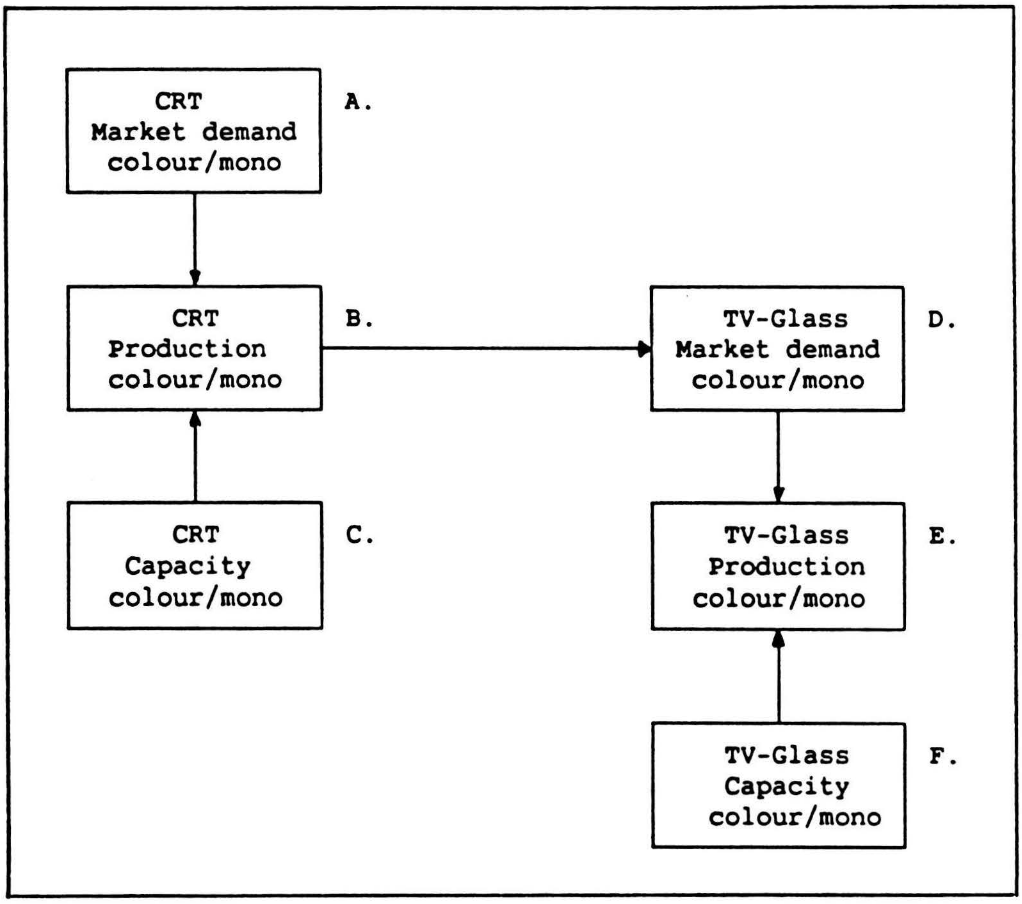
2.1 MODEL

The market demand for TV-Glass parts is totaly dependent of the production of CRT's. CRT factories are the only consumers of TV-Glass factories. For this reason the market demand for CRT have to be examined before the market demand for TV-Glass parts can be explored.



Some general remarks:

A. Market demand CRT:
- Strong growth of market demand of colour CRT's in Asia (especially in Korea); modest growth in W-Europe and N-America.
- Market demand of monochrome CRT's is slowly decreasing, due to the strong decrease of CRT demand for monochrome T.V.'s and the moderate growth of CRT demand for monochrome monitors.

B. CRT production:
- Strong growth of colour CRT production in Korea and Taiwan, Singapore and Thailand.
- Colour production in Japan is decreasing.
- Modest increase of colour CRT production in W-Europe and N-America.

C. CRT capacity:
   - Colour capacity is increasing world-wide, monochrome capacity is decreasing world-wide.
   - Capacity of monochrome CRT's is almost entire concentreted in Korea (about 50%) and Taiwan (about 45%).

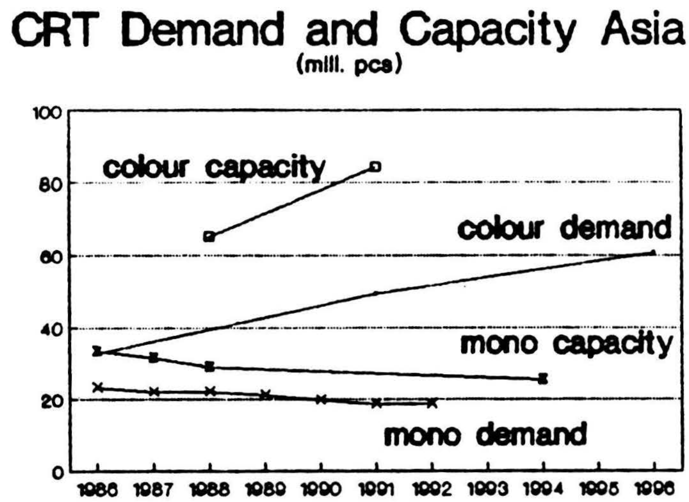
D. TV-Glass demand:
   - Total dependent of production of CRT's.

E. TV-Glass production:
   - Two Japanes companies (ASAHI and NEG) supplied in 1988 about 50% of the world-wide demand.
   - Samsung Cornick (Korea) is the strongest grower for colour sets: 17.0M sets in 1988 and 22.0M sets in 1989.

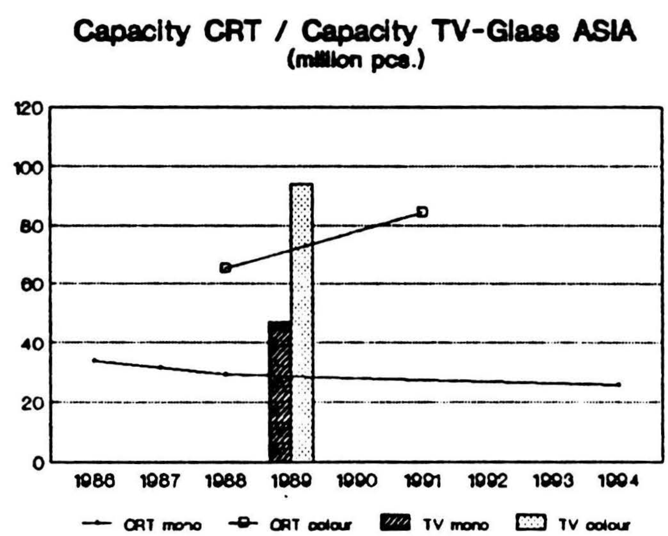
F. TV-Glass capacity:
   - Expectation of increase of capacity (only colour) 12% for the coming four years.
   - This growth will take place especially in Japan and Korea.

2.2 CRT DEMAND, CRT CAPACITY AND TV-GLASS CAPACITY.

2.2.1 Asia



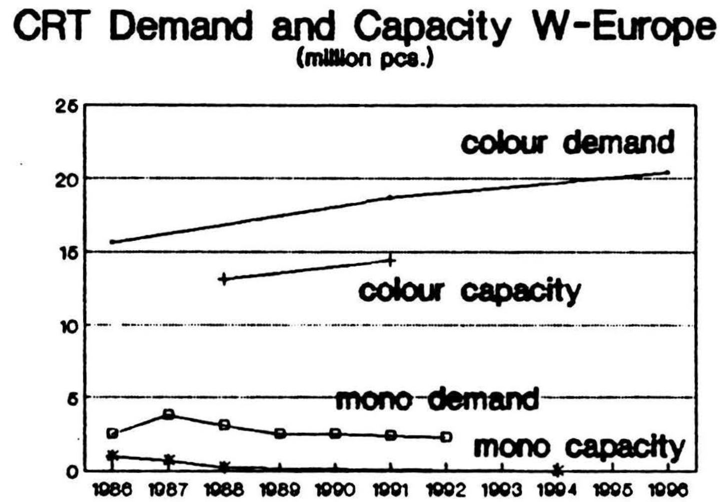
Sources: [2], [3], [4], [7] and [8]



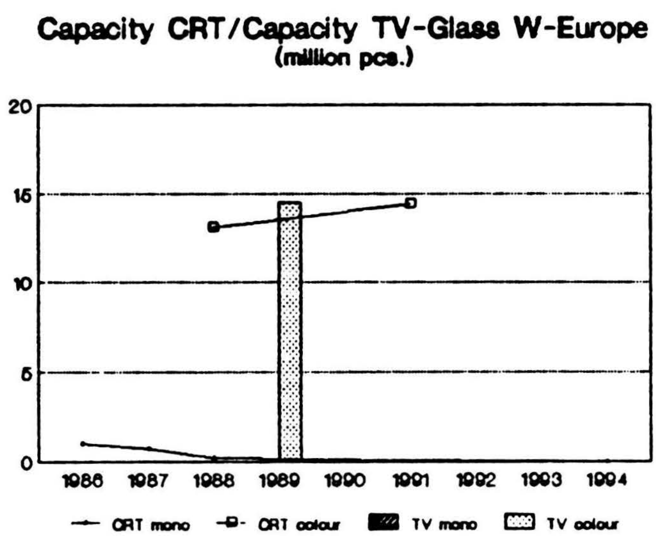
Sources: [7], [8] and [9]

* Overcapacity for colour CRT; capacity of colour CRT is growing faster then the demand for colour CRT's.
* Overcapacity for mono CRT, but is decreasing.
* Overcapacity TV-Glass mono over mono demand CRT.
* Overcapacity TV-Glass colour over colour demand CRT.

2.2.2 W-Europe



Sources: [2], [3], [4], [7] and [8]

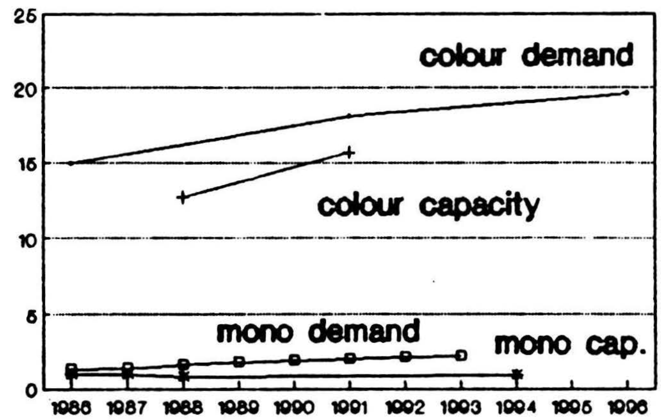


Sources: [7], [8] and [9]

* Undercapacity for colour CRT, import of colour and mono CRT's is necessary.
* Capacity of TV-Glass matches requirement.

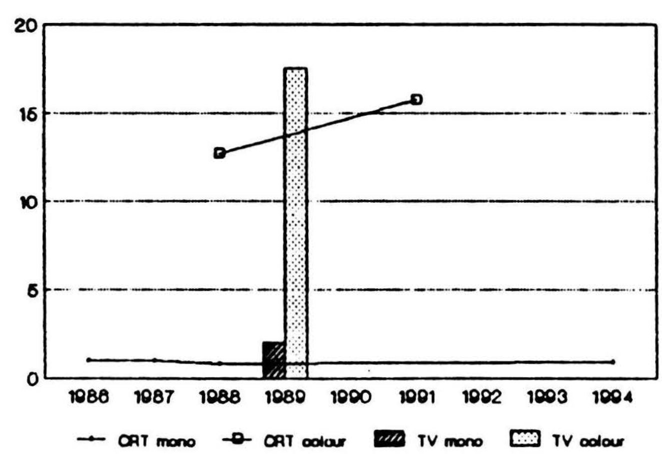
2.2.3 N-America

CRT Demand and Capacity N-America
(million pcs.)



Sources: [2], [3], [4], [7] and [8]

Capacity CRT/Capacity TV-Glass N-America
(million pcs.)

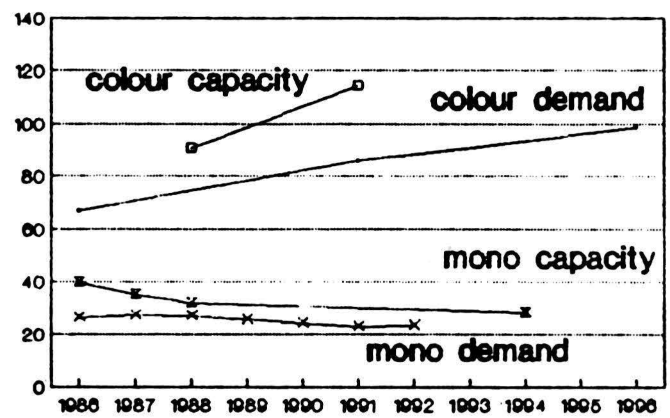


Sources: [7], [8] and [9]

* Undercapacity for mono and colour CRT, import of colour and mono CRT is necessary.
* Overcapacity for TV-Glass colour and TV-Glass mono.

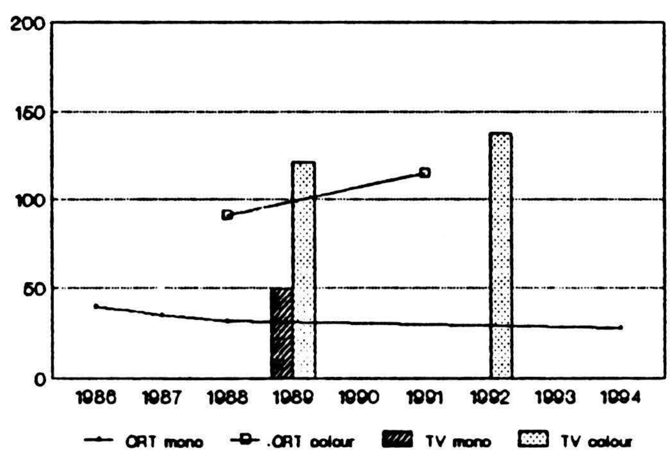
2.2.4 World-wide

CRT Demand and Capacity World-wide
(mill. pcs)



Sources: [2], [3], [4], [7] and [8]

Capacity CRT / Capacity TV-Glass World
(million pcs.)



Sources: [7], [8] and [9]

* Overcapacity for colour CRT's over colour demand.
* The same for mono capacity.
* These overcapacities are totally located in Asia.
* Colour capacity CRT is growing faster then colour demand.
* Overcapacity for TV-Glass over CRT capacity: mono and colour.
* The overcapacity world-wide for TV-Glass over CRT capacity (colour and mono) is located in Asia and in N-America; W-Europe has to import glass parts.

2.3 TV-GLASS SITUATION IN TAIWAN ANNO 1990.

Glass makers in Taiwan:

	Monochrome	Colour
Philips	x	x
Picvue	x	-
PGC (Asahi)	-	screens only

	Philips	Picvue	PGC
* Yearly capacities:			
Monobulb	3.6M	1.2M	-
Colour screens	1.8M	-	7.0M
Colour cones	3.0M	-	-
* Procuct range:			
Monobulb	12"-20"	3"-17"	-
Colour screens	14"	-	14"-21"

Extension plans PGC:
- Extend colour screen capacity to 10.0M in sept. '90. This extension will be made to produce 51 FS screens.
- From april '90 production of up to 7.0M colour cones.

This means a total colour production capacity at the end of 1990 of 11.8M colour screens and 10.0M colour cones.

Possible threats to TV-Glass factory Chupei:
- Current strong position on the field of colour cones could be weakened, due to the announced production of colour cones by PGC.
- The possibility for TV-Glass Chupei to produce 51 FS SC for the colour CRT factory could be disturbed by cheap offers of PGC for their 51 FS SC. This is realistic threat, because today PGC is the supplier of the 14" SC to the Philips colour CRT in Chupei. And PGC delivers screens of a good quality for a competive price (below the Factory Standard Price of Philips TV-Glass Chupei).

The capacity of colour CRT factories is expected to be about 9.5M in Taiwan in 1992/1993. In 1990 the capacity is about 7.3M (2.3M Philips and 5.0M Chunghwa [8]). So, the overcapacity of colour screen capacity (capacity from 8.8M to 11.8M; demand 7.3M) will increase and an overcapacity for colour cones (capacity from 3.0M to 10.0M, demand 7.3M) will occur in 1990 in Taiwan. This requires an increase in the export of colour glass parts from Taiwan to other countries.

The capacity of mono CRT factories is expected to stay on the same level in Taiwan (see also 4.2) as it is nowadays.

2.4 DATA C.R.T. AND T.V.-GLASS

2.4.1 A: Market demand CRT

The total market of CRT's can be divided in colour and monochrome CRT's. Colour as well as monochrome CRT's are produced for TV's and monitors.

* **Asia**

Colour CRT Demand Asia
(million pcs.)

	TV			Monitor			Total		
	1986	1991	1996	1986	1991	1996	1986	1991	1996
Japan	13.0	13.4	13.7	3.1	5.4	9.8	16.1	18.8	23.5
Korea	7.0	14.0	15.3	0.2	1.5	4.3	7.2	15.5	19.6
Rest Asia	7.7	10.4	11.4	1.7	3.9	4.3	9.4	14.3	15.7
Total Asia	27.7	37.8	40.4	5.0	10.8	18.4	32.7	48.6	58.8

Source: [2]

CRT Demand Asia
(mill. pcs.)

	Colour			Monochrome		
	TV	MON	TTL	TV	MON	TTL
1986	27.7	5.0	32.7	11.4	12.2	23.3
1987				9.2	12.8	22.0
1988				8.4	13.6	22.0
1989				7.3	13.8	21.1
1990				5.8	14.0	19.8
1991	37.8	10.8	49.1	4.6	14.0	18.6
1992				4.5	14.0	18.5
1993					14.5	
1994						
1995						
1996	40.4	18.4	60.7			

Sources: [2], [3] and [4]

*** Europe**

CRT Demand W-Europe
(million pcs.)

	Colour			Monochrome		
	TV	MON	TTL	TV	MON	TTL
1986	15.1	0.5	15.6	0.9	1.6	2.5
1987				0.6	3.2	3.8
1988				0.4	2.7	3.1
1989				0.3	2.2	2.5
1990				0.2	2.3	2.5
1991	17.1	1.6	18.7	0.1	2.3	2.4
1992				0.0	2.3	2.3
1993					2.2	
1994						
1995						
1996	18.0	2.4	20.4			

Sources: [2], [3] and [4]

*** USA**

CRT Demand USA
(million pcs.)

