Proceedings International Conference of Technology Management, Business and Entrepreneurship 2012 (ICTMBE2012),
Renaissance Hotel, Melaka, Malaysia 18-19 Dec 2012

EFFECT OF DIFFERENT MACHINING APPROACH ON PRODUCTIVITY

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ABSTRACT

This research paper will discuss the issue of different machining approach towards the productivity of the assembly line by using computer simulation. The data needed to generate the simulation has been collected at a metal fabricating company and entered into the ProModel simulation software. The different arrangement and combination of the machining approach in the assembly line which has been simulated will be evaluated to determine which one produces the improved productivity. The assembly line which produces more output in the shorter period of time with the alternate combination will be chosen as the better choice as the productivity has been improved. Different machining approach will result in different productivity which much will affect the profit of the corresponding company. From three approaches, the automatic option stands out as the least productivity time as a whole but dynamic effect towards the following process has taken place which might concern people of real practice since it fasten the process on the changed station but not the case on the latter.

Keywords: Assembly line, Productivity, ProModel, Simulation

1. Introduction

According to Groover (2010), manufacturing can be defined in two ways, one technologically, and the other one economically. Manufacturing in the technological term means the application of physical and chemical processes to alter the geometry, properties, or appearance of a given starting material to make parts or products. It also includes assembly of multiple parts to make products. In the economic term, manufacturing means, the transformation of materials into items of greater value by means of one or more processing or assembly operations. In easy words, manufacturing adds value to the material by changing its shape or properties, or by combining it with other materials that have been similarly altered.

Basically, this process is not as easy as it seems. A lot of problems could occur during this process which requires a lot of preparation and consideration so that everything will run as it should be. Two main method can be done to achieve this desire, one through the rigorous on the floor tests combined with mathematical problem solving, and the other one through simulation by the aid of computer software which will give the prediction on how well the whole or partly processes of manufacturing could be done to be compared with the real one. These two processes start quite a long time ago to help people in the manufacturing field to make decisions which will greatly affect the company future. But the preferable method is to use the computer simulation which is cheaper and more appropriate in the new millennium as we are really lack of time in doing many things including manufacturing.

1.2 Background of Study

Manufacturing has become part of all human activity since a long time ago until it is quite impossible to track back when all of this whole process started. This is because, human body itself is a very complex system which produces a lot of things such as voice, movement, idea to create a book, journal and the list seems endless. If we really want to establish this entire event, we must find the first human or creature that live in this world. But the problem is, after centuries, scientist kept finding the older human body than the previous finding.

On a focused manner, the history of manufacturing can be separated into two subjects. The first one is man's discovery and invention of materials and processes to make things, while the second one is the development of the systems of production. According to Groover (2010), the event of human discovery to invent materials and processes to make things started several millennia ago. Some of the processes are the casting process, hammering (forging), and grinding which dated back more than 6000 years ago. For this research paper, the focus is towards the development of the production systems and how it can be improved through few changes.

1.3 Problem Statement

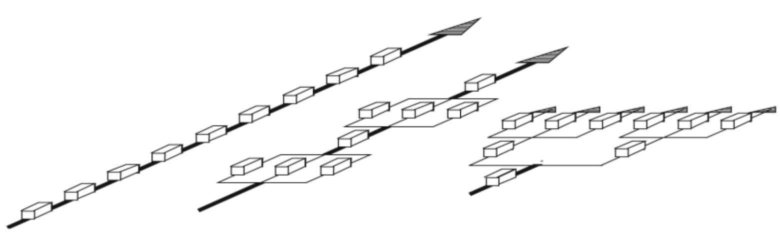
Kochan et al.(1986) stated that "The possible permutations and combinations of work pieces, tools, pallets, transportation vehicles, transport routes, operations, etc., and their resulting performance, are almost endless. Computer simulation has become an absolute necessity in the design of practical systems, and trend towards broadening its capabilities is continuing as system move to encompass more and more of the factory". To further support the statement, a real example of the problem in the manufacturing system should be included. Based on the cases being handled by ProModel Software Company (a software company which provide a simulation software to simulate the manufacturing system), a lot of problems being faced in the manufacturing process can be successfully overcome with the use of a computer simulation like theirs. One of the examples where this simulation software could be implemented is in metal fabrication industry. The situation in this company is that they have three methods of accomplishing their production in the assembly line. The assembly line consists of four stations which is the pressing station, shearing station, inspection station and the packing station. The vital point or station in this research paper is the second station which is the pressing station. In this station, the company implemented three types of machines to accomplish their production in the assembly line. The first one is the implementation of the automatic pressing machine, the second one is the semiautomatic pressing machine, and the last one is the manual pressing machine. These three machines being used in the assembly line alternately without really knowing which combinations out of he three machines can really be beneficial towards the productivity.

