HYBRID MODEL FOR SUPPLIER SELECTION, PROCUREMENT, AND PRODUCTION

Catur Kurniawan[1], Nur Hildawati[2]

University of Pembangunan Nasional Veteran Jakarta, Indonesia
E-mail : catur_k444@yahoo.com

ABSTRACT

The integration of supplier selection process, procurement, and production using hybrid model generates the best approach to replicate the real system itself until produce some valid output estimation as a high trusty decision making. Areas such as supplier selection, reorder point, materials (re-)ordering, production capacity, scheduling, status and entity location, operator swing for multi jobs and multi locations, these the partial objects which are integrated by using a combination of mathematical model and simulation model to reach the optimization or the estimate information of the entities amount, time and cost. The model is capable of handling the production operations both with strict limitations due date in Make To Order (MTO) environment, as well as handling orders which strive for the repetition of ordering raw materials based on demanding patterns of deterministic or probabilistic Make To Stock (MTS) environment.

***Key words**: hybrid model, supplier selection, procurement, production*

1. INTRODUCTION

The crucial point of integration between the supplier selection with manufacturing systems ranging from procurement, fabrication and assembly which particularly related with the adoption of Just-In-Time which emphasizes the reduction of material supply (Pearson & Ellram 1995) where deliverability and quality become the main criteria (Chapman, 1989; Chapman and Carter, 1990). It is mainly applied in manufacturing operating systems use MTO. Even tough, in some manufacture which their product consist of few characteristics variant of standard products which is using homogeneous raw materials, it also requires MTS operating system. So this paper yields the optimization or estimates future information supply to decision makers in manufacturing management regarding supplier selection, reorder point, ordering the amount of raw materials, production capacity, production scheduling, property status and location of the entity, as well as multiple assignment operator competence on the multiple jobs and locations, as the partial objects which are integrated by using a combination of mathematical model and simulation model to the hybrid model in MTO and MTS operating circles.

1.1. Modeling System: Manufacturing as a complex system

Manufacturing is an aggregate of operations and production activities which are interrelated in the manufacturing industry such as product design, material selection, production planning, production, inspection, management and marketing products (Chang et. Al, 1991). Complexity occurs because of variability and interdependence (Harrel, et.al). Variability of manufacture elements such as the arrival, entities, process, locations, resources, and path network will potentially cause the probabilistic nature.

1.2. Integration of Manufacturing Systems Using Hybrid Model

Sub operations and production activity in each section in the manufacturing requires the problem solving by approaching most appropriate method of characteristics. Supplier selection and inventory systems using mathematical model, while simulation model is applied to the shop floor which contains the probabilistic nature. Hybrid model is defined as the combined system between simulation and mathematical model. Simulation model are usually discrete, and mathematical model are usually continuous, so they both interaction models called hybrid model (Bemporad et al, 2006).

1.3. Dual Production System Operating Environment MTO and MTS

Manufacturing which has a standard product type should implement dual system of MTS and MTO. Dual system can refine the sudden rising demand or assure availability of finishing goods from the uncertain market nature (Cattani, et al., 2003), reduce the risk of back ordering when the raw material defected. (Rajagopalan, 2002), lower production costs due to MTO time efficiency (Eynan and Rosenbaltt, 1995).

2. THEORETICAL BACKGROUND

2.1 Production Operating System in Manufacturing

Bertrand et. al, (1990) classified manufacturing systems based on the company's strategy in handling the consumer demand consist of: MTS and MTO. Another production system are Assembly To Order (ATO) and Engineering To Order (ETO).

2.2 Procurement Process and Supplier Selection

In the principle, supplier selection is important because the enterprise that puts attention to aspects of supplier selection strategy proved to have positive benefits in terms of quality of buyer-seller relationships and improved financial buyer performance (Carr and Pearson, 1999). Some of the literatures looked at the reality of the difficulty in dealing with many suppliers because of the differences of their characteristics (Maturana et al., 2004). Supplier selection is important to support the company to develop and maintain its competitiveness in the market (Sarkis and Talluri, 2002). Competitiveness is achieved at the desired quality level and at the right price, the level of technical support required, and the service level desired (Dobler et al., 1996). Some previous researchers used many techniques, such as supplier selection by Ghodsypur and O'Brien (1998) and Shiau et al (2004) used AHP technique. The further model added the limiting capacity owned by each vendor by Ghodsypur and O'Brien (2001) and Benson (2004). To cope with the price factor and delays, Cakravastia and Nakamura (2001, 2002) put negotiations as consideration for supplier selection, then Cakravastia and Takahashi (2002) developed a model of manufacturing planning made by Kolisch (2001) by adding material procurement barriers from suppliers. The negotiation model was completed into a supplier selection model which also involves negotiating by Cakravastia and Takahashi (2004).