	Colour			Monochrome		
	TV	MON	TTL	TV	MON	TTL
1986	14.5	0.4	14.9		1.3	1.3
1987					1.4	1.4
1988					1.6	1.6
1989					1.8	1.8
1990					1.9	1.9
1991	17.1	1.0	18.1		2.0	2.0
1992					2.1	2.1
1993					2.2	2.2
1994						
1995						
1996	18.3	1.3	19.6			

Sources: [2], [3] and [4]

** World-wide

World-wide demand colour CRT
(million pcs.)

	TV			Monitor			Total		
	1986	1991	1996	1986	1991	1996	1986	1991	1996
Total Asia	27.7	37.8	40.4	5.0	10.8	18.4	32.7	48.6	58.8
W-Europe	15.1	17.1	18.0	0.5	1.6	2.4	15.6	18.7	20.4
USA	14.5	17.1	18.3	0.4	1.0	1.3	14.9	18.1	19.6
World-wide	57.3	72.0	76.7	5.9	13.4	22.1	63.2	85.4	98.8

Source: [2]

World-wide demand colour CRT
(million pcs.)

	TV	TV	Monitor	Monitor	TTl(min)		TTl(max)
1986	62.5	57.3	5.9	9.4	63.2	67	71.9
1987	63.3			10.1			
1988	65.5			11.2			
1989	67.7			12.6			
1990	70.1			14.0			
1991	72.2	72.0	13.4	15.6	85.4	86	87.8
1992	74.1			17.5			
1993	75.4			19.4			
1994	76.5			20.7			
1995	77.2			21.8			
1996		76.7	22.1		98.8		98.8

Sources: [1] and [2]

World-wide demand mono CRT
(million pcs.)

	TV	Monitor	Total
1986	12.3	14.0	26.3
1987	9.8	17.4	27.2
1988	8.8	17.9	26.7
1989	7.6	17.8	25.4
1990	6.0	18.2	24.2
1991	4.7	18.3	23.0
1992	4.5	18.9	23.4
1993			
1994			
1995			
1996			

Sources: [3] and [4]

2.4.2 B: Production CRT.

*** Asia, W-Europe, USA and World-wide**

Production colour CRT
(million pcs.)

	TV			Monitor			Total		
	1986	1987	1988	1986	1987	1988	1986	1987	1988
Japan	25.0	26.4		5.1	6.1		30.1	32.5	35.0
Korea	10.2	13.6		0.3	0.4		10.5	15.0	21.0
Rest Asia	5.3	5.8		0.5	1.2		5.8	7.0	9.0
Total Asia	40.5	45.8		5.9	7.7		46.4	54.5	65.0
W-Europe	12.2	12.9		0.0	0.1		12.2	13.0	13.0
USA	12.8	13.5		0.1	0.0		12.9	13.5	12.0
World-wide	65.5	72.2		6.0	7.8		71.5	81.0	90.0

Sources: [2], [5] and [6]

Production colour CRT world-wide
(million pcs.)

	Total			
	1982	1988	1989	1992/1993
Japan	22.0	35.0	28.0	25.0
Korea	2.0	23.4	24.0	30.0
Rest Asia	3.0	9.0	12.7	20.0
Total Asia	27.0	67.4	64.7	75.0
W-Europe	9.0	13.8	14.4	15.5
USA	10.0	14.3	17.0	23.0
World-wide	46.0	95.5	96.1	113.5

Source: [11]

Rest Asia 1992/1993: Taiwan 9.5
Singapore 5.5
Thailand 5.0

2.4.3 C: Capacity CRT

*** Asia**

	Colour		Monochrome			
	1988	1991	1986	1987	1988	1990-1995
Japan	35.3	38.1	6.1	4.2	2.0	0
Korea	20.0	27.8	14.0	14.3	14.0	12.0-14.0
Rest Asia	9.8	18.2	13.5	13.0	13.0	12.0-13.0
Total Asia	65.1	84.1	33.6	31.5	29.0	24.0-27.0

Sources: [7] and [8]

Capacity Asia
(mill. pcs.)

	Colour	Monochrome
1986		33.6
1987		31.5
1988	65.1	29.0
1989		
1990		
1991	84.1	
1992		
1993		
1994		25.5 [24-27]
1995		

Sources: [7] and [8]

*** Europe**

CRT Capacity W-Europe
(million pcs.)

	Colour	Monochrome
1986		1.0
1987		0.7
1988	13.1	0.2
1989		
1990		
1991	14.4	
1992		
1993		
1994		0.0
1995		

Sources: [7] and [8]

*** USA**

CRT Capacity USA
(million pcs.)

	Colour	Monochrome
1986		1.0
1987		1.0
1988	12.7	0.8
1989		
1990		
1991	15.7	
1992		
1993		
1994		0.9 [0.8-1.0]
1995		

Sources: [7] and [8]

**** World-wide**

Capacity colour CRT
(million pcs.)

	Colour	Monochrome
1986		39.6
1987		34.9
1988	90.9	31.6
1989		
1990		
1991	114.2	
1992		
1993		
1994		28.0
1995		

Sources: [7] and [8]

2.4.4 E: TV-Glass production (including LATAM)

**** World-wide**

Output Colour TV-Glass factories 1989.
(million pcs.)

	1988	1989	
Company	Colour Sets	SC	CC
ASAHI	27	31.0	29.0
CAV	6	4.5	4.5
NEG	23	22.4	24.3
OI	7	7.6	7.6
Samsung Cornick	17	22.0	22.0
Philips	11	9.1	11.1
Schott	5	4.6	5.5
Thomson	3	5.8	6.8
Picvue	-	0.0	0.0
Hangkuk	3	3.0	3.0
Total	102	110	114

Source: [9] and [10]

2.4.5 F: Capacities TV-Glass factories

*** Asia**

Capacities TV-Glass factories 1989
(million pcs.)

Factory	Plant	SC	CC	Monobulb
ASAHI	Funabashi (J)	14.4	14.4	-
	Takasago (J)			-
	Kansai (J)	9.0	9.0	-
	Tao-Yan (T)	6.4	-	-
	Singapore	7.0	-	-
NEG	Notogawa (J)			-
	Takatsuhi (J)	25.0	25.0	25.0
Samsung Cor.	Suwon (K)	18.0	18.0	5.0
	Gumi (K)	6.0	6.0	-
Hangkuk	Gumi (K)	9.0	9.0	6.0
Picvue	Picvue (T)	-	-	7.0
Philips	Chupei (T)	1.8	3.0	4.0
Total		96.6	84.4	47.0

Source: [9]

Capacities TV-Glass factories Asia 1989
(million pcs.)

	SC	CC	Monobulb
Total Japan	48.4	48.4	25.0
Total Korea	33.0	33.0	11.0
Total Taiwan	8.2	3.0	11.0
Singapore	7.0	-	-
Total Asia	96.6	84.4	47.0

Source: [9]

*** W-Europe**

Capacities TV-Glass factories 1989
(million pcs.)

Factory	Plant	SC	CC	Monobulb
Schott	Mainz (D)	5.1	3.5	-
Thomson/RCA	Bagneaux (F)	3.4	4.5	-
Philips	Aachen (D)	4.5	5.4	-
	Simonstone (UK)	2.5	-	-
Total		15.5	13.4	-

Source: [9]

Estimated capacities TV-Glass factories 1992

Factory	Plant	SC	CC	Monobulb
Schott	Mainz (D)	7.0	6.0	-
Thomson/RCA	Bagneaux (F)	2.5	3.0	-
Philips	Aachen (D) and Simonstone (UK)	7.0	6.0	-
Total		14.5	15.5	-

Source: [11]

*** N-America**

Capacities TV-Glass factories 1989
(million pcs.)

Factory	Plant	SC	CC	Monobulb
Corning	Monterry (Mex)	-	0.4	2.0
	State Coll (USA)	5.0	5.0	-
Owens/NEG	Columbus (USA)			-
	Pittston (USA)	8.5	8.5	-
Thomson/RCA	Circleville (USA)	3.5	4.5	-
Total		17.0	18.4	2.0

Source: [9]

** World-wide

Capacities TV-Glass factories 1989
(million pcs.)

Factory	Plant	SC	CC	Monobulb
ASAHI	Funabashi (J)	14.4	14.4	-
	Takasago (J)			-
	Kansai (J) >	9.0	9.0	-
	Tao-Yan (T)	6.4	-	-
	Singapore	7.0	-	-
Corning	Monterry (Mex)	-	0.4	2.0
	State Coll (USA)	5.0	5.0	-
NEG	Notogawa (J)			-
	Takatsuhi (J) >	25.0	25.0	25.0
Owens/NEG	Columbus (USA)			-
	Pittston (USA) >	8.5	8.5	-
Thomson/RCA	Bagneaux (F)	3.4	4.5	-
	Circleville (USA)	3.5	4.5	-
Samsung Cor.	Suwon (K)	18.0	18.0	5.0
	Gumi (K)	6.0	6.0	-
Schott	Mainz (D)	5.1	3.5	-
Hangkuk	Gumi (K)	9.0	9.0	6.0
Picvue	Picvue (T)	-	-	7.0
Philips	Aachen (D)	4.5	5.4	-
	Simonstone (UK)	2.5	-	-
	Chupei (T)	1.8	3.0	4.0
Total		129.1	116.2	49.0

Source: [9]

** World-wide key colour glassmakers capacities

	1989		1992/1993	
Asahi	32.7	27	40.6	28
Corning (USA + Korea)	23.0	19	29.0	20
HEG (Korea)	8.5	7	8.7	6
NEG + OI/ NEG Japan and USA	31.5	26	31.9	22
Chinese	3.6	3	13.1	9
Schott	4.8	4	4.4	3
Philips	9.7	8	10.2	7
Thomson	6.1	5	7.3	5
	121.0	99	145.0	100

Source: [11]

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APPENDIX 3: WARM PINNING REQUIRED FOR SCENARIO N1.

1. Market demand.

	1991	1992	1993	1994
14"	1.8	2.4	2.4	3.6
36 FS	0.6	1.1	1.1	?
51 FS	0.8	1.0	1.2	1.2
Total	3.2	4.5	4.6	4.7

2. Estimated factory yields.

Colour cones: 14" : 90% (1991-1994)
51 FS: 85% (1991-1994)
Colour screens: 14" : 80% (1991-1994)
51 FS: 70% (1991-1994)

3. Estimated press speeds.

Colour cones (cuts/min):

	1991	1992	1993	1994
14"	14	15	16	17
51 FS	10	11	12	13

Colour screens (cuts/min):

	1991	1992	1993	1994
14"	10	12	12	14
51 FS	6	6.5	6.5	7

4. Time required for colour cones production.

	1991	1992	1993	1994
14"	3174	4320	4051	3922
51 FS	1569	1783	6012	1810
Total	4743	6103	6012	5732

Total net press hours per year about 22,000. Available percentage of total production hours for colour screens and mono:
1991: 78%;
1992: 72%;
1993: 73%;
1994: 74%.

5. Estimated capacity per warm PIM.

Utilization about 73%.
14" yield: 80%;
51 FS yield: 70%.

Capacity per warm PIM: 14" : 546K;
51 FS: 478K.

Extension is required for: 1990 : 1,34M (about 3 PIM's);
1992 - : 2,80M (about 5 PIM's).

6. How many lines in use for warm pinning? and 7. The cold pinning bottle-neck.

1991: assume 3 PIM's on one line; universal glass.

Hours required for pressing: (net output/factory yield) : press speed per hour:

14"	: (2.4M/0.80):600 =	5000 hours
51 FS:	(0.8M/0.70):360 =	3175 hours

Total		8175 hours

All 14" screens can be warm pinned on one line, 51 FS and the remaining 40% to be cold pinned 14" screens are no problem for the cold pinning capacity: 0.96 + 0.8 = 1.76M (max.= 1.86M).

1991: assume 3 PIM's on one line; one glass for mono and one glass for colour screens.

Hours required for pressing: (net output/factory yield) : press speed per hour:

14"	: (2.4M/0.75):600 =	5000 hours
51 FS:	(0.8M/0.70):360 =	3175 hours

Total		8175 hours : 3 = 2725

1 line 3 PIM's for 14" : 2725 hours: 1.31M production
1 line 0 PIM's for 14" : 2275 hours: 1.09M production
1 line 0 PIM's for 51 FS: 450 hours: 0.11M production
1 line 0 PIM's for 51 FS: 2725 hours: 0.69M production

To be cold pinned:

40% of 1.31M 14"	= 0.52M
100% of 1.09M 14"	= 1.09M
100% of 0.80M 51FS	= 0.80M

Total	2.41M

1992-1993: assume 3 PIM's on one line and 2 PIM's on another; one glass for 14" and 51 FS. Another glass is required for mono parts.

Number to produce: 14" : 2.4M
51 FS : 0.8M

Speeds: 10 cuts/min. for 14" and 6 cuts/min for 51 FS.

Hours required for pressing:

14" : (2.4M/0.80):600 = 5000 hours
51 FS: (0.8M/0.70):360 = 3174 hours

Total 8174 hours: 3 = 2725 hours per press.

1 line 3 PIM's for 14" : 2725 hours ==> 1.31M production
1 line 2 PIM's for 14" : 2275 hours ==> 1.09M production
1 line 2 PIM's for 51 FS: 450 hours ==> 0.11M production
1 line 0 PIM's for 51 FS: 2275 hours ==> 0.69M production

To be cold pinned:

3	40% of 1.31M 14"	= 0.52M	3	40% of 1.31M 14"	= 0.52M
2	60% of 1.09M 14"	= 0.65M		100% of 1.09M 14"	= 1.09M
2	33% of 0.11M 51FS	= 0.04M		100% of 0.11M 51 FS	= 0.11M
	100% of 0.69M 51FS	= 0.69M	2	33% of 0.69M 51 FS	= 0.33M
Total		1.90M			2.05M

1992-1993: assume 3 PIM's on one line and 2 PIM's on another; one glass for 14", one glass for 51 FS and also another glass is required for mono parts.

Number to produce: 14" : 2.4M
51 FS : 0.8M

Speeds: 10 cuts/min. for 14" and 6 cuts/min for 51 FS.

5 PIM's available for warm pinning. Percentage of screens which will be warm pinned:
14" : (5*120) / (3*600) = 33%
51 FS: (5*120) / (3*360) = 56%

Maximum production function:
0.67 * ## 14" + 0.44 * ## 51 FS = 1.89

Maximum production alternatives:
- 2.8M 14";
- 4.3M 51 FS;
- 0.8M 51 FS and 2.30M 14".

1992-1993: assume 3 PIM's on one line and 2 PIM's on another; one glass for 14", 51 FS and mono parts.

```
Number to produce: 14"   : 3.5M
                   51 FS : 1.0M
```

Speeds: 12 cuts/min. for 14" and 6.5 cuts/min for 51 FS.

Hours required for pressing:

```
14"  : (3.5M/0.80):720 = 6076 hours
51 FS: (1.0M/0.70):390 = 3663 hours
                         -----------
Total                    9739 hours

1 line 3 PIM's for 14"  : 5300 hours ==> 3.05M production
1 line 2 PIM's for 51 FS: 3663 hours ==> 1.00M production
1 line 2 PIM's for 14"  : 1637 hours ==> 0.94M production

To be cold pinned:
50% of 3.05M 14"    = 1.53M        50% of 3.0M 14"    = 1.50M
39% of 1.00M 51 FS  = 0.39M        39% of 1.0M 51 FS  = 0.39M
67% of 0.94M 14"    = 0.55M            -
                      -----                             -----
Total                 2.55M                             1.89M
```

Maximum production volume (based on cold pinning capacity is 1.86M) <u>1.0M 51 FS and 3.0M 14"</u>, under the restriction that 1637 + 5300 = 6937 hours will be filled with pressing monoparts.

1992-1993: assume 3 PIM's on one line and 2 PIM's on another; one glass for 14" and 51 FS. Another glass is required for mono parts.

```
Number to produce: 14"   : 3.5M
                   51 FS : 1.0M
```

Speeds: 12 cuts/min. for 14" and 6.5 cuts/min for 51 FS.

Hours required for pressing:

```
14"  : (3.5M/0.80):720 = 6076 hours
51 FS: (1.0M/0.70):390 = 3663 hours
                         -----------
Total                    9739 hours: 3 = 3246 hours per press.

1 line 3 PIM's for 14"  : 3246 hours ==> 1.87M production
1 line 2 PIM's for 14"  : 2830 hours ==> 1.63M production
1 line 2 PIM's for 51 FS:  416 hours ==> 0.11M production
1 line 0 PIM's for 51 FS: 3246 hours ==> 0.89M production
```

To be cold pinned:

50% of 1.87M 14"	= 0.94M	50% of 1.87M 14"	= 0.94M
67% of 1.63M 14"	= 1.09M	100% of 1.63M 14"	= 1.63M
39% of 0.11M 51 FS	= 0.04M	100% of 0.11M 51 FS	= 0.11M
100% of 0.89M 51 FS	= 0.89M	39% of 1.0M 51 FS	= 0.39M
	-----		-----
Total	2.96M		3.07M

50% of 1.87M 14"	= 0.94M	50% of 1.87M 14"	= 0.94M
67% of 1.42M 14"	= 0.95M	100% of 0.45M 14"	= 0.45M
-		100% of 0.11M 51 FS	= 0.11M
-		39% of 1.0M 51 FS	= 0.39M
	-----		-----
Total	1.89M		1.89M

Maximum production volume (based on cold pinning capacity is 1.86M) depends on which products will produced on which line. According to given examples maximum production volumes are:
- 3.29M 14" or
- 2.32M 14" + 1.0M 51 FS.

1992-1993: assume 3 PIM's on one line and 2 PIM's on another; one glass for 14", one glass for 51 FS and also another glass is required for mono parts.

Number to produce: 14" : 3.5M
51 FS : 1.0M

Speeds: 12 cuts/min. for 14" and 6.5 cuts/min for 51 FS.

Hours required for pressing:

14" : (3.5M/0.80):720 = 6076 hours: 3 = 2025 hours per press.
51 FS: (1.0M/0.70):390 = 3663 hours: 3 = 1221 hours per press.

