The effect of automated production on product design : an introduction from a technological viewpoint

THE EFFECT OF AUTOMATED PRODUCTION ON PRODUCT DESIGN

An introduction from a technological viewpoint.

A.C.H. van der Wolf.

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A.C.H. van der Wolf. University of Technology Eindhoven, Netherlands.

Summary: The automation of the batch production of components will dramatically change the part of the productdesigner. Apart from designing the shape of the product, his job well be extended toward that of technological work planner. In the coming years great effort is necessary in providing the designer a reliable technological databank. The costs of implementation of such an information system in a factory have to be balanced by the rise of productivity.

Prof.Dr.Ir. A.C.H. van der Wolf,
University of Technology
P.O. Box 513,
5600 MB EINDHOVEN.
Netherlands.

1. INTRODUCTION.

When discussing automated production, it seems essential to distinguish production of compontent parts from that of finished products. Although the assembly process is often already engraved in the component design, it plays its part more clearly in the production of finished products, where several component parts are to be brought together. For the technological viewpoint it is - for the time being - sufficient to look at the batch production of component parts.

In designing components - for batch production in a factory - the matter of shape of a product as an expression of its function, is of old an important feature. Until recently the "paper design" was the only problem that had to be solved by the design office.

Today there is growing trend to automate this batch production. From observations of the present production type in factories, KEGG and CARTER [1] give three reasons for this trend:
- the low degree of utilization of the capital investment,
- the extreme complexity of today's batch production, and finally,
- the poor predictability of this type of production among others caused by technological bottlenecks.

Though - as seen from the viewpoint of the investors of capital - the first reason has enough importance to take up automation vigorously, the part of the technologist and of the designer becomes prominent especially in the third point. In the transition to automated batch production, the designer should not only consider the volume of the series, but the manufacturing possiblities should also play an essential part in the design stage. The following quotation of KEGG is appropriate here: "In the automated factory of the future with integrated design department there will no more be place for the many informal systems which are being used now to take care of the interruptions - which are the result of the poor predictability - of today's batch production".

The above mentioned transition to the flexibly automated machining factory of the future is not a phenomenon by itself. BELL [2] describes this transition - when placed in a general social context - in connection with that of the industrial society to the post-industrial society, in which physical exertion of the human being in the production process is exchanged for mental exertion, whereas at the same time production increases. MERCHANT [3] properly observes that problems such as the effect of automated production on employment, require ample discussion. CIRP may consider itself lucky that it is already paying attention to the subject of "Technology Assessment" for a number of years.

In automation of the production of compound products, nearly all previous considerations will apply. However, a new consideration must be added now, namely that manufacturing process called "assembly". BOOTHROYD *et al* [4] conclude that the rapid progress in knowledge and skills, as can be seen for instance in the manufacturing processes "cutting" and "forming" these years, unfortunately is missing in the assembly process. Yet, it will be evident that in the automated manufacturing of finished goods - as already mentioned - the assembly is for the greater part laid down in the design. Methods to judge a design on its merits of manufacturing ease cannot leave this out.

2. TECHNOLOGY AND DESIGN FOR AUTOMATED PRODUCTION.

The designing of a product is a complicated matter, as many influences play a part in it. Selection of possibilities is sometimes taken arbitrarily. Considerations with respect to size, shape and quality of the product as far as its function is concerned, are often restricted by the technological possibilities in a factory. The available machining plant and the technological know-how determine to a large extent the choice of the management.

It is true, in a non-automated batch manufactory, the quantitive control of the technology is important, It is, however, not an essential condition for the production [5], because of the fact that during manufacturing, enough possibilities exist to interfere and direct the process toward the desired specifications by variation of the production parameters. With the transition to automated production this situation alters drastically. The designer must assess his technologies objectively in advance and he must state how certain geometries in his design should be manufactured. Interference during production is ruled out, if, at least for the time being, we assume automation to be installed without adaptive control. The methods which up till now are being used for setting up strictly mechanized mass production systems will - with some adaptions - have to be introduced in the designing of automated batch manufacturing. These adaptions will, in manufacturing products of some complication, especially be connected to the shift of interest in the question: "How large a series can be made with this die?" [6] towards the question: "What are the technological possibilities, for the designer, of a certain type of manufacturing process?".

