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Determining the Forecasting Model on Inventory, Planning and Control for the Laser Fastec Lamination Core Production

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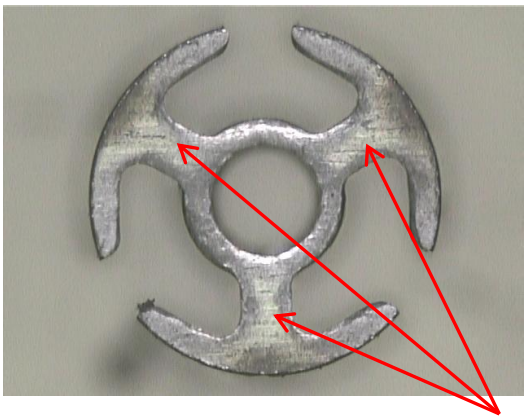
Abstract

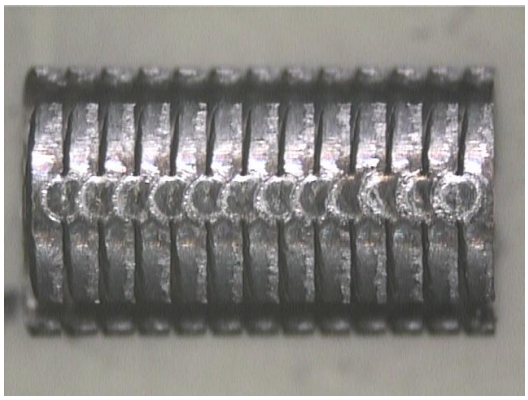
The scope of study is to determine the forecasting method that can be used for company X to their product model 2.55x13. The production output of this model takes the history of production chart of company X from January 2007 until July 2011. These data's will be analysed by using three types of forecasting models such as naive model data with trend, three months moving average model and exponential smoothing model with smoothing constant 0.1 and 0.5. These three types of forecasting models will be analysed one by one and comparing the suitability of each other by determining the best forecasting model which can be implemented to minimize the material purchase and stock inventory will be the objective for this study. Each of the forecasting models will also calculate the overall forecast error by using mean absolute per cent error (MAPE) as a comparison to choose the forecasting model that can give the impact to lower overall error. The entire data will be summarised from the calculation by using Microsoft excel to input each forecasting formula. Results of the study found that the exponential smoothing with smoothing constant $\alpha = 0.5$ is the most suitable forecasting model that can be applied to make forecasting for the laser fastec lamination core model diameter 2.55x13 for the company X. The use of this model would enable control of the production output and at the same time the purchase of raw material can be controlled according to the needs of production when it is necessary to be produced.

Keywords : Forecasting, exponential smoothing model, mean absolute percent error, laser fastec lamination core, production.

1. Introduction

Laser lamination core is one of the parts that is used inside a mobile phone's vibration motor .It is made by press/stamping machine using iron plates that is stacked with several pieces. Refer the structure of actual laser fastec lamination core for model 2.55x13 that is produced in the company X as below.



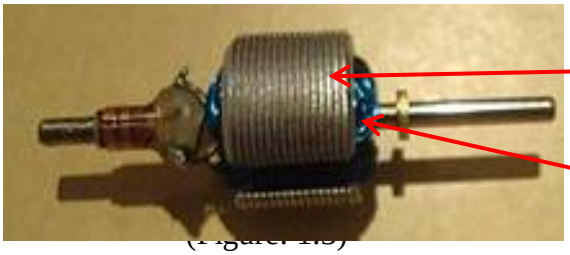


(Upper View)
(Figure: 1.1)

Coil wire wind at this area

(Side View)
(Figure: 1.2)

The laser lamination core allows the magnetic field to be created from the reaction of current flow through coil wire those winds to the laser lamination core. The reaction of the current flow and direction of wire coil that winds to the slot of iron core creates N (north) or S (south) magnetic fields at the edge of three pole of laser lamination core. Please refer to the example of actual photo as below.



(Source:http://en.wikipedia.org/wiki/Brushed_DC_Electric_Motor)

(Source: http://www.precisionmicrodrives.com/new-vibration-motors/304-103-worlds-smallest-smd-4mm-vibration-motor)

The highest cost in making lamination core comes from the usage of raw materials of the iron plates that is known as silicon steel. It also depends on the source of silicon steel material stock that is available at the time when it is needed to be used to produce the laser lamination core. However, too many stocks will create over use of expenses and create unnecessary cash money flow with no profit during the accounting period. Therefore, good forecasting will take

into account every important matter to the balance of all the sources of the company in proper manner, such as raw material and manpower arrangement.

All the usage of sources depends on the planning of production of goods that come from the forecasting for the future that is needed to be sold to the customers. According to Chan et al. (1999) too many stock that is not necessary may encounter error during the forecasting.

1.1. Research Background

Company X's production planning and their production output is the objective of this research and to determine whether it is well planned and balanced to the customer needs. From the source of this company's internal production output data and comparison of sales to customers it was shown that the product that had been made in the production for several years exceeds the necessary quantity compared to the sale of quantity to the customer. Therefore, we understood that most probably, there is some error from the planning to the production that was made before. From the research also we found that there was no exact method/model of forecasting that is followed as a basis for the forecasting of the product to be produced.

Please refer to the actual details of the production output quantity and sale quantity as shown as below as a reference purpose and as a comparison for the review of effectiveness of forecasting that is made previously.