5 PIM's available for warm pinning. Percentage of screens which will be warm pinned:
14" : (5*120) / (3*720) = 28%
51 FS: (5*120) / (3*390) = 51%

Maximum production function:
0.72 * ## 14" + 0.49 * ## 51 FS = 1.89

Maximum production alternatives:
- 2.6M 14";
- 3.9M 51 FS;
- 1.0M 51 FS and 1.94M 14".

APPENDIX 4: FINANCIAL ANALYSIS PINNING AND POLISHING.

Contents:

4.1 Cost estimation Phase III.
4.2 General view on variable expenses (existing situation).
4.3 Pinning
    4.3.1 Cost of investment
    4.3.2 Operating expenditures
    4.3.3 Comparison warm and cold pinning.
4.4 Polishing
    4.4.1 Investment costs
    4.4.2 Operating expenditures modular line
    4.4.3 Operating expenditures Philiflows
    4.4.4 Pay-back time for a mono investment

Annex 4.1: Headcounts
Annex 4.2: Budget indirect material pinning and polishing dpt.
Annex 4.3: Estimated utilities consumption 2nd line.
Annex 4.4: Difference in expenditures of polishing mono screens on modular line instead of polishing on Philiflows.
Annex 4.5: Expenditures per product based on variable operating expenditures when polished on modular line or Philiflow.

4.1 COST ESTIMATION - Phase III.

The cost estimation is based on the following principles:

1. 51 FS production.
2. One pinning line and one polishing line.
3. Without SEFU's.
4. Without spare parts.
5. As pressed color cone (edge and lug), which means that the color finishing line isn't necessary anymore and the space is available for c/s polishing.
6. Import parts based on phase II invoice with the exchange rate of 1 Dfl = 13.78 NT$.
7. Local price based on phase II market price.

AA. Pinning.

	EHV	Local
- Loading / washing / drying/ inspection of raw screen		1,500K
- auto pre-heating loading		2,000K
- Pre-heating oven x 1		11,000K
- PIM's x 2	27,661K	] 2,000K
- PPLT x 1	20,101K	
- Himmel cooling unit x 1		
- Annealing lehr * 1		6,500K
- PPSH meas/pinout/cullet car x 2	18,204K	600K
- Pinning to polishing conveyor x 1		2,500K
- Auto PPSH measurement x 1		3,000K
- Miscellaneous		393K
	-------	-------
Total	65,944K	30,034K

N.B.: - Modifying existin 2.2 M oven in S1 building for annealing lehr.
- Modify c/c line five 1.5M lehr for pre-heating oven.

BB. Polishing

	EHV	Local
- Supply & repair conveyor		3,000K
- Modules x 5	73,157K	] 3,500K
- Transportation system	24,087K	
- Power pack	4,992K	
- Slurry system modification		500K
- Packing conveyor and lifting device		800K
- Working platform		1,500K
- Miscellaneous		964K
	--------	-------
Total	102.236K	10.264K

CC. PED

	Local
- Demolish wall between S2/S3	500K
- Floor preparation	1,000K
- Utilities supply/electrical	1,500K
- Utilities supply/mechanical	3,000K
- 1.5T hoist for pinning	500K
- Lighting	1,000K
- Ventilation	1,000K
- Miscellaneous	500K

Total	9,000K

DD. Regroup of c/c A2 insertion

- Preaheating oven	1,000K
- A2 M/C with mechanisation	500K
- Annealing lehr	3,000K
- Teleflex conveyor	500K

Total	5,000K

EE. Press tools 51 FS x 1.5 sets 37,500K

Total: 96M + 112.5M + 9M + 5M + 37.5M = NT$ 260M

4.2 GENERAL VIEW ON VARIABLE EXPENSES (EXISTING SITUATION).

4.2.1 Pinning and polishing capacity (* 1,000 NT$):

Expenses	Pinning	Module
Polishing		
	1L; 3S	1L; 3S
Wages/social costs *	3,984	6,237
Indirect material **	487	21
Utilities: - purchased ***	7,515	2,505
- process cost	1,413	471
- own made	1,599	3,751
Total utilities	10,527	6,727
R + M: - spare parts (N) ****	2,630	2,630
- spare parts (S)	150	150
- man costs (N)	2,656	2,656
- man costs (S)	227	227
Total repair and maintenance	5,663	5,663
TOTAL EXPENSES	20,661	18,648

* Wages pinning and module polishing based on agreed manning 28 department (31 direct). Wages/social costs are split up in pinning and polishing required like written down in the forgoing section. Expenses used for calculation are:
G3: 304,000 NT$/year;
G4: 336,000 NT$/year;
G5: 416,000 NT$/year.

** Indirect material expenditures based on budget, but split up as described in annex 2 (in budget are the total expenditures equally divided over pinning and polishing. The expenditures to make for sheets on the modular line and the Philiflows are <u>not</u> included in this figure, in the calculation further on these expenditures for sheets are calculated as consumption expenditures.

*** Purchased utilities are for the pinning and polishing department only the amount of kWh required. In technical data the used ratio 1:1 for pinning:polishing. A better ratio is pinning:polishing 3:1 (see annex 3). This ratio is used.

Utilities process cost is direct related to the quantity of purchased utilitities, so the used ratio is also 3:1.

Utilities own made: ratio's used: Pinning : Polishing (based on annex 3):
Cool water: 1:5; Compressed air: 1:12; normal water: 1:1; soft water 1:1.6; hot water: 1:1 and demi water normal 1:1 (see annex 3).

**** All repair and maintence expenditures for pinning and modular polishing are rough estimations. Till now, this equipment is not used for production and exact figures over required amount of repair + maintenace are not availabe. Estimation is 4% of replacement value of investment.

4.2.2 Comparison module polishing and Philiflow polishing (1,000 NT$):

Expenses	Module Polishing 1L; 3S	Philiflow Polishing 1L; 3S
Wages/social costs *	6,237	9,889
Indirect material **	21	774
Utilities: - purchased ***	2,505	2,981
- process cost	471	570
- own made	3,751	1,506
Total utilities	6,727	5,057
R + M: - spare parts (N) ****	2,630	1,545
- spare parts (S)	150	250
- man costs (N)	2,656	2,431
- man costs (S)	227	163
Total repair and maintenance	5,663	4,389
TOTAL EXPENSES	18,648	20,109

4.3 PINNING.

3 Alternatives should be analyzed:
- extension current capacity with 2 PIM's;
- extension cold pinning with one cold pinning line;
- warm pinning: 2 PIM's on TA1 and 3 PIM's on TA2.

4.3.1 Costs of investment.

	EHV	Local
*** Extension current capacity:**		
- PIM's x 2	27,661K	
- Transport adaptions		20,000K
- Extension of pre-heating oven		8,000K
- PPSH measurement	18,204K	
	-------	-------
Total	45,865K	28,000K
*** A second cold pinning line:**		
- Loading/washing raw screen		1,500
- Autom. preheating loading		2,000
- Pre-heating oven x 1		11,000
- PIM's	27,661K	
- PPLT	20,101K	
- Annealing lehr		6,500K
- Auto PPSH measurement x 1		3,000K
- PPSH measurement	18,204K	
- Regrouping costs		4,500K
	-------	-------
Total	65,996K	28,500K
*** Warm pinning**		
- PIM's x 5	69,152K	]
- Product handling device		10,000K (for PIM's x 5, product handling device and Himmel cooling unit)
- Himmel cooling unit x 1	3,200K	]
- PPSH meas/pinout/	18,204K	
	-------	-------
Total	90,556K	10,000K

4.3.2 Operating expenditures.

Two types of operating expenditures:
- variable expenditures: dependent on the number of shifts and lines in use;
- consumption expenditures: dependent on the number of screens pinned.

* Variable expenditures (1 line, 4 shifts):

*** Extension current capacity:**

Wages/social costs	:	1,216K NT$;
Indirect material	:	325K NT$;
Utilities	:	3,509K NT$;
Repair & Maintenace	:	2,955K NT$;

Total		8,005K NT$.

Explanation variable expenditures extension cold pinning line:
- wages/social costs: only one extra inspector required for inspection pinned screens after annealing;
- indirect material: assumed 50% of indirect material new cold line;
- utilities: pre-heating will take more energy, annealing probably a little less. Pre-heating is about 25% of utility costs. Assumption: 25% of utilities of an extra cold line will be necessary for the extension.

*** New cold pinning line:**

Wages/social costs	:	5,312K NT$;
Indirect material	:	649K NT$;
Utilities	:	14,036K NT$;
Repair & Maintenace	:	3,780K NT$;

Total		23,777K NT$.

Explanation variable expenditures new cold pinning line:
- The Repair & Maintenance expenditures are estimated as 4% of the investment to make (see 3.1).
- Headcount: see annex 1.

*** Warm pinning:**

Wages/social costs	:	2,880K NT$;
Indirect material	:	116K NT$;
Utilities	:	2,531K NT$;
Repair & Maintenace	:	4,022K NT$;

Total		9,531K NT$.

Explanation variable expenditures warm pinning:

- wages/social costs: 1 auxiliary and 1 inspector * 4 shifts: 4 * (416K + 304) = 2,880K;
- indirect material: no stainless wool required;
- utilities purchased: no pre-heating and annealing required (only 5.5% purchased utilities cold pinning required: instead of 1279.5 kWh only 72 kWh);
- process costs are direct related to purchased utilities: so, also 5.5% of expenses required of cold pinning;
- own made: 88% of cold pinning required (no expenses for pre-heating oven).
- repair and maintenance is estimated as being 4% of the total investment.

*** Consumption expenditures:**

*** Cold pinning (extension and new line):**

- Pin consumption : 3.045 pins per screen
- Price pins : 210 NT$/100 pcs.

Total consumption expenditures per screen: NT$ 6.395

*** Warm pinning:**

- Pin consumption : 1/yield pressing * 3,045 pins per screen;
- Price pins : 210 NT$/100 pcs;
- average yield pressing: 80%.

Total consumption expenditures per screen: 7.993 NT$/screen.

4.3.3 Comparison of the alternatives.

Expenditures of operating 1 line 4 shifts per year (1000 NT$); warm pinning 3+2 PIM's and cold pinning 2 PIM's extension or 2 PIM's in a new line.

	extension cold pinning	new cold pinning	warm pinning
Total investment	73,865	94,496	100,556
Variable expenditures:			
- Wages/social costs	1,216	5,312	2,880
- Indirect material	325	649	116
- Utilities	3,509	14,036	2,531
- Repair and maintenance	2,955	3,780	4,022
Total 1 line 4 shifts	8,005	23,777	9,531
Total consumption expenditures per screen (NT$)	6.395	6.395	7.993
Capacity	± 1.2M	1.86M	dependent on glasstypes in use

4.4 POLISHING.

A number of extension alternatives should be taken into account:
- a second 5 module line (as calculated in chapter 2);
- two 5 module lines (a second and a third);
- a second 5 module line and one 3 module line;
- a second 5 module line and two 3 module lines;
- change the current situation and go to a situation of 4 lines with each four modules.

4.4.1 Investments costs for the different alternatives modular line.

Module costs investment costs based on 5 modules are: 73,157K (budget phase III). Transport and powerpack: 5 modules 29M (also budget phase III), estimated is transport and powerpack investments costs for 4 modules 24M and for 3 modules in a line 19M. Local costs are estimated as 10M for every new line to built. Regrouping and change costs of modules (for example: to make a pre-grinding module a polishing module) are not calculated. Regrouping costs will be about the same for all alternatives, and change costs will only not occur in the case of installing 1*5 modules.

Alternative	EHV	Local	Total
1: 2*5	102	10	112
2: 3*5	204 [184]	20	224 [204]
3: 2*5 + 1*3	165	20	185
3: 2*5 + 2*3	228	30	258
4: 4*4	233 [213]	30	263 [243]
5: 1*6	20	-	20
6: 1*7	40	-	40

Table 1: Investment costs (M. NT$) extension alternatives polishing. The given alternatives are the available capacities after extension.
[] = When the share opportunity for high-glossing will be used.

Extra costs will be required for extension and adaption of the slurry systems. The cost per alternative depends on the number of modules to be served by a slurry system and the maximum capacity of the slurry system, which is unknown at the moment. The system has been built for 2 pre-grinding modules, 6 polishing modules and 2 high-glossing modules. Wether or not it's possible to connect more modules with a certain system has to be examined.

Alternative	Pre-grinding	Polishing	High-glossing
1: 2*5	-	-	-
2: 3*5	1	3	1 [-]
3: 2*5 + 1*3	1	2	-
3: 2*5 + 2*3	2	4	-
4: 4*4	2	2	2 [1]
5: 1*6	-	-	-
6: 1*7	-	-	-

Table 2: Number of modules to be served by the slurry systems above designed maximum.
[] = When the share opportunity for high-glossing will be used.

The above mentioned share opportunity will save some costs, because one module less has to be bought. But on the other hand an investment should be made for designing a good share control.

4.4.2 Operating expenditures modular line.

Two kinds of operating expenditures:
- one dependent on the number of lines and shifts which are in use variable expenditures;
- one dependent on the screens: consumption expenditures.

* **Variable expenditures** (1 line, 3 shifts), excluding sheets consumption!!

Wages/social costs	:	6,237K NT$;
Indirect material	:	21K NT$;
Utilities	:	6,727K NT$;
Repair & Maintenace	:	4,247K NT$;
Total		17,232K NT$.

* **Consumption expenditures:**

Calculations are based on data from Technical report BM/TR 89/09 and updates from the trial production in december 1989.

- Consumption of abrasives:

Pre-grinding	:	Al_2O_3	:	3.0 kg/100 screens;
Polishing	:	Pumice	:	12.5 kg/100 screens;
High-glossing	:	CeO	:	1.0 kg/100 screens;

- Prices of abrasives:

AL2O3	:	3808 NT$/100 kg;
Pumice	:	1372 NT$/100 kg;
Cerium oxide	:	24750 NT$/100 kg.

- Expenditures for abrasives per screen (satinized):

Al_2O_3	: 0.030	*	38.08	=	1.142 NT$
Pumice	: 0.125	*	13.72	=	1.715 NT$
Total					2.857 NT$

- Expenditures for abrasives per screen (high-gloss):

Al_2O_3	: 0,030	*	38.08	=	1.142 NT$
Pumice	: 0.125	*	13.72	=	1.715 NT$
CeO	: 0.010	*	247.50	=	2.475 NT$
Total					5.332 NT$

- Consumption of sheets (sheet per number of screen):

Pre-grinding	:	about 2,000 (measure from trial)
Pre-polishing	:	80,000 - 90,000 (average 85,000);
Polishing	:	60,000 - 70,000 (average 65,000);
Soft-polishing	:	120,000 - 130,000 (average 125,000);
High-glossing	:	15,000.

- Prices of sheets (invoice prices fase II minus general costs and uplift, local or direct supply):

Grinding sheet	:	4,968 NT$;
Pre-polishing sheet	:	4,258 NT$;

Polishing sheet	:	4,258 NT$;
Soft-polishing sheet	:	5,677 NT$;
High-gloss sheet	:	8,516 NT$.

- Expenditures for sheets per screen (satinized):

Pre-grinding	:	4,968 / 2,000 = 2.484 NT$;
Pre-polishing	:	4,258 / 85,000 = 0.050 NT$;
Polishing	:	4,258 / 65,000 = 0.066 NT$;
Soft-polishing	:	5,677 / 125,000 = 0.047 NT$;

Total expenditures for sheets pers screen		2.647 NT$.

- Expenditures for sheets per screen (high-gloss):

Pre-grinding	:	4,968 / 2,000 = 2.484 NT$;
Pre-polishing	:	4,258 / 85,000 = 0.050 NT$;
Polishing	:	4,258 / 65,000 = 0.066 NT$;
Soft-polishing	:	5,677 / 125,000 = 0.047 NT$;
High-glossing	:	8,516 / 15,000 = 0.568 NT$;

Total expenditures for sheets pers screen		3.215 NT$.

Total consumption expenditures:

Satinized : 2.857 + 2.647 = 5.504 NT$;
High-gloss: 5.332 + 3.215 = 8.547 NT$.

4.4.3 Operating expenditures Philiflow polishing.

Two kinds of operating expenditures:
- one dependent on the number of lines and shifts which are in use variable expenditures;
- one dependent on the screens: consumption expenditures.

* **Variable expenditures** (1 line, 3 shifts):

Wages/social costs	:	9,889K NT$;
Indirect material	:	774K NT$;
Utilities	:	5,057K NT$;
Repair & Maintenace	:	4,389K NT$;

Total		20,109K NT$.

*** Consumption expenditures:**

- Consumption of sheets:

		Tivi (85%)	Bivi (15%)	Average
Pre-grinding	:	2,500	2,000	2,425
Polishing	:	3,000	1,800	2,820
Glossing	:	1 - 2 months		58,000
High-glossing	:	6,000	6,000	6,000

* Number of products for glossing:
1,4 M (production per line per year) / 3 (glossing machines per line) / 8 (average life-time of 1.5 month) = 58,000 pcs.

- Average prices of sheets:
  - Pre-grinding : 1,235 NT$
  - Polishing : 1,525 NT$
  - Glossing : 200 NT$
  - High-glossing : 5,250 NT$
- Expenditures for sheets per screen:
  - pre-grinding : 1,235/ 2,425 = 0.509
  - polishing : 1,525/ 2,820 = 0.541
  - glossing : 200/58,000 = 0.003
  - high-glosssing : 5,250/ 6,000 = 0.875

Total expenditures sheets for satinized screen: 1.928
Total expenditures sheets for high-gloss screen: 1.053

- Consumption of abrasives:
  - Pre-grinding : Plako-20 : 2.7 kg/100
  - Polishing : Sand : 5.5 kg/100
  - Glossing : Pumice : 1.5 kg/100 or 2.5 kg/100(HG)
  - High-glossing : Cerium : 2.5 kg/100
- Prices:
  - Plako-20 : 6843 NT$/100 kg.
  - Sand : 440 NT$/100 kg.
  - Pumice : 1372 NT$/100 kg.
  - Cerium-oxide : 12750 NT$/100 kg.