The various CAD/CAM systems coming into use, are offering possibilities for this. Two examples - one from forming and the other one from the world of cutting - will illustrate this.

The first example concerns a system being used in "N.V. Philips' Gloeilampenfabrieken" at Eindhoven. The flattening process is taken here as a typical example. In Appendix I the various possibilities are summed up that the product designer has at his disposal. The designer, after typing in the required flattening geometry and after interactive dialogue with the computer, can assess the technological possibilities (See Fig. 1). Firstly he must indicate, by a certain code, the work material in question. Through a computer data file, in which all available data on work material is stored, the computer then outputs nominal values for the material parameters of interest, for instance the strain hardening exponent. The user may now correct these values. The same procedure holds for the predeformation of the sheet material and for the coefficient of friction between workpiece and tool. The programme calculates every wanted measure before or after flattening, if the remaining measures are introduced by the designer. At the same time the maximum flattening force is calculated. The programme gives a list of tool materials that can resist the pressure force. Together with its background of material data files, the programme offers the flexibility to quickly look up a number of alternatives in flattening.

In the cutting process there are a multitude of possibilities for the designer to attain the ultimate shape. Most important is it, however, to make the most efficient choice in the sense of minimum costs or of minimum cutting time from the many possibilities there are to realize a definite product shape of required quality. In the classical line of reasoning such an optimum was trifled because in the non-automated machining factory the cutting process itself took but a small part of the total manufacturing time. In an automated batch production however, the machining time will take a relatively more important part of the total machining time. In such a situation the designer must lay down not only the shape of the product, but he must also plan its production scheme. There will be no more time in the machine shop to adjust or correct this scheme, let alone to plan the whole scheme. The funtion of the designer will change to one of designer-work planner who, with the support of a computer and several electronic appliances, will attend to the total geometrical and technological input for the production. Or to quote KALS [7]: "Automation of production will by itself necessarily bring about the automation of work planning".

In a conventional situation it sufficed that the work planner had a global knowledge of the application areas, belonging to the various tool materials. (See Fig. 2). For the modern computer controlled machines more insight is necessary. The choice within a certain area of tool materials may have a profound influence on the costs per product. HIJINK [8] rightly emphasized that the designer who also handles cutting operations, must have a quick insight into the consequences of a certain choice. Fig. 3 shows costs as a function of cutting speed in the situation A and B for tool material P20 as shown in Fig. 2. In this case it concerns the turning of a standard workpiece (diameter = 100 mm, length =

100 mm). The diagrams may be called from the computer data bank for any point of Fig. 2 (A, B, C, etc.). At the Eindhoven University of Technology these are used by the designers/ work planners to obtain a rapid insight in the different cutting options as for costs and cutting time. Moreover, in the diagram, the interrupted line indicates the number of cuts that may be obtained from one cutting edge of the chosen tool with the work material. On this line in the diagram, the point is indicated of the number of cuts per cutting edge for a life time T = 30 min., this being applied in many factories.

Ultimately, the use of these and related techniques will lead to a renovation of the machining plant towards high machining powers and wide ranges of speeds. The most important effect however, will be that the designer fixes his product optimally not only in shape but also in its manufacturing scheme. The designer should intensely occupy himself with technology.

In many instances (see for instance [9]) warnings have been heard against the uncriticized application of systems as described in these examples. Factories that switch over to automated production will have to realize that tomorrow's techniques are not built into the system they buy today. So the first word of "Flexible Automation" will, not in the last place, also refer to the system of automation itself!