2.3 Inventory System

According to Fitzsimmons (2001) Economic Order Quantity (EOQ) model can assume a constant level of demand and there is no stock out. In such situation the demand is constant for a large number of consumers purchase periodically in small amounts and stock out are not allowed to be occurs. Furthermore, Fitzsimmons (2001) adds that kind of simple EOQ cannot handle for the uncertainty in the inventory level or at the replenishment lead time. Uncertainty can lead the risk of stock out. To reduce this risk, additional supplies can be stored for anticipating the excess of demand in the lead time. The concept of service level is a key of inventory control under uncertainty.

2.4 Mathematical Model

According to J.D.C. Little, 1970, The useful mathematical model should be simple, complete, easy to manipulate, adaptive, communicative, the model explains the studied situation, the model has relevant information that appropriate for decision making. Optimization is a mathematical method using iteration derivatives and differential functions to get the minimum or maximumobjective functions. Set parameters, index and determination of constraint variables are used to declare the problem in a mathematical algorithm.

2.5 Simulation Model

Deming (1989) states, “Management system reacts upon the prediction. Rational prediction requires systematic learning and comparison of short-term and long-term results from possible implemented alternative actions”. Simulation precisely provides all needs. Schriber (1987) suggested "Simulation is the model of a

ISSN : 1978-774X

process to simulate and respond the actual system that can be replayed any time". Finally, a practical definition related to dynamical systems given by Harrel et al., (2004) "Simulation is the imitation of dynamical systems using computer model to evaluate and develop the performance of the system". Simulation can maintain system performance (Lloyd and Melton 1997); Simulations have been proven about their effectiveness to deal with complex issues surrounding the manufacturing decisions. Kochan (1986); Simulation can minimize the costs incurred as the result of system development. Harrel (2000).

2.6 Integration with Hybrid Model

Several previous studies have attempted to integrate the operational factors on manufacturing production systems by raw material procurement factor. D'Amours et al., 1996 has developed a model for planning price and action scheduling bases with multiple products to produce a symbiotic manufacturing network. Li and O'Brien (1999) have developed a two-stage model to design the efficient supply chain. In fact, hybrid model is dependable not only in theory, but also its ability to model, analyze, and synthesize the controllers in a broad range of application (PJ Antsaklis, 2000) including the manufacturing system (DL Pepyne et al., 2000 and Fabulduzzi, 1999). Venkateswaran and Jones, (2004), proposed a hybrid model based on production planning architectural simulation which consists of System Dynamics (SD) at the enterprise level and Discrete Event Simulation (DES) for the production floor level. McLean et al., (2000), proposed architectural assignment for manufacturing with simulation techniques. Byrne, et al, (1999), did the merge of analytical approach with hybrid simulations on production planning.

3. RESEARCH METHOD

This research uses partial solution methodology toward each ones at local parts. Then, make a relation among these partial model by submitting the results of the settlement operation process and formed as the output variable from a prior local section to be accepted as an input variable to another local section and continuously occurs until it builds an unbroken chain of information from upstream to downstream which is the characteristic of global integration. Partial solution at each local part uses different models, where the selection of application solutions based on the excellence of the model's characteristic to match with dominant behavior in the local section. The models are the mathematical model and simulation model. The dominant behavior is deterministic or probabilistic, either continuous or discrete. Mathematical model is suitable to solve deterministic problems and or continuous, while the simulation model is suitable to solve probabilistic problems and or discrete. The using of different models for problems solving in an integrated information chain is the characteristicof hybrid model. Trigger variables are included as the seed of frame work. If the number of units of trigger variable is greater than the process capacity, there will be more than one terms process (recursive). Methodology applications on the manufacturing system which processes products with standard designs are shown in Figure 1. Generally the model works as follows:

3.1. P0 as Trigger Parameter

Forecasting of market study play role as trigger input parameter to generate of finishing goods order (Q_{ai}).This parameter is further decomposed into variable of material requirements which accepted in the fabrication as the arrival of a new entity.