- Expenditures per product for abrasives:

		Normal	High-gloss
Plako-20	:	0.027 * 68.43 = 1.848	0.027 * 68.43 = 1.848
Sand	:	0.055 * 4.40 = 0.242	0.055 * 4.40 = 0.242
Pumice	:	0.015 * 13.72 = 0.206	0.025 * 13.72 = 0.343
CeO	:		0.025 * 247.5 = 6.188
Total		2.296	8.621
Expenditures sheets		1.053	1.928
Total variable expenditures per screen:		3.349	10.549

4.4.3 Comparison operating expendutures polishing on module and on Philiflow.

Expenditures of operating 1 line 3 shifts per year (NT$):

	Polishing module	Polishing Philiflow
Variable expenditures: 1L;3S:		
Wages/social costs	6,237K	9,889K
Indirect material	21K	774K
Total utilities	6,727K	5,057K
Total repair and maintenance	4,247K	4,389K
	-------	-------
Total 1 line 3 shifts	17,232K	20,109K
Total consumption expenditures per screen (satinized)	5.504	3.349
Total consumption expenditures per screen (high-gloss)	8.547	10.549

4.4.4 Payback-time for a mono investment in modules.

The subjoined calculations have been carried out to see what the diffence of expenditures will be when an amount of 2.4M mono screens to polish can be (partly) polished on the modular line. This diffence in expenditures can be used to invest in an extra extension of the modular line, if required.

A comparison of expenditures for polishing on the modular line should include:

1. The cost per shift on Philiflow and modular line: manpower costs, utilities costs, indirect material and repair and maintenance required.
2. The expenditures per product: consumption of abrasives and sheets.
3. The linespeeds and number of repairs of Phiiflows and modular line.
4. The rejects wich are caused by handling during polishing on the Philiflow and which will not exist on the modular line (bruise and broken screens).
5. The rejects from CRT which are caused by handling during polishing on the Philiflows:
   - CRT-rejects due to inside scratches and inside bruise: these rejects are compensated rejects by the TV-Glass factory to the CRT.
   - CRT-rejects caused by outside bruise will not be compensated by the TV-Glass factory. But the outgoing sampling of the TV-Glass factory shows a level of bulb with bruise of about 3500 PPM. Estimated is that 70% of these bulbs will be a reject one due to the bruise. And although this will not be compensated by the TV-Glass factory it is a loose for the CRT factory caused by the polishing on the Philiflows.

The method which is used to calculate 1, 2 and 3 is as follows: the total expenditures per shift (manpower, utilities consumption, indirect material and expenditures of repair and maintenance), the expenditures per product (for abrasives and sheets) and the linespeeds combined together gives a expenditure per product. Assumed is that their is no idle time during the production (100% utilization). These expenditures per product has calculated for processing on the modular line and for processing on the Philiflows (see annex 4). The difference between these expenditures give the advantage of polishing on the modular line.

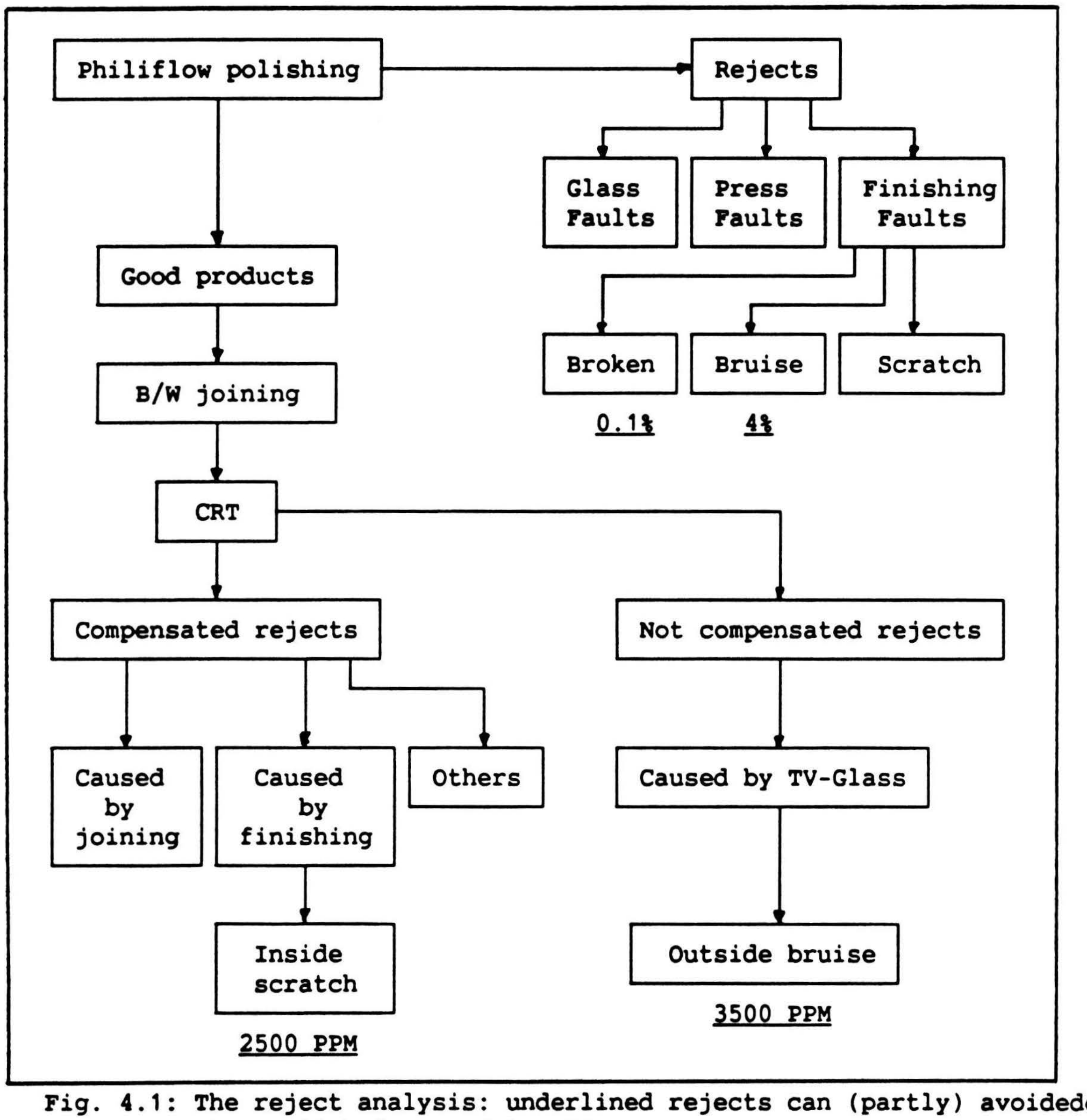


Fig. 4.1: The reject analysis: underlined rejects can (partly) avoideded when polished on modular line.

The rejects caused by bruise on the Philiflows are about 4% of the total number of screens processed. Saving in the amount of broken screens will be about 0.1% of the total polished screens. This means that polishing on the modular line saves 4.1% of the press-capacity which is needed to press the mono screens. For a bottle-neck situation (overoccupation presses) can be calculated that the savings in press hours per million mono screens to polish are:

1M * 4.1% / speed = 600 / yield = 0.85 = 80.4 press hours.
80.4 * 20.000 NT$ (cost per press hour) = 1.61M NT$ per year.

The costs of rejects from CRT caused by handling faults on the Philiflows are as follows:
- The compensated rejects due to bruise of the CRT is about 2500 PPM. FSP

monobulb = 250NT$, material can be re-used and should be subtracted: costs per bulb: 250-30 = 220 NT$. Per million produced monobulb: 2500 * 220 = 0.55M NT$.
- The non-compensated rejects are to calculate as follows: the outgoing sampling shows that the level of monobulb with outside bruise is 3500 PPM. 70% of these will be result in a reject tube. So, 2450 PPM of the delivered monobulb will be a rejected tube in the CRT due to polishing faults on the Philiflows.
  Costs in case of market demand is bigger then production: 2450 * FSP tube = 2450 * 550 = 1.35M NT$.

Total savings per million screens to polish when polished on modular line instead of in Philiflows:
- due to bruise and broken : 1.61M
- due to less compensated rejects : 0.55M
- due to less reject in CRT : 1.35M

Total savings for the Glass-factory (when presses are bottle-neck again) 2.16M NT$ per million pcs. to deliver. Savings for the CRT factory (when the demand exceeds the supply) 1.35M NT$ per million tubes.

Pay-back times:

Remarks:
* In subjoined calculations is not taken into account the investments to make in extension of the slurry systems.
* The required (extra) expenditures for a transportation system which can handle one-fold, two-fold and three-fold transportation are not taken into account either.
* Investment costs as calculated in section 4.1.
* The pay-back times are based on the savings in the Glass-factory, the possible savings for the CRT factory have not been taken into account in the calculations for the pay-back times.
* Investments for carriers (turntables) and polishing heads to make for polishing mono screens on the modular line are not been taken into account.
  Cost per carrier: 100K NT$.
  Cost per polishing head: 140K NT$ (2/3 of invoice price head in Phase II).

Pay-back times for a line with 5 modules (1 pre-grinding, 3 polishing and 1 high-glossing); investment costs 112M NT$:

Config.	glass type	operational savings (M NT$)	## of MS	reject savings (M NT$)	total savings (M NT$)	pay-back time (years)
1/2	423	12.8 - 16.4	1.9	4.1	16.9 - 20.5	5.4 - 6.6
	328	6.6 - 9.0	2.0	4.3	10.9 - 13.3	8.4 -10.3
2/2	423	23.0	2.3	5.0	28.0	4.0
	328	16.1	2.4	5.2	21.3	5.3
2/3	423	25.2 - 29.2	2.4	5.2	30.4 - 34.4	3.3 - 3.7
	328	15.9 - 18.6	2.4	5.2	21.1 - 23.8	4.7 - 5.3

Pay-back times for a line with 3 module modueles (1 pre-grinding and two polishing); a high-gloss module should be borrowed from an "colour-5-module" line; investment costs 73M NT$.

Config.	glass type	operational savings (M NT$)	## of MS	reject savings (M NT$)	total savings (M NT$)	pay-back time (years)
1/2	423	9.8 - 15.8	1.6	3.5	13.3 - 19.3	3.8 - 5.5
	328	7.4 - 11.2	1.8	3.9	11.3 - 15.1	4.8 - 6.5
2/3H	423	25.3	2.1	4.5	29.8	2.4
	328	18.8	2.3	5.0	23.8	3.1

ANNEX 4.1: HEADCOUNTS.

* Polishing and pinning department (#27).

Indirect:

Department manager	0.5
Engineer A	1
Foreman	3

	G3	G4	G5
On station:			
Raw screen unpack	1		
Pinned screen inspection and measurement	1		
Finished screen inspection	2		
Finished screen packing	1		
Outside station:			
Auxiliary			2
Process control			1
Glue operator		0.33	
Stack mover	1		
Relief	1		
Total direct per shift	6	1.33	3

Assumptions: - incoming inspection pinning (between washing and pre-heating oven) has been automated;
- only one inspector required for pin inspection; automation of measurement is een pre-condition; otherwhise a second inpector is required.

* Cold Pinning:

	G3	G4	G5	
On station:				
Unpacking/washing	1			
Pinning inspection	1			
Outside station:				
Relief	0.5			
Stack mover	0.5			
Auxiliary			1	
Total	3.0		1	(4.0)

* Warm pinning:

	G3	G4	G5	
Outside station:				
Inspector	1			
Auxiliary			1	
Total	1		1	(2)

* Polishing modular line: **1 line, 1 shift:**

	G3	G4	G5	
On station:				
Finishing inspection	2			
Finished screen packing	1			
Outside station:				
Auxiliary			1	
Process control		1		
Glue operator		0.33		
Stack mover	0.5			
Relief	0.5			
Total per shift	4	1.33	1	(6.33)

* Polishing Philiflow: **2 lines, 1 shift:**

	G3	G4	G5	
On station:				
Pre-grinding	1	1		
Polishing	1	1		
Glossing	2			
High-glossing	2			
Inspection	1	1		
Cone unpack	1			
Screen unpack	1			
Screen pack	1			
Outside station:				
Auxiliary			1	
Process control		1		
Glue operator		0.33		
Repair worker		1		
Stack mover		1		
Relief		3		
Total	10	9.33	1	(20.33)

ANNEX 4.2: BUDGET INDIRECT MATERIAL PINNING AND POLISHING DPT (#27).

Dept. 27: Pinning/polishing

Amount in NT$ 1,000

Item	Description	Pinning	Polishing
1.	Stainless steel wool	400	
2.	Graphite pin	80	
3.	Pre-grinding disc (14")		
4.	Pre-grinding disc (51 FS)		
5.	Polishing disc (14")		
6.	Polishing disc (51 FS)		
7.	Edge polishing disc		
8.	Vacuum sucker, GS 911	5	
9.	Nan Pao bond No-105, GS-303		6
10.	PVC hose 34x25 GS-201		5
11.	PVC hose 34x25 GS-201		6
12.	Rubber gloves		1
13.	Rubber apron		1
14.	Cotton gloves		
15.	Soft yellow pencil	2	2
16.	Palm broom		
Total		487	21

The estimation of expenditures for pre-grinding discs and polishing discs is not used, because a better estimation can be made based on technical data BM/89/09 and the invoice prices of Phase II of these discs (better sheets).

ANNEX 4.3: ESTIMATED CONSUMPTION EXPANSION 2nd LINE.

Equipment	Electric consumption (kWh)	Comp. air (NM_3/Hr)	Soft Water (M_3/Hr)	Cooling Water (M_3/Hr)
1. Pinning line				
Drying/washing station	2	100	5	
Lehr inlet device	5	5		
Pre-heating oven	670	20		
PPLT	20	20		4
PIM * 2	40	10		
Annealing lehr	537.5			
Sagittal height meas.	1	2		
Recir. cooling system	4		0.5	
Total pinning line	1279.5	157	5.5	4
2. Polishing line				
Economy module * 5	375			
Hydraulic power unit	50	1700 (Economy module, Hydraulic power unit and Longitudinal transport combined)		20
Longitudinal transport	5		4	
Raw screen & repair conveyor	30	50		
Washing/drying conveyor	2	100	5	
Total polishing	462	1850	9	20

Data from: report AIB/E/LS-039/88 1988-12-19
minutes 20/222 (Mr. van Gastel) 1988-11-23
report BM-TS 88/04 1988-08-16

ANNEX 4.4: DIFFERENCE IN EXPENDITURES OF POLISHING MONO SCREENS ON MODULAR LINE INSTEAD OF POLISHING ON PHILIFLOWS.

The difference of expenditures per screen times the number of screens which can polished in a certain (modular) configuration is the subjoined calculation.

The standard number of screens which has been the starting point of the calculations is:
- 14" F: 1.8M of which 25% high-gloss;
- 15" F: 0.3M of which 100% high-gloss;
- 17" : 0.1M, no high-gloss required;
- 20" : 0.2M of which 100% high-gloss;

Total: 2.4M mono screens.

Calculations are carried out for of universal glass and for 328 glass. The most left calculation (with the highest profits) is 423 glass, the righside is filled with the 328 calculation.

<u>Alternative 1: One extra 5-module line.</u>

1.1 One-fold pre-grinding; two-fold polishing.

* 14":	S :	1.35M * 5.1	= 6.9	1.35M * 1.04	= 1.4
	HG:	0.45M * 9.97	= 4.5	0.45M * 5.91	= 2.7
15":	HG:	0.08M * 17.43	= 1.4	0.21M * 11.86	= 2.5
			----		----
		Total	12.8M NT$		6.6M NT$
* 14":	S :	0.49M * 5.1	= 2.5	0.86M * 1.04	= 0.8
	HG:	0.45M * 9.97	= 4.5	0.45M * 5.91	= 2.7
15":	HG:	0.3 M * 17.43	= 5.2	0.3 M * 11.86	= 3.6
17":	S :	0.1 M * 12.57	= 1.3	0.1 M * 6.98	= 0.7
20":	HG:	0.2 M * 9.90	= 2.0	0.2 M * 6.16	= 1.2
			----		----
		Total	15.5M NT$		9.0M NT$

* 14":	S :	1.05M * 5.1 = 5.4	1.14M * 1.04 = 1.2
	HG:	0.45M * 9.97 = 4.5	0.45M * 5.91 = 2.7
15":	HG:	0.3 M * 17.43 = 5.2	0.3 M * 11.86 = 3.6
17":	S :	0.1 M * 12.57 = 1.3	0.1 M * 6.98 = 0.7
		----	----
	Total	16.4M NT$	8.2M NT$

Depending on the screens to be polished on the modular line (5 modules; 3 for polishing), the expenditures will be between 12.8 and 16.4M NT$ lower then when this number of screens was polished on the Philiflows.