3. CONCLUSIONS.

The preceding (argumentation) has only reference to the manufacturing of single components. The process of assembling does not play any part here. Summarizing, the following conclusions can be made:

- Batch production too, will be automated in the next coming years.
- The part of the product designer will, in the production process, be extended toward that of technological work planner.
- The designer-technologist will need objective and structural information regarding all machining options.
- The information in question should be "realible", viz. "up to date" for the machining centre with its adjoining stock-rooms.
- Additions and corrections into the system must be straightforward without a chance of mistakes.
- The designer-technologist should have the aforementioned information at his disposal in a quick and user-friendly way.
- The costs, necessary for the implementation of such an information system should be covered out of the rise of productivity, that the automated batch production will undoubtedly effect.

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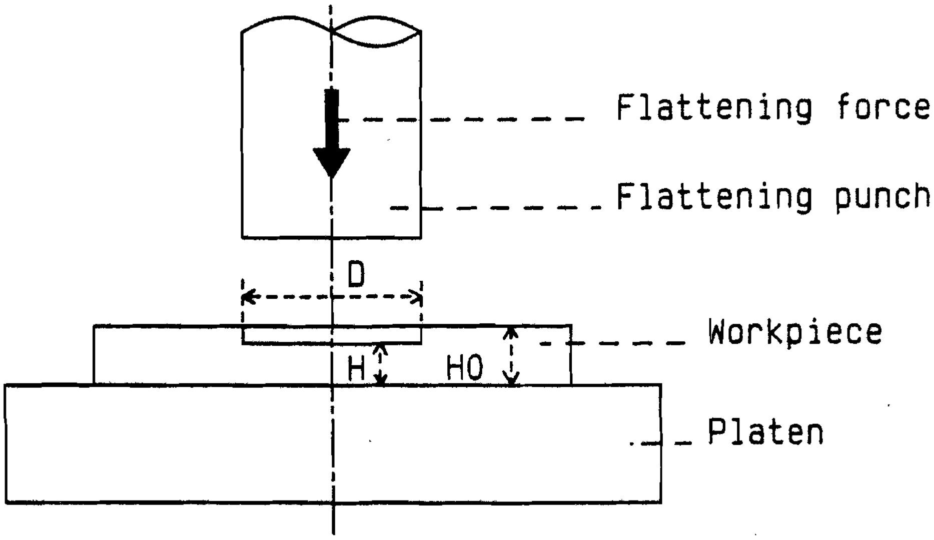


Date	:	1982.03.31
User	:	DE DEUGD
Material code	:	N286
Drawing number	:	8122 031 56831
Name of product	:	Rooster 3
Material thickness [mm]	:	H0 = .25
Height after flattening [mm]	:	H = .1
Diameter after flattening [mm]	:	D = 1.6
Pre-deformation [-]	:	Eps0 = 0
Specific stress [N/mm↑2]	:	C = 1270
Strainhardening exponent [-]	:	N = .39
Coefficient of friction [-]	:	M = .4

<u>Results calculation of round flat in plate</u>

The maximum flattening force	:	6932	N
The maximum stress on the tool	:	6471	N/mm↑2

The normal stress on the tool is <u>too high</u>

Fig. 1. Flattening in sheet plate.