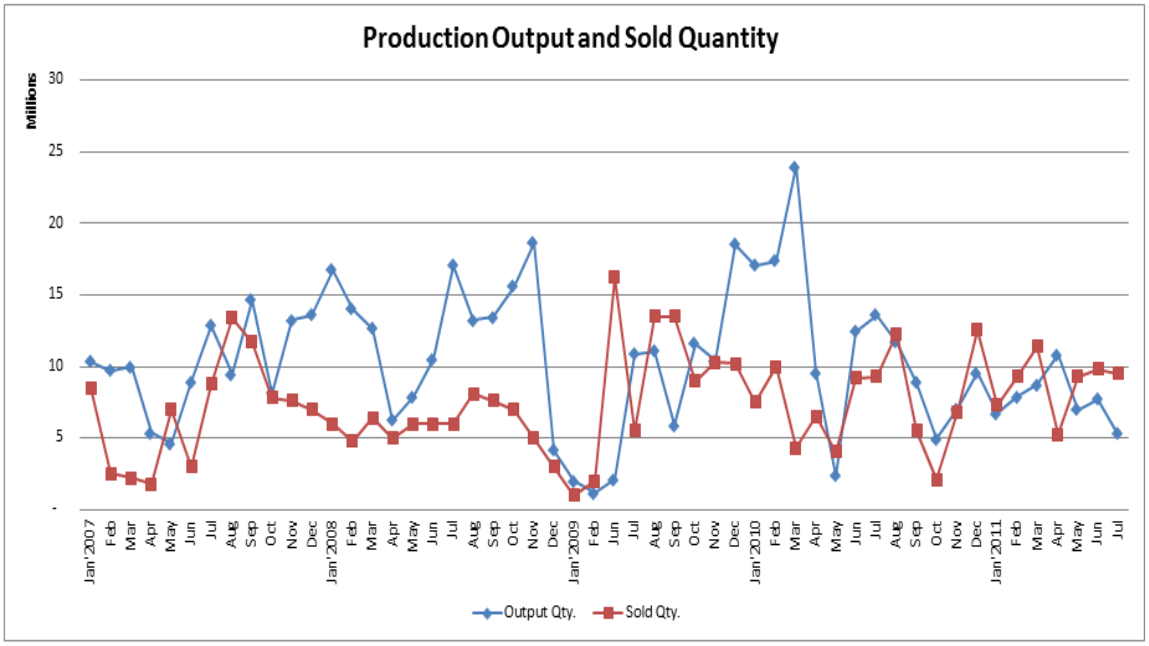


Figure: 1.5
(Source: Company X production chart and delivery data)

The above data illustrated the need for this research to be conducted in forecasting a model that can be followed by this company in the future to make the best production planning.

Several forecasting books explains that one of the general forecasting approaches is quantitative approaches .Under this approach there are three categories of forecasting

models .One of it, is time-series forecasting model. Under the time-series forecasting model there are also three common types of models such as the naive model, moving average model and exponential smoothing model. Therefore, this project will be looking into these three types of forecasting models to do research by finding the most suitable forecasting model to be used to forecast laser lamination core production in future.

1.2. Problem Statement

The decline in request from the customers have over the time, reduced the selling price to make lamination core because of the end product for this lamination core is mobile phone and the price is becoming drastically lower due to competition among the mobile phone makers over the world to provide to the consumers with good function and quality mobile phones at cheaper prices. Gene Koprowski (2006), the number of mobile phone subscribers will increase upwards by 50 per cent in the next four years". IDC - Press Release on 29 Mar 2011 said that "the worldwide smart phone market is expected to grow 49.2% in 2011 as more consumers and enterprise user's turn in their feature phones for smart phones with more advanced features". Latest IDC - Press Release on 04 Aug 2011 also said that the worldwide mobile phone market grew 65.4% over the year in the second quarter of 2011 (2Q11).

Therefore, from the above information, we found that the expected growth of 49.2% by smart phones to 65.4%. The increase in numbers of mobile phones in the market leads customer to demand from the supplier a reduction of price of mobile phones. Data finding from the research done on this company found that high monthly cost came from the purchase of raw materials such as silicon steel. Therefore, raw material in cure one of the highest costs in producing the laser lamination core in this company. As we understand the steel price is always increasing all the time. Please refer to the actual results as below from the previous result that was recorded by the purchasing department of this company for the ten highest purchased conditions in the year 2010.

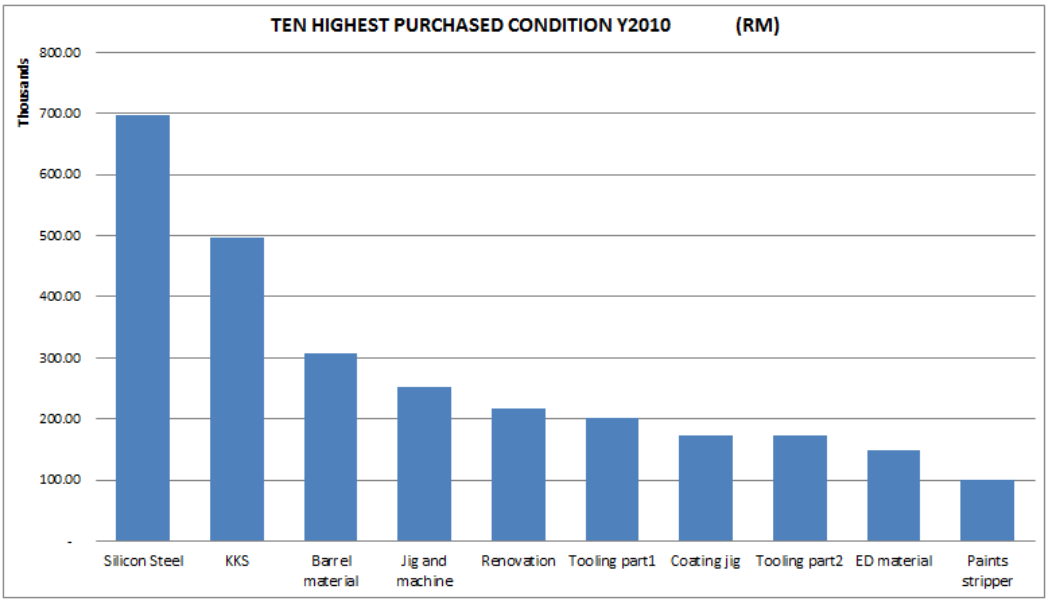


Figure: 1.6
(Source: Company X purchasing data for year 2010)

The competition among mobile phone makers around the world affects the selling price of mobile phones which continually decrease over time, as a result all the parts and one of those

parts such as mobile phone vibration motor selling price continue to decline. Due to the decrease of the selling price of mobile phone vibration motor, the laser lamination core is also affected to adjust and reduce its prices over time because customers periodically request for cost price to be lowered.

The selling price will continue to decline even though the costs of making lamination core such as silicon raw material and manpower salary arises. Therefore, to make sure businesses can be competitive in the market and can always compete among the competitors, one of the action that is needed to be taken is to control the production of output and at the same time the purchase of raw material can be controlled according to the needs of production when it is necessary to be produced.

1.3. Research Scope and Objective

1.3.1. Research scope

Research scope is the production output of main model of laser fastec lamination core model diameter 2.55x13(refer to figure 1) that is sold to the main customers.

1.3.2. Objective

The objectives of this project are mentioned as follows.

1) To decide the model of forecasting that is suitable to be used for the laser fastec lamination core.
2) To improve the material purchase base to necessary quantity needed.
3) To minimize the stock inventory.

2. Literature Review

Rob J Hyndman (2009), said that forecasting is about predicting the future as accurately as possible, given all the information available including historical data and knowledge of any future events that might impact the forecasts. M.Z. Babai and Y. Dallery (2005), showed that when the forecast uncertainty is absolute, the safety quantities are constant and they are equivalent to a safety stock.