1.2 Two-fold pre-grinding and two-fold polishing.

* 14":	S :	1.35M * 7.27 = 9.8	1.35M * 4.16 = 5.6
	HG:	0.45M * 12.14 = 5.5	0.45M * 9.03 = 4.1
15":	HG:	0.3 M * 19.64 = 5.9	0.3 M * 14.74 = 4.4
17":	S :	0.1 M * 12.57 = 1.3	0.1 M * 8.24 = 0.8
20":	HG:	0.05M * 9.90 = 0.5	0.2 M * 6.16 = 1.2
		----	----
	Total	23.0M NT$	16.1M NT$
			(97% utilization)

1.3 Two-fold pre-grinding and three-fold polishing.

* 14":	S :	1.35M * 8.11 = 10.9	1.35M * 4.09 = 5.5
	HG:	0.45M * 12.98 = 5.8	0.45M * 8.96 = 4.0
15":	HG:	0.3 M * 19.64 = 5.9	0.3 M * 14.74 = 4.4
17":	S :	0.1 M * 12.57 = 1.3	0.1 M * 8.24 = 0.8
20":	HG:	0.13M * 9.90 = 1.3	0.2 M * 6.16 = 1.2
		----	----
	Total	25.2M NT$	15.9M NT$
			(95% utilization)

* 14":	S :	1.35M * 8.78 = 11.9	1.35M * 5.00 = 6.8
	HG:	0.45M * 13.66 = 6.1	0.45M * 9.87 = 4.4
15":	HG:	0.3 M * 19.64 = 5.9	0.3 M * 14.74 = 4.4
17":	S :	0.1 M * 12.57 = 1.3	0.1 M * 8.24 = 0.8
20":	HG:	0.2 M * 9.90 = 2.0	0.2 M * 6.16 = 1.2
		----	----
	Total	27.2M NT$	17.6M NT$
			(87% utilization)

* 14":	S :	1.35M * 10.10 = 13.6	1.35M * 5.56 = 7.5
	HG:	0.45M * 14.97 = 6.7	0.45M * 10.43 = 4.7
15":	HG:	0.3 M * 19.64 = 5.9	0.3 M * 14.74 = 4.4
17":	S :	0.1 M * 12.57 = 1.3	0.1 M * 8.24 = 0.8
20":	HG:	0.2 M * 9.90 = 2.0	0.2 M * 6.16 = 1.2
		----	----
	Total	29.5M NT$	18.6M NT$
		(90% ultilization)	(82% utilization)

2. One extra 3 module line: 2 modules polishing.

2.1 One fold pre-grinding and two-fold polishing.

* 14":	S :	1.20M * 6.47 = 7.8	1.35M * 2.97 = 4.0
	HG:	0.45M * 11.34 = 5.1	0.45M * 7.84 = 3.5
		----	----
		Total 12.9M NT$	7.4M NT$

* Only satinized:

14":	S :	1.35M * 6.47 = 8.7	
17":	S :	0.1 M * 10.87 = 1.1	

		Total 9.8M NT$	

* 14":	S :	0.63M * 6.47 = 4.1	0.95M * 2.97 = 2.8
	HG:	0.45M * 11.34 = 5.1	0.45M * 7.84 = 3.5
15":	HG:	0.3 M * 18.47 = 5.5	0.3 M * 14.02 = 4.2
17":	S :	0.1 M * 10.87 = 1.1	0.1 M * 7.13 = 0.7
		----	----
		Total 15.8M NT$	11.2M NT$

2.2 Two-fold pre-grinding and three-fold polishing (<u>100%</u>).

* 14":	S :	1.35M * 9.56 = 12.9	1.35M * 6.21 = 8.4
	HG:	0.45M * 14.43 = 6.5	0.45M * 11.09 = 5.0
15":	HG:	0.3 M * 18.47 = 5.5	0.3 M * 14.04 = 4.2
17":	S :	0.06M * 10.87 = 0.7	0.1 M * 7.13 = 0.7
20":	HG:		0.12M * 4.51 = 0.5
		----	----
		Total 25.6M NT$	18.8M NT$

* 14":	S :	1.25M * 9.56 = 12.0	
	HG:	0.45M * 14.43 = 6.5	
15":	HG:	0.3 M * 18.47 = 5.5	
17":	S :	0.1 M * 10.87 = 1.1	

		Total 25.1M NT$	

Annex 4.5: **Expenditures per product based on variable operating expenditures when polished on modular line or Philiflow.**

<u>CALCULATIONS FOR A MODULAR LINE WITH FIVE (5) MODULES.</u>

FILE: EXPEND 5 WK1 (PINNING & POLISHING CAPACITY REQUIRED).

	Polishing module	Polishing Philiflow
Variable expenditures:		
Wages/social costs	6237	9889
Indirect material	21	774
Total utilities	6727	5057
Total repair and maintenance	4247	4389
Total 1 line 3 shifts	17232	20109
Total consumption expenditures per screen (satinized)	5.504	3.349
Total consumption expenditures per screen (high-gloss)	8.547	10.549

Hours available 3 shifts:	7080	7080
M.E.:	94.6	98.6
M.A.F.:	102.6	104
Net available hours:	6528	6712
Yield:	96.5%	95.0%

Linespeeds when universal glass is in use:

		Modular line:							
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	191		275	390	390	395	420	435	515
14"	191		282	354	354	393	431	393	531
15"	128		267	303	303				
17"	128		248	248	248				
20"	128	153							

Linespeeds when 328 glass will be used for mono screens:

		Modular line:							
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	255		290	400	465	410	445	505	540
14"	255		296	414	427	423	452	485	533
15"	170		280	370	370				
17"	170		273	308	308				
20"	170	180							

* Line speed * net available hours = maximum input;
* Maximum input * consumption expenditures + variable expenditures = TOTAL variable expenditures;
* Maximum input * yield / 1.1 (10% repair) = maximum output;
* TOTAL variable expenses / maximum output = VARIABLE EXPENSES PER PRODUCT

VARIABLE EXPENSES PER PRODUCT (328 GLASS,satinized):

		Modular line:							
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	17.48		16.65	13.80	12.74	13.61	13.04	12.23	11.65
14"	17.48		16.44	13.54	13.32	13.39	12.93	12.48	11.92
15"	24.28		17.02	14.41	14.41				
17"	24.28		17.30	16.04	16.04				
20"	24.28	22.99							

VARIABLE EXPENSES PER PRODUCT (328 GLASS, high-gloss):

		Modular line:							
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	25.82		20.12	17.27	16.21	17.08	16.50	15.70	15.31
14"	25.82		19.91	17.01	16.79	16.86	16.40	15.95	15.39
15"	32.62		20.49	17.88	17.88				
17"	32.62		20.76	19.51	19.51				
20"	32.62	26.46							

* Line speed * net available hours = maximum input;
* Maximum input * consumption expenditures + variable expenditures = TOTAL variable expenditures;
* Maximum input * yield / 1.1 (10% repair) = maximum output;
* TOTAL variable expenses / maximum output = VARIABLE EXPENSES PER PRODUCT.

VARIABLE EXPENSES PER PRODUCT (UNIVERSAL GLASS,satinized):

	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
					Modular line:				
12"	22.04		17.22	13.99	13.99	13.89	13.44	13.19	12.12
14"	22.04		16.94	14.77	14.77	13.93	13.26	13.93	11.94
15"	30.98		17.54	16.20	16.20				
17"	30.98		18.41	18.41	18.41				
20"	30.98	25.94							

VARIABLE EXPENSES PER PRODUCT (UNIVERSAL GLASS, high-gloss):

	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
					Modular line:				
12"	30.38		20.68	17.46	17.46	17.36	16.91	16.66	15.59
14"	30.38		20.41	18.24	18.24	17.40	16.72	17.40	15.41
15"	39.31		21.01	19.67	19.67				
17"	39.31		21.88	21.88	21.88				
20"	39.31	29.41							

CALCULATIONS FOR A MODULAR LINE WITH FOUR (4) MODULES.

FILE: EXPEND.4 WK1 (PINNING & POLISHING CAPACITY REQUIRED).
FOR A FOUR MODULE EXTENSION OF THE MODULAR CAPACITY.

	Polishing module	Polishing Philiflow
Variable expenditures:		
Wages/social costs	6237	9889
Indirect material	17	774
Total utilities	5382	5057
Total repair and maintenance	3398	4389
Total 1 line 3 shifts	15033	20109
Total consumption expenditures per screen (satinized)	5.504	3.349
Total consumption expenditures per screen (high-gloss)	8.547	10.549

Hours available 3 shifts:	7080	7080
M.E.:	94.6	98.6
N.A.F.:	102.6	104
Net available hours:	6528	6712
Yield:	96.5%	95.0%

Linespeeds when universal glass is in use:

	Philiflow	Modular line: 1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	191		275	390	390	395	420	435	515
14"	191		282	354	354	393	431	393	531
15"	128		267	303	303				
17"	128		248	248	248				
20"	128	153							

* Line speed * net available hours = maximum input;
* Maximum input * consumption expenditures + variable expenditures = TOTAL variable expenditures;
* Maximum input * yield / 1.1 (10% repair) = maximum output;
* TOTAL variable expenses / maximum output = VARIABLE EXPENSES PER PRODUCT.

VARIABLE EXPENSES PER PRODUCT (UNIVERSAL GLASS,satinized):

	Philiflow	Modular line: 1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	22.04		15.82	13.00	13.00	12.92	12.52	12.31	11.37
14"	22.04		15.58	13.69	13.69	12.95	12.36	12.95	11.22
15"	30.98		16.11	14.94	14.94				
17"	30.98		16.86	16.86	16.86				
20"	30.98	23.43							

VARIABLE EXPENSES PER PRODUCT (UNIVERSAL GLASS, high-gloss):

	Philiflow	Modular line: 1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	30.38		19.29	16.47	16.47	16.39	15.99	15.78	14.84
14"	30.38		19.05	17.16	17.16	16.42	15.83	16.42	14.69
15"	39.31		19.57	18.41	18.41				
17"	39.31		20.33	20.33	20.33				
20"	39.31	26.90							

Linespeeds when 328 glass will be used for mono screens:

	Philiflow	1	Modular line: 1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	255		290	400	465	410	445	505	540
14"	255		296	414	427	423	452	485	535
15"	170		280	370	370				
17"	170		273	308	308				
20"	170	180							

* Line speed * net available hours = maximum input;
* Maximum input * consumption expenditures + variable expenditures = TOTAL variable expenditures;
* Maximum input * yield / 1.1 (10% repair) = maximum output;
* TOTAL variable expenses / maximum output = VARIABLE EXPENSES PER PRODUCT.

VARIABLE EXPENSES PER PRODUCT (328 GLASS,satinized):

	Philiflow	1	Modular line: 1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	17.48		15.33	12.84	11.92	12.68	12.17	11.47	11.14
14"	17.48		15.14	12.61	12.42	12.48	12.08	11.69	11.20
15"	24.28		15.65	13.37	13.37				
17"	24.28		15.89	14.80	14.80				
20"	24.28	20.86							

VARIABLE EXPENSES PER PRODUCT (328 GLASS, high-gloss):

	Philiflow	1	Modular line: 1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	25.82		18.79	16.31	15.39	16.15	15.64	14.94	14.60
14"	25.82		18.61	16.08	15.89	15.95	15.55	15.16	14.67
15"	32.62		19.12	16.84	16.84				
17"	32.62		19.36	18.27	18.27				
20"	32.62	24.33							

CALCULATIONS FOR A LINE WITH THREE (3) MODULES.

FI . EXPEND. 3 JK1 (PINNING & POLISHING CAPACITY REQUIRED).
FOR A THEE MODULE EXTENSION OF THE MODULAR CAPACITY.

	Polishing module	Polishing Philiflow
Variable expenditures:		
Wages/social costs	6237	9889
Indirect material	13	774
Total utilities	4036	5057
Total repair and maintenance	2548	4389
Total 1 line 3 shifts	12834	20109
Total consumption expenditures per screen (satinized)	5.504	3.349
Total consumption expenditures per screen (high-gloss)	8.547	10.549

Hours available 3 shifts:	7080	7060
M.E.:	94.6	98.6
N.A.F.:	102.6	104
Net available hours:	6528	6712
Yield:	96.5%	95.0%

Linespeeds when universal glass is in use:

			Modular line:						
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	191		269	286	286	311	414	311	429
14"	191		241	241	241	258	361	258	361
15"	128		202	202	202				
17"	128		162	162	162				
20"	128	102							

* Line speed * net available hours = maximum input;
* Maximum input * consumption expenditures + variable expenditures = TOTAL variable expenditures;
* Maximum input * yield / 1.1 (10% repair) = maximum output;
* TOTAL variable expenses / maximum output = VARIABLE EXPENSES PER PRODUCT.

VARIABLE EXPENSES PER PRODUCT (UNIVERSAL GLASS,satinized):

			Modular line:						
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	22.04		14.61	14.11	14.11	13.48	11.69	13.48	11.50
14"	22.04		15.57	15.57	15.57	14.96	12.48	14.96	12.48
15"	30.98		17.37	17.37	17.37				
17"	30.98		20.11	20.11	20.11				
20"	30.98	28.25							

VARIABLE EXPENSES PER PRODUCT (UNIVERSAL GLASS, high-gloss):

			Modular line:						
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	30.38		18.07	17.58	17.58	16.95	15.16	16.95	14.97
14"	30.38		19.04	19.04	19.04	18.43	15.95	18.43	15.95
15"	39.31		20.84	20.84	20.84				
17"	39.31		23.58	23.58	23.58				
20"	39.31	31.71							

Linespeeds when 328 glass will be used for mono screens:

			Modular line:						
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	255		281	351	351	369	430	369	526
14"	255		272	299	299	326	417	326	449
15"	170		253	253	253				
17"	170		206	206	206				
20"	170	122							

* Line speed * net available hours = maximum input;
* Maximum input * consumption expenditures + variable expenditures = TOTAL variable expenditures;
* Maximum input * yield / 1.1 (10% repair) = maximum output;
* TOTAL variable expenses / maximum output = VARIABLE EXPENSES PER PRODUCT

VARIABLE EXPENSES PER PRODUCT (328 GLASS,satinized):

			Modular line:						
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	17.48		14.25	12.66	12.66	12.04	11.49	12.04	10.53
14"	17.48		14.51	13.77	13.77	13.15	11.65	13.15	11.27
15"	24.28		15.13	15.13	15.13				
17"	24.28		17.15	17.15	17.15				
20"	24.28	24.64							

VARIABLE EXPENSES PER PRODUCT (328 GLASS, high-gloss):

			Modular line:						
	Philiflow	1	1/2	2/2	2/2	2/3	2/3	2/3	2/3
12"	25.82		17.72	16.13	16.13	15.50	14.95	15.50	14.00
14"	25.82		17.98	17.24	17.24	16.62	15.12	16.62	14.73
15"	32.62		18.60	18.60	18.60				
17"	32.62		20.62	20.62	20.62				
20"	32.62	28.11							

APPENDIX 5: LINESPEEDS.

1. Used parameters in calculations.

Idle-time in cycle-time (seconds):

	Cylinder up	Cylinder down	Index time	Total
One-fold	1.3	2.0	1.0	4.3
Two-fold	1.5	3.5	1.0	6.0
Three-fold	1.5	3.5	1.0	6.0

Glassremovals (gram per screen):

Two rules:

* Shearmark should be removed after 0.3 mm glassremoval of the surface of the screen.
* Minimal glassremoval during polishing is 11 gram for a 14" CMT screen: the minimal glassremoval of other screens is related to this rule.

Needed glassremovals:

	L*B	Total glassremoval required	Glassremoval polishing required	Glassremoval pre-grinding
14" CMT	7.77	62.9	11.0	51.9
12" FS	5.52	44.7	7.8	36.9
12" MI	6.03	48.8	8.5	40.3
12" MII	6.09	49.4	8.6	40.7
14"	6.88	55.7	9.7	46.0
15"	8.54	69.2	12.1	57.1
17"	11.05	89.5	15.6	73.8
20"	14.59	118.2	20.7	97.5

Estimated glassremovals during pre-grinding.

Data has been collected from other existing production situations. Comparison of these data leaded to the following glass-removals during pre-grinding (grams/sec):

	One-fold	Two-fold 80%
14" CMT	5.40	4.32
12"	4.00	3.20
14"	5.00	4.00
15"	6.00	4.80
17"	8.00	6.40
20"	10.00	8.00

Estimated glassremovals during polishing

Estimated is that the glassremoval per second is the same for all screens. This means that for little screens the polishing time is shorter and for bigger screens the polishing time is longer.

Adaptions in the pressure of the lifting cylinder will change the glassremoval per second. But limitations exists on changing of the pressure. If the pressure is to high, the screen will be damaged: the edges of the surface of the screen will get some "grey scratch".

Calculations have been carried out for two- and three-fold polishing. Two different assumptions has been made:
- glassremoval three-fold per module is the same as glasremoval two-fold: three-fold glassremoval per screen is two third of two-fold glassremoval;
- glassremoval three-fold per screen is the same as glassremoval two-fold per screen (herefore has the pressure of the lifting cylinder to be increased and this increase is limited).

Total glassremovals used in the calculations for polishing on the modular line are (calculations are based on 14" CMT, so the glassremovals are given for the theoretical possibility of making 14" CMT screens of the different glasstypes and in the current used time: 20.6 seconds), when polishing will be done in three steps:
universal glass (colour sceens and mono): 14.0 gram;
407 glass (colour screens) : 17.5 gram (1.25* 423 glass);
328 glass (mono parts) : 18.5 gram (1.32* 423 glass).

The total glassremovals over all modules in use when 2, 4 or 5 modules has been estimated. The best case and the worst case are explained, the middle value is the average of the best and the worst. The ratio's between the glasstypes of 3 modules polishing (1.23 and 1.32 times 423 glass) are used to determine te glassremovals of 407 and 328 glass.

Total glassremoval when 2 modules are in use for polishing:
* Worst case: 5.7 and 2.0 gram in 20.6 seconds.
* Best case: 7.0 and 2.0 gram in 20.6 seconds.

	Best		Worst
423 glass	9.1	8.4	7.8
407 glass	11.4	10.5	9.7
328 glass	12.1	11.1	10.3

Total glassremoval when 4 modules are in use for polishing:
* Worst case: one extra module in use for soft polishing (current third step), increase for 423 glass only 2 gram: from 14.0 to 16.0 gram glassremoval in 20.6 seconds.
* Best case: 10 + 6.5 + 3 + 1.5 = 21 gram in 20.6 seconds.

	Best		Worst
423 glass	21.0	18.5	16.0
407 glass	26.3	23.1	20.0
328 glass	27.8	24.4	21.1

Total glassremoval when 5 modules are in use for polishing:
* Worst case: one extra module in use for polishing (current second step) and one extra module in use for soft-polishing: glassremovals of modules: 8 + 4 + 4 + 2 + 2 = 20 gram in 20.6 seconds.
* Best case: glassremovals on the 5 modules: 11 + 8 + 5 + 2.5 + 1.5 = 28 gram in 20.6 seconds.

	Best		Worst
423 glass	28.0	24.0	20.0
407 glass	35.0	30.0	25.0
328 glass	37.0	31.7	26.4

Linespeed for 51 FS SC and 20".

The size of these screens requires one-fold processing during pre-grinding and during polishing. The surface of a 20" screens is only a little less then the surface of a 51 FS screen. Before the new modular line was installed it was calculated that the linespeed of the modular line for 51 FS SC was 180 pcs/hour (with the normal colour screens glass). The bottle-neck is polishing by 180 pcs./hour and the maximum capacity of the needed one-fold pre-grinding is 220.
The process time is 14 seconds and the total cycle-time is 20 seconds. These figures give a linespeed for universal glass of:

* Process time = $\frac{17.5 \text{ gram}}{14.0 \text{ gram}}$ * 14.0 seconds = 17.5 seconds;

* Cycle-time: 17.5 + 6.0 = 23.5 seconds.

* Linespeed: 3600/23.5 = 153 pcs/hour.