3.2. From P1 to P2

Connectivity fabrication of the purchasing activity lies in the location of the first machines that performed internal transactions such as raw material consumption. It is named as a material depleted or demand (*d*) of the fabrication. Processing time result from the production simulation model of P1 is then used to be the information to determine the Economic Order Quantity (EOQ) in P2.

3.3. From P2 to P3

Connectivity between sustainable inventory, procurement and supplier selection are protocoled by manufacturing targets. Initially in previous research, the two targets is the given parameter, in this study these two parameters are fixed by retrieved EOQ formula with uncertain demand to produce reorder point (R_n) and next quantity allocation (q_n).

3.4. From P3 to P1

Connectivity supplier selection to fabrication is characterized by obtaining the variable of delivery time of raw materials by selected supplier ($ELTa_i$) marks the commencement of production activities and sustainability.

3.5. From P1 to P4 and or Recursive Termination

After the fabrication, the final flow of frame work can lead to P4 as a finishing goods or recursive back to P2.

4. RESULTS AND DISCUSSION

4.1. Market Forecasting as a Trigger Parameter to Generate Hybrid Model

As a manufacture which is combines dual operating system (MTO and MTS) with various standardized product designs and mostly uses homogeneous raw materials, then the forecasting order quantity value of the finishing goods variable (Qa_i) is based on seasonal patterns. This value is the initial trigger of hybrid model to be received into the material arrival in warehousing and inventory system.