The above idea suggests that there is a need for a simulation technology in order to overcome not only the manufacturing problem itself, but also to decide which combination will produce the best outcome for the company. Basically there are two ways in accomplishing this objective. The first method is by field measurement which is costly and time consuming. While the second method is through computer simulation which had been mentioned and proposed in the above statement. It also could be derived that the application of simulation being even broader, relevant and practical as the time passes by suitable with the technological change that continuously happen. This research intends to simulate the assembly line in manufacturing system to validate or determine the effect of different machining approach towards the productivity of the manufacturing system.

2. Literature Review

2.1 What is an Assembly Line?

Assembly line is a manufacturing process in which parts are added to a product in a sequential manner using optimally planned logistics to create a finished product much faster than with handcrafting-type methods Groover (2010). This is where the materials available in the manufacturing system being joined together to create a product which could be neither finished product nor half finished product which will be supplied for another process. Basically there are two main types of assembly line. The first type of an assembly line is the single model production line where every product is identical. As an example is the assembly line to produce a car, there is only one type of window, one type of door, one type of tyre and so on to produce a single type of car. While the second type of assembly line is the mixed-model production line. This type of assembly line applies to the situations where there is soft variety in the product made on the line. Modern automobile is an example, where there are many types of car body, door, tyre and so on to produce many types of cars. Cars coming off this assembly line have variations in options and trim representing different models and in many cases different nameplates of the same basic car design. From those two types of assembly lines based on the journal of some considerations relating to the reintroduction of assembly lines in the Swedish automotive industry by Jonsson et al. (2004), there are several flow patterns or design of the assembly line. The first type is the single product flow pattern. The second pattern is the semi-parallel product flow pattern, and the last pattern is the parallel product flow pattern.



Note: From left to right: a single product flow pattern (e.g. a traditional assembly line), a semi-parallel product flow pattern (e.g. the Volvo Kalmar plant), and a parallel product flow pattern (e.g. the Volvo Uddevalla plant)

Figure 1: Patterns of the assembly line.

2.2 The Relation between Productivity and Simulation

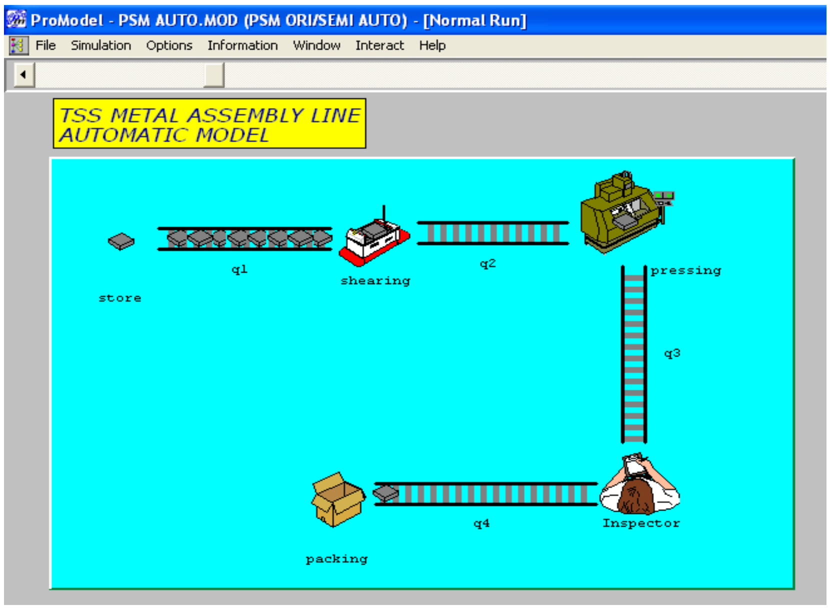
After going through journals and books, it could be identified how strong the correlation between computer simulation and manufacturing system in determining and improving the productivity of the system itself. As being written previously, productivity being measured by calculating the ratio between input and output. It is not an easy task in order to achieve the optimal productivity, as it had been said by Park et al. (2002), difficult lies in the need to synchronize several processes to create a flow through the plant. There are larger numbers of constraints and very little work in process is allowed. From the above statement, we could see that the higher managerial position want to cut off as much work as possible so that the cost needed through the manufacturing process could be minimized greatly. In contrast to that demand, higher productivity rate is being desired by the higher authority of the organization. A tool that could solve this big problem is in dire need, but at the same moment, will not consume a large proportion of the cost required.