For 2 modules polishing:

- 407 glass:

Extension proces time	News proces time	Cycle time	Linespeed
1.53 *	21.42	27.42	131
1.67 *	23.38	29.38	122
1.80 *	25.20	31.20	115

- 423 glass:

Extension proces time	News proces time	Cycle time	Linespeed
1.53 *	26.78	32.78	110
1.67 *	29.23	35.23	102
1.80 *	31.50	37.50	96

When the modular line will extended to 4 or 5 modules polishing, the bottle-neck will be pre-grinding at a linespeed of 220.

A summerize of the estimated linespeeds is:

- 423 glass:

	2 modules	3 modules	4 modules	5 modules
Best	110		220	220
	102	153	187	200
Worse	96		153	180

- 407 glass:

	2 modules	3 modules	4 modules	5 modules
Best	131		220	220
	122	180	200	220
Worse	105		180	220

2. Tables

Explanation of the tables.

- The required glassremovals are mentioned in the left colums.
- The needed cycle-time (per screen) is calculated based on the total glassremoval required and the glassremovals possible. Also the idle times in the cycle-time have been taken into account.
- The cycle-times of pre-grinding and polishing are mentioned: multiplying of the cycle-time per screen and the number of screens on a carrier.
- After this the realized glassremovals are given. Because the calculation of the needed cycle-time is based on the total glassremoval required, is it possible that the glassremoval during polishing is too low to repair the outside roughness caused by pre-grinding.
- The two most right colums give the possible linespeed per hour. In the column 'capacity per hour' the linespeed is calculated based on the needed cycle-time. In the last column the maximum linespeed is calculated based on the minimal glassremoval required during polishing. Per row is the lowest value in this two columns the maximum linespeed on the modular line for the given screen type.

Tables are only given for 3 modules polishing in 423 glass. The same calculations have been made for 2, 4 and 5 modules polishing, based on the before mentioned glass removals. Also the results for 407 glass (for colour screens) and 328 glass (for mono screens) are available. All the outcomes are written down in appendix 5, which contains all linespeeds and the maximum capacities of a modular line for a certain screen type.

14" CMT	51.9	1	11.0	2	62.9	12.4	12.4	24.8	43.6	19.2	62.9	290.2	428.8
12" FS	36.9	1	7.8	2	44.7	11.3	11.3	22.5	27.9	16.9	44.7	319.5	526.9
12" MI	40.3	1	8.5	2	48.8	11.9	11.9	23.9	30.6	18.2	48.8	301.4	501.2
12" MII	40.7	1	8.6	2	49.4	12.0	12.0	24.1	30.9	18.4	49.4	299.2	497.9
14"	46.0	1	9.7	2	55.7	11.8	11.8	23.7	37.7	18.0	55.7	304.0	462.9
15" FS	57.1	1	12.1	2	69.2	12.6	12.6	25.2	49.7	19.5	69.2	286.2	403.1
17"	73.8	1	15.6	2	89.5	12.9	12.9	25.9	69.2	20.3	89.5	278.0	337.4
20"	97.5	1	20.7	2	118.2	13.9	13.9	27.8	96.0	22.2	118.2	259.1	274.2

14" CMT	51.9	1	11.0	2	62.9	12.7	12.7	25.4	45.5	17.5	62.9	283.0	394.5
12" FS	36.9	1	7.8	2	44.7	11.6	11.6	23.2	29.2	15.5	44.7	310.0	489.7
12" MI	40.3	1	8.5	2	48.8	12.3	12.3	24.6	32.1	16.7	48.8	292.3	464.6
12" MII	40.7	1	8.6	2	49.4	12.4	12.4	24.8	32.4	16.9	49.4	290.1	461.5
14"	46.0	1	9.7	2	55.7	12.2	12.2	24.3	39.3	16.5	55.7	296.1	427.4
15" FS	57.1	1	12.1	2	69.2	12.9	12.9	25.8	51.5	17.7	69.2	279.6	369.9
17"	73.8	1	15.6	2	89.5	13.2	13.2	26.4	71.2	18.3	89.5	272.8	307.6
20"	97.5	1	20.7	2	118.2	14.1	14.1	28.2	98.2	20.0	118.2	254.9	248.3

14" CMT	51.9	1	11.0	2	62.9	13.1	13.1	26.1	47.3	15.6	62.9	275.6	357.1
12" FS	36.9	1	7.8	2	44.7	12.0	12.0	24.0	30.8	14.0	44.7	300.3	448.3
12" MI	40.3	1	8.5	2	48.8	12.7	12.7	25.4	33.7	15.1	48.8	282.9	424.0
12" MII	40.7	1	8.6	2	49.4	12.8	12.8	25.6	34.1	15.3	49.4	280.7	421.0
14"	46.0	1	9.7	2	55.7	12.5	12.5	25.0	41.0	14.8	55.7	288.0	388.3
15" FS	57.1	1	12.1	2	69.2	13.2	13.2	26.4	53.4	15.8	69.2	272.9	333.8
17"	73.8	1	15.6	2	89.5	13.5	13.5	26.9	73.2	16.2	89.5	267.6	275.5
20"	97.5	1	20.7	2	118.2	14.4	14.4	28.7	100.5	17.6	118.2	250.8	220.9

APPENDIX 6: CAPACITIES MODULAR LINE.

On the following pages are given the linespeeds calculated as described in appendix 5. Figures are concerning 2 modules polishing, 3 modules polishing, 4 modules polishing and 5 modules polishing. At the end of the appendix a few graphs are added.

Linespeeds for universal glass; 2 modules polishing.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		233	233	233	249	350	249	350
			218	218	218	232	328	232	328
			205	205	205	218	308	218	308
	51 FS	110							
		102							
		96							
Mono	12"		272	304	304	332	418	332	456
			269	286	286	311	414	311	429
			267	270	270	292	410	292	405
	14"		257	257	257	276	385	276	385
			241	241	241	258	361	258	361
			227	227	227	242	340	242	340
	15"		216	216	216				
			202	202	202				
			190	190	190				
	17"		174	174	174				
			162	162	162				
			152	152	152				
	20"	110							
		102							
		96							

Maximum capacity per modular line: universal glass; 2 modules.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		1.589	1.589	1.589	1.698	2.387	1.698	2.387
			1.487	1.487	1.487	1.582	2.237	1.582	2.237
			1.398	1.398	1.398	1.487	2.101	1.487	2.101
	51 FS	0.750							
		0.696							
		0.655							
Mono	12"		1.855	2.073	2.073	2.264	2.851	2.264	3.110
			1.835	1.950	1.950	2.121	2.823	2.121	2.926
			1.821	1.841	1.841	1.991	2.796	1.991	2.762
	14"		1.753	1.753	1.753	1.882	2.626	1.882	2.626
			1.644	1.644	1.644	1.760	2.462	1.760	2.462
			1.548	1.548	1.548	1.650	2.319	1.650	2.319
	15"		1.473	1.473	1.473				
			1.378	1.378	1.378				
			1.296	1.296	1.296				
	17"		1.187	1.187	1.187				
			1.105	1.105	1.105				
			1.037	1.037	1.037				
	20"	0.750							
		0.696							
		0.655							

Linespeeds for 328 or 407 glass; 2 modules polishing.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		262 259 245	278 261 245	278 261 245	302 282 263	402 392 368	302 282 263	417 392 368
	51 FS	131 122 115							
Mono	12"		285 281 277	373 351 333	373 351 333	411 389 367	436 430 425	416 389 367	537 526 499
	14"		275 272 269	319 299 283	319 299 283	350 326 307	422 417 413	350 326 307	478 449 424
	15"		262 253 239	271 253 239	271 253 239				
	17"		221 206 193	221 206 193	221 206 193				
	20"	131 122 115							

Maximum capacity per modular line: 328 and 407 glass; 2 modules.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		1.787	1.896	1.896	2.060	2.742	2.060	2.844
			1.766	1.780	1.780	1.923	2.673	1.923	2.673
			1.671	1.671	1.671	1.794	2.510	1.794	2.510
	51 FS	0.893							
		0.832							
		0.784							
Mono	12"		1.944	2.544	2.544	2.803	2.973	2.837	3.662
			1.916	2.394	2.394	2.653	2.933	2.653	3.587
			1.889	2.271	2.271	2.503	2.898	2.503	3.403
	14"		1.875	2.176	2.176	2.387	2.878	2.387	3.260
			1.855	2.039	2.039	2.223	2.844	2.223	3.062
			1.835	1.930	1.930	2.094	2.817	2.094	2.892
	15"		1.787	1.848	1.848				
			1.725	1.725	1.725				
			1.630	1.630	1.630				
	17"		1.507	1.507	1.507				
			1.405	1.405	1.405				
			1.316	1.316	1.316				
	20"	0.893							
		0.832							
		0.784							

Linespeeds for universal glass; 3 modules polishing.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		270	325	325	357	414	357	487
	51 FS	153							
Mono	12"		275	390	390	395	420	435	515
	14"		282	354	354	393	431	393	531
	15"		267	303	303				
	17"		248	248	248				
	20"	153							

Maximum capacity per modular line: universal glass; 3 modules

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		1.841	2.216	2.216	2.435	2.823	2.435	3.321
	51 FS	1.043							
Mono	12"		1.875	2.660	2.660	2.694	2.864	2.967	3.512
	14"		1.923	2.414	2.414	2.680	2.939	2.680	3.621
	15"		1.821	2.066	2.066				
	17"		1.691	1.691	1.691				
	20"	1.043							

Linespeeds for 328 or 407 glass; 3 modules polishing.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		280	380	380	403	429	425	527
	51 FS	180							
Mono	12"		290	400	465	410	445	505	540
	14"		296	414	427	423	452	485	533
	15"		280	370	370				
	17"		273	308	308				
	20"	180							

Maximum capacity per modular line: 328 and 407 glass; 3 modules.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		1.910	2.592	2.592	2.748	2.926	2.898	3.594
	51 FS	1.228							
Mono	12"		1.978	2.728	3.171	2.796	3.035	3.444	3.683
	14"		2.019	2.823	2.912	2.885	3.083	3.308	3.635
	15"		1.910	2.523	2.523				
	17"		1.862	2.101	2.101				
	20"	1.228							

Linespeeds for universal glass; 4 modules polishing.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		290	405	429	414	443	487	541
			283	395	395	406	433	443	531
			276	357	495	396	422	396	520
	51 FS	220							
		187							
		153							
Mono	12"		301	410	501	421	459	516	552
			292	402	465	412	446	507	539
			283	394	450	403	433	481	526
	14"		304	421	463	431	464	531	564
			296	414	427	423	452	485	553
			288	388	403	415	441	435	542
	15"		286	403	403				
			280	370	370				
			273	334	334				
	17"		278	337	337				
			273	308	308				
			267	276	286				
	20"	220							
		187							
		153							

Maximum capacity per modular line: universal glass; 4 modules.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		1.978	2.762	2.926	2.823	3.021	3.321	3.690
			1.930	2.694	2.694	2.769	2.953	3.021	3.621
			1.882	2.435	3.376	2.701	2.878	2.701	3.546
	51 FS	1.500							
		1.275							
		1.043							
Mono	12"		2.053	2.796	3.417	2.871	3.130	3.519	3.765
			1.991	2.742	3.171	2.810	3.042	3.458	3.676
			1.930	2.687	3.069	2.748	2.953	3.280	3.587
	14"		2.073	2.871	3.158	2.939	3.164	3.621	3.846
			2.019	2.823	2.912	2.885	3.083	3.308	3.771
			1.964	2.646	2.748	2.830	3.008	2.967	3.696
	15"		1.950	2.748	2.748				
			1.910	2.523	2.523				
			1.862	2.278	2.278				
	17"		1.896	2.298	2.298				
			1.862	2.101	2.101				
			1.821	1.882	1.950				
	20"	1.500							
		1.275							
		1.043							

Linespeeds for 328 or 407 glass; 4 modules polishing.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		305	418	493	429	465	527	561
			296	410	455	420	452	518	549
			287	402	416	411	439	470	537
	51 FS	220							
		200							
		180							
Mono	12"		325	430	520	446	494	539	585
			314	420	511	434	477	528	569
			302	410	501	422	460	516	553
	14"		325	439	536	452	494	553	593
			315	430	506	442	479	543	578
			304	421	464	432	464	533	564
	15"		304	417	481				
			295	410	444				
			287	403	404				
	17"		292	409	409				
			285	375	375				
			278	339	339				
	20"	220							
		200							
		180							

Maximum capacity per modular line: 328 and 407 glass; 4 modules.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		2.080	2.851	3.362	2.926	3.171	3.594	3.826
			2.019	2.796	3.103	2.864	3.083	3.533	3.744
			1.957	2.742	2.837	2.803	2.994	3.205	3.662
	51 FS	1.500							
		1.364							
		1.228							
Mono	12"		2.216	2.933	3.546	3.042	3.369	3.676	3.990
			2.141	2.864	3.485	2.960	3.253	3.601	3.880
			2.060	2.796	3.417	2.878	3.137	3.519	3.771
	14"		2.216	2.994	3.655	3.083	3.369	3.771	4.044
			2.148	2.933	3.451	3.014	3.267	3.703	3.942
			2.073	2.871	3.164	2.946	3.164	3.635	3.846
	15"		2.073	2.844	3.280				
			2.012	2.796	3.028				
			1.957	2.748	2.755				
	17"		1.991	2.789	2.789				
			1.944	2.557	2.557				
			1.896	2.312	2.312				
	20"	1.500							
		1.364							
		1.228							

Linespeeds for universal glass; 5 modules polishing.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		310	421	511	434	472	531	568
			299	412	466	422	456	520	552
			287	402	416	411	439	470	537
	51 FS	220							
		200							
		180							
Mono	12"		326	431	520	447	495	540	586
			312	419	510	433	475	526	567
			298	407	487	418	454	512	547
	14"		325	439	536	453	495	554	593
			313	439	501	441	477	542	577
			301	418	449	428	459	513	560
	15"		304	418	483				
			294	409	370				
			284	390	390				
	17"		292	411	411				
			284	371	371				
			276	326	326				
	20"	220							
		200							
		180							

Maximum capacity per modular line: universal glass; 5 modules.
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		2.114	2.871	3.485	2.960	3.219	3.621	3.874
			2.039	2.810	3.178	2.878	3.110	3.546	3.765
			1.957	2.742	2.837	2.803	2.994	3.205	3.662
	51 FS	1.500							
		1.364							
		1.228							
Mono	12"		2.223	2.939	3.546	3.048	3.376	3.683	3.996
			2.128	2.858	3.478	2.953	3.239	3.587	3.867
			2.032	2.776	3.321	2.851	3.096	3.492	3.730
	14"		2.216	2.994	3.655	3.089	3.376	3.778	4.044
			2.135	2.994	3.417	3.008	3.253	3.696	3.935
			2.053	2.851	3.062	2.919	3.130	3.499	3.819
	15"		2.073	2.851	3.294				
			2.005	2.789	2.523				
			1.937	2.660	2.660				
	17"		1.991	2.803	2.803				
			1.937	2.530	2.530				
			1.882	2.223	2.223				
	20"	1.500							
		1.364							
		1.228							

Linespeeds for 328 or 407 glass; 5 modules polishing.

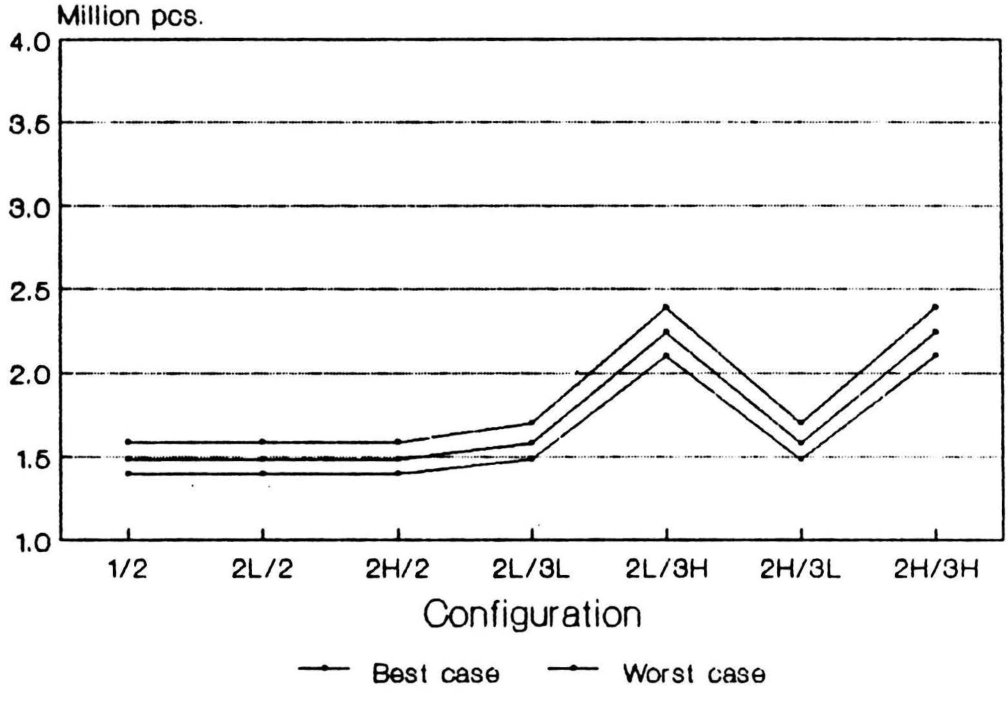
Three speeds are mentioned: the upper is the best case
and the lowest is the worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		329	438	530	453	499	550	594
			315	426	520	439	480	537	575
			302	414	478	425	460	523	556
	51 FS	220							
		220							
		220							
Mono	12"		356	457	544	478	539	570	628
			339	442	530	460	514	553	604
			321	426	516	441	487	535	579
	14"		351	461	556	480	532	580	629
			336	448	544	464	511	565	609
			321	435	529	448	488	549	587
	15"		327	437	531				
			314	426	520				
			300	414	467				
	17"		310	426	490				
			300	417	446				
			289	408	396				
	20"	220							
		220							
		220							

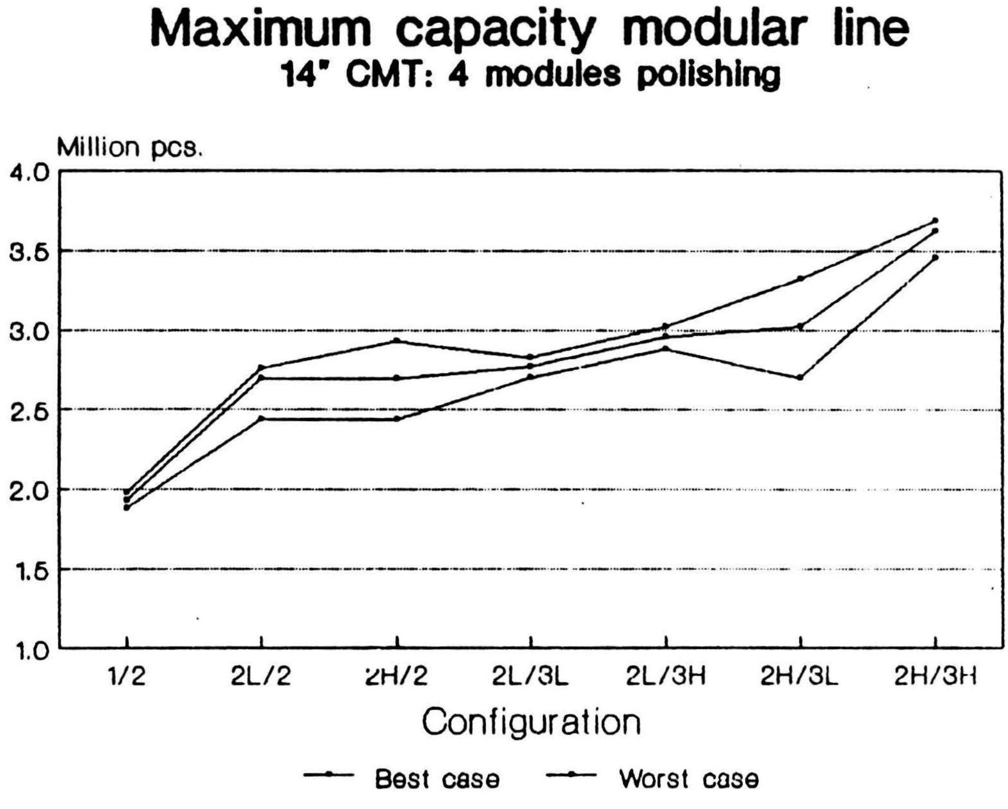
Maximum capacity per modular line: 328 and 407 glass; 5 modules.
Three speeds are mentioned: the upper is the best case and the lowest is tts worse case. And in the middle .... indeed.