2.1. Naive model

Rob J Hyndman (2009), highlighted that naive forecasting is where the forecast of all future values of a time series are set to be equal to the last observed value. J. Scott Armstrong and Michael C. Grohman (1972), said that naive methods are those which use data on only the dependent variable (e.g., a measure of sales). Typically, an analysis is carried out to see whether the dependent variable shows any regularity over time. The time pattern is then projected into the future.

Results of studies conducted regarding electricity power supply in Washington found that when the data contain some outliers, the exponential smoothing methods are suitable in this condition because it gives more weight to the most recently observed and the performance evaluation shows that an exponential smoothing method yields more accurate forecast than other methods said Hossein Javedani, Muhammad Hisyam Lee and Suhartono (2010).

2.2. Moving Average Model

Rob J Hyndman (2009), found a moving average is a time series constructed by taking averages of several sequential values of another time series. For an example, five months moving average is calculated by simply summing the data during the past five months dividing them by five. The differences between the forecast accuracy of various moving average lengths are rarely statistically significant. When they are, the differences usually are not more than a cent or two per bushel. Consequently, the selected length of moving average to use for basis forecasting may not matter according to Robert B. Hatchett, B. Wade Brorsen, and Kim B. Anderson (2010).

Russell J. Elias, Douglas C. Montgomery and Murat Kulahci (2006), found even the selection of short spans cannot prevent forecast lag if the moving average model is applied to a prediction and series exhibiting a linear trend.

2.3. Exponential Smoothing Model

According to Philipp K. Janert (2006), all exponential smoothing methods are conveniently written as recurrence relations, the next value is calculated from the previous one. Philipp K. Janert (2006), found smoothing control α is within ($0 < \alpha \leq 1$), controls the amount of smoothing, if $\alpha = 1$, the curve is not smoothed at all, if $\alpha = 0$, the curve is absolutely smooth, in fact, it shows no variation at all (i.e. it is a flat line)".

Imrul Kaes (2009), obtained results showed future demand of the particular raw material can be forecasted very precisely with the adaptive exponential smoothing method. Cihan Aksop (2010), made conclusion from the research of AR(1) process, a comparison of moving average and exponential smoothing technique is made by evaluating mean and variance of the error terms. Some simulations are also presented that exponential smoothing is suitable for AR (1) models.

Peter R. Winters (2010), conclude, there are several advantages of exponential forecasting model over more conventional forecasting models such as (1) it gives better forecasts,(2) it requires less information and storage space, (3) it responds more rapidly to sudden shifts in the time series so that it routinely protects the forecaster.

3. Research Methodology

This research/project is carried out in the industry of metal stamping company that is fully owned by Japanese. The main business of this company is to make tooling parts of metal stamping dies, service of dies, produce laser fastec lamination core and produce laser fastec lamination coating core. However, the main product that is produced by this company is to produce laser fastec lamination core. Therefore, this project is concentrated to the one model under the production of laser fastec lamination core that is called as model 2.55x13.

3.1. Research design

This research is aimed at finding the solution in which forecasting models can be used to make better forecasting for the company. The research will start with discussion with the company production manager and purchasing manager to discuss about how they record the

data of production output and the data of purchased and sold product. If they have recorded all the data in proper manner, therefore, we have to request the data as research data. After receiving the data we have to summarize it.

Therefore, we choose the quantitative data of production output of model 2.55x13 laser lamination core as data to be studied and compared among the three forecasting models such as naive model, moving average model and exponential smoothing model. The same data will be used to calculate the entire three models and to look into the condition of the best forecasting model to be used. Forecasting model to the production output will be compared with the actual product that is sold as reference whether the production output is enough to cover customers' orders or not. The nearest results of forecast of each model after the calculation of each forecasting models are going to be chosen as the best forecasting method that can be used for this company.

3.2. Data collection

Data that will be studied is the data of production that is recorded to the production chart. The data that is going to used is model 2.55x13 laser fastec lamination core production output. The data range is taken fifty two months from Jan'2007 until July'2011. The actual data that will be used for the analysis will be available as appendix A.

3.3. Data Analysis

The above data is going to be used to calculate the forecast for each forecasting model such as naive model, moving average model and exponential smoothing model. All the calculation is done by using Microsoft Excel and then analysed. The data will produce inputs which are then be used to make a table and the calculation formula for each forecasting model. From the calculated data the line graph will be created. Each forecasting method will also calculate the overall forecast errors using the mean absolute per cent error (MAPE) method.

3.3.1. Naive model

From the above fifty two months sample data, it will calculate and get fifty naïve forecasting model data.

3.3.2. Moving average model

This research is going to use three months of moving average. It is calculated by simply summing the data during the past three months and dividing them by three. From the above fifty two months sample data, it will be calculated and get forty nine moving average forecasting model data.

3.3.3. Exponential smoothing model

This research calculation will use smoothing constant $\alpha = 0.1$ and 0.5 as study. From the above fifty two months sample data, it will be calculated and get fifty one exponential smoothing forecasting model data.

3.3.4. Mean absolute per cent error (MAPE) method

Using this MAPE method the overall forecast errors will be compared with all the three forecasting models as above and the one with the least error is chosen.

3.4. The forecasting methods

3.4.1. Naive model

Actual production outputs of laser lamination core model 2.55x13 for the two months will be calculated to obtain results of forecasting for the third month. The data with trend, the forecast is equal to the last value of the series plus or minus the difference between the last two values of the series.

3.4.2. Moving average model

Actual production outputs of laser lamination core model 2.55x13 for the three months will be calculated to get the forecast for the fourth month. Common/simple moving average forecast formula as follow.

$$F_t = MA_n = \left(\sum_{i=1}^{n} A_{t-1} \right)/n \quad (3.1)$$

Remarks,
i = an index that corresponds to time periods
n = number of periods (data points) in the moving average
A_t = actual value in period t-i
MA_n = Moving average
F_t = Forecast for time period t

3.4.3. Exponential smoothing method

Production outputs of laser lamination core model 2.55x13 will calculate with smoothing constant $\alpha = 0.1$ and $\alpha = 0.5$. Basic exponential smoothing forecast formula as follow.

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \quad (3.2)$$

Remarks,
F_t = Forecast for period t
F_{t-1} = Forecast for the previous period
α = smoothing constant($0 < \alpha \leq 1$)
A_{t-1}= Actual demand or sales for the previous period

3.4.4. Mean absolute per cent error (MAPE) method

The formula to calculate overall forecast error MAPE as follow,

$$\text{MAPE} = \left[\frac{\sum \left(\frac{|\text{Actual} - \text{Forecast}|}{\text{Actual}} \right) \text{X } 100}{\text{n}} \right] \quad (3.3)$$

$$= \left[\sum \frac{\left[\left(\frac{|\text{Error}|}{\text{Actual}} \right) \text{X } 100 \right]}{\text{n}} \right]$$

4. Data Analysis and Results

4.1. Naive model

Referring to the raw data of actual output quantity from appendix A the example calculation of the naïve model with trend that was mentioned in the forecasting method as above is as given below. Production outputs of laser lamination core model 2.55x13 for the two months are taken for calculation as follows.

