Design of disturbances control model at automotive company

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Abstract. The discussion was conducted at PT. XYZ which produces automotive components and motorcycle products. The company produced X123 type cylinder head which is a motor vehicle forming component. The disturbances in the production system has affected the company performance in achieving the target of Key Performance Indicator (KPI). Currently, the determination of the percentage of safety stock of cylinder head products is not in accordance to the control limits set by the company (60% - 80%), and tends to exceed the control limits that cause increasing the inventory wastage in the company. This study aims to identify the production system disturbances that occurs in the production process of manufacturing components of X123 type cylinder head products and design the control model of disturbance to obtain control action and determine the safety stock policy in accordance with the needs of the company. The design stage has been done based on the Disturbance Control Model which already existing and customized with the company need in controlling the production system disturbances at the company. The design of 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. The model can assist the automotive company in taking the decision to perform the disturbances control action in production system cylinder head while controlling the percentage of the safety stock.

Keywords: production system, disturbance control model, safety stock

1. Introduction
The sustainability of the automotive industry is influenced by the ability to react to the uncertainties and dynamics that occur. Associated with the production system, uncertainty is categorized into two groups: environmental uncertainty and uncertainty associated with production processes [1]. Uncertainty of the production system arises in the form of interruptions of the production system. The existence of a disruption of the production system leads to deviations (variance) between planning and actual conditions. Next, irregularities that occur will cause inefficiency and inhibit the achievement of corporate targets that reduce productivity in the industry.

[2] categorizes uncertainties into uncertainty of inputs and process uncertainties including: lack of /unavailability of raw materials, lack / unavailability of production operators, lack / unavailability of machine capacity, defective products and late delivery of products.

Risk and uncertainty are included in inventory analysis involving many variables. However, the most important role as risk and uncertainty is the variation in demand and lead time. Variations are absorbed in the form of safety stock or buffer stock or fluctuation stock. Safety stock is an additional stock kept as a buffer to prevent stockout due to random noise from nature or the environment [3].

To improve the Production Planning and Inventory Control (PPIC) function in the food industry, a smart and adaptive PPIC model has been developed to improve the effectiveness of PPIC functions.
The PPI model adopts to the disturbance of the production system that occurs with the provision of safety stocks and changes periodically adjusted to the disturbance of the production system [4]. Subsequently, it is conducted a study on the use of the Disturbance Control Model consisting of Disturbance Control Action Sub Model, Advanced Control of Disturbance Policy Sub Model and Safety Stock Sub Model at the baking company [5]. The model has been applied to other food companies producing beef sausages [6]. Utilization of Disturbance Control Model that has been done in the food industry (bread-producing company and sausage-producing company) shows that the design of the disturbance control model can help the company to know the recommendation of action to be done as well as the follow-up policy.

In the process of finding a model, we use classification technique based on data mining concept which is the technique that explains and distinguishes the classes or concepts, with the aim that the model obtained can be used to predict classes or objects that have unknown class labels. The derived model is based on the analysis of the data training can be represented in various forms such as if decision tree. Decision tree algorithm works based on entropy of information contained in observation data. Training data is used by the decision tree algorithm to determine which attributes have the largest "decisive power". Determination of decisive power is arranged based on how pure or homogeneous data in each attribute to the data in the Class Attribute [7].

Considering the dynamics and uncertainty of high market in automotive industry company, it is necessary to study the utilization of Disturbance Control Model to know the policy of production inventory control with case study in automotive industry. PT. XYZ is a subsidiary of PT AI, Tbk which carries out joint venture with PT HM Corp., Ltd. The plant produces product on machining process for several type of H brand. The product studied in this research is cylinder head. Cylinder head is an important component that is part of motor engine, because it plays a major role in controlling airflow and fuel dispersal. Cylinder head is made of ingot ingredient mixture (with 40% ingot and 60% scrub of rejected component) melted at high temperature. Then the ingot is printed using jacket core mold (solid sand mold with coated sand resin material) using machine Low pressure die casting. In engine motor cylinder head functions as combustion chamber, drainage and disposal ducts, spark plug holder, cooling coat, and for valve mechanism. As one of the important components in engine motors, the cylinder head must be resistant to extreme high temperatures as it acts as a combustion chamber. In addition, the cylinder head must be free from leaks, as it is the fuel feed and discharge ducts in the engine. Figure 1. The following is a cylinder head image used on motor type A.

![Figure 1. Cylinder head component for type A motorcycle](image)

Problems of PT. XYZ is a disturbance in the production system that affects the performance in achieving KPI target company, as well as determining the percentage of safety stock that has not been in accordance with the control limits set by the company, and even tend to exceed the control limit has the potential to increase the waste of production in the company. This study aims to obtain inventory of production system disturbance that occurs and designing the control model of disturbance to obtain control action and safety stock policy in accordance with the needs of the company.