This is where computer simulation comes with a big hand to help the company achieve that seemingly impossible desire. According to Harrell et. al. (2011), rather than leave decisions to chance, simulation provides a way to validate whether or not the best decision are being made. Furthermore, simulations avoid the expensive, time consuming, and disruptive nature of trial-and-error techniques. It is no longer relevant to rely on the traditional trial-and-error methods with the emphasis today on time based competition. The power of simulation lies in the fact that it provides a method of analysis that is not only formal and predictive, but is capable of accurately predicting performance of even the most complex systems.

The need and urge to implement computer simulation in the manufacturing process can easily being seen by the words of Jonathan (2001)," An international contractor has reported productivity improvements due to the simulation ranging from 30% to 300%. In this case, for every hour of simulation analysis used a saving of $2,500 achieved in 1999". In this statement we can easily see the simple figure of how the computer simulation could affect the productivity of the manufacturing system. Even though the example taken was from a construction site, but it is still a manufacturing system. Although construction even rather complicated as it deals with people (human resource), materials, costs, elements of nature (weather etc) and much more. A computer simulation still could provide some form of solution which is worth while to be considered.

The next big thing in manufacturing is to utilize all of the resources available to the maximum so that the cost and time could be minimized to the very least level. As it has been apposed," In manufacturing industries, keeping a high utilization rate is a key success factor ", Lin et al. (2008). Based on that, it is wise to select the perfect method to coordinate all of the resources available so that it could be used to the maximum to achieve the highest productivity efficiency level and nothing would be wasted if possible. It also mean the move or choice to manipulate the computer simulation software is the right way as it is less costly but could make a really big difference.

3. Discussions and Results



3.1 The assembly line implementing automatic pressing machine

psm auto.idb - Output Viewer 3DR

Report for psm auto

Locations for psm auto

Name	Scheduled Time (MIN)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization
store	480.00	999999...	100.00	324.89	67.69	99.00	44.00	0.01
q1	480.00	999999...	56.00	68.55	8.00	8.00	8.00	93.40
shearing	480.00	1.00	48.00	9.99	1.00	1.00	1.00	99.94
q2	480.00	999999...	47.00	0.25	0.02	1.00	0.00	0.32
pressing	480.00	1.00	47.00	4.96	0.49	1.00	1.00	48.59
q3	480.00	999999...	46.00	0.94	0.09	1.00	0.00	0.94
Inspector	480.00	1.00	46.00	8.99	0.86	1.00	1.00	86.20
q4	480.00	999999...	45.00	1.24	0.12	1.00	0.00	1.05
packing	480.00	1.00	45.00	8.76	0.82	1.00	1.00	82.10

Table 4.3.1.1: Output of automatic pressing system, 1

For the first station, the shearing station which is the station to shear the material, it reached up until 99.94% of utilization rate which is good since it nearly reaches its full usage capacity. The second station which is the pressing station showed the figure of 48.59% of utilization rate. This low utilization does not mean that the implementation of an automatic is not good. This means that the automatic pressing machine does not reach its full potential in utilization since it requires less processing time to be compared with the time available for processing which results in the low utilization rate. In the meantime, this mean that the manufacturer can add more input into this new machining approach since it not even reach half of its utilization capacity. But this require more adjustment in the assembly line since the input is feed up to the line in batches of 100 which mean it is impossible to suddenly add up more input just in this station and not others since the process is in sequence, one after another. For the third station which is the inspector, showed more percentage of utilization rate which is 86.20%. While the last station, the pressing station, only has the figure of 82.10% of the utilization rate. Both of the last two stations are well above 80% of its utilization rate which is acceptable.