		1/1	1/2	2L/2	2H/2	2L/3L	2L/3H	2H/3L	2H/3H
Colour	14"/36FS		2.244	2.987	3.614	3.089	3.403	3.751	4.051
			2.148	2.905	3.546	2.994	3.274	3.662	3.921
			2.060	2.823	3.260	2.898	3.137	3.567	3.792
	51 FS	1.500							
		1.500							
		1.500							
Mono	12"		2.428	3.117	3.710	3.260	3.676	3.887	4.283
			2.312	3.014	3.614	3.137	3.505	3.771	4.119
			2.189	2.905	3.519	3.008	3.321	3.649	3.949
	14"		2.394	3.144	3.792	3.274	3.628	3.955	4.290
			2.291	3.055	3.710	3.164	3.485	3.853	4.153
			2.189	2.967	3.608	3.055	3.328	3.744	4.003
	15"		2.230	2.980	3.621				
			2.141	2.905	3.546				
			2.046	2.823	3.185				
	17"		2.114	2.905	3.342				
			2.046	2.844	3.042				
			1.971	2.782	2.701				
	20"	1.500							
		1.500							
		1.500							

Maximum capacity modular line
14" CMT: 2 modules polishing

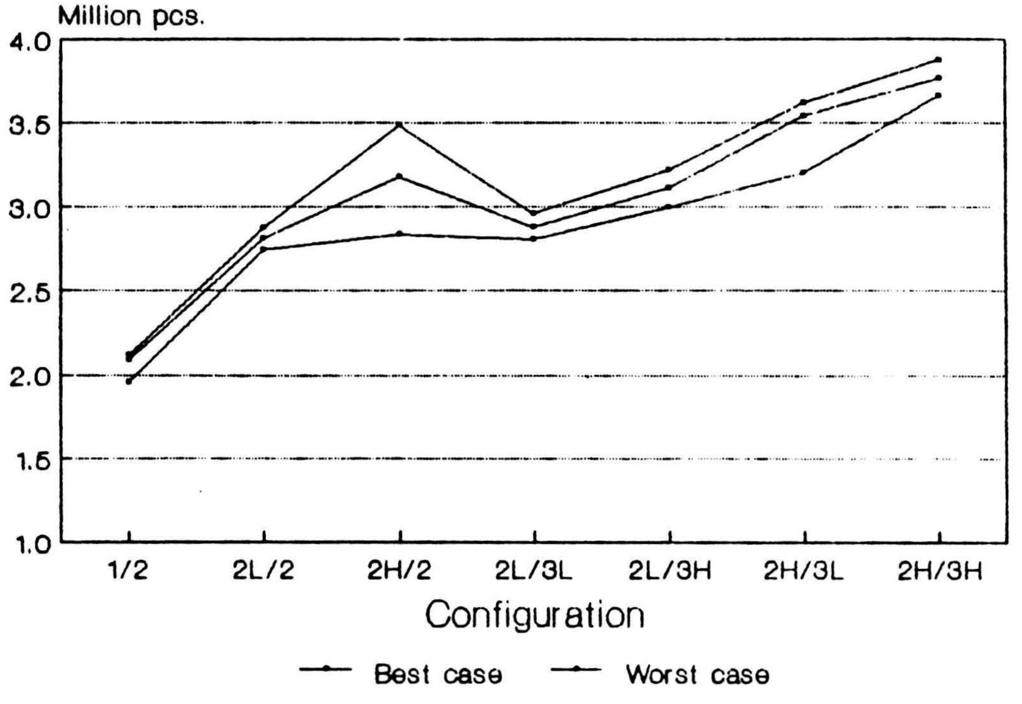


- 1/2 : 1-fold pre-grinding
  2-fold polishing
- 2L/2 : 2-fold pre-grinding (80%)
  2-fold -polishing
- 2H/2 : 2-fold pre-grinding (100%)
  2-fold polishing
- 2L/3L : 2-fold pre-grinding (80%)
  3-fold polishing (67%)
- 2L/3H : 2-fold pre-grinding (80%)
  3-fold polishing (100%)
- 2H/3L : 2-fold pre-grinding (100%)
  3-fold polishing (67%)
- 2H/3H : 2-fold pre-grinding (100%)
  3-fold polishing (100%)



- 1/2 : 1-fold pre-grinding
  2-fold polishing
- 2L/2 : 2-fold pre-grinding (80%)
  2-fold -polishing
- 2H/2 : 2-fold pre-grinding (100%)
  2-fold polishing
- 2L/3L : 2-fold pre-grinding (80%)
  3-fold polishing (67%)
- 2L/3H : 2-fold pre-grinding (80%)
  3-fold polishing (100%)
- 2H/3L : 2-fold pre-grinding (100%)
  3-fold polishing (67%)
- 2H/3H : 2-fold pre-grinding (100%)
  3-fold polishing (100%)

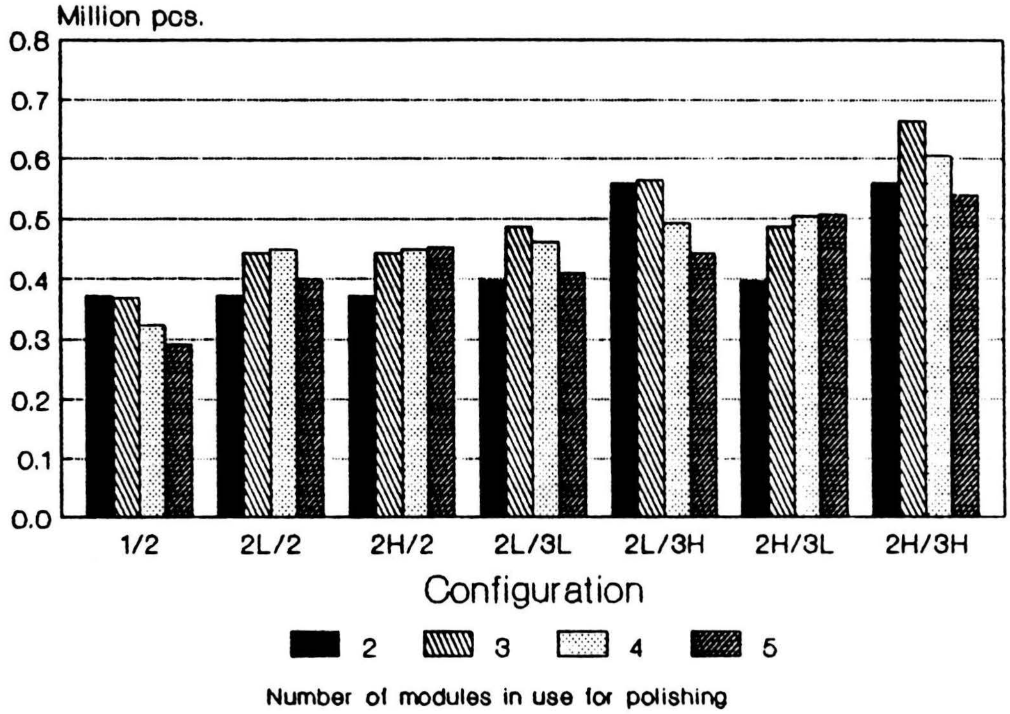
Maximum capacity modular line
14" CMT: 5 modules polishing



- 1/2 : 1-fold pre-grinding
  2-fold polishing
- 2L/2 : 2-fold pre-grinding (80%)
  2-fold -polishing
- 2H/2 : 2-fold pre-grinding (100%)
  2-fold polishing
- 2L/3L : 2-fold pre-grinding (80%)
  3-fold polishing (67%)
- 2L/3H : 2-fold pre-grinding (80%)
  3-fold polishing (100%)
- 2H/3L : 2-fold pre-grinding (100%)
  3-fold polishing (67%)
- 2H/3H : 2-fold pre-grinding (100%)
  3-fold polishing (100%)

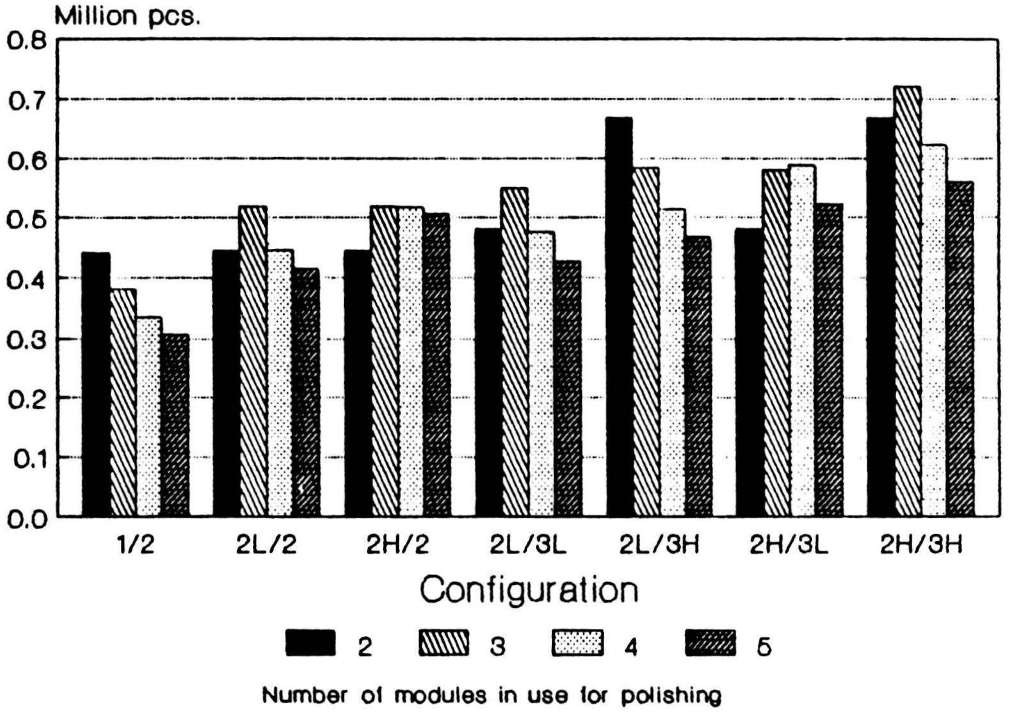
Output per module: 14" CMT

423 glass: 2/3/4/5 modules polishing



- 1/2 : 1-fold pre-grinding
  2-fold polishing
- 2L/2 : 2-fold pre-grinding (80%)
  2-fold -polishing
- 2H/2 : 2-fold pre-grinding (100%)
  2-fold polishing
- 2L/3L : 2-fold pre-grinding (80%)
  3-fold polishing (67%)
- 2L/3H : 2-fold pre-grinding (80%)
  3-fold polishing (100%)
- 2H/3L : 2-fold pre-grinding (100%)
  3-fold polishing (67%)
- 2H/3H : 2-fold pre-grinding (100%)
  3-fold polishing (100%)

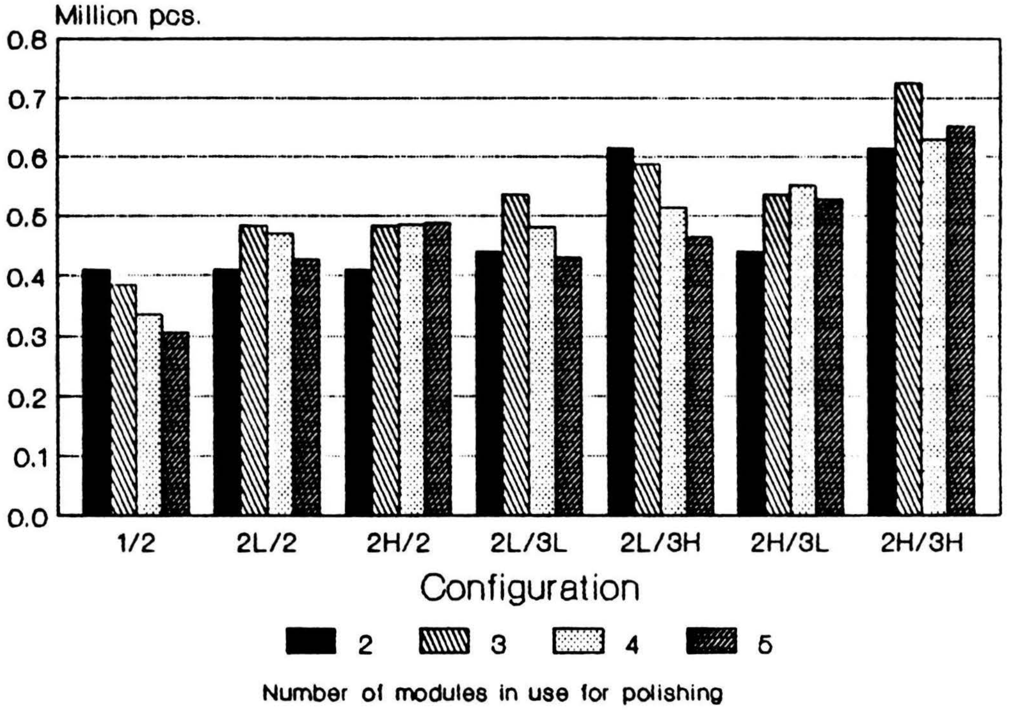
Output per module: 14" CMT
407 glass: 2/3/4/5 modules polishing



- 1/2 : 1-fold pre-grinding
  2-fold polishing
- 2L/2 : 2-fold pre-grinding (80%)
  2-fold -polishing
- 2H/2 : 2-fold pre-grinding (100%)
  2-fold polishing
- 2L/3L : 2-fold pre-grinding (80%)
  3-fold polishing (67%)
- 2L/3H : 2-fold pre-grinding (80%)
  3-fold polishing (100%)
- 2H/3L : 2-fold pre-grinding (100%)
  3-fold polishing (67%)
- 2H/3H : 2-fold pre-grinding (100%)
  3-fold polishing (100%)

Output per module: 14"F mono

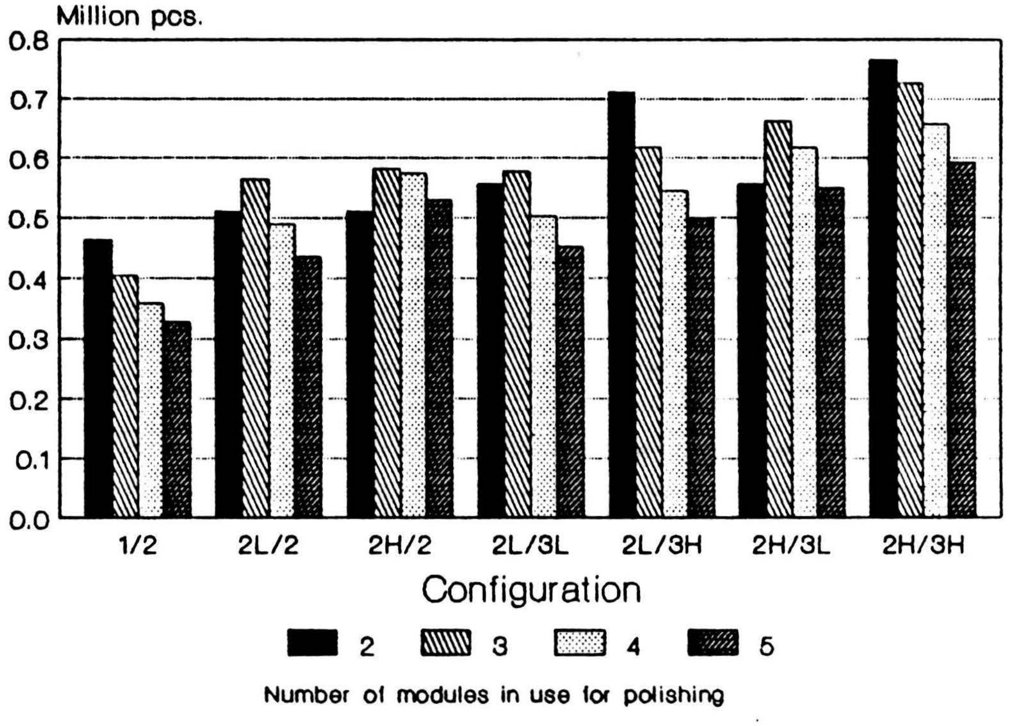
423 glass: 2/3/4/5 modules polishing



- 1/2 : 1-fold pre-grinding
  2-fold polishing
- 2L/2 : 2-fold pre-grinding (80%)
  2-fold -polishing
- 2H/2 : 2-fold pre-grinding (100%)
  2-fold polishing
- 2L/3L : 2-fold pre-grinding (80%)
  3-fold polishing (67%)
- 2L/3H : 2-fold pre-grinding (80%)
  3-fold polishing (100%)
- 2H/3L : 2-fold pre-grinding (100%)
  3-fold polishing (67%)
- 2H/3H : 2-fold pre-grinding (100%)
  · 3-fold polishing (100%)