Table: 4.1

Month	Production Output actual(pcs)	Change from previous month(pcs)	Forecast (pcs)
Jan '2007	10,336,968		
Feb	9,707,311	629,657	
Mar			10,336,968

Therefore, all the data as mentioned in appendix A will be calculated using the same way as above by using Microsoft excel programme with error calculation MAPE and the results after calculation will be referred as appendix B. The trend conditions of actual quantity of output against the forecast are shown as below figure 4.1.

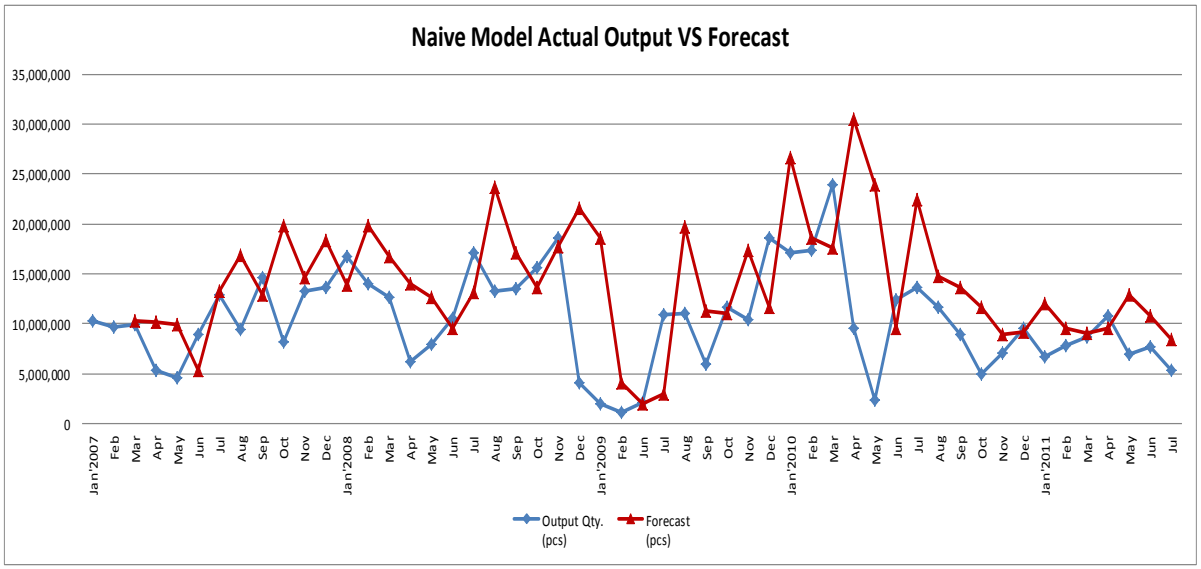


Figure: 4.1

From the above figure 4.1 what we can interpret from the trend is the naïve model forecasting is almost higher than the actual output quantity. To understand this condition better refer to the figure 4.2below showing that the error at minus side which actually shows us that the naïve forecasting model is almost higher than the actual output. From the data point it was

understood that the quantity forecast is 70% of the month is higher than the actual output quantity.

It is evident from figure 4.1 that there is a period of increasing and decreasing during the production of the product. The significant increase in period is during Jun '2009 to Mar '2010. During this period we can see that the characters of naïve forecasting model. Other period the forecast quantity is almost higher as mentioned above.

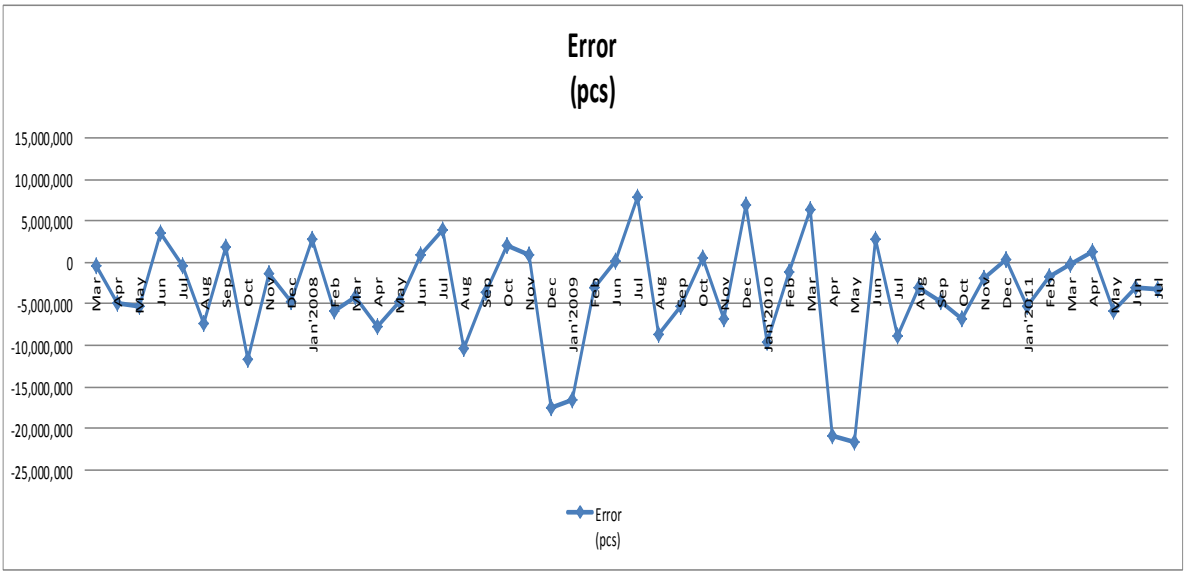


Figure: 4.2

Overall forecast error MAPE for Naïve model is 90.1%, which is of very high error. The total quantity forecast against total sold quantity from April '2007 to July '2011 is about 321.3 million pieces therefore this quantity will become stock inventory to the company if this forecasting model is chosen. The total forecast quantity during this period is about 693.4 million pieces, therefore in following this forecasting quantity of the raw materials requires the need to be on standby and making purchases in accordance to the forecasting quantity.

Figure 4.2 also shows that, there is abnormality during two periods from Dec '08 to Jan '09 and from Apr '10 to May '10. The error at minus side is obviously higher was effected due over production on Nov '08 and Mar '10(refer figure 1.5). Unbalance of previous month output affected the forecasting of the next following month forecasting. Therefore, when the too obvious abnormal condition happen naïve forecasting model can give indicator on that situation. However, when the situation of the following month drastically increases or decreases the forecasting quantity may over produce or less produce.