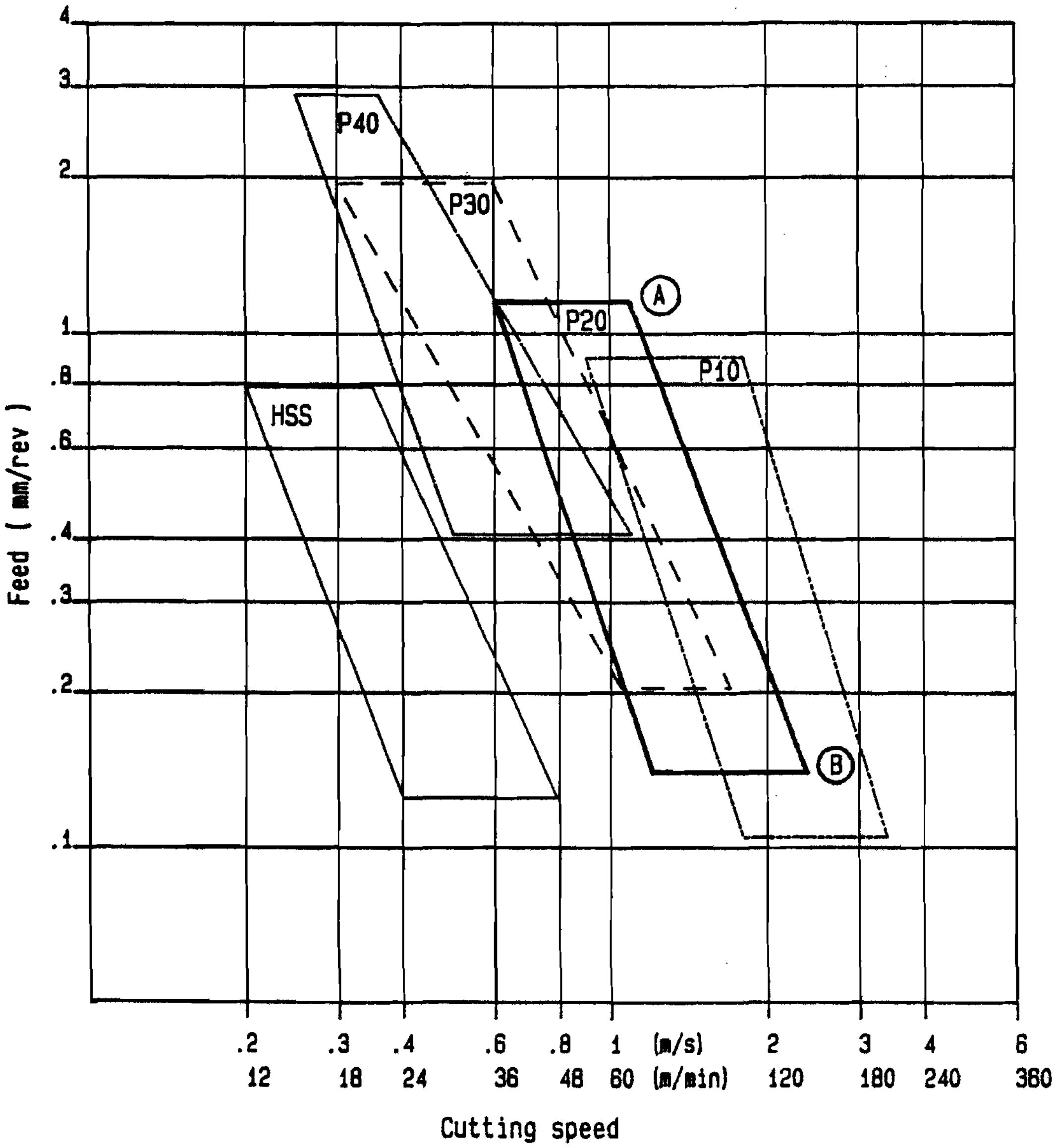


Fig. 2. Application areas of tool materials in cutting.

man-mach.hr. costs 50 hfl
costs/edge 2.5 hfl
idle time 0.5 min
changetime/edge 1.0 min

C' (Taylor) 200.0 m/min
y (Taylor) 0.33
feed 1.10 mm/rev
workpiece diameter 100 mm
length of the cut 100 mm

man-mach.hr. costs 50 hfl
costs/edge 2.5 hfl
idle time 0.5 min
changetime/edge 1.0 min

C' (Taylor) 461.0 m/min
y (Taylor) 0.33
feed 0.15 mm/rev
workpiece diameter 100 mm
length of the cut 100 mm