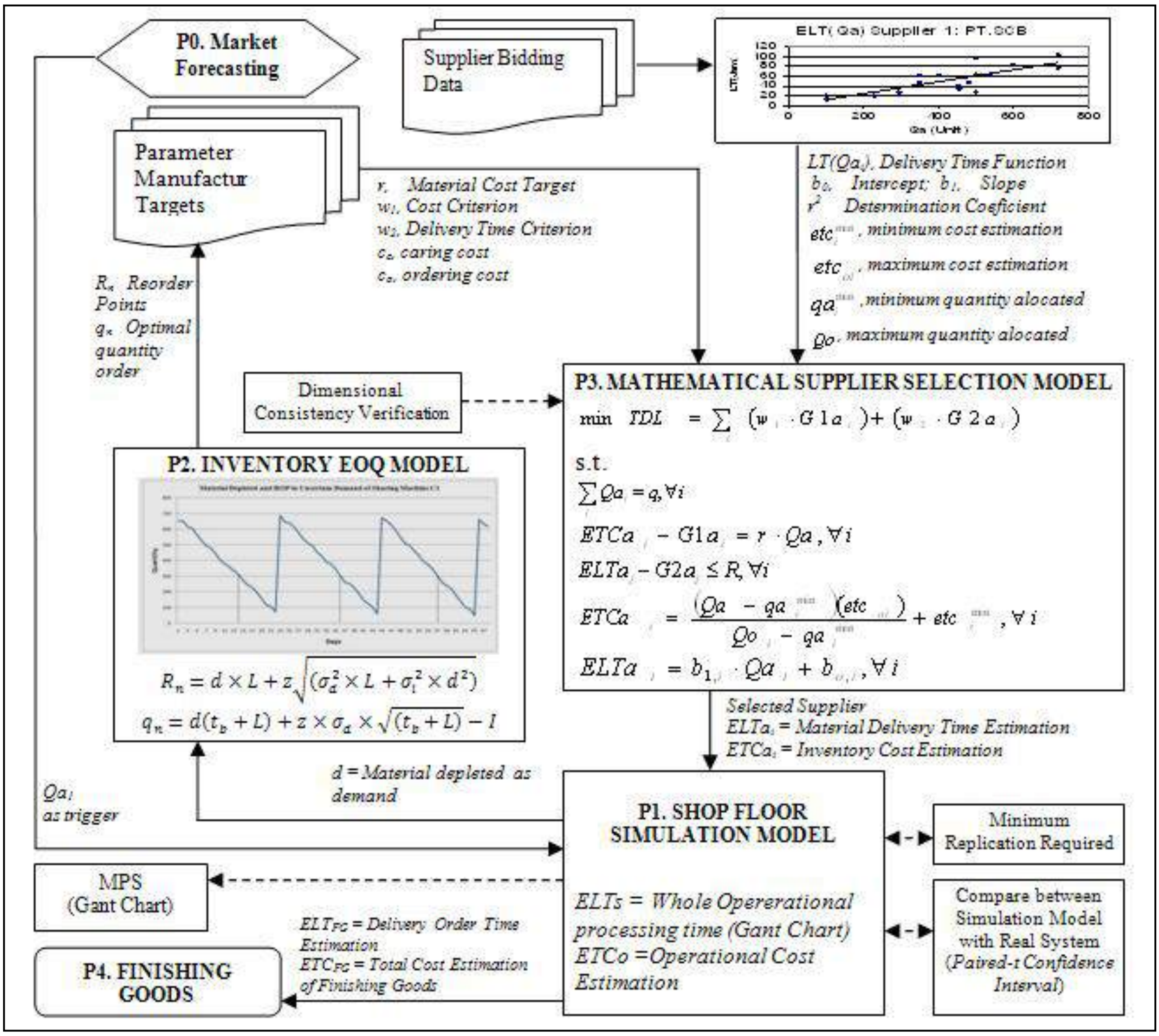

Figure 1. Research Methodology Framework

4.2. P0, Arrival Material Parameters

The number of raw material arrivals to the warehouse location is a bill of material decomposition which is computes from market forecasting product demand (*d*) reduced by inventory on hand. Variable raw material inventory will be updated immediately after raw material receipt.

4.3. P1, Production Simulation Model

The arrival variable of raw material on warehouse location as inventory availability then to be informed to the location of the first machine which initially processed them in work shop as signal to begin the fabrication process. Simulation model used in this section, especially for manufacturing which operates manually, where the characteristics of the manufacturing process most possibly occurs on probabilistic circumstances. Design and development of the simulation procedure is done to improve the work efficiency of modeling design and effectiveness of simulation output against the actual system. The model is designed by using ProModel® software tools. To simplify the problem, the model is designed without the burden of the job queue, with no initial inventory of raw materials. The needs for simulation design are (1) for the preparation of optimum production schedule for each customer orders receipt in order to be specified due date delivery estimate for *d* day to customers, (2) for the necessity of raw materials ordering by the procurement division based on manufacturing production schedules to assure the availability of raw material to the *q* number of units.

4.3.1. Collecting, Entering and Analyzing Data from The Real System

In this section, data are recorded into the simulation program, includes the location of each machine, bill of materials as an entity, path networks, resources, and the occurred processes either the time process also. Location of machines, facilities and networks are drawn up to replicate reality situationin a certain scale using graphic tools in ProModel®. Entity Flow Diagram (EFD) derived from the processing map and product structure. While the processing time data is collected from each machine for each performed entity with the amount of sufficiency data. Verification is to compare simulation model with the designed concept. Improvement process doing by trial and repeatedly to achieve a model with the congruity concept based on verification techniques. Model validation done by comparing simulation output with real production operational schedule in the field using the Paired-t Confidence Interval method.

4.3.2. Gant Chart for Master Production Schedule

Gant chart as Master Production Schedule obtained by activating the Object Linking Embeded (OLE) procedure in which a number of code added to make the field data from the ProModel® simulation software in order to export to the notepad® files and Excel® spreadsheet to become kind of database management system. Field made the information about the files name, time segment, main management activity, location of machining process, product name, process sequences, the level of product, and entity name. Files consist of rows of data per time segment so that the gant chart matrix can be arranged through the available query system. (eg. using a spreadsheet program Excel® pivot table).

4.3.3. Uncertainty on Production Shop Floor in Relation to Procurement

Possible permutations and combinations of cut of the work piece, equipment, transportation, migration routes, operating processes, and others directly proportional increase to the amount, so the more items involved will be the higher levels of probabilistic. As it consequence will put the higher value of uncertainty. Conversely, the fewer items involved will decrease probabilistic level (Kochan, 1986). Judging from the position of the entities flow, since the upstream on reception table of raw material then flows to the fabrication floor as WIP, then proceed to the assembling floor until turn to be finishing goods, then the upstream position has a small probability level, while the downstream has a great probability level. Probability value is measured from the coefficient of determination (r^2) and can also be seen from the requirement of minimum replication from results of running simulation. The less probabilistic levels it means the less need for the minimum replication. Procurement part directly related with the production in the upstream position. Where the first internal transaction consumption of raw materials (depleted material) occurs. While the factors that potentially generate a high probability value on the shop floor are: a manual process time deviation; engine failure; operators swing, and production line balancing.