4.2. Moving average model

Production outputs of laser lamination core model 2.55x13 for the three months are taken for calculation as follows.

Table: 4.2

Month	Production output actual (pcs)	Forecast (pcs)
Jan '2007	10,336,968	
Feb.	9,707,311	

Mar.	9,965,953	
Apr.		10,003,411

Therefore, all the data as mentioned in appendix A will be calculated the same as above by using Microsoft excel programme with error calculation MAPE and the results after calculation will be available as appendix C. The trend conditions of actual quantity of output against the forecast are shown as below in figure 4.3.

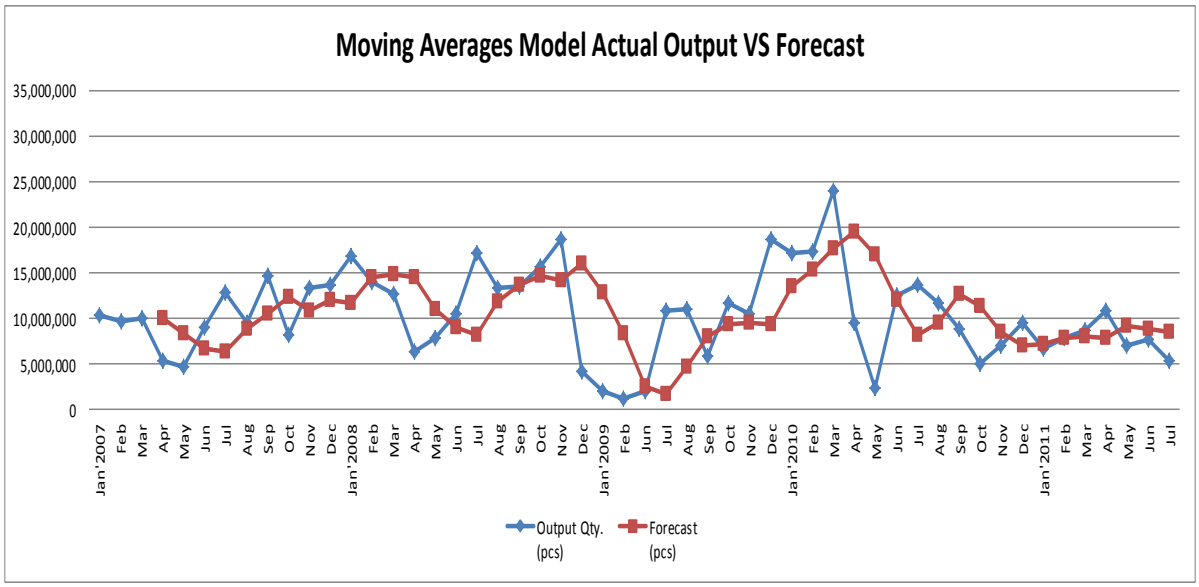


Figure: 4.3

From the figure 4.3 above what we can analyse from the trend is the moving average model forecasting rather than the actual output quantity but sometimes it is lower than the actual output quantity. To better understand this condition refer to figure 4.4 below showing that the error at minus side and plus side are more about similar and this actually shows us that the moving average forecasting model trend is more balanced than the actual output. From the data point we understood that the quantity forecast at minus side is 45% and plus side is 55% of month, therefore the minus side is a little bit lower than the plus side in certain short periods than the actual output quantity.

Overall trend shows that within three months of average, the forecasting is adjusted to the nearest actual output quantity and the trend is follow the situation of actual output quantity. During the obvious period Dec ’08 to Jan ’09 and Apr ’10 to May ’10 the error is less than naïve model.

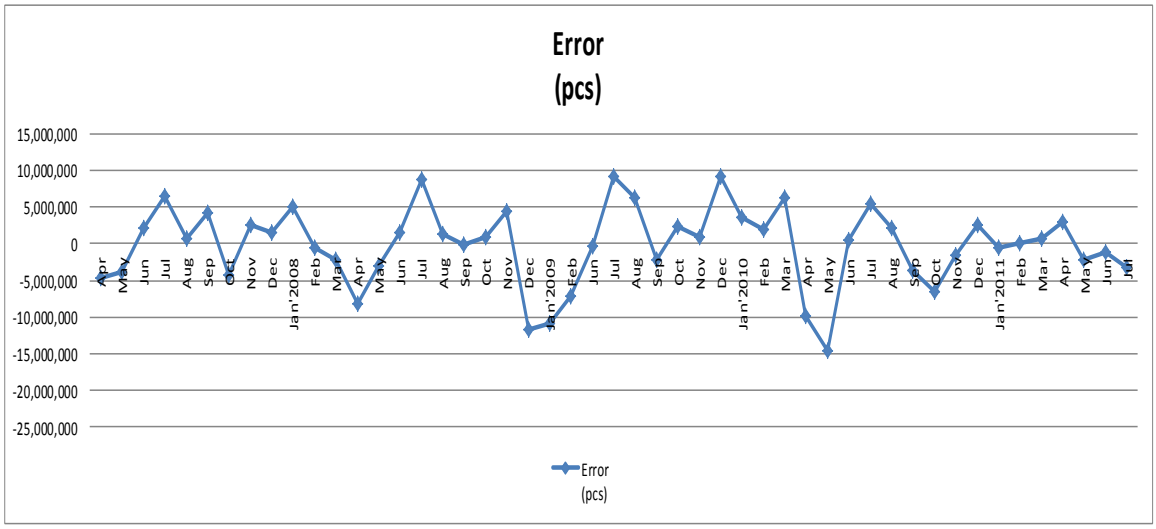


Figure: 4.4

Overall forecast error MAPE for moving average model is 69.7%, which is still high as an overall error. The total quantity forecast against total quantity sold from April '2007 to July '2011 is about 142.1 million pieces, therefore this quantity will become stock inventory to the company if this forecasting model is chosen. The total forecast quantity during this period is about 514.3 million pieces, therefore to follow this forecasting quantity of raw materials need to be purchased to meet the forecasting quantity.

Overall error can be judged as stable in any period even during the period that the production quantity is high against the sold quantity.

4.3. Exponential smoothing method

Refer to the raw data of actual output quantity from appendix A the example calculation of the exponential smoothing method with smoothing constant, $\alpha = 0.1$ and 0.5 that was mentioned in the forecasting method above are given as below.

Therefore, all the data as mentioned in appendix A will be calculated the same as above by using Microsoft excel programme with error calculation MAPE and the results after calculating will be available as appendix D for smoothing constant, $\alpha = 0.1$ and appendix E for smoothing constant, $\alpha = 0.5$.

4.3.1. Exponential smoothing method with $\alpha = 0.1$

The trend conditions for the smoothing constant, $\alpha = 0.1$ of actual quantity of output against the forecast are shown in figure 4.5 below.