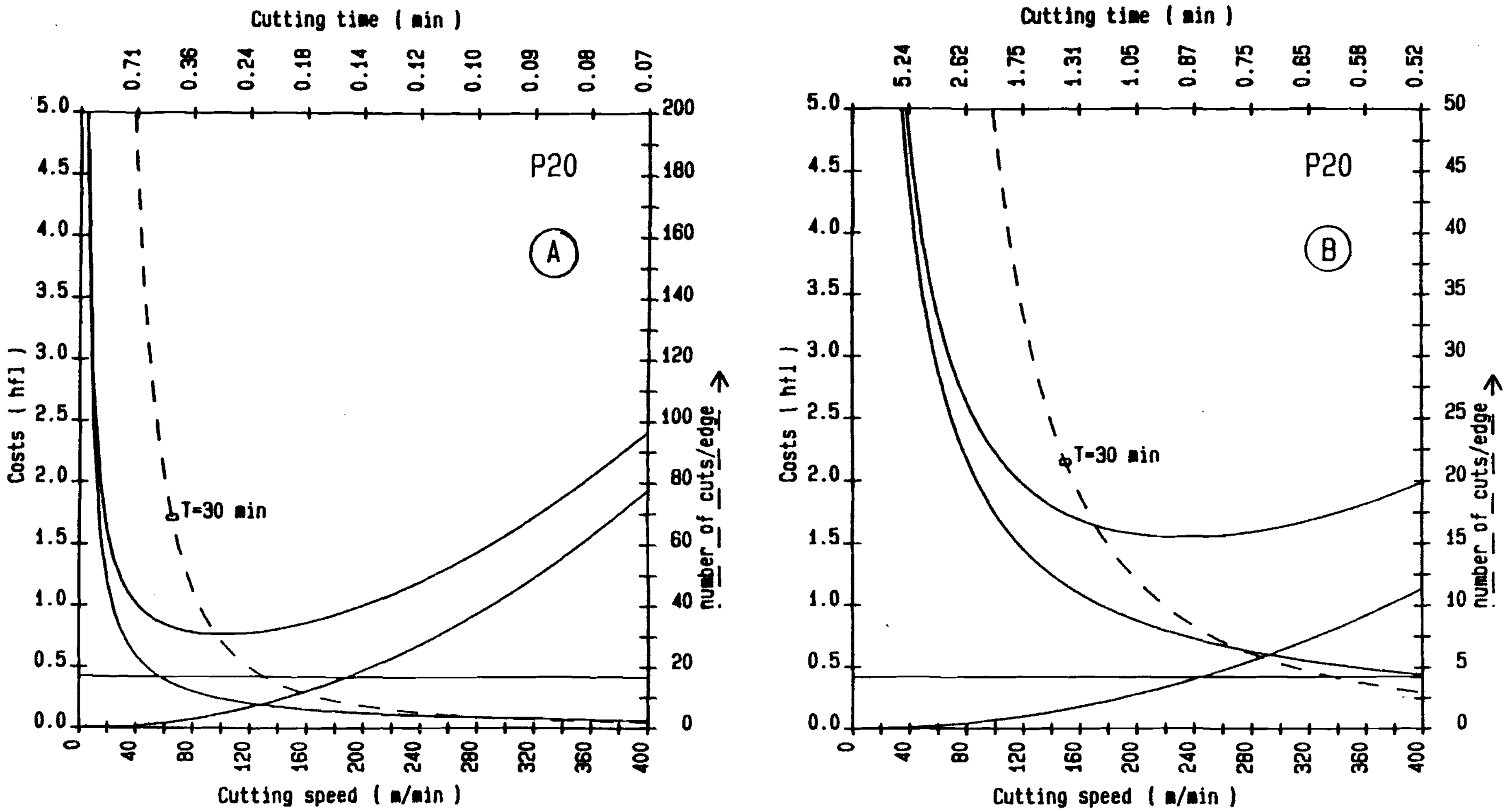


Fig. 3. Costs as a function of cutting speed for the turning of a standard workpiece.

TECHNISCHE VOORLICHTING MACHINEFABRIEKEN

CFT
Mechanische Technologie

TECHNOLOGIE
SPAANLOZE VORMGEVING

INHOUDSOVERZICHT COMPUTERPROGRAMMA'S

MFT 3-5212-1

2 pagina's - pagina 1

april 1983

1. ALGEMEEN

1.1 INLEIDING

Dit blad geeft een inhoudsoverzicht van de computerprogramma's die de afdeling "Mechanische Technologie" van het C.F.T. beschikbaar heeft op het gebied van de spaanloze vormgeving. De programma's zijn bestemd voor de constructeurs van produkten en gereedschappen. De opbouw is zodanig dat het constructeurs in staat stelt de diverse vormgevende bewerkingen zelfstandig door te rekenen. De betrokken groep "spaanloze vormgeving" geeft hierbij desgewenst de nodige ondersteuning.

