Spreadsheet simulation for industrial application: a case study

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ABSTRACT
The paper reports and demonstrates the spreadsheet simulation that used for production planning and inventory control in a composite based product manufacturer. It covers the development of the spreadsheet simulation template and the application. The findings show that the application of the spreadsheet simulation positively improve the time to estimate the production lead time, and monitoring activities on material usage included raw material, chemical and ancillary. Besides, it provides well-managed documentations for production planning and control.

Keywords: Spreadsheet simulation, production planning, inventory control

INTRODUCTION

Since it was introduced, electronic spreadsheet programs have become familiar and useful tools for decision-making process. The capabilities of the package have extended its uses beyond financial applications. Khan (1999) stated that the advantage of using a spreadsheet is its commercial availability, simplicity and ease of building a simulation model in a familiar and user friendly environment and quick update of data to test monitor the simulation for its '*what if*' questions rather than using simulation languages or simulation software packages which are costly and difficult to learn. Moreover, it was attracted many researchers to apply it such as Al-Faraj et.al, (1991), Paulson, (1991), and Seal (1995) in optimising queuing system, Cornwell and Modianos (1990), Przasnyski (1990), Khan (1999), Turner and Williams (2005), Ashayeri and Lemmes (2006), and Kumar and Phrommathed, (2006) for operations management, and Ezingeard and Race (1995), Gilmour (1998), Sezen (2006), and Greasley (2008) for inventory control. In the other hand, the developments of formulations and functions of modern spreadsheets have provided an interactive modelling environment in which the user can take the opportunity to apply powerful quantitative tools, like simulation technique, to develop models for the purpose of system analysis. A simulation model benefits the production management of a factory through gaining its capital insights in respect of resources (man-machine) utilisation, production output etc.

In manufacturing industries nowadays computer simulation has been adopted and emerged as an advanced, sophisticated and flexible management analysis tool which is able to take account of the complexities and dynamic changes within the production environment (Khan, 1999). Computer simulation allows researchers to develop models to represent the real system to study the total system behaviour. It can evaluate the performance of the production system without risking the disruption of existing techniques and effective and proper allocation of resources to increase manufacturing activity. This paper is then organised to provide some methodologies to develop a spreadsheet simulation for production planning in a composite base product's manufacturer. The next section of this paper will explain the research approach, the developed spreadsheet simulation and discussion of the findings. In addition, the paper will end with some useful conclusions and thoughts for future research.

RESEARCH APPROACH

An intensive case study was conducted. The selected company is a manufacturing company which situated in Melaka, Malaysia and currently active in producing components for aerospace industry. The products are composite base products. For discussion, a product was selected. To produce the product, it will go through at least 13 processes without rework. The process includes kitting, lay up, bonding, curing, de-mould, trimming, dimensional, glass wrapping, final bagging, NDT, painting, final inspection and packaging. In the normal practice, the product will be produced in a set which consist of 8 units of panel.

The main objective of the study is to develop a spreadsheet simulation template for the use of production planning. The second objective is to optimise inventory management in the direction of reducing production cost. The spreadsheet simulation template is developed based on the current manual system by using Microsoft office Excel 2003. The software is chosen because of knowledge of staff. The development idea of the spreadsheet simulation is due to manual system weaknesses especially in production planning and inventory control. The spreadsheet simulation was developed to predict the production lead time, inventory usage (included raw material, chemical and ancillary) base on a demand or required production per panel. The developed spreadsheet simulation template contains seven data sheets that linked to each others. **Table 1** presents the data sheet's name, and the purposes.

Table 1: Data Sheet

Sheet	Purpose	Description
DATA ENTRY	Estimate production lead time	As a main sheet of the system. The sheet is linked to TIME DATA and MATERIAL.
MATERIAL	Estimate material usage	Shows the usages of material require for completing the panel. It is linked to DATA ENTRY, MONITORING ANCILLARY, MONITORING CHEMICAL and BOM DATA.
MONITORING ANCILLARY	Generate an actual vs. plan usage of ancillary material	Its shows the different of material usage between plan and actual usage. The summary of the results shows in graph and pie chart. It is linked to MATERIAL and DATA PAGE.
MONITORING CHEMICAL	Generate an actual usage vs. plan usage of chemical material.	Its shows the different of material usage between plan and actual usage. The summary of the results shows in graph and pie chart. It is linked to MATERIAL and DATA PAGE.
TIME DATA	As a database to estimate production lead time.	Linked to DATA ENTRY
BOM DATA	As a database to estimate Material usage.	Linked to MATERIAL
DATA PAGE	As a database to estimate Monitoring Material Usage.	linked to MONITORING ANCILLARY and MONITORING CHEMICAL

In the other hand, there are nine main formulas (equation) based on common calculation in manual system have been chosen for the development of the spreadsheet simulation. The following are the formulas:

1) ∑ Cycle time per panel = ∑ Cycle time in section Kitting + ∑ Cycle time in section Clean Room (Lay Up) + ∑ Cycle time in section Clean Room (Bonding) + ∑ Cycle time in section Auto Clave + ∑ Cycle time in section De-mould + ∑ Cycle time in section Trimming + ∑ Cycle time in section Dimensional + ∑ Cycle time in section Glass Wrap + ∑ Cycle time in section Final Bagging + ∑ Cycle time in section NDT + ∑ Cycle time in section Painting
2) Cycle time per quantity = Quantity X ∑ Cycle time per panel
3) Days to complete product/ shipment =((Quantity X ∑ Cycle time per panel) / 60 min)
4) Hours to complete product/ shipment =((Quantity X ∑ Cycle time per panel) / 60 min)/ 12 hours
5) % Difference of material usage= ((Actual Usage – Plan Usage)/ Plan Usage) X 100%
6) Total Actual Usage = Total usage for a week
7) Miss Usage = % Difference of material usage ≤ -10 %
8) Hit Usage = -10% < % Difference of material usage < 10%
9) Above Usage = % Difference of material usage ≥ 10%

SPREADSHEET SIMULATION

As mentioned in the previous, the spreadsheet simulation is programmed to calculate the production lead time, and inventory usage of the quantity per panel. To simulate the result, the user is only required to enter the number of demand (in panel) in the front page of spreadsheet simulation template-DATA ENTRY. Then, the estimate production lead time will be appeared. To visualize the expected material usage or the need of materials, the user should go to the data sheet called MATERIAL. To produce the selected product, a total of 33 core materials are used. **Table 2** shows the template that used in the development of the spreadsheet simulation for the material usage monitoring system.

Table 2: Material usage monitoring template

No	Description
1	The system will appear automatically to confirm the usage of panel
2	The details information of the material. **Part Number** = The identity number of material. Each material has it own part number. **Description** = The name of the material **Material Categories** = There are two types of material that is direct and indirect. Direct is material that being used to produce the product where indirect material is material that used to support the production. **Item type** = This is refer to the types of material. The types of material refer to condition of material whether it is chemical, ancillary, core or raw material. **Raw Material Purchase Spec** = The Specification of material that used to order the material. **Material Description** = The detail description of the material. **Quantity Need** = Quantity need for production depends on quantity of panel. **Quantity Order** = Quantity need by business supply operation to order the material. It same with quantity need but the unit is different. So the systems convert it automatically. **UOM** = Unit of material. Each material has it own unit.

In addition, the developed spreadsheet simulation had included material usage guidance system to prevent the waste of material by referring the UOM for ordering, management and production. By using this system, the management is able to get the detail about the miss, hit and above material usage. For definition, *miss* refers to less use material, *hit* means moderate use material and *above* means over use material. The system will produce a graph for plan versus actual usage and pie chart for the percentage of *miss*, *above* and *hits* material. To be more specific, two different data sheets were created- MONITORING ANCILLARY and MONITORING CHEMICAL. The MONITORING ANCILLARY used to manage a total of 9 ancillary materials meanwhile the MONITORING CHEMICAL used to manage 11 types of chemical or additive materials in production operation. Similar to the data sheet-MATERIAL, the simulation result only can be appeared while the user enters the quantity panel to be produced. To organize it into proper documentations, Material Usage Guidance System template was developed as shown in **Table 3**.

For the assumption, the system will functions very well if capacity intact that is man power, machine, size of working place and management in good condition. All the aspect will help to produce product within the time prescribed. System would be able to function well with if every section has a good capacity planning. Besides, process deliver a product must be quickened, avoidable waiting felled that can avoid delay to the last section. The cycle time of the system will match with production if the working hours are 12 hours per day for every section. The values of material usage also consider the perfect panel. For this reason, the scrap or rework panel cannot achieve the usage of material estimate by the system.

Table 3: The Material Usage Guidance System template

No	Description
1	The details of the material. **ERP No** = Each material have it own part no. **Material** = The name of the material **Description** = The detail of the material. **Plan (MPS Requirement)** = The usage linked with usage of material require from the material sheet. **Total Actual Usage (MPS Usage)** = The actual usage of material for production. Total from one usage to seven usage of material between completing the panel. **% Different** = The different of percentage between actual usage and the plan usage.
2	Total Actual Usage **No 1** = There are seven column of actual usage material. It can be key in less than seven usages depends on the conditions. **Usage** = The usage of the material (Need to fill by user). **UOM** = Unit of Material for Usage in production. **Converted** = The usage of the material usage depends on UOM requirement from management. It will automatically convert. **UOM** = Unit of material for converted unit.
3	Summary for Actual VS Plan Material Usage **Plan (MPS Requirement)** = The usage linked with usage of material need from material sheet. **Total Actual Usage (MPS Usage)** = The actual usage of material for production. Total of usage from one data to seven usage data between completing the panel. **% Different** = The different of percentage between actual and plan usage of material. The colour coding will shows depends on result whether the material in miss, above or hits range. Red shows *above* material, green shows *hit* and blue shows *miss* usage.
4	The summary of material usage. The system will show 1.00 for material in between hits, miss or above.
5	**The Graph** Its shows the plan versus actual usage for each material.
6	**The Pie Chart** Its shows the percentages category of material either hits, miss or above material.