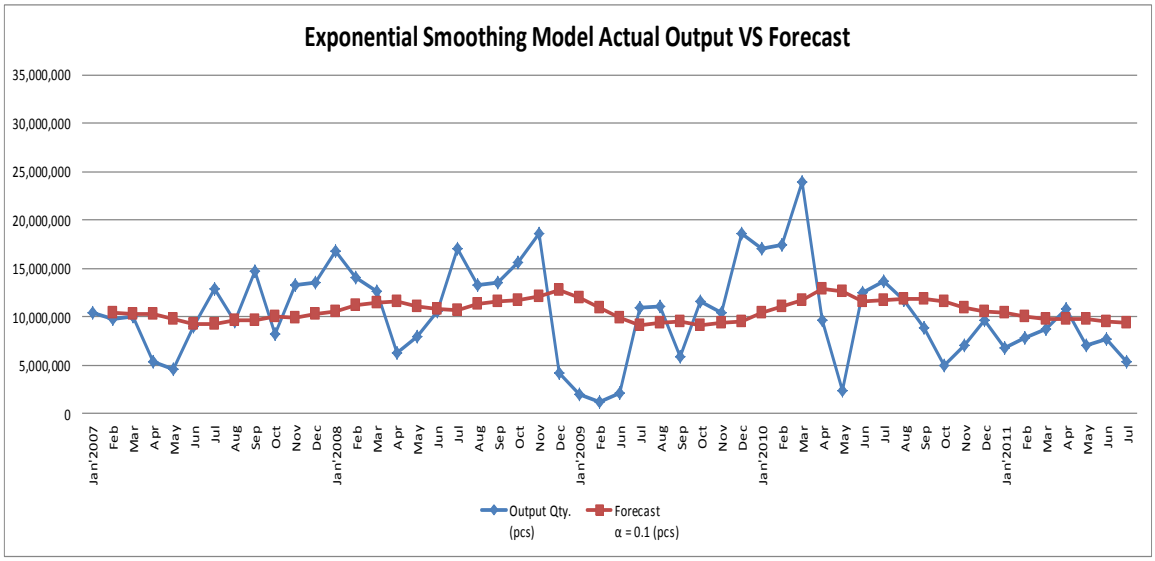


Figure: 4.5

From the figure 4.5 above what we can summarize from the trend is the exponential smoothing model with $\alpha = 0.1$. To understand this condition better refer to figure 4.6 below. It shows that the error at minus side and plus side are also about similar and that it actually shows us that the exponential smoothing forecasting model with $\alpha = 0.1$ trend is more balanced than actual output. From the data point we understood that the quantity forecast at minus side is 55% and plus side is 45% of month, therefore the minus side a little bit higher than the plus side but it looks like make balancing in a little bit longer period than the actual output quantity.

Above figure 4.5 trend shows that any increases or decreases to the output do not affect the forecasting much.

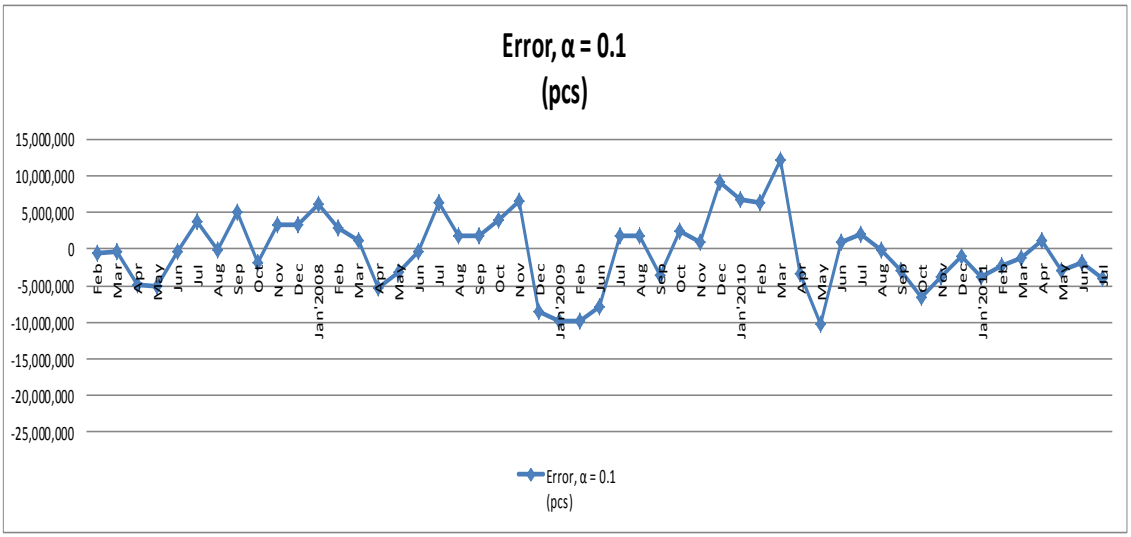


Figure: 4.6

Overall forecast error MAPE for exponential smoothing model with $\alpha = 0.1$ is 74.4%, which is still considered high as an overall error. The total quantity forecast against total sold

quantity from April '2007 to July '2011 is about 148.1 million pieces, therefore this quantity will become stock inventory to the company if this forecasting model is chosen. The total forecast quantity during this period is about 520.2 million pieces, therefore to follow this forecasting quantity the raw materials also need to be purchased to meet the forecasting quantity.

Trend of figure 4.6 shows the error is stable in the centre of axial, that means the forecasting model is almost the same all the time.

4.3.2. Exponential smoothing method with $\alpha = 0.5$

The trend conditions for the smoothing constant, $\alpha = 0.5$ of actual quantity of output against the forecast are shown below in figure 4.7.