1.2 OPBOUW PROGRAMMA'S

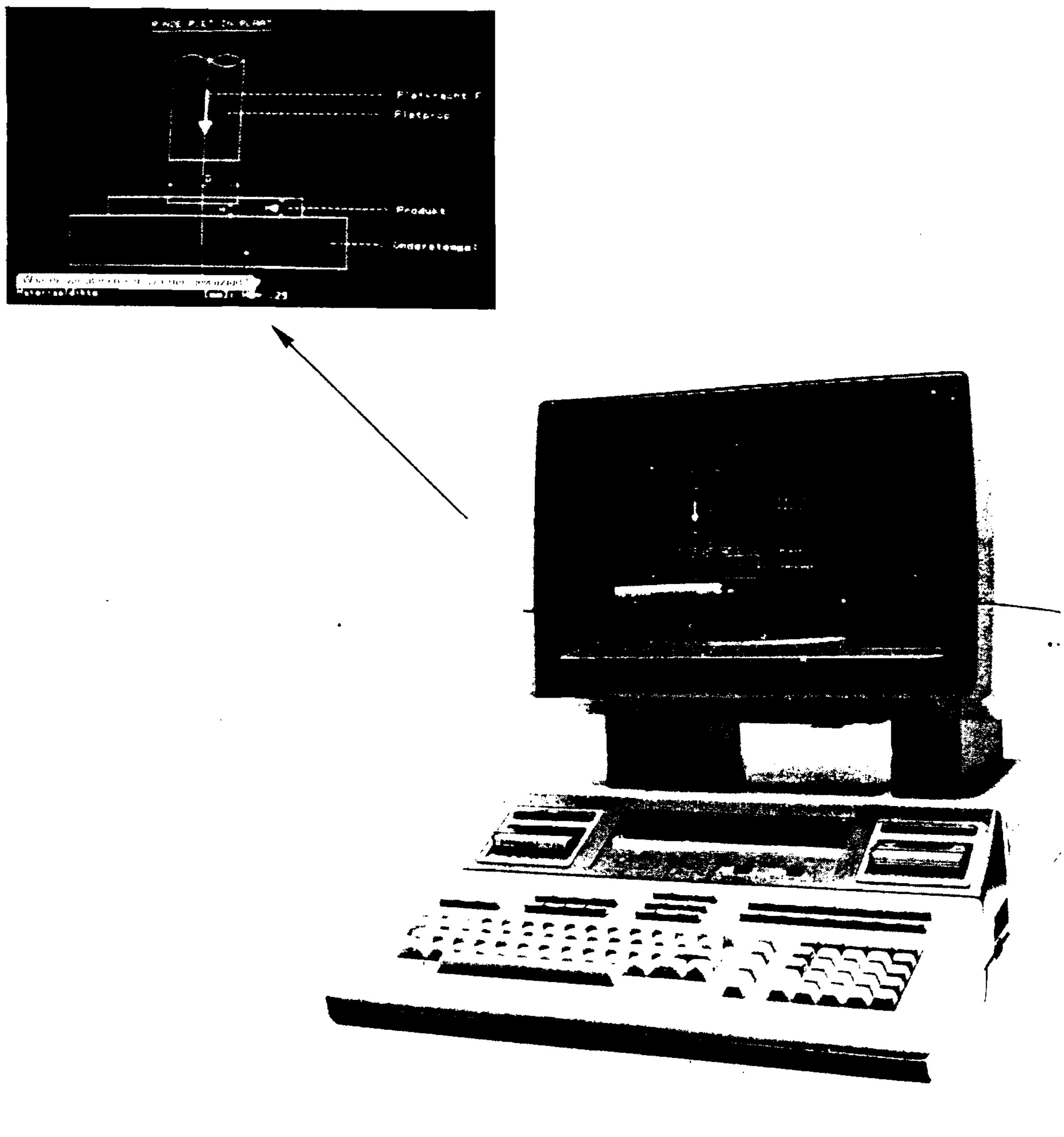
De programma's bestaan uit drie, bij elke bewerking terugkerende delen:

- Het informatiedeel.
  Hierin bevindt zich algemene informatie over de betrokken bewerking, alsmede een aantal specifieke aanwijzingen en tenslotte de adressen voor nadere informatie.
- Het invoerdeel.
  Hier worden de gegevens voor het rekenen ingevoerd.
  Per bewerking geeft het programma aan welke gegevens nodig zijn.
  De gevraagde maten van de werkstuk-/produktgeometrie worden aangeduid in een schematische afbeelding van de bewerkingsopstelling (zie foto). Voor de gegevens die verder nodig zijn biedt het programma richtwaarden aan. Hiervan worden de richtwaarden voor de materiaalconstanten, die bij de bewerking van belang zijn, opgeroepen uit een gegevensbestand *).
  Opmerking:
  De laatstingevoerde gegevens worden bewaard en kunnen op een willekeurig tijdstip daarna weer worden opgeroepen.
- Het uitvoerdeel.
  Dit deel geeft eerst de ingevoerde gegevens weer en daarna de resultaten van de berekening. Voorzover dit bij de desbetreffende bewerking van toepassing is, wordt hierna ook een lijst gepresenteerd van de gereedschapmaterialen die in aanmerking komen.

*) Het betreft hier bij Philips genormaliseerde produktmaterialen die bestemd of geschikt zijn voor bewerken door plastisch vervormen.

1.3 NADERE INFORMATIE EN ADVIES

Hiervoor kan men terecht bij:
Contactadres C.F.T. · Vakgebied 1, gebouw SAQ, tel. (7)34775.



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2. PLETTEN

2.1 IN TE VOEREN GEGEVENS

a. De maten van de werkstuk-/produktgeometrie vóór en ná het pletten; zie de schema's onder 2.3.
Elk van deze maten kan ook met het programma worden berekend als tenminste alle overige maten worden ingevoerd.

b. De materiaalgegevens die betrekking hebben op het plastisch vervormen:
- de specifieke spanning (C)
- de verstevigingsexponent (n)

Het programma biedt voor C en n richtwaarden aan die worden betrokken uit een gegevensbestand (zie 1.2).

c. Overige gegevens:
- De voordeformatie (EpsØ), een factor die de invloed van tevoren uitgevoerde vervormingen in de berekening brengt.
  Opmerking:
  EpsØ = 0 als het materiaal spanningsarm gegloeid is.
- De wrijvingscoëfficient (M), waarmee de invloed van de wrijving tussen gereedschap en werkstukmateriaal in rekening wordt gebracht. Een richtwaarde (M = 0,4) wordt gegeven.

2.2 RESULTATEN

a. De maximaal benodigde pletkracht (F) in verband met de persbelasting.

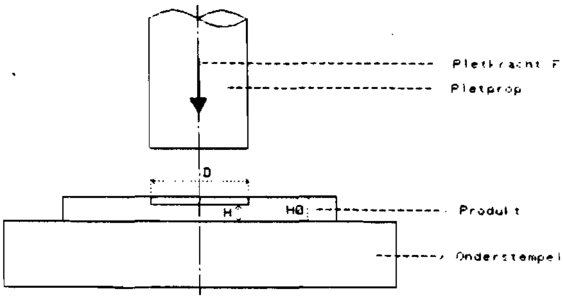
b. Een eventueel gevraagde geometrie-maat vóór of ná het pletten.

c. De maximaal optredende drukspanning op het gereedschapoppervlak.