2. Research Methodology

The research activity begins with preliminary research on companies that become the object of research along with the literature study. Based on the research objectives, in accordance with data processing needs, data collection activities are conducted based on company information tracking based on interview method and open questionnaire to obtain the supporting data related to Production
Planning & Inventory Control function PPIC of to the company and find out the external and internal disturbances related to PPIC functions that occur in the company. The next stage is the design of Disturbance Control Model for PT XYZ with reference to the Disturbance Control Model that has been developed before to help companies get a solution to overcome the disturbance of production system that occurs. The design of the disturbance control model used J48 learning algorithm which is one of the variants of some decision tree algorithms that have been developed. The algorithm will be implemented in the WEKA software package (Waikato Environment for Knowledge Analysis). This stage will produce Disturbance Control Model of Production System at PT XYZ as an automotive company and will end the activity research as a whole. This research will be conducted using the following steps.

![Flowchart of research methodology](image)

**Figure 2.** Flowchart of research methodology

3. Result and Discussion

3.1. Key Performance Indicator at Production Division of PT XYZ
Disturbance of production system in PT XYZ has influenced company to fulfill their target Key Performance Indicator (KPI). The design of the disturbance control model will be determined based on KPI Division of Production of PT XYZ to fit the company's needs. The following are selected KPI Division of Production based on interview with PT XYZ Production Division Head: Quality (reduced rejection & claim), Cost (reduced spoilage) and Delivery (fulfillment of Production Achievement Rate, decreasing of man hour / unit, increasing of OEE and reducing of machine downtime).
3.2. Requirement of Design of Production Disturbance Control Model at PT XYZ
The design of production disturbance control model at PT XYZ will be developed based on the previously designed Disturbance Control Model for the food industry, then adjusted to the need of controlling production system disturbance in the company to support the achievement of company’s KPI Production Division. Disturbance Control Model of Production System in food industry is consisting of Disturbance Control Action Sub Model, Advanced Control of Disturbance Policy Sub Model and Safety Stock Sub Model. The Sub Model of Disturbance Control Action produces a recommendation of interference control action using protocol mechanism or rule base. The Sub Model of Advanced Disturbance Control Policy produces an advanced policy decision on fault control. The Safety Stock Sub Model produces a safety stock value using the Average Calculation method. The model is expected can control the disruption of production systems that occur in the industry [5].

3.3. Safety Stock Policy Analysis at PT XYZ
The calculation is performed to obtain a percentage of the Finished Good (FG) safety stock which is sent to the assembly department. The company policy in determining the safety stock for FG is 60% - 80% of the production plan in one work shift. In this research, safety stock policy analysis for company is only done for finished product that is cylinder head component by using data in January 2016 until June 2016. The actual percentage of safety stock during the observation period has an average exceeding the limits set by the company that is 60-80%.

Disturbance of Production System at PT XYZ
Disturbance of the production system includes internal disturbances and external disturbances. Internal disturbance of production system include production process, energy supply, labour, down time, tool change / setting, reject casting, and reject machining. The external disturbances of the production system include supply and demand disturbances. Internal disturbances caused by reject machining resulted from errors caused by machine process or errors caused by operator component errors by jig. The disturbance caused by reject casting is caused by the existence of components that do not meet the quality of the desired company and it can be known during machining process. The disturbance caused by tool change or setting is caused by tools that have exhausted life so that there is a need to change tool or the mistake in placement tool. Disturbance caused by down time caused by the disturbance that occurs in the machine caused by program error on the machine or damage to the machine. Disorders caused by labour factors can be due to lack or absence of manpower in the production line, the existence of daily or monthly production planning mistakes, or the inability of operators in machine operation. The disruption of energy supply is caused by the unavailability of energy supply that serves to support the sustainability of production process, such as power failure. Disturbance caused by the production process can be caused by the unavailability of goods available between processes on the production line, the change of the model that must be produced by the line concerned, or the existence of components of the product that stock out.