Output per module: 14"F mono

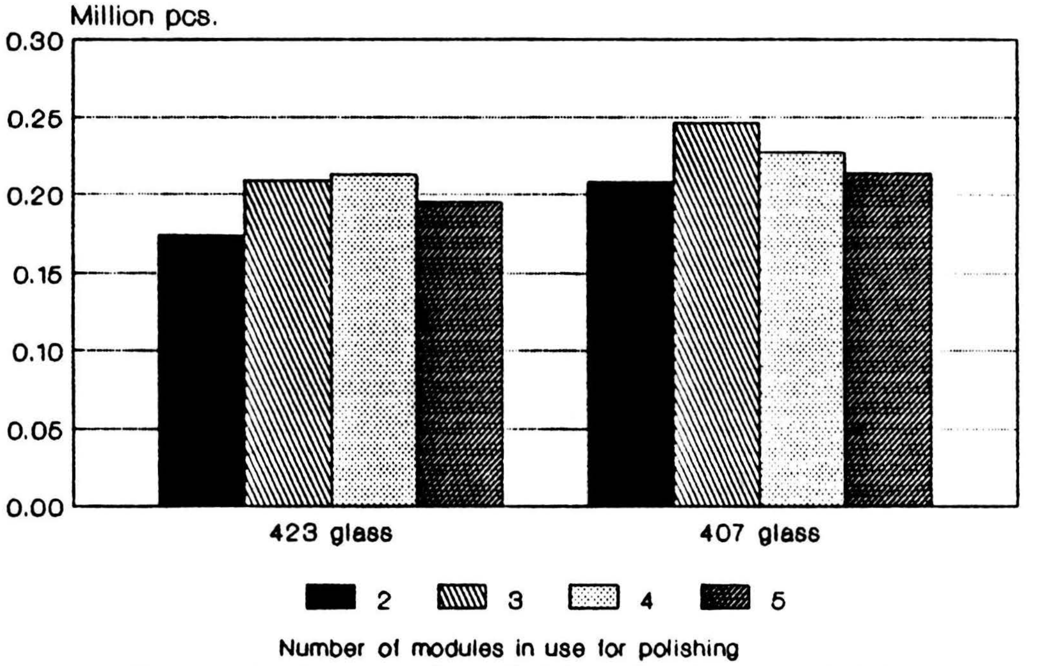
328 glass: 2/3/4/5 modules polishing



- 1/2 : 1-fold pre-grinding
  2-fold polishing
- 2L/2 : 2-fold pre-grinding (80%)
  2-fold -polishing
- 2H/2 : 2-fold pre-grinding (100%)
  2-fold polishing
- 2L/3L : 2-fold pre-grinding (80%)
  3-fold polishing (67%)
- 2L/3H : 2-fold pre-grinding (80%)
  3-fold polishing (100%)
- 2H/3L : 2-fold pre-grinding (100%)
  3-fold polishing (67%)
- 2H/3H : 2-fold pre-grinding (100%)
  3-fold polishing (100%)

Output per module: 51 FS

2/3/4/5 modules polishing



Pre-grinding and polishing both one-fold

APPENDIX 7: MASTER LAY-OUT OF THE TOTAL S-BUILDING.

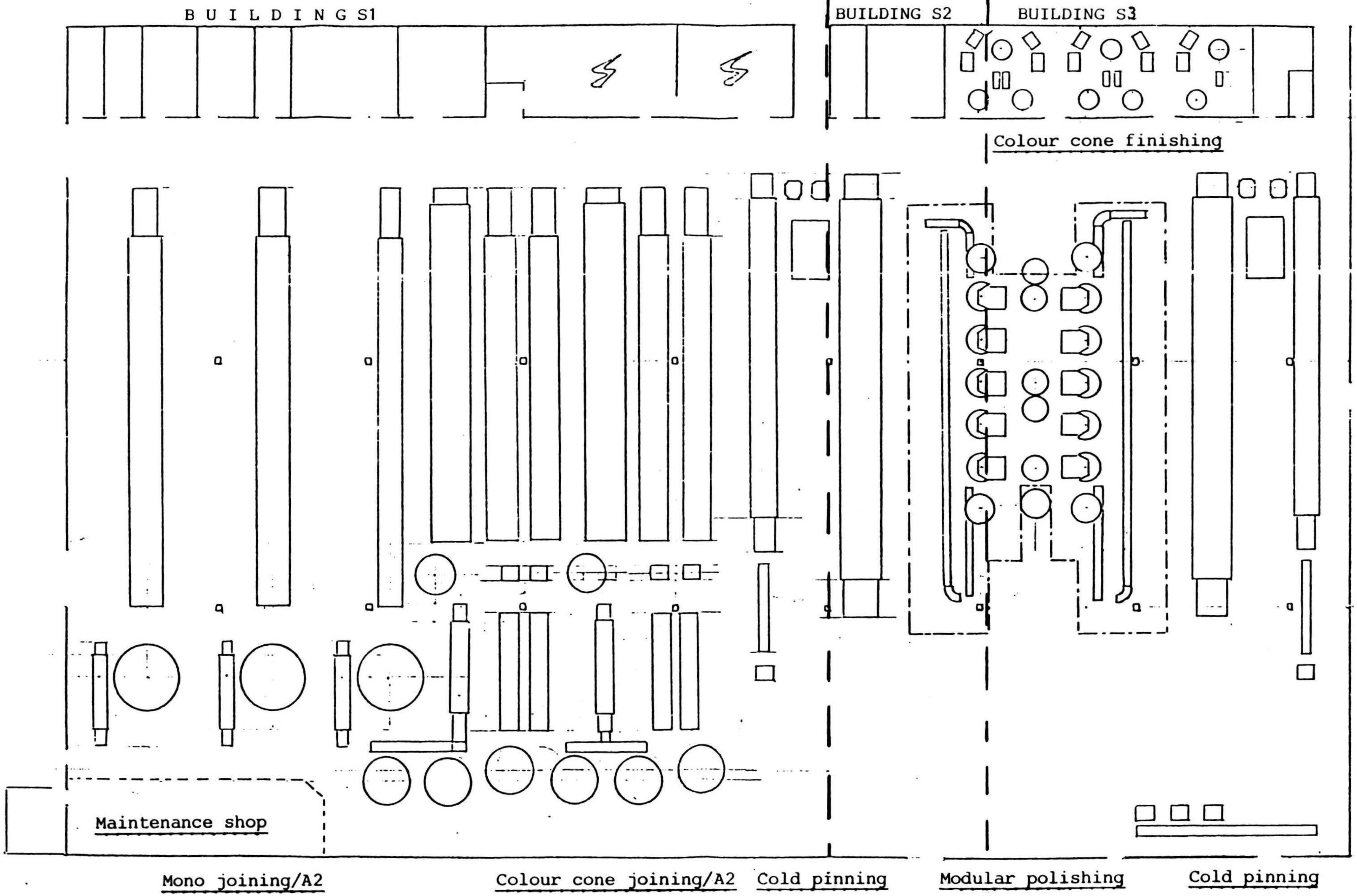
On the next page a lay-out is given of the total S-building in such a way that all necessary processes can be executed in the existing areas.

Space for an extension of the pinning and polishing capacity is created by:

- Regrouping of colour cone neck-cone and A2 insertion.
- Move the mono neck-cone joining machines in the direction of the A2 insertion machine. The only reason why they are still located in their current positions is history.
- The created space in the S1 building can be used as a maintenance shop, which is now located in building S3.
- The existing maintenance shop from the S3 building can be used to house the colour cone finishing equipment.

When it is possible to extend the current pinning capacity, a second cold pinning line is not necessary. In this case the colour cone finishing equipment doesn't have to move to the maintenance shop in the S3 building, but can remain in building S2, where a little regrouping is necessary when a second polishing line will be placed.

The two polishing "streets" (where even four Sealing Edge Finishing Units are placed in the drawing) can house up to 9 modules when the SEFU's are idle (this is so when screens can be made "as pressed"). The space in between the two polishing lines houses the three slurry sytems. When eventually the number of modules in one line will be extended, the extensions of the slurry systems can be placed also in between the two polishing "streets".


BUILDING S1
BUILDING S2
BUILDING S3
Colour cone finishing
Maintenance shop
Mono joining/A2
Colour cone joining/A2
Cold pinning
Modular polishing
Cold pinning

APPENDIX 8: OCCUPATION OF ALTERNATIVE POLISHING CAPACITIES FOR ALTERNATIVE SCENARIO's.

Calculations are made for universal glass. The used scenario's are (number of screens to polish; million pcs. per year):

	Colour		Mono				
	14"/36 FS	51 FS	12"	14"	15"	17"	20"
F1A	1.89		0.88	2.28	0.22	0.11	0.22
F1B	1.89	0.58	0.88	2.28	0.22	0.11	0.22
F2A	2.52		0.88	2.28	0.22	0.11	0.22
F2B	2.52	0.58	0.88	2.28	0.22	0.11	0.22
F3A	3.36		0.88	2.88	0.22	0.11	0.22
F3B	3.36	0.58	0.88	2.88	0.22	0.11	0.22
N1A	2.4	0.8		1.8	0.3	0.1	0.2
N1B	3.5	1.2		1.8	0.3	0.1	0.2

Scenario's F1A to F3B refer to the press occupation scenario's as seen before, and the scenario's N1A and N1B are referring to scenario N1, which is a big deviation of the six forgoing scenario's. Scenario N2 is not taken into account.

All figures are million pcs. per year to polish.

When in a certain situation (scenario, configuration) the number of screens to polish are placed in a square means that that in this situation the capacity is insufficient to polish all colour screens.

When a overcapacity exists in a certain situation, the overcapacity is given as a part of line(s). For example : [-0.36 lines] means that 0.36 line of the projected capacity is idle. All colour screens and monoscreens can be polished in this situation and still there exists some 36% of one line idle capacity.

Cakculations have been made for four alternative situations:
- 2 * 5 modules;
- 2 * 5 modules and 2 * 3 modules;
- 3 * 5 modules;
- 4 * 4 modules.

Alternative 1: 2 * 5 modules.

	1/2	2/2	2L/3L	2H/3H
F1A	14" : 1.89 mono : 14": 1.83	14" : 1.89 mono : 14": 2.28	14" : 1.89 mono : 14": 2.28	[- 0.16 line]
F1B	14" : 1.89 51FS : 0.58 mono : 14": 0.73	14" : 1.89 51FS : 0.58 mono : 14": 1.35	14" : 1.89 51FS : 0.58 mono : 14":1.72	14" : 1.89 51FS : 0.58 mono : 14": 2.28 12": 0.77
F2A	14" : 2.52 mono : 14": 1.15	14" : 2.52 mono : 14": 2.03	14" : 2.52 mono : 14": 2.28 12": 0.24	14" : 2.52 mono : 14": 2.28 12": 0.88 15": 0.22 17": 0.11 20": 0.18
F2B	14" : 2.52 51FS : 0.58 mono : 14": 0.06	14" : 2.52 51FS : 0.58 mono : 14": 0.65	14" : 2.52 51FS : 0.58 mono : 14": 0.89	14" : 2.52 51FS : 0.58 mono : 14": 2.28 12": 0.11
F3A	14" : 3.36 mono : 14": 0.27	14" : 3.36 mono : 14": 1.09	14" : 3.36 mono : 14": 1.58	14" : 3.36 mono : 14": 2.28 12": 0.88 15": 0.19
F3B	14" : 3.36 51FS : 0.15	14" : 3.36 51FS : 0.47	14" : 3.36 51FS : 0.58 mono : 14": 0.03	14" : 3.36 51FS : 0.58 mono : 14": 1.45
N1A	14" : 2.40 51FS : 0.73	14" : 2.40 51FS : 0.80 mono : 14": 0.29	14" : 2.40 51FS : 0.80 mono : 14": 0.46	14" : 2.40 51FS : 0.80 mono : 14": 1.84
N1B	14" : 3.50 51FS : 0.11	14" : 3.50 51FS : 0.43	14" : 3.50 51FS : 0.58	14" : 3.50 51FS : 1.00

Alternative 2: 2 * 5 + 2 * 3 modules.

	1/2	2/2	2L/3L	2L/3H
F1A	[- 0.67 lines]	[-1.22 lines]	[-1.41 lines]	[-2.16 lines]
F1B	All mono	[-0.38 lines]	[-0.60 lines]	[-1.38 lines]
F2A	[-0.26 lines]	[-0.81 lines]	[-1.31 lines]	[-2.00 lines]
F2B	14" : 2.52 51FS : 0.58 mono : 14": 2.28 12": 0.88 15": 0.22 17": 0.04	14" : 2.52 51FS : 0.58 mono : 14": 2.88 12": 0.88 15": 0.22 17": 0.11 20": 0.22	[-0.14 lines]	[-1.16 lines]
F3A	14" : 3.36 mono : 14": 2.28 12": 0.88 15": 0.22 17": 0.11 20": 0.04	14" : 3.36 mono : 14": 2.88 12": 0.88 15": 0.22 17": 0.11 20": 0.22	[-0.59 lines]	[-1.47 lines]
F3B	14" : 3.36 51FS : 0.58 mono : 14": 2.28	14" : 3.36 51FS : 0.58 mono : 14": 2.28 12": 0.88	14" : 3.36 51FS : 0.58 mono : 14": 2.28 12": 0.88 15": 0.22	[-0.79 lines]
N1A	[-0.21 lines]	[-0.50 lines]	[-0.60 lines]	[-1.40 lines]
N1B	14" : 3.50 51FS : 1.20 mono : 14": 1.15	14" : 3.50 51FS : 1.20 mono : 14": 1.50	14" : 3.50 51FS : 1.20 mono : 14": 1.80 15": 0.18	[-0.36 lines]

* Overcapacity is given in 1 * 3 lines.
* In the calculations has not been taken into account the high-gloss which is required for about 25% of the mono screens. This should be done by the borrow and share opportunity.
* In scenario's F3B and N2 are some colour screens processed on the 3-module line. This is necessay because of the undercapacity when only 2 lines of 5 modules are available (see alternative 1).

Alternative 3: 3 * 5 modules.

	1/2	2/2	2L/3L	2H/3H
F1A	14" : 1.89 mono : 14": 2.28 12": 0.88 15": 0.22 17": 0.11 20": 0.10	[-0.47 lines]	[-0.65 lines]	[- 1.16 line]
F1B	14" : 1.89 51FS : 0.58 mono : 14": 2.28 12": 0.36	14" : 1.89 51FS : 0.58 mono : 14": 2.28 12": 0.88 15": 0.22 17": 0.11 20": 0.10	[-0.08 lines]	[0.59 lines]
F2A	14" : 2.52 mono : 14": 2.28 12": 0.77	[-0.18 lines]	[-0.38 lines]	[-0.97 lines]
F2B	14" : 2.52 51FS : 0.58 mono : 14": 1.98	14" : 2.52 51FS : 0.58 mono : 14": 2.28 12": 0.21	14" : 2.52 51FS : 0.58 mono : 14": 2.28 12": 0.88 15": 0.22 17": 0.11	[-0.40 lines]
F3A	14" : 3.36 mono : 14": 2.19	14" : 3.36 mono : 14": 2.28 12": 0.88 15": 0.22 17": 0.11	[-0.03 lines]	[-0.71 lines]
F3B	14" : 3.36 51FS : 0.58 mono : 14": 1.10	14" : 3.36 51FS : 0.58 mono : 14": 2.12	14" : 3.36 51FS : 0.58 mono : 14": 2.28 12": 0.46	[-0.14 lines]
N1A	14" : 2.40 51FS : 0.80 mono : 14": 1.80	14" : 2.40 51FS : 0.80 mono : 14": 1.80 15": 0.30 17": 0.10 20": 0.20	[-0.17 lines]	[-0.62 lines]
N1B	14" : 3.50 51FS : 1.15	14" : 3.50 51FS : 1.20 mono : 14": 0.52	14" : 3.50 51FS : 1.20 mono : 14": 0.79	14" : 3.50 51FS : 1.20 mono : 14": 1.80 15": 0.30 17": 0.10 20": 0.10

Alternative 4: 4 * 4 modules.

	1/2	2/3H
F1A	[-0.26 lines]	[-1.34 lines]
F1B	14" : 1.89 51FS : 0.58 mono : 14": 2.28 12": 0.88	[-0.49 lines]
F2A	14" : 2.52 mono : 14": 2.28 12": 0.88 15": 0.22 17": 0.11 20": 0.10	[-1.05 lines]
F2B	14" : 2.52 51FS : 0.58 mono : 14": 2.28 12": 0.06	[-0.20 lines]
F3A	14" : 3.36 mono : 14": 2.88 12": 0.56	[-0.67 lines]
F3B	14" : 3.36 51FS : 0.58 mono : 14": 1.38	14" : 3.36 51FS : 0.47 mono : 14": 2.12 12": 0.88 15": 0.22 17": 0.11 20": 0.10
N1A	14" : 2.40 51FS : 0.80 mono : 14": 1.38	[-0.45 lines]
N1B	14" : 3.50 51FS : 1.15	14" : 3.50 51FS : 1.20 mono : 14": 1.80

Comparison 4*4 and 3*5:

- 3*5 can produce a little more when big screens will be polished (51 FS), only small screens gives a little advantage to 4*4.
- 3*5 more improvement opportunities: 2-fold pre-grinding gives no improvement in linespeeds for 4*4 and it does give an improvement of about 25% in the 3*5 case.
- Investment in number of modules can be the same: for both 14 modules in total, but in the 3*5 only one is a share-and-borrow module and in the 4*4 two modules are share-and-borrow ones. And in the 4*4 case one more longitidunal transport is required.^E