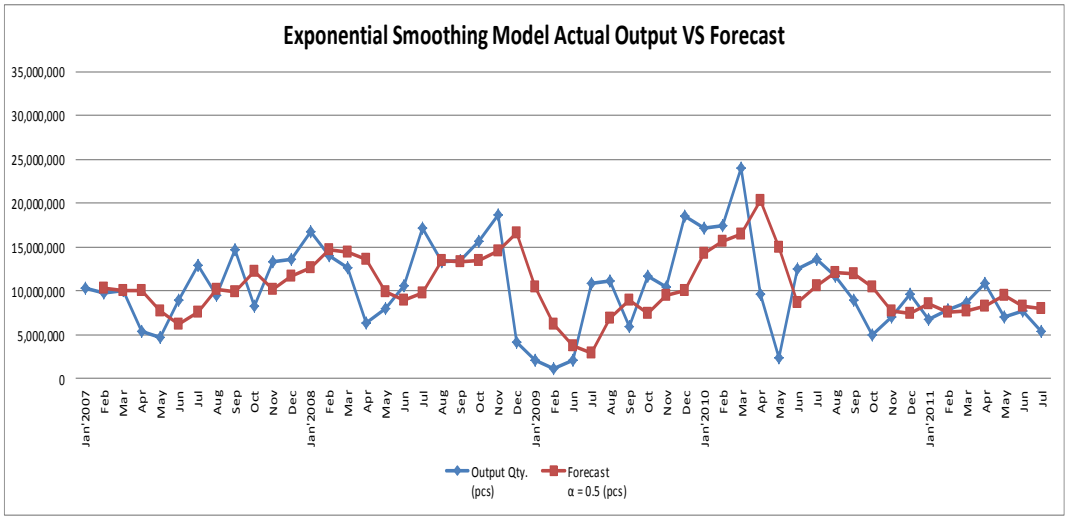


Figure: 4.7

From the above figure 4.7 what we can conclude from the trend is the exponential smoothing model with $\alpha = 0.5$. To better understand about this condition refer figure 4.8 below which shows that the error at minus side and plus side are almost similar and that it that it shows us that the exponential smoothing forecasting model with $\alpha = 0.5$ trend is more balanced than actual output. From the data point we understood that the quantity forecast at minus side is 51% and plus side is 49% of month, therefore the minus side and the plus side considered as the same and the trend looks like it is making balance in the long period than the actual output quantity.

From the figure 4.7 we understood that if the exponential constant is higher which is more than 0.1 the trend becomes similar with the actual output.

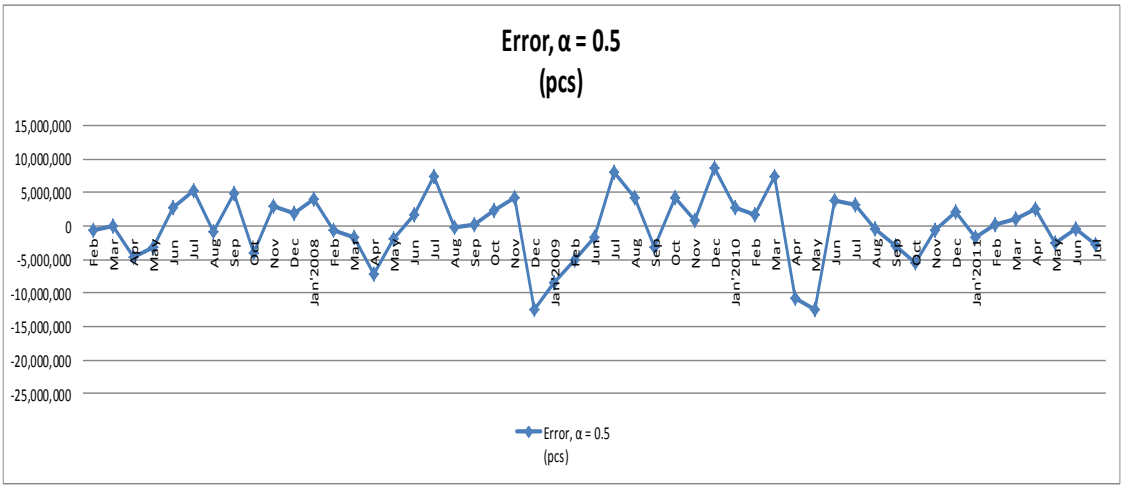


Figure: 4.8

Overall forecast error MAPE for exponential smoothing model with α = 0.5 is 61.8%, which is still high as an overall error but it is the smallest error shown among the entire above forecasting models. The total quantity forecast against total sold quantity from April '2007 to July '2011 is about 141.7 million pieces, therefore this quantity will become stock inventory to the company if this forecasting model is chosen. The total forecast quantity during this period is about 513.9 million pieces, therefore to follow this forecasting quantity the raw materials also need to purchase to meet the forecasting quantity.

Overall trend from figure 4.8 shows the error is stable and the points of error also fluctuate at the centre of axial. This indicates that the trend condition is in control at all the period.

4.4. Summary results

All the forecast data from the three type models are summarised as Appendix F. This data is summarized from April '2007 until July '2011 to make sure all the judgements are done in the same period.

To judge the objectives of the project, table 4.3 below had summarized the evaluation items for easier judgement in choosing which the suitable forecasting model to be use is. Summarizing evaluations items can also be judged whether it is able to improve the raw material purchase base to necessary quantity needed and which can minimizes the stock inventory.

Table: 4.3

No.	Evaluation items against objective (Period : Apr'07 - Jul'11)	Naïve (data with trend)	Moving Averages (3 months)	Exponential (α=0.1)	Exponential (α=0.5)
1	Stock inventory condition (million pcs) (Total forecast - total sold)	321.3	142.1	148.1	141.7
2	Total produce quantity (million pcs)	693.4	514.3	520.2	513.9
3	Overall forecast error-MAPE (%)	90.1	69.7	74.4	61.8

The figure below shows the condition of each evaluation items refer as below, No.1 for figure 4.9, No.2 for figure 4.10 and No.3 for figure 4.11.

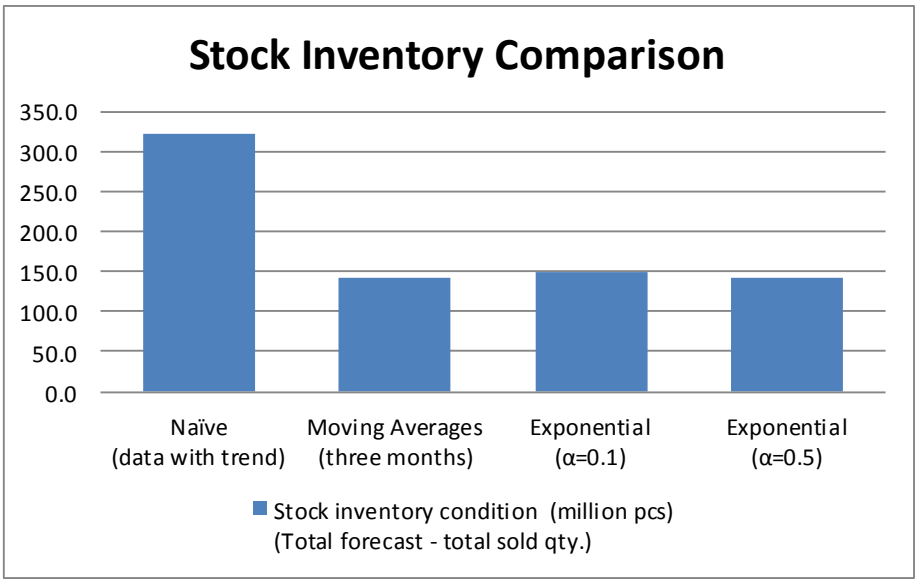


Figure: 4.9

Figure 4.9 above shows that exponential smoothing with smoothing constant α = 0.5 can be chosen as forecasting because the stock inventory is less compared with the other models.