The q1 is only an imaginary queue to get the data of the waiting time for the input (entity) before it enters the each station. For q1, the utilization rate is 93.40% which mean nearly all the pieces could enter the first station, the shearing station, nearly all at once, without long waiting and it run smoothly. The second queue, q2 only reach 0.32% of the utilization rate which is very low. This indicates that the processed entity from the shearing station will come out from the station in low entity number before it enters the second station. In q3, the utilization rate is slightly higher with 0.94% of the utilization rate which also means the entity from the pressing station will come out in a small number at one time. The last queue, q4, showed the utilization rate of 1.05% which has the same meaning as the previous queue.

As the conclusion, even though this system implementing an automatic pressing machine which significantly reduce the time for the pressing process, but the other station still utilizing mostly human power with the assistance of machine which is not synchronize the whole process. This has result problem in other area as well as in the pressing station itself. The most noticeable one is the low utilization percentage in this station which is 48.59% is due to the lateness and waiting time of other station while the pressing station had finished the entire task. This event had caused the pressing station to be in the idle state for more than half of the time of the operation hour with as much as 51.41% of idleness, equal to more than 4 hours. This is because the assembly line is producing the product that has the relation with other station and not a stand alone process.

3.2 The assembly line implementing semiautomatic pressing machine

psm ori semi auto.idb - Output Viewer 3DR

File View Tools Window Help

Views: <undefined view>

Report for psm ori semi auto

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | E

Locations for psm ori semi auto

Name	Scheduled Time (MIN)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization
store	480.00	999999...	100.00	326.76	68.08	99.00	44.00	0.01
q1	480.00	999999...	56.00	68.55	8.00	8.00	8.00	93.40
shearing	480.00	1.00	48.00	9.99	1.00	1.00	1.00	99.94
q2	480.00	999999...	47.00	1.56	0.15	1.00	1.00	2.05
pressing	480.00	1.00	46.00	9.88	0.95	1.00	1.00	94.71
q3	480.00	999999...	45.00	0.75	0.07	1.00	0.00	0.73
Inspector	480.00	1.00	45.00	9.17	0.86	1.00	1.00	85.93
q4	480.00	999999...	44.00	0.71	0.06	1.00	0.00	0.59
packing	480.00	1.00	44.00	8.72	0.80	1.00	1.00	79.92

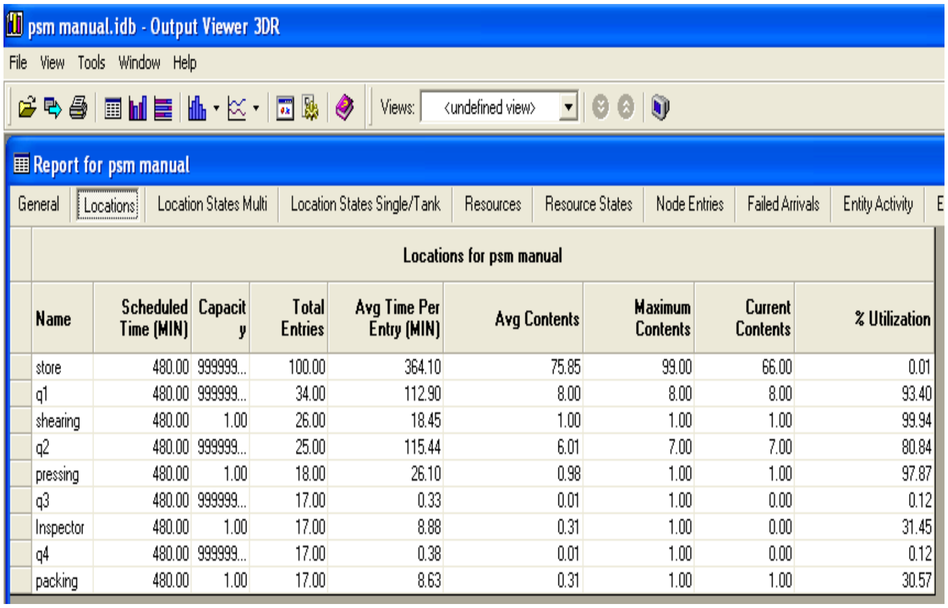
Table 4.3.2.1: Output of semiautomatic pressing system

The main four stations to assemble the parts have a very different utilization rates. For the first station, the shearing station which is the station to shear the material it reached up until 99.94% of utilization rate which is good. The second station which is the pressing station showed the figure of 94.71% of utilization rate. For the third station which is the inspector, showed a lesser percentage of utilization rate which is only 85.93%. While the last station, the pressing station, only has the figure of 79.92% of the utilization rate.

The q1 is only an imaginary queue to get the data of the waiting time for the input (entity) before it enters the each station. For q1, the utilization rate is 93.40% which mean nearly all the pieces could enter the first station, the shearing station nearly at once, without long waiting and it run smoothly. The second queue, q2 only reach 2.05% of the utilization rate which is very low. This indicates that the processed entity from the shearing station will come out from the station in low entity number before it enters the second station. In q3, the utilization rate is even lower with only 0.73% of the utilization rate which also means the entity from the pressing station will come out in a very small number at one time. The last queue, q4, showed the lowest utilization rate with only 0.59% figure which has the same meaning as the previous queue but with the lower percentage.

As the conclusion, the implementation of the semi automatic machine in the pressing station had a good result in term of utilization rate and idle time. This is because the utilization rate had been more than 79% for all station available which indicates the time of operation is 6 hours and 19.2 minutes out of full 8 hours of operation time. The idle time left realistically being used for the workers to rest and eat during the recess hour.

3.3 The assembly line implementing manual pressing machine



Locations for psm manual

Name	Scheduled Time (MIN)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization
store	480.00	999999...	100.00	364.10	75.85	99.00	66.00	0.01
q1	480.00	999999...	34.00	112.90	8.00	8.00	8.00	93.40
shearing	480.00	1.00	26.00	18.45	1.00	1.00	1.00	99.94
q2	480.00	999999...	25.00	115.44	6.01	7.00	7.00	80.84
pressing	480.00	1.00	18.00	26.10	0.98	1.00	1.00	97.87
q3	480.00	999999...	17.00	0.33	0.01	1.00	0.00	0.12
Inspector	480.00	1.00	17.00	8.88	0.31	1.00	0.00	31.45
q4	480.00	999999...	17.00	0.38	0.01	1.00	0.00	0.12
packing	480.00	1.00	17.00	8.63	0.31	1.00	1.00	30.57

The main four stations to assemble the parts have a very different utilization rates. For the first station, the shearing station which is the station to shear the material it reached up until 99.94% of utilization rate which is good. The second station which is the pressing station showed the figure of 97.87% of utilization rate. For the third station which is the inspector, showed a lesser percentage of utilization rate which is only 31.45%. While the last station, the pressing station, only has the figure of 30.57% of the utilization rate.

The q1 is only an imaginary queue to get the data of the waiting time for the input (entity) before it enters the each station. For q1, the utilization rate is 93.40% which mean nearly all the pieces could enter the first station, the shearing station nearly at once, without long waiting and it run smoothly. The second queue, q2 only reach 80.84% of the utilization rate which is high. This indicates that the processed entity from the shearing station will come out from the station in low entity number, but have to wait for a long period of time before it enters the second station to be processed due to the slow manual process in the pressing station. In q3, the utilization rate is low with only 0.12% of the utilization rate which also means the entity from the pressing station will come out in a very small number at one time. The last queue, q4, showed the same utilization rate as q3 with only 0.12% figure which has the same meaning as the previous queue.

For the conclusion, it is very obvious that the action of sticking with the use of manually operated machine had caused a chained effect problem to the system it self. We could notice that the time for the manual machine had greatly consumed a big amount of time for the station itself. As the result, the subsequent station and processes had been affected. This had been proven since the idle time for both of the stations after the pressing station had increased compare to the shear and pressing machine. This is because these two stations consumed a lot of time waiting for the entity to arrive and be process rather than processing the entity itself with a very significant consumption of waiting time both for more than 5 hours. Clearly, this station is the culprit for other station high idleness. It can be concluded the station of pressing is the bottleneck in the system. This further supports the reason of alternating the machining approach in the station of pressing.

3.4 Effect on occupied queue

Table 1: Occupied queue

Name	automatic	semiautomatic	manual
q1	100	100	100
q2	2.4	15.25	95.81
q3	8.97	7.03	1.15
q4	11.58	6.48	1.35

The above table indicates the entity activity in the occupied queue according the changes made. This is also an important indicator of how the assembly line reacts towards the change in the pressing station which will subsequently contributes in the fluctuation of the production time as indicated in the objective of the research. In q1, which is the queue just before the shearing process, it is uniformly 100% occupied across the alternate machining approach, indicating that the line is being filled by the entity waiting to be processed. This can be considered normal as the beginning of processing.

In q2, for the automatic approach, there is 2.4% queue occupied, 15.25% for the semiautomatic approach and as much as 95.81% for the manual approach. The low percentage in q2 is due to the quicker or shorter machining process due to the automatic pressing machine later after this queue. This does not allow the long waiting of the entity before processing. The combination of human and machines has significantly increase the processing time in the semiautomatic approach as the percentage increases more than 7 folds which make more entity in the waiting state. The manual approach showed the highest percentage as the pressing process after that queue is fully manual or human operated and significantly increases the waiting rate.

After q2 and the pressing process, we could see a new pattern developed as the vice versa situation take place in q3. For the automatic, there is 8.97% percent is occupied which is the highest from the rest. This is due to the manual process of inspection after pressing and q3 which is not in balance with the quick machining in the automatic pressing approach. Even though, the process in the pressing station is short, the station of inspection which manually operated could not handle the fast entity feeding from the previous station making the entity being stuck in the third queue for some time. The low percentage of the occupied queue in respectively both the semiautomatic and manual approach is due to the additional time required to process the entity in the pressing station which reduced the waiting entity in q3 subsequently and respectively making the queue less occupied.

The effect of the change in the pressing machining approach seems has been reduced as the process further away from the changed station. The gap of occupied queue has been reduced even it is still quite high as being shown in table 2. From the gap of 6.57% it has been reduced to 2.61% in q4 with the automatic pressing station. While in the other approaches the changes is quite small.

This has partly explained what happened in the subsequent processes even if the change is being made only in one station which has contributed to the reduction of the production time. The effect seems to be quite complex and it remains but reduced significantly on the following processes after the changed station towards the end.

4. Conclusions

Table 2: Total average time in system

automatic	semi automatic	Manual
251.79 minutes	256.36 minutes	254.41 minutes

As for the contribution of this paper, it provides an insight of how a different machining approach will affect the whole production time in the assembly line. This paper focuses on alternating different machining approach or mechanisms which is fully automatic, semiautomatic and the traditional manual machining method on one of the selected station, in this case is the pressing station. This attempt has successfully see the result where the option of using the automatic pressing machine has the better result towards the production time as it reduces the processing time compared with other approaches tested.

The main consideration before we jump into the conclusion, we must evaluate first whether the objective of this research paper has been meet which to improve the productivity of the assembly line. For this very reason we take a look upon the average time in the system as this is where it shows whether the implementation of the different types of pressing machine will help to make the whole processing time faster to complete. As the result shown in table 2, the implementation of the automatic pressing machine has resulted in the lowest average time in system which is 251.79 minutes in comparison with second lowest, the implementation of manual pressing machine, with the value of 254.41 minutes and the last one is the implementation of the semi automatic pressing machine. Based on this factor, the best option of combination in the assembly line is the automatic pressing machine implementation. Based on this data, we could see by implementing the automatic pressing machine into the pressing station has significantly reduced the time of processing which mean higher productivity by reducing the time and new batch of entity could enter the system to process more output.

In this research, a systematic methodology was developed to design and simulate the assembly line in the manufacturing system by the computer software of ProModel. The reason why this simulation process is so important is due to the high cost of a field test that requires a lot of time and capital that does not fit the requirement of today's hectic life style and fast decision making. Through the utilization of computer software, the restriction of doing a simulation virtually that seems to be impossible in the past decades can be eliminated yet the result is promising and comparable with the real world event. The objective of this research paper which to look upon the effect of different machining approach towards the production time to improve the productivity of the assembly line and subsequently the company itself had been accomplished just by using computer software that imitates the real situation but in the virtual form. This hopefully will help the better understanding of the effect of changing the machines in an assembly line or in the manufacturing system in general. Even if the resulting production time might be reduced, a few consideration regarding the dynamic effect upon the subsequent machines or station should always been look trough before real implementation to avoid future problem that always being followed by additional cost.

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