4.3.4. P2, EOQ Inventory Model

If four factor as mentioned in Article 4.3.3 above assumed doesn't exist, therefore the problem becomes simple, certain, and deterministic. While this research is still considered four factors above exist, such that EOQ model selection in the form of uncertain applied. Information of consumption of raw materials at the site of the first engines which use the raw materials will update the status of inventory form of reduced inventories and the update of frequency information of raw material usage. The probabilistic nature of the model requires EOQ inventory model with uncertain demand. Service level is used to determine the reorder point (ROP). Equation of ROP (R_n) varies with the value of material needs and lead times vary form as follows:

$$\mathbf{R_n} = \bar{d}\bar{L} + z\sqrt{(\sigma_d{}^2\bar{L} + \sigma_L^2\bar{d}^2)}$$

Where:

$\bar{d}$ = average dailydemand

$\bar{L}$ = average lead time

$\sqrt{(\sigma_d{}^2\bar{L} + \sigma_L^2\bar{d}^2)}$ = standard deviation of demand during lead time

$z\sqrt{(\sigma_d{}^2\bar{L} + \sigma_L^2\bar{d}^2}$ = safety stock

σ_d = standard deviation of demand

σ_L = standard deviation of lead time

z = 1.97 for a 95% of service level

While the equation for the optimum order quantity (q_n) with a value of the raw materials vary and lead time are varied:

$$\mathbf{q_n} = \bar{\mathbf{d}}(\mathbf{t_b} + \mathbf{L}) + \mathbf{z}\boldsymbol{\sigma}_\mathbf{d}\sqrt{(\mathbf{t_b} + \mathbf{L})} - \mathbf{I}$$

Where I is the minimum inventory. Subscript in R_n and q_n marks circulate termination for n order.

4.4. Algorithm Technique Codification From P1 to P2

Codification simulation model techniques (P1) is done using ProModel® software, whereas EOQ model (P2) using a spreadsheet program Excel®. Describe as follows:

1. Fill out the dialog box of raw material arrival entity with a sufficient amount in order to exceed stopping rule.
2. Make codification OLE from syntax in ProModel® to DBMS external files such as TXT formats to capture material depleted in every hours range during the running progress.
3. Replicate 33 times running to get the value of the minimum replication requirements.
4. Enlarge the capacity of the buffer size set locations to accommodate entities WIP while they run in larger size.
5. Registering multi competence resources at some points of machining locations to raise machinery utility and resources, and reduce cycle time.
6. Insert the cutting machine failure factor (C_1) as a first machine on the shop floor.
7. Entering the absence of cutting machine operators (C_1) factor and involves replacement operator at a certain time (swing operator).
8. Importing results of TXT format data to XLS spreadsheet format for easy data processing.
9. Reversing axis Q against P by inserting additional lines of constant Q when there is no change in Q at the same P, and convert units of hour time to units of time of day clock.
10. Taking the average of material depleted from minimum replication. Replication of the simulations carried out to obtain a certain level of confidence intervals for the occurrence of a particular error (called *e*) between the point estimate $\bar{x}$ and the average estimated value of the real μ unknown. Equation number of replication:

$$n = \left[\frac{(Z_{\alpha/2})s}{e}\right]^2$$

where,

$Z_{\alpha/2}$ = standard normal distribution

s = standard deviation
e = error

11. Turn the information of reduction of inventory into unit material requirements per unit of time.
12. Calculate the value Q_{opt} and ROP.
13. Shows cumulative material depleted during effective work time before it be segmented accordance with value of ROP, with provide countdown (*L*) as manufacturing target.
14. Marking rows of data to appear ROP line.
15. Giving Q_{opt} value on the raw data at countdown *L*, and add with the current stock in hand value.
16. Repeating this procedure until the raw material exhausted.
17. Presenting data in graphics.

4.5. P3, Mathematical Model for Supplier Selection

In this study, the model essentially uses a linear estimation function as the research conducted by the Catur Kurniawan, 2007. Chain is the level of decision making in the determination of order quantities of each supplier by first evaluating bids received from all suppliers (Cakravastia et.al, IJPE, 2002).