DISCUSSION

Spreadsheet simulation was designed for flexibility because everyone can use the system without requires expertise high to handle. Hence, the moderator can alter if there have any changes in the process flow, BOM, material or the standard of material specifically to the particular data sheet. Although, any changes in the programmed spreadsheet simulation system required a password. The password is created to avoid any user to delete the programmed formulas and system without permission.

The most important element for the development of the spreadsheet simulation was the data. The data is referred to raw data as listed in the formulas. For the development of the system, three types of data page were created- time data, BOM data and data page. The data page is like a "mother" to the system. Besides, the entire data sheet is linked to each other. In addition, the proper output format and architecture of the simulation is also required to ensure that an organize documentation can be produced. It is crucial for manufacturing personnel to plan and develop the next action if needed.

In terms of accessibility, the spreadsheet simulation is able to simulate the result less than 1 minute. However, it is depend on the performance of the computer. In addition, the gap analysis between simulation result and actual performance shows 90 percent accuracy. In the other hand, the value of cycle time and BOM is update at least one in three month's period to ensure that the simulation result able to reach almost 100 percent actual performance. **Table 4** summarizes the achievement of spreadsheet simulation compared to the manual system in terms of time to predict the production lead time, capability, direct information, and inventories efficiency.

Table 4: Manual system vs. Spreadsheet simulation

Aspect	Manual system	Spreadsheet simulation
Time	Time required to estimate a cycle time and usage of material is 1 hours.	Time required to estimated cycle time and usage of material less than 1 minute.
Capability	Only experienced people able to calculate cycle time and the usage of material.	Everyone is able to use the system to estimate the cycle time and the usage of material.
Direct Information	Usage of the material unable to seen clearly.	Usage of the material visible through graph and chart generate by the system.
Efficiency	Low rate efficiency in term of the accuracy, quality and flexibility.	High rate efficiency in term of the accuracy, quality and flexibility.

The shortage of the system is the count time on standard cycle time and excluding value for overtime. The standard working time is 8 hours a day. The problem arose when not all the section work for 8 hours a day. This is because the product (selected) must go through 13 sections to complete. Each section has a different capacity from the aspect of manpower, process, machine and facilities. The system can be more effective if the user especially manufacturing planner able to expect any common problem that happen during production through his/her experienced.

CONCLUSION

As conclusions, the spreadsheet simulation applications had improved the accountability for all parts and material; ensure all parts are ordered with adequate lead time, reducing the number of emergency purchases and cost of express freight. Besides, the spreadsheet simulation able to optimize maintenance inventory and improve information available for equipment specification. Spreadsheet simulation is flexible was not easy like one thing particle suffixed to the emphatic word in sentence. Sometimes the spreadsheet simulation with plain and foolproof is better. The spreadsheet simulation is not necessarily very complex which needs long durations of training. Therefore, Microsoft Excel 2003 was selected to facilitate spreadsheet simulation application. If the spreadsheet simulation is using more complex programming and the result only legible by experienced individual, criteria production for flexibility could not be created. With advantage as can produce data less from one minute is one benefit can be described as robustness of the production planning. Besides, with combination monitoring system in this spreadsheet simulation, effectiveness production planning was approved.

The spreadsheet simulation also was tested to determine how far the graph effectiveness to the production leads time. The graph is provided to facilitate user to the real picture material status- missing, hit and above. Although the spreadsheet simulation was contributed the accuracy data and value time for manufacturing, it limited to several constraints. The manufacturing planner has to design and develop many spreadsheet simulations to cover all products due to different process, process cycle time and material involved. For the future, it was suggested to develop a multipurpose spreadsheet simulation which considered all constraints and linked each other for raw material monitoring. In the other hand, in order to develop future research in this area, the following research questions should be evaluated:

- Are there any spaces to improve the current spreadsheet simulation system?
- What are the critical success factors that influenced the application of spreadsheet simulation totally?
- What are the common problems faced by the organisation to sustain the application of spreadsheet simulation?

The authors of this paper intend to provide details of such research questions in the future publications. The authors believe that the above research solution may prove useful in helping to improve the spreadsheet simulation as effective approach for production planning and control.

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