Disturbances are classified based on the classification factor of the disturbance in accordance with the results of interviews and data obtained from the company. Reject casting is the most dominant disorder that occurs in the company. The frequent disturbance due to reject casting is leakage tester, kropos, and misrun with frequency more than 150 times for 6 months. The next disturbance is the interference with the frequency of 51-150 times for 6 months, is cutting. If the company continues to experience such disturbances it will affect the achievement of the KPI, especially on reject points and lost time. The control action status is determined based on the following factors: Frequency, Severity, Disturbance Impact and KPI Achievement. Categorization of these factors in accordance with predetermined categories and has been validated to the company, can be seen in table 1.
Table 1. Category of disturbance classification factor

| Frequency          |                       |                       |                       |
|--------------------|-----------------------|-----------------------|-----------------------|
| 1. Seldom (0-50 times/6 month) | 2. Occasionally (51-150 times/6 month) | 3. Often (>150 times/6 month) |                       |
| Severity           |                       |                       |                       |
| 1. Not severe (trouble in casting, AE dan MC still operating) | 2. Severe (MC stopped) | 3. Extremely severe (AE stopped) |                       |
| Disturbance Impact |                       |                       |                       |
| 1. AR >=67%        | 2. 33%<AR<66%         | 3. AR <=33%           |                       |
| KPI Achievement    |                       |                       |                       |
| 1. Good (0-1 KPI not achieved) | 2. Moderate (2-3 KPI not achieved) | 3. Bad (4-5 KPI not achieved) |                       |

(Source: Interviewed head of production division PT. XYZ)

3.4. Design of Disturbance Control Model at PT XYZ

Disturbance control model is a model that takes into account the disturbances of the production system that occur including demand, supply and internal disturbances of the company's production system. The disturbance control model designed for handling of disturbances at PT XYZ is the result of the development of the existing Disturbance Control Model and adapted to the disturbance control requirements of PT XYZ. This model consists of sub-model of risk level of interference, sub action control model of disturbance, and sub model of determination of safety stock.

By using software WEKA 3.8.1 we obtain decision tree with class that used is level of risk of disturbances. Based on the decision tree, there are 19 rules in decision-making on the level of risk of disturbances, for example: If the severity is not severe, the risk level of the disturbance is low; If the severity is severe, and the impact is >6 hours, and the frequency is sometimes, and the achievement of the KPI is moderate, then the level of risk of disturbance is high, etc. The decision tree can be seen at figure 3.

![Disturbance risk level decision tree](image)

The second sub model is the sub model to know the status for doing the action. This sub-model gives the result of a status for doing maintain action but no action, no immediate action, and immediate action. Decision tree obtained from the operation of WEKA software can be seen in figure 4 below. Based on the resulted decision tree, we obtained 15 rules in decision making on status for action. The following are some examples of decision rules that are formed, among others:

- If the severity is not severe, and impact <3 hours, then the status of action is maintain but no action.
- If the severity is not severe, and the impact of 3-6 hours, and the percentage of KPI achievement is, then the status of action is not immediately, etc.
The action of disturbance control that is done based on class level in the sub-model of risk level of the disturbance and the sub-model of action status. If the level of risk of moderate disturbance and the status of action is not immediate, then the action is to transfer the process to another line or making PICA. If the high risk level of disturbance and the status of action is immediate action, then the action taken is the dismissal of production.

Table 2. Disturbance control action matrix

| Disturbance risk level | Status for the action | Recom. action |
|------------------------|-----------------------|---------------|
| Low                    | Maintain no action    | 1             |
| Medium                 | Not immediate action  | 3,4           |
| High                   | Immediate action      | 3,4           |

Table 3. Examples of disturbance control action

| No | Disturbance | Keyword | Severity | Freq. | Dist. Impact | Achiev. KPI | Status for the action | Recom. action |
|----|-------------|---------|----------|-------|--------------|-------------|-----------------------|--------------|
| 1  | Empty WIP among process in a line | Empty WIP | Seldom | Severe | AR ≥ 66% | Good | Low | Maintain, no action needed | 1             |
| 2  | Delay caused by supplier | Supplier | Seldom | Not severe | 33%<AR<66% | Moderate | Low | Not immediate action | 3,4           |
| 3  | Coolant leakage | Down time machine | Seldom | Severe | AR ≥ 66% | Good | Low | Not immediate action | 3,4           |
| 4  | Leak test | Reject casing | Often | Not severe | AR ≥ 66% | Moderate | Low | Maintain, no action needed | 1             |
| 5  | Porous | Reject casting | Occasionally | Not severe | AR ≥ 66% | Moderate | Low | Maintain, no action needed | 1             |
| 6  | Customer complain and request a product based on the company’s standard (affect the company’s image) | Demand | Seldom | Severe | 33%<AR<66% | Moderate | Medium | Not immediate action | 5,6           |
The control action in table 2 is a combination of the results of the two sub models. The action contained in the table in the form of numbers is an action that exists on the explanation of the action taken when the disturbance occurs. In table 3, there are examples of disturbances control action. In case of leaking tester trouble with low level of noise risk and maintain status, then action that need to be done is action number 1 that is change of work shift.

If continuous and repeated disturbance occurs, further action is required based on the preceding action. For example, if the disturbance of porous caused by reject casting with the increment of the number of occurrences each month, then the action previously done that changