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Production Scheduling Improvement of Nut Manufacturing Process Using Production Time Forecasting

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PRODUCTION SCHEDULING IMPROVEMENT OF NUT MANUFACTURING PROCESS USING PRODUCTION TIME FORECASTING

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Abstract

This research aims to study the optimization of the auto part manufacturing process to increase efficiency and ensure the punctuality of product delivery. The study found that the problems were that the setup for each manufacturing engine model was slow; spare parts for the engine was not enough for the manufacturing process; and the engine did not work to its full potential. This made the manufacturing process take more time than expected. To compensate for the unexpected additional time, spontaneous overtime was necessarily implemented. Therefore, by gathering the previous manufacturing plan, manufacturing details and delivery records, as well as the manufacturing process examination records. The data were then analyzed using the MINITAB program to forecast the production time. The data received from the forecast were used to create a new manufacturing plan which led to more accurate manufacturing results. After the forecast had been made, it could be concluded that this forecasting method can be applied to help increase overall manufacturing output, ensure timely product delivery, and reduce additional costs from unexpected problems such as overtime expenses and shipping fees for delayed delivery. And reduce the delay in the process, and even prevent late delivery.
Keywords: *Manufacturing Management Optimization, Manufacture Regression Analysis*

1. Introduction

Today's market has been increasingly competitive, especially the auto part manufacturing industry. Also, management and production output the inconsistent demands proper supplies. The manufacturing planning process is an important part that can reduce manufacturing costs. Meanwhile, increase competitiveness to gain advantages over competitors. The general factors that affect these problems include character of the manufacturer, manufacturing machine models, manufacturing performance goals, and other conditions such as the time used to change and set up machine models in nut production, inadequate spare parts, and underperforming machines.

Also, study and analyze problems encountered in the nut manufacturing process in the auto part manufacturing industry using five sample groups. Because nuts that are produced in the manufacturing process consist of constant errors. The forecasting method to suggest a solution to the problems by analyzing the data of collections from January 2021 to November 2022 is which information was a case study of Nut manufacturing company.

Elucidating the comparison results as shown in Figure 1, that is every month the production rate is not as planned, resulting in the quantity of work pieces being insufficient to meet the needs of each customer's order. Therefore, such information it has been taken into account in the analysis results to assess the production planning in the next step. The comparison results are shown as shown in Figure 2, every month there is a delay in requesting delivery of work pieces. And the aforementioned cause affects the transportation cost.

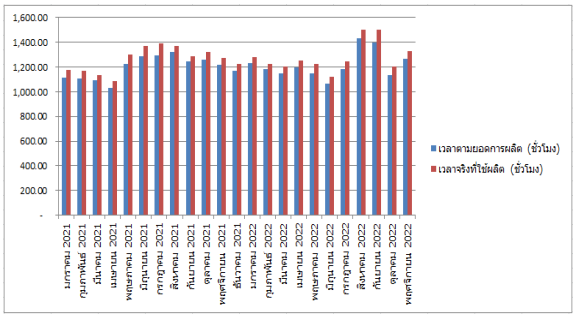

Figure 1 The expected hours (blue) and the actual hours (red) used to manufacture nuts each month, from January 2021 to November 2022

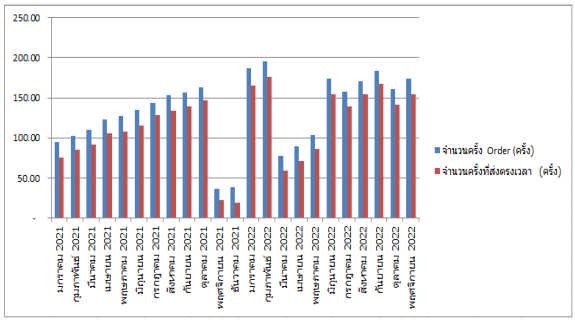

Figure 2 The number of orders received each month (blue) and the number of punctual product deliveries (red), from January 2021 to November 2022

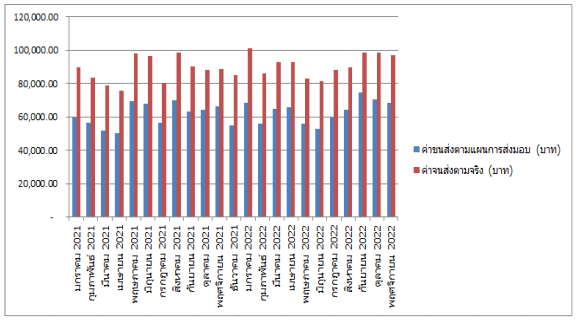

Figure 3 The expected shipping fee (blue) and the actual shipping fee (red), from January 2021 to November 2022

2. Literature Review

2.1 Forecast

A forecast is a prediction of an event. What will happen in the future forecast is based on Past data are available in systematic analysis from mathematical or statistical principles such as smoothing methods, discrete analysis, regression analysis. Is a quantitative forecast (Quantitative forecasting) and qualitative forecasting (Qualitative forecasting) will rely on the experience or judgment of the forecaster to make a forecast. (Thanakorn Jindabunjerd, 2011)

Forecasting using the qualitative method (Qualitative Methods) it is a method that relies mainly on expertise in estimation and expert opinion. It is mostly used for long-term decisions, especially in cases where external factors affect demand for a product. Or in the event that the past data is limited or does not exist. (Busaba Pruksaphanrat, 2009)

Forecasting by quantitative methods (Quantitative Methods) this method relies on mathematical principles to help predict what you want in the future. Which techniques are classified in this category and are widely used (Busaba Pruksaphanrat, 2009).

Multiple linear regression analysis (Linear Multiple Regression Analysis)

Multiple regression analysis is the study of relationships and creating forecasting equations by using 2 or more independent variables or source variables (X) to predict 1 dependent variable (Y).

In multiple regression analysis, multiple correlation coefficients must be obtained. (Multiple correlation coefficient) To know the relationship between the independent variable or the source variable and the dependent variable. For the multiple regression analysis, regression equations must be used to predict the values of the dependent variable (Y) and to find the standard error. (Standard error) as well as multiple correlation (multiple correlation) to find the highest possible relationship between the independent variable or the source variable and the dependent variable. There are three important assumptions in multiple regression analysis: [7]

3. Method

The researcher studied the optimization of the manufacturing planning process for nuts, which are an important component of the auto part industry. It is process improvement research conducted by overgoing the study process as follows:

1. Forecasted the number of possible customer orders that the manufacturing planning department received from a marketing agency.
2. Monthly production record.
3. Manufacturing department’s working process record.
4. Product delivery record.

Take production data (Actual) November 2022 and time (Time) actually used in production. To calculate using Regression in order to know the actual production time to produce that amount of time to produce how much.

By sorting the amount of production (Actual) from the least to the highest, which determines the amount of production (Actual) as the starting variable. And the actual production time (Time) is a dependent variable when calculated by using Regression to forecast each Part. By setting the amount of production (Actual) to be (X) and the actual production time (Time) to be (Y) when calculating, you will get the actual production time of each number of parts, such as Part. SW06131A0. After making a forecast, you will get a method for calculating the time that should be used in production at "Time = -0.6607 + (0.000068* Actual) which when calculating the number of production is 4,753,047 pieces, it can predict the time that should be used in production at 322.55 hours.

When obtaining the predicted value of the time spent in production, it can be known that If wanting to produce the number of workpieces to meet the production plan How many hours will it take to produce?

$$Capacity$$
$$: 102{,}600\ For\ 7\ hours, Need\ 430{,}000\ pcs.$$

$$Time = -0.6607 + (0.000068 * 430{,}000)$$

$$Must\ plan\ production\ for\ 28.57\ hours.$$

Therefore, when using the forecasting time to set up the new production schedule this makes it possible to set the production schedule more accurately.

4. Data analysis and review

This analysis shows the difference between the planned or expected time used for manufacturing and the actual time used. The data was gathered in November 2022 before the forecast was made.

Figure 4-5 Shows the manufacturing process and production value of Part.SW06131A0 before forecasting

Figures 4 and 5 show that Part.SW06131A0 actually used a total of 304 hours in the manufacturing which exceeded the plan resulting in unexpected overtime on three weekends (6 days in total or 84 hours) and additional manufacturing shifts on three weekdays (42 hours).

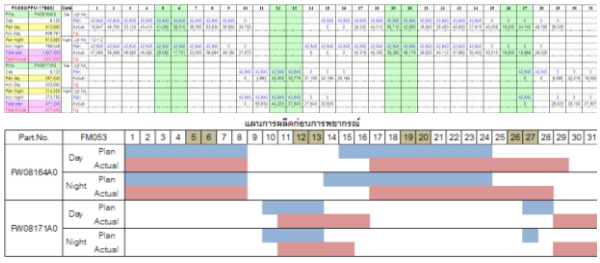

Figure 6-7 Shows the manufacturing process and production value of Part.FW08164A0 & Part.FW08171A0 before forecasting

Figures 6 and 7 show that Part.FW08164A0 used a total of 208 hours in the manufacturing which exceeded the plan resulting in unexpected overtime of 56 hours and weekend overtime for 2 days (28 hours). Because of the delay in Part.FW08164A0, the following Part.FW08171A0 used a total of 66 hours in manufacturing which exceeded the plan resulting in unexpected overtime of 77 hours and late product delivery.

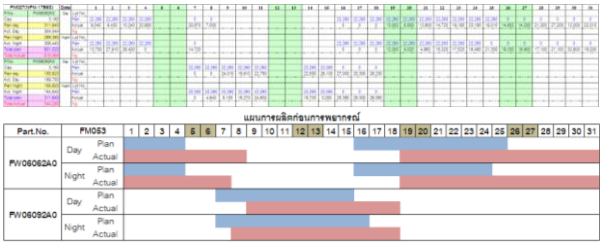

Figure 8-9 Shows the manufacturing process and production value of Part.FW06062A0 & Part.FW006092A0 before forecasting

Figures 8 and 9 show that Part.FW06062A0 used a total of 162 hours in the manufacturing which exceeded the plan resulting in unexpected overtime of 56 hours and weekend overtime for 4 days (56 hours). Because of the delay in Part.FW06062A0, the following Part.FW006092A0 used a total of 88 hours in manufacturing which exceeded the plan resulting in unexpected overtime of 44 hours and late product delivery.

The forecasting method used in the analysis is the linear regression analysis via the Minitab program. A regression model was created to illustrate the relationship and used for forecasting future data as shown in the following figures.

4.1 Production quantity data

There are five items (manufacturing parts) used in the manufacturing. Each item used a different manufacturing amount and production time. However, the production time may be ever so slightly inaccurate for some items.

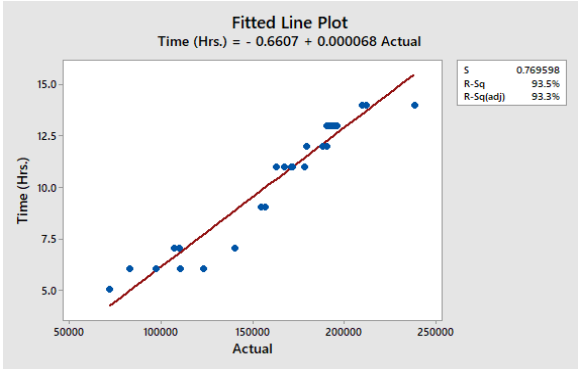

Figure 1 The relationship between the actual production output (Actual) and time used to manufacture (Hrs.) of Part.SW06131A0

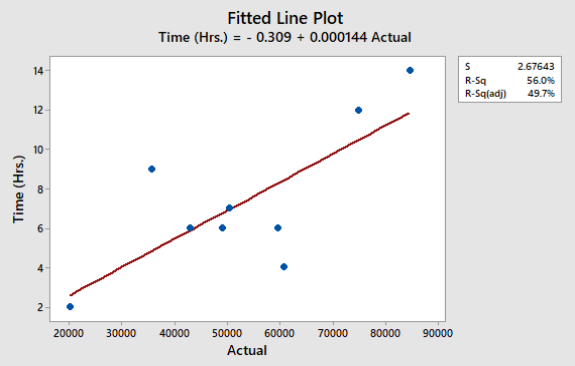

Figure 2 The relationship between the actual production output (Actual) and time used to manufacture (Hrs.) of Part.FW08164A0

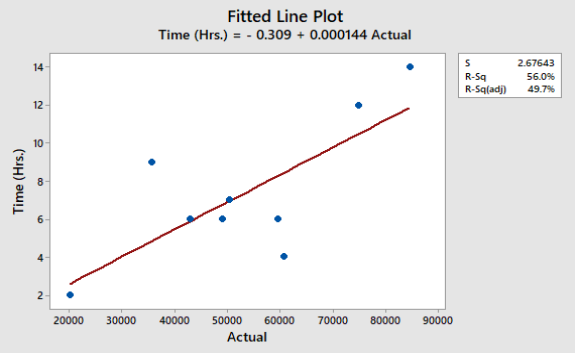

Figure 3 The relationship between the actual production output (Actual) and time used to manufacture (Hrs.) of Part.FW08171A0

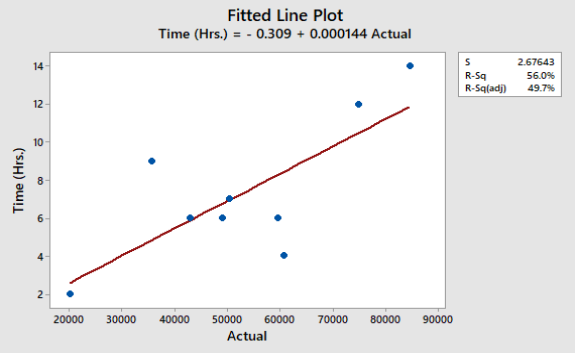

Figure 4 The relationship between the actual production output (Actual) and time used to manufacture (Hrs.) of Part.FW06062A0

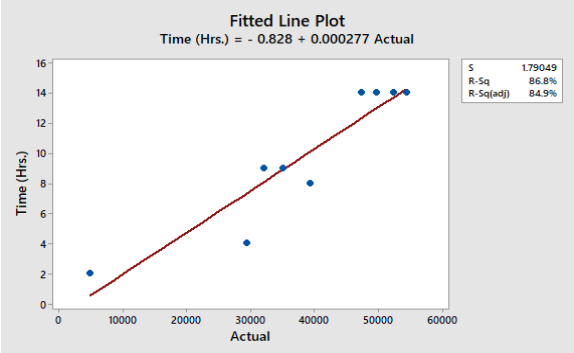

Figure 5 The relationship between the actual production output (Actual) and time used to manufacture (Hrs.) of Part.FW06092A0

4.2 Analysis of the factors that affect production time

This case study concerns the manufacturing of nuts by forming machines. The researcher analyzes factors that affect production time. Initially, the observation was production time is related to production output. The detail of five items concerned nut's manufacturing is put in Minitab to analyze and find a correlation as shown in Figure 1 to Figure 5. The result shows that the production output increases as the time used to manufacture increases as well.

Analysis results from Minitab program of Part.SW06131A0, FW08164A0, FW08171A0, FW06062A0, and FW06092A0

Table 1 Linear regression equation of production time of each Part.

Part no.	สมการถดถอยเชิงเส้นตรง
SW06131A0	Time : - 0.6607+0.000068 Actual
FW08164A0	Time : - 3.408 + 0.000175 Actual
FW08171A0	Time : - 0.309 + 0.000144 Actual
FW06062A0	Time : 0.506+0.000250 Acutal
FW06092A0	Time : - 0.828 + 0.000277 Actual

An example of an application of a linear regression equation to find the production time of Part.SW06131A0

In November 2022, the production output was 4,753,047 pieces. The production time can be calculated as follows:

$$Time = -0.6607 + (0.000068 * 4753047)$$
$$= 322.55$$

Then, the derived linear regression equation can be used to predict the production time of each part. The results are shown in Table 2.

