Production System Disturbances of Heavy Equipment Component Industry

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Abstract

The uncertainty of the production system arises in the form of production system disturbances. PT ABC is a company that produces heavy equipment components. Based on preliminary research, it is known that there is a need to solve the problems of production planning and inventory control (PPIC) in the company related to the disturbances of the production systems faced by the company. The purpose of this study is to map the production system disturbances and provide solution to improve the function of PPIC in facing the disturbances of the production system at PT ABC. Based on the Key Performance Indicator (KPI) of PPIC, we do mapping of production system disturbances occurs. Next, the data processing and analysis are carried out descriptively and by using the Classification Technique - Association Rules. The disturbances mapping results show that the high severity disturbances associated with the MRP PPIC Model, with the type of disturbances of raw materials having a high impact on KPI. The production process cannot run according to planning and scheduling because the flow of information that is less integrated between divisions causes each division to process based on their respective policies. The company needs an improvement in the MRP system in releasing production and ordering of materials, and also control the disturbances of the production system.

Keywords

uncertainty, production system, disturbances, KPI of PPIC, association rules.

1. Introduction

1.1 Background

Related to the production system, uncertainty is categorized into two groups, namely environmental uncertainty and uncertainty associated with the production process (Mula et.al., 2006). The uncertainty of the production system arises in the form of production system disruptions. The existence of a disruption of the production system causes a deviation (variance) between the planning and the actual conditions that will cause inefficiencies and inhibit the achievement of the company's targets so as to reduce productivity in the company.

Production Planning and Inventory Control (PPIC) is one of the main activities in a production system. The aim of PPIC is to plan and control production inputs in an industry as efficiently as possible to produce production output in accordance with market demand. Medium-term PPIC system - short consists of several subsystems or sub-functions including Demand Management, Master Production Scheduling, Rough Capacity Planning, Raw Material Requirement Planning, Distribution Resource Planning and Final Assembly Scheduling (Fogarty, 1991). Conventional PPIC models are unable to adjust flexibly to anticipate and control the complexity and disturbances of production systems in the industry.

To improve the functions of the Production Planning and Inventory Control (PPIC) in the food industry, a smart and adaptive PPIC model has been developed to improve the effectiveness of the PPIC function. The PPIC model adapts to the disturbances of the production system that occurs with the provision of safety stock which changes periodically in accordance with the disturbances of production systems that occur (Marie, 2011). Next, a study on the use of the Disturbances Control Model consisting of the Disturbances Control Action sub-model, the Disturbances Control Advanced Policy sub-model, and the Inventory Tolerance sub-model which can update the value of safety supplies of raw materials and finished products in bread producing companies. The related model has been applied to other food companies producing beef sausages. The company has difficulty in determining safety

stock for the supply of raw materials and finished beef sausage products related to efforts to anticipate supply disturbances, disturbances of demand and also the internal disturbances of production systems that occur in production activities (Marie, 2015).

Next, following up on the research that has been carried out by considering the dynamics and high market uncertainty in the automotive industry companies, a study of the disturbances of the production system of the automotive company, PT XYZ was carried out. The result is the using classification technique from data mining approach. The research found that the dominant disturbance is in the production process at PT XYZ as an automotive company comes from casting reject. The design of the disturbance control model for the company consists of the sub model of Disturbance Risk Level to know the level of risk of low, medium, or high disturbance, sub model Status is done in the future combining with sub model Disturbance Control Action to know the control action to be used and sub model of Safety Stock Calculation to know safety stock policy based on the disturbance that happened. (Marie, 2017)

PT. ABC is a manufacturing company with a Make to Order manufacturing system. The company is engaged in the production of heavy equipment components, manufacturing equipment, building construction equipment and components that are tailored to customer orders. PT. ABC has become a company capable of producing high quality products for local and export customers, which are divided into two categories, namely semi-finish components and fabrication parts. Production activities to produce semi-finish components are called first process, namely cutting, the next second process includes bending, chamfering, and boring, while for fabrication parts that are semi-finished components are followed by fabrication processes namely welding, machining, and finishing.

1.2 Research Question

Based on preliminary research in the company, it is known that there is a need to solve the problems of planning and controlling production in the company related to the disruption of production systems faced by the company in the face of uncertainty faced so far.

1.3 Purpose of the Study

The purpose of this study is to analyze the functions of Production Planning and Inventory Control (PPIC) and provide alternative solutions to improve the effectiveness of the PPIC function in dealing with production system disturbances in heavy equipment component producing industries. Case studies conducted at PT ABC. The implementation of a solution to solving the problem of uncertainty related to the industry will improve performance, especially the function of production planning and inventory control in the heavy equipment industry.

2. Review of Related Literature

2.1. Material Requirement Planning (MRP)

Material Requirements Planning (MRP) is a computerized information system developed specifically to help manufacturers manage dependent demand inventory and schedule replenishment orders. The key inputs of an MRP system are a bill of materials database, a master production schedule, and an inventory record database. Using this information, the MRP system identifies the actions planners must take to stay on schedule, such as releasing new production orders, adjusting order quantities, and expediting late orders (Krajewksi, 2013). The effectiveness and efficiency of the PPIC function of a company is very dependent on the accuracy of the company running the MRP stage.

2.2. Association Rules

Data mining is a series of processes to explore the added value of a data collection in the form of knowledge / information that has not been known manually (Larose, 2006). Data mining is divided into several groups based on tasks that can be done, namely: description, estimates, predictions, classifications, clusters and associations. The main steps taken in carrying out data mining are describing data, making conclusions about statistical attributes, reviewing visually using graphs and diagrams, and looking for potential relationships between variables, building predictive models based on patterns that found in the previous step and testing the model. To do this, a program is needed that can display or detect patterns and regularities in the data so that strong or very visible patterns can be used to make predictions. Association rules is a data mining technique used to determine the rules of association between particular combinations of an item. The methods aim to find out patterns that often appear or occur

between many transactions, where each transaction consists of several items, and, thus, this method will support the recommendation system through the discovery of patterns between items in the existing transactions (Fadlina, 2014).

3. Research Methodology

Based on the research objectives, according to data processing needs, data collection activities were conducted based on company information tracking based on the interview method and using open questionnaires to obtain the company's Key Performance Indicator (KPI) and other supporting data related to the Production Planning & Inventory Control (PPIC) function at the company . Next, interviews were conducted and the use of open questionnaires to identify production system disturbances that occurred in the form of external and internal disturbances that occurred in selected companies. Furthermore, further analysis is carried out to determine the relationship between production system disturbances that occur with the PPIC function in the company. This research will be carried out using the stages according to the following flowchart at figure 1.



Figure 1. Flowchart Methodology

4. Result & Discussion

PT. ABC produces high-quality products for local and export, which are divided into two categories, namely semifinish components and fabrication parts. Production capacity produced by PT. ABC is 80,000 tons per year of consumption of steel sheet metal.



Figure 2. Raw Material Steel Plate

Products produced by PT. ABC is the components needed by the heavy equipment industry, civil works, automotive, agricultural equipment, and machinery industry in general, including semi-finished components and assembly components. The production process carried out for semi-finish components is the process of cutting, bending, chamfering, and boring, while for fabrication parts that are semi-finished components are followed by fabrication processes including welding, machining, and finishing.



Figure 3. Semi Finished Good : Semi Finished



Figure 4. Assembly Component : Excavator

The following are KPIs from several Divisions at PT ABC related to production system activities.

- a. KPI Sales Division is acceptance and management of orders according to the standard time agreed with the customer.
- b. KPI PPIC Division is making production scheduling according to the standard time and capacity in each part of production using the KGS global control system. The maximum amount of raw material inventory is 2 months of production
- c. KPI Purchasing Division is to provide materials, materials and services needed for timely production processes and competitive prices
- d. KPI Quality Division is to ensure products are sent to customers according to quality standards of materials and processes requested

4.1 PPIC Mapping at ABC Company

Based on the results of interviews with the General Manager and PPC staff on ABC companies, supported by PPIC data that has been obtained from the company, things can be known as follows:

- 1. The function of Forecasting that is carried out by the company is the projection of production demand to be the customer to find out the product demand related to the information on raw material requirements for the plan to order raw materials to the supplier. Raw materials include local raw materials of 75% with lead times of 1 2 months and import standards of 25% with lead times of 4 5 months.
- 2. Every component of the finished product produced by the company always has imported raw material.
- 3. Forecasting or demand projections are carried out for the next 6 months. Forecasting that already has a Purchase Order (PO) number and order due date will be an Order, namely the Customer Model Component that has been completed with its specifications. Due date for each PO is per month. PO is made based on an

agreement with the customer. Each PO will be completed with a completion time (production lead time) of no more than 2 weeks.

- 4. Based on the PO that has been made, the company will then prepare a Production Plan for the 1st and 2nd months (the month) which will also be detailed into the day production plan.
- The company checks production capacity for production plans that have been made. Calculation of production capacity requirements is the multiplication of the Standard Time with the number of products according to the production plan (= Loading Hour). Loading Hour will be compared with Available Hour. The calculation of Available Hour has covered the multiplier factor of Efficiency of 0.85 (indirect job) and 0.95 (availability of operators). Multiplier efficiency factors due to indirect job and the availability of these operators are suggested to be further evaluated and updated according to the conditions of the production floor in the company, because one of the reasons for not fulfilling customer demand is due to the calculation of production time requirements that have not considered% allowance and indirect jobs (includes meeting and 5R activities). The calculation of Available Hour is only done for the welding division, because the machine / jig / equipment data owned by the company is only for the welding division. The basis for determining the Welding Division is selected in the calculation because the Welding Division is a Division that is very dependent on operator skills. The Welding Division is often the bottleneck work station in the production process because the completion of many customer product orders requires welding. The bottleneck work station can change due to variations in production orders that vary each period. However, for some work stations it has the potential to become a bottleneck station due to a damage engine.
- 5. Production operators in companies include permanent employees and contract employees Workforce planning activities have not been carried out properly. Determination of contract employee needs is based on demand fluctuations. The existence of labor regulations that do not allow for contractual provisions causes companies to often experience a shortage of skilled operators for welding work.
- 6. At the beginning of the 3rd week of each month, the day production plan will be adjusted / adjustments considering changes, checking the availability of raw materials vs. raw material requirements for production plans, unavailability of production operators and the disruption of production systems that occur.
- 7. At present the company determines the safety stock equal to 20% of the total raw material needs. Raw materials include 40-50 variants, including variants that are both common and specific. The total supply of raw materials must not exceed 20,000 tons considering the durability of the floor of the raw material storage area that should not exceed 5 tons / m2. Inventory of finished products (Finished Good / FG) is as big as the average requirement for 1 week, especially for FG that has the most complaints or from assembly lines that require related FG components at the beginning of the assembly process.

4.2 Production System Disturbances Mapping at ABC Company

The following is the result of Disturbances Production System Mapping at PT ABC obtained based on the knowledge from the General Manager at PT ABC. The Impact criteria was associated with the impact of the disturbances that caused the achievement of Key Performance Indicators (KPI) in each division regarding the PPIC function.

No	Source	Source	Туре	Duration	Impact	Severity	Freq	Model	Divison
1	Change in production				-				
	amount from the						Rather		
	customer	External	Demand	Long	Moderate	High	Often	MPS	PPIC
2	The difference in stock								
	data between IS KGS and			Very			Rather		
	actual	Internal	Machine	Short	Low	High	Often	MRP	PPIC
3	Delay in the delivery of								
	local raw materials due to								
	the length of the								
	administration process at		Raw				Rather		
	the suppllier	External	Material	Long	High	High	Often	MRP	PPIC
4	Late delivery of raw								
	materials because there is								
	insufficient stock in the		Raw				Rather		
	supplier	External	Material	Moderate	High	High	Often	MRP	PPIC
5	Changes in product								
	models from customers								
	with less than 4 months	External	Demand	Moderate	Moderate	Moderate	Rare	MPS	PPIC
6	The production								
	department is not								
	consistent in inputting	External	Operator	Very Long	Moderate	High	Often	MRP	PPIC

 Table 1. Example of Disturbances Characteristic at ABC Company Mapping

4.3 Disturbances Analysis Based on Association Rules

One stage of the association analysis that attracted the attention of many researchers to produce efficient algorithms is the analysis of high frequency patterns. The importance of an assumption can be known by two benchmarks, namely: support and confidence. Support (supporting value) is the percentage of the combination of items in the database, while confidence (the value of certainty) is the strong relationship between items in the association rules.



Figure 5. Disturbances Characteristics Pareto Diagram

The Pareto diagram at Figure 5 describes the disturbing factors that often occur, among others, are disturbances with moderate severity that are more common when compared to disturbances with high severity. Furthermore, the disturbances that occur most often are related to the Material Requirement Planning (MRP) function in PPIC when compared to other PPIC models such as Demand Management (DM), Master Production Scheduling (MPS) and Scheduling. Next, the results of the mapping of production system disturbances that occur indicate that most of the disturbances that occur have a moderate duration, causing an impact on high KPIs and rare frequencies. Then, the disturbances that occur have a high degree of severity and moderate impact have a number of events that are not much different from one another.

To find the pattern that occurred, an analysis was performed using the a priori algorithm association rules method. The following below is a pattern obtained by using the association rules method a priori algorithm. By using the the rules graph at figure 6, we know that The high severity disturbances associated with the MRP PPIC Model, with the type of disturbances of raw materials having a high impact on KPI.



Figure 6. Disturbances Impact Factor based on Association Rules

4.4 Analysis

Disturbances that occur at PT. ABC related to the business process of producing heavy equipment components include disturbances at the Sales, PPIC, Purchasing, Production and Quality Control divisions. What is meant by this disturbances is the cause of non-achievement of the KPI of each division. Sources of disturbances can occur from both external and internal, but more disturbances comes from external sources.

The business process of producing heavy equipment components starts from the Sales Division. The Sales Division is dealing with customers both in receiving orders and handling complaints. The difference in forecast with real orders will interfere with production planning. This difference occurs because there are changes / additions to the number of requests from customers that are often accompanied by changes in leadtime. The lead time set by the customer < lead time of the production section. This change in customer demand will also disturb the production section. The disturbances experienced by the sales division actually comes more from external customers and internal unpreparedness in planning. This Sales Division does not have fast and accurate access to production capabilities, and there is no integrated information with all divisions.

Next the PPIC Division plans to meet customer requests received by the sales. PPIC will deal with production and purchasing divisions for purchasing raw materials and subcontracts. Disturbances at the purchasing division will trigger disturbances in the production and purchasing division. The change in the number of requests will trigger an error in determining the amount of production. Disturbances mapping show also that there is engine damage and the delay in sending raw materials from the supplier. Indirectly the disturbances in the production division comes from the sales division.

The source of the disturbances of the PPIC division came from internally both in the planning system and in HR. While external sources indirectly come from customers, suppliers and subcontracts. Disturbances in the production division will have an impact on the delay in product delivery, and the low quality of the product. While the source of the disturbance comes from internal, both in planning, capability and availability of operators and machine reliability. While sources originating from external sources come from the ability of suppliers and subcontracts. The calculation of PPIC ABC company currently uses Microsoft Excel and manual, so that it can make calculation errors by PPIC operators and subsequent accumulation of calculation errors in other PPIC functions and actions that must be carried out by PPIC staff. The company's PPIC data is still not integrated so that it is very potential to cause miscalculation of PPIC functions such as Determination of Master Production Schedule, Ordering Planning of Raw Material Requirements to suppliers, Production Scheduling, Production Capacity Check and Determination of Customer Order Completion Time. With the integration of the company's current PPIC data calculation file, coupled with the possibility of insertion or order changes, PPIC operators have difficulty updating the calculation data in the PPIC file and the potential for causing data updates is not carried out and the next is PPIC calculation data to be not accurate.

Careful calculation of production capacity in accordance with the data of the master production schedule and calculation of the availability of production hours for each work station is a matter that must be prioritized by the company. For heavy equipment producing industries with a make to order strategy and engineer to order with company characteristics that highly prioritize customer satisfaction while minimizing customer complaints, it is very potential to experience an external production system disturbances (demand change). This condition causes companies to determine the policy of providing safety supplies for finished products for requests for 2 months. Supplier of raw materials with the procurement of imports and locales as well as variants of raw materials that vary according to customer demand (with a variant of finished products that are also many) causes the company to require a non-simple Material Requirement Planning module.

In general, based on global analysis of the PPIC model applied by the company today, companies need an integrated information system to maximize the PPIC function in the company. Taking into account the number of finished product variants with the need for variations in the production process for different product variants, sufficient time and thought is needed to obtain accurate mapping and analysis of the PPIC model applied by the company today.

Customization of customer orders is carried out, among others, resulting in a backlog of customer orders. Based on the results of interviews with company resource persons, it is known that there are many incidents of production system disturbances that occur and the potential causes disturbances to the target of meeting customer demand cause the company to require a non-simple Material Requirement Planning module. The company also needs an

information system to support the Production Scheduling module which is integrated with other PPIC modules to streamline the PPIC function in the company. Considering so many disturbances in the production systems faced by the company, both internal and external, related to the company's need to continue to increase customer satisfaction, the company has a policy of providing safety stock for both raw materials and finished products.

In the case of PT ABC, the available information system has not been integrated with all production units so that there is an error in translating production orders that have an impact on the procurement of raw materials, determining the amount of production and the delivery schedule to customers who are often late. Input for the MRP system in the form of Master Production Schedule often changes due to changes in the model and the number of products requested by the customer in less than 4 months. Figure 4 shows the flow of information in the form of orders obtained from internal and external customers and material flows in the form of raw materials, semi-finished products and finished products that occur on the production floor which is input and output in the company's MRP system.



Figure 7. Information Flow (Order) and Product Flow (Delivery Product)

Next, the calculation of the actual capacity has not been done correctly which results in the load profile of available resources not always in accordance with what is needed. As a result of the disturbances of the production master schedule and the inconsistency of the load profile it affects the inventory status of raw materials which will affect the material ordering schedule and delay in production due to unmet resources. To avoid material shortages, often the material planning part estimates the purchase of raw materials in excess of the required amount. Furthermore, the production department also does the same thing by increasing the amount of production from the number of PO to anticipate additional PO from the customer. But this cannot anticipate the fulfillment of customer requests that always change in the middle of the production schedule that has been carried out.

5. Discussion

Uncertainty is defined as any unpredictable event that disturbs the production process in a manufacturing system that is planned by MRP, MRP II or ERP system (Ho, 2003). In the Indonesian case, the limited national supply of heavy equipment manufacturers may jeopardize the availability of heavy equipment for construction since its share is about 20% of the total demand. The balance of future demand and conditions of heavy construction equipment availability seems not to be the focus of attention. Heavy equipment suppliers have not been able to respond to the demand because it is not possible for them to increase their production of heavy equipment in a relatively short time. This condition may hamper the development of the national construction industry as a whole (Simatupang, 2016).

Manufacturing planning and control entails the acquisition, use, and allocation of limited resources in production activities so as to satisfy customer demand over a specified time in the most efficient and effective way. The available planning tools like MRP, MRP II or ERP are very good for scheduling, but completely ignore the uncertainty and capacity, issues. Managing uncertainty effectively and efficiently requires balanced planning and control. One must understand which uncertainty to tackle, and how to tackle it, in order to obtain the maximum improvement of the system. The approach based on KPI and its measurement has the potential to solve problems of uncertainty in demand, supply and process (Wazed, 2010).

Heavy equipment component industry with a make to order strategy and engineer to order with company characteristics that highly prioritize customer satisfaction while minimizing customer complaints, it is very potential to experience an external production system disturbances (demand change). The industry has specific markets and are limited by market trends and also has customized demand characteristics, large product variants with not large quantities per variant, limited special market users, high quality raw material requirements, requiring sufficient raw material procurement lead times and big investment in raw materials, requires technology and high-skilled workforce to produce high-quality products. Characteristics of the industry cause the heavy equipment component industry need safety stock for raw material and safety lead time for component that can be adjusted based on the dynamics and disturbances that occur.

Based on a pattern obtained from the production system disturbances mapping by using the association rules method a priori algorithm, we know that the high severity disturbances associated with the MRP PPIC Model, with the type of disturbances of raw materials having a high impact on KPI, the company need Material Requirement Planning (MRP) which is supported by excellent information system design, with a good database management system, integrated and facilitates the flow of information and communication between PPIC support divisions, simple, flexible so that it is easy to adjust and has supporting functions:

- a. To find out the needs and availability of capacity of each production work station.
- b. To find out the needs and availability of raw materials.
- c. To find out the needs and availability of labor.
- d. To browse and find out the order fulfillment status.

e. To find out if there is a disturbances in the production system and do action of controlling the disturbances that occurs.

6. Conclusions and Future Research

The results of the mapping disturbance analysis at PT ABC show that the production process cannot run in accordance with the planning and scheduling that has been made because of the misinformation that also has an impact on KPI achievement. Information flow and information flow and material flow that are the input and output of the company's MRP system do not match what happens on the production floor. The occurrence of a chain of disturbances is caused by a lack of integrated information between divisions and suppliers, so that each division processes based on their respective policies and information systems need to be built regarding MRP functions with integrated databases between each PPIC division where each department related to PPIC functions has access according to their needs. The company needs an improvement in the MRP system and Standard Operation Procedure (SOP) for each division in releasing production and ordering of materials. The company also requires an information system in the form of a dashboard that can display real conditions on the production floor as well as the status of each agreed order, while monitoring the disturbances of the production system that occurs, so that it can immediately control and make adjustments so as to meet the KPI of each PPIC division. Regarding the disturbances of production systems that occur, companies can control the disturbances of the production system that occurs by providing safety stock for raw materials and finished products in order to support the smooth running of business processes and fulfillment of KPIs for each PPIC division in the company.

For the future research, we recommend to apply the disturbance control model, as has been done in previous studies in the automotive industry, starting with mapping the production system disturbances in accordance with the relevant KPI, then by utilizing the classification technique approach we got the disturbances control model consists of sub-model of the risk level of the disturbance, sub-model of action status, sub- model action control of the disturbance, and sub-model of determining the safety stock to assist the automotive company in taking the decision to perform the disturbances control action in production system (Marie, 2017).

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Biography

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