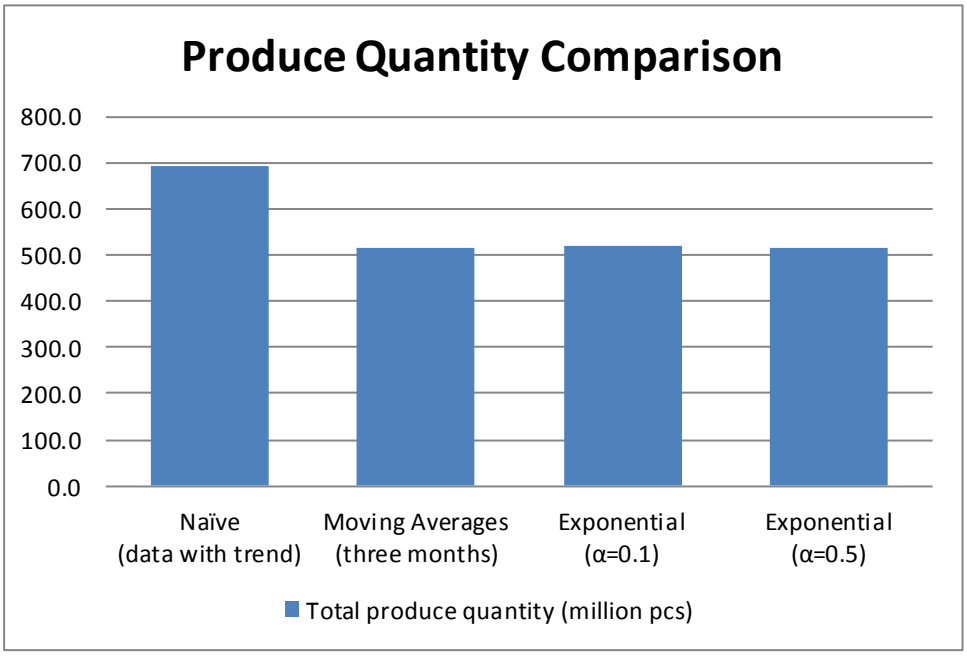


Figure: 4.10

Figure 4.1 above shows the result that exponential smoothing with smoothing constant α = 0.5 also can be chosen as forecasting because the total produced quantity is lesser compared with the other forecasting models, therefore it can improve the raw material purchase.

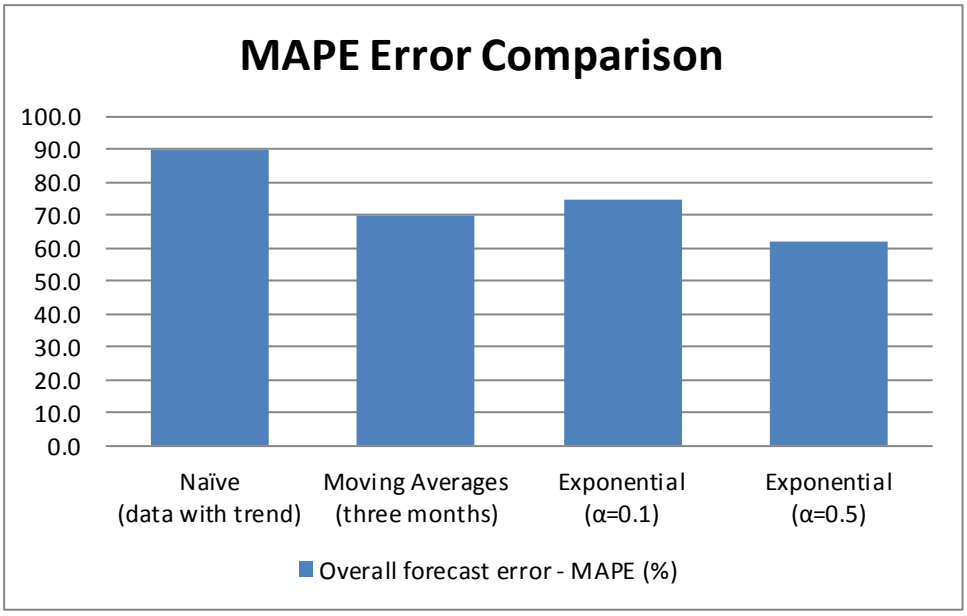


Figure: 4.11

Figure 4.11 above shows that exponential smoothing with smoothing constant $\alpha = 0.5$ can also be chosen as forecasting because the overall forecast error is lesser among the other forecasting models.

5. Conclusion

Naïve forecasting model trend shows that the characteristic to produce the quantity of production is higher than the actual output. Therefore, the error of forecasting is higher compared to actual condition whether at minus or plus side. If quantity of the production drastically increase or decrease for the following month, naïve forecasting method is difficult to follow the trend because the method follows the previous months different quantity of two months. Due to this, the condition of naïve forecasting will make error during change of production within two months. In overall the naïve forecasting method trend will produce high production quantity and it will affect the high stock inventory against the sold quantity. Therefore, among all the three types of forecasting method that were researched, naïve forecasting method is the worst condition for all evaluation items such as table 4.5.

Moving average with three months average shows that the forecasting quantity always follows the trends of production as average within the three months. The production quantity is less than the quantity produced by naïve forecasting method but about the same quantity (figure 4.10) produced by other types of forecasting method. It is also the same condition of stock inventory (figure 4.9) with moving average and exponential smoothing method. However, for the overall forecast error MAPE it is better than naïve method and exponential smoothing with smoothing constant 0.1 but a little bit worse than the exponential smoothing with smoothing constant 0.5.

Exponential smoothing forecasting method with smoothing constant shows that the trend of the forecasting is affect by the condition of the smoothing constant.

Comparison within 0.1 and 0.5 shows the higher smoothing constant means the better result. The evaluation items such as table 4.5 show this condition.

Therefore, from all the results as above it was found that the exponential smoothing with smoothing constant $\alpha = 0.5$ is the most suitable forecasting model that can be applied to make forecasting for the laser fastec lamination core model diameter 2.55 x 13 for the company X. The use of this forecasting model will enable the control of)the production output and at the same time the purchase of raw material can be controlled according to the needs of production when it is necessary to be produced.

This result also confirmed the previous study by Imrul Kaes(2009), who obtained the result which showed future demand of the particular raw material can be forecasted very precisely with the adaptive exponential smoothing method. Previous research conducted by Peter R. Winters (2010) also concluded that several advantages of exponential forecasting model is that it gives better forecast and it requires less information and storage space.

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