4.5.1. Evaluation of Simple Statistics Data Regression Toward the Past as information input parameter P3

Manufacturing as a buyer of raw material suppliers offer data processing and also taking into account the past reputation of the supplier in question. Data is evaluated by making the regression equation for all the suppliers that submit bids. Statistical products produced at this stage is obtained regression equation and coefficient of determination (r^2).

General form: $\widehat{Y} = b_0 + b_1 X$

Special form: $ELTa_i = b_0 + b_1 Qa_i$

where,

$\hat{Y}$ = variables that predicted
X = Predictor
b_0 = Intercept
b_1 = Slope
$ELTa_i$ = the estimated number of allocated quantity lead time orders at supplier *i* (time)
Q_{ai} = Quantity of material allocated to supplier *i* (units)

4.5.2. Mathematical Algorithms P3 to P1

Chain-level decision model contained in P1 model below. Objective function of this model is to minimize the total level of dissatisfaction in the supply chain, and it is described in the equation (1) constraint (2) ensure that once an order is allocated to supplier, the quantity should be between the lower and upper bidding limits from the supplier. Finally, a linear approximation for supplier performance given by the equation (5) and (6). The optimal solution is obtained by applying the technique of mixed-integer programming. Model development is done by simplicity. In equation (2) is limiting quantity orders where the quantity allocated to a supplier with total manufacturing material requirements. Estimated procurement performance is given in equation (3) and equation (4). While the estimated lead time procurement process entirely based on past supplier as stated in equation (6), as described below:

Index

i Supplier

Parameter (from supplier)

$b_{0,i}$ $b_{1,i}$ the coefficients of the linear regression equation
$etc_i^{\min}$ prices offered by supplier *i* at the smallest orders (money)
etc_{oi} prices for a number of orders allocated to supplier *i* (money)
$qa_i^{\min}$ minimum quantity allocation at supplier *i* (units)
Q_{ai} quantity of material allocated to supplier *i* (units)
Qo_i The maximum quantity allocation offered supplier i (units)

Parameter (from manufacturing)

R targeted level of manufacturing lead time (time) obtained from the model EOQ in P2
q quantity of material required manufacturing (unit). Retrieved from EOQ model in P2.
r price per unit of the targeted manufacturing (money)
w_1 criteria of price of manufacturing
w_2 criteria of manufacturing lead time

Variables:

$ELTa_i$ the estimated number of allocated quantity lead time orders on supplier i (time)

G_1a_i gap material cost criteria order

G_2a_i gap material order price criteria

Objective:

$\min\ TDL = \sum_i (w_1 . G1a_i) + (w_2 . G2a_i)$(1)

s.t.

Delimiter the quantity

$$\sum_i Qa_i = q, \forall i \quad (2)$$

Estimated Performance

$$ETCa_i - G_1a_i = r . Qa_i, \forall i \quad (3)$$

$$ELTa_i - G_2a_i \leq R, \forall i \quad (4)$$

where,

$$ETCa_i = \frac{(Qa - qq^{min})(etc_{oi} - etc^{min})}{Qo_i - qa_i^{min}} + etc_i^{min}, \forall i \quad (5)$$

$$ELTa_i = b_{1,i} . Qa_i + b_{o,i}, \forall i \quad (6)$$

4.5.3. Selected Supplier

The mathematical model will produce the variable of in the total level of dissatisfaction with the decision variables TDL (Total Dissatisfaction Level) for all suppliers. The decision chosen supplier is a supplier which has the smallest level of dissatisfaction among all suppliers that submit bids. From the smallest of the TDL, is also obtained the estimated delivery time (*$ELTa_i$*) and procurement costs (*$ETCa_i$*).

4.6. P1 to P4, Assemblying the Finishing Goods

In the end, all entities will lead to downstream as finishing goods. Seen from the timeline, if the process starts from zero inventory position, it shall arrive at P4 as finishing goods takes as much time plus the time of the procurement process of the production process, or *$ELTa_i$ + ELTs*. This formula can be counted onto MTO operating environment, while the cost of production for the cost of procurement and operational costs of production (*$ETCa_i$ + ETCo).*

4.7. Terms and Recursive

If the order quantity or amounts to the MTO and MTS forecasting marketing in a number of d units of finishing goods is greater than the ability of suppliers to deliver raw materials selected number q, there will be n times the term delivery of raw materials. Parameter I or minimum inventory stock keeping fabrication not out. Recursive properties are suitable for operating environments MTS or MTO with a large order quantity.