Table 2 The comparison between the results of the current production time and new alternatives

Part no.	แผนผลิต (Plan)	ยอดผลิต (Actual)	เวลาที่ใช้ในแผน (Hrs.)	เวลาที่ใช้ผลิตจริง (Hrs.)	เวลาพยากรณ์ (Hrs.)	ประหยัดเวลาในการผลิต(Hrs.)	(%)
SW06131A0	4,719,600	4,753,047	406	304	322.55	83	26
FW08164A0	1,627,920	1,637,840	322	208	283.21	39	14
FW08171A0	471,240	477,442	126	66	68.44	58	84
FW06062A0	601,020	604,730	266	162	151.69	114	75
FW06092A0	311,640	334,290	126	88	91.77	34	37

According to Table 2, the proposed method can save production time for each part. Part.SW06131A0 shows a 26% decrease; Part.Fw08164A0 a14% decrease, Part.FW08171A0 an 84% decrease; Part.FW06062A0 a 75% decrease; and Part.FW06092A0 a 37 % decrease.

5. Result and Discussion

Forecasting using Linear Regression can improve the efficiency of the manufacturing planning process as illustrated: (post-forecasting manufacturing planning)

Figure 10-11 Showing the manufacturing process and production value of Part.SW06131A0 after forecasting

Figures 10 and 11 show that Part.SW06131A0 will take 323 hours to completely manufacture the product and require less overtime work. Overtime were reduced to 26%

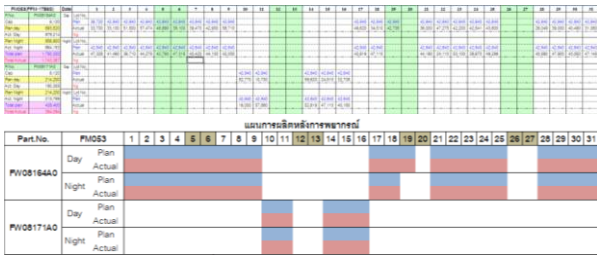

Figure 12-13 Showing the manufacturing process and production value of Part.FW08164A0 and Part.FW08171A0 after forecasting

Figures 12 and 13 show that Part. FW08164A0 will take 323 hours and Part. FW08171A0 will take 69 hours to completely manufacture the product and require less overtime work. FW08164A0 overtime were reduced to 14% and FW08171A0 were reduced to 84%

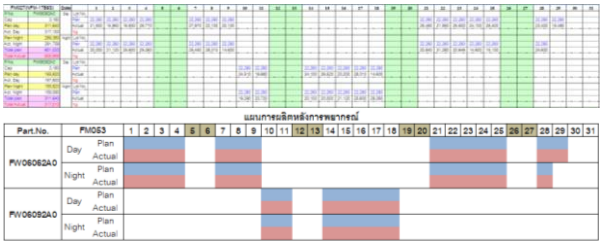

Figure 14-15 Showing the manufacturing process and production value of Part.FW06062A0 and Part.FW06092A0 after forecasting

Figures 14 and 15 show that Part. FW06062A0 will take 152 hours and Part. FW06092A0 will take 92 hours to completely manufacture the product and require less overtime work. FW06062A0 overtime were reduced to 75% and FW06092A0 were reduced to 37%

6.Conclusions

When using forecasting techniques that use mathematical data for processing, manufacturing planning is more efficient. Compared to the original figure, it can be concluded that the actual production time was reduced by 35%. These techniques help increase manufacturing planning forecast by 78% and reduce late delivery problems. Product delivery efficiency increased from 86% to 94%. In addition, it also reduces the overhead costs caused by manufacturing problems such as overtime costs from 1,353 hours were reduced to 780 hours, and additional shipping costs caused by late delivery were reduced from 44% to 20%. However, since the presented problems are complex, involve a lot of data, and have to consider punctual product delivery, the calculation needs to be aided by using Minitab. The linear regression method is appropriate for complex data because it point out the data spacing which helps with the scheduling. Forecasting using linear regression helps to better estimate manufacturing planning. In the future, the researcher will use other forms of regression to help predict manufacturing planning to be able to forecast more accurately.

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