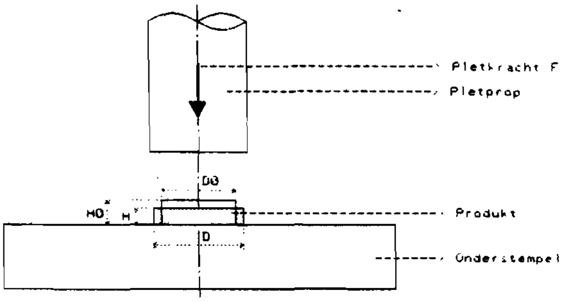
d. Een lijst van de gereedschapmaterialen die in staat zijn de optredende drukspanning (zie c) op te nemen.
Hiervoor raadpleegt het programma een gegevensbestand met de bij Philips genormaliseerde materialen.

2.3 PLETBEWERKINGEN (geometrieen)

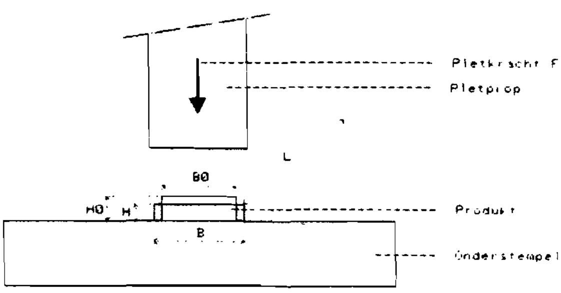
2.3.1 RONDE PLET IN PLAAT



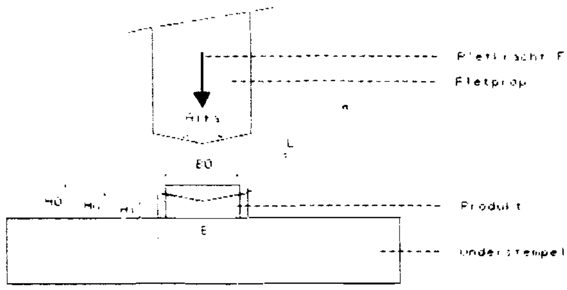
2.3.2 RONDE PLET



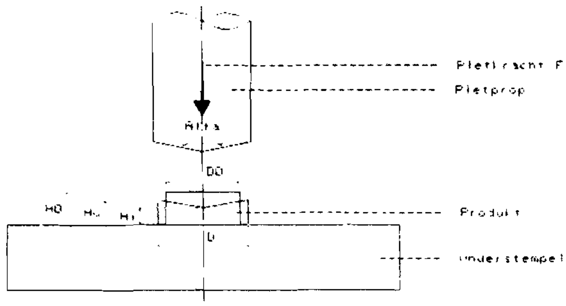
2.3.3 PLET IN STRIP



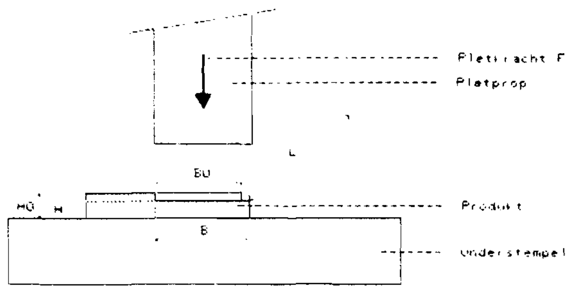
2.3.4 DAKSTEMPEL IN STRIP



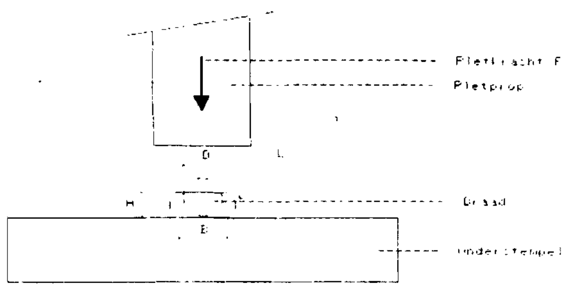
2.3.5 DAKSTEMPEL IN RONDE PROP



2.3.6 PLETTEN RAND AAN STRIP



2.3.7 PLETTEN VAN DRAAD



2.3.8 DAKSTEMPEL IN STRIP (gedeeltelijk)