5. CONCLUSION

Hybrid model was tested in manufacturing which is using homogeneous materials made from sheet metal order of lighting fixtures product. The 2028 raw material sheet metal was shear in cutting machine (C_1) for 67 days and it still needs 9.2 days after as estimated lead time to made up about 8112 pcs of finishing goods. Information was received from upstream into the EOQ Model With Uncertain Demand to obtain the optimum number of orders of raw materials (Q_{opt}) of 653 sheet ordering and meet ROP respectively on day 14th, day 36th, and day57th. Q_{opt} and ROP_n later admitted into a mathematical model of supplier selection in which each supplier has a different reputable track record marked by the values of intercept and slope. So it can be regressed the response speed of the supply of raw materials about the quantity demanded to manufacture. Price bidding crireria is also a considered. Winner supplier is those who have the lowest TDL of two criteria mentioned above. Mathematical model supplier selection which is running in Lingo resulting the 3rd supplier, with a TDL value of 1.72E+08, and the estimated lead time of supply of raw materials (*ELTA*) for 6.2 days and the estimated procurement costs (*ETCa*) at 6.56E+07. The overall time required for the fulfillment of inventory is the sum of the average simulation time of production with an estimated lead time of raw material supply for 82.4 days.

From that research it can be concluded Hybrid model can work for MTO and MTS operating environment.

6. REFERENCES

(a) Bertrand, J.W.M., Wortman, J.C., dan Wijngaard, J., (1990), Production Control: A Structural and Design Oriented Approach, International Journal of Production Economics.

(b) Cakravastia, A., Toha, I.S., Nakamura, N., (2000). A model for partner selection

in efficient supply chain. Proceedings of Joint Fifth International Symposium on Logistics and Third Annual Conference of the Japan Society of Logistics Systems, pp. 189–196.
(c) Cakravastia, A, Isa S. Toha, Nobuto Nakamura, (2002), A two-stage model for the design of supply chain networks, International Journal of Production Economics, Vol 80, 2002, 231-248.
(d) Cakravastia, A. dan Takahashi, K., (2002a), A Model for Supplier Selection and Manufacturing Planning in Make-to-Order Environment, Proceedings of the Sixth China-Japan International Conference on Industrial Management (ICIM'2002), 292-297.
(e) Carr, A.S & Pearson, J.N. (1999), Strategically managed buyer-supplier relationships and performance outcomes, Journal of Operations Management, 17, 5, 497.
(f) Harrel, Ghosh, Royce O. Bowden, (2004), Simulation using promodel, 2nd ed. McGraw.
(g) Kurniawan Catur, (2007), Pengembangan Model Integrasi Proses Pengadaan dan Produksi Menggunakan Model Matematis dan Simulasi Studi Kasus : PT Citilite Buana Putra, Institut Teknologi Bandung.
(h) Kolisch, R., (2001), Make-to-Order Assembly Management. Springer.
(i) Li, D., O'Brien, C., (1999), Integrated modeling of supply chain efficiency, International Journal of Production Economics 59, 147–157.
(j) Pearson, J.N. &Ellram, L.M. (1995), Supplier selection and evaluation in small versus large electronics firms, Journal of Small Business Management.
(k) Talluri,S. dan Sarkis, J. (2002), A model for Performance Monitoring of Suppliers, International Journal of Production Research, 40, 16, 4257-4269.
(l) Venkateswaran, Albert Jones, (2004), Hierarchical Production Planning Using A Hybrid System Dynamic-Discrete Event Simulation Architecture, Proceedings of the 2004 Winter Simulation Conference.

AUTHOR BIOGRAPHIES

Catur Kurniawan is a lecturer in Department of Industrial Engineering, University of Pembangunan Nasional Veteran Jakarta. He received his Master of Industrial Engineering from Bandung Institute of Technology (ITB) in 2007. His research interests are in the area of Integrated Model of Procurement, Supplier Selection, and Shop Floor using Mathematical and Simulation. His email address is <catur_k444@yahoo.com>

Nur Hildawati is an undergraduate of Industrial Engineering from University of Pembangunan Nasional Veteran Jakarta. Her research interest in the area of Hybrid Model of Supplier Selection, Procurement, and Production. Her email address is <nurhilda31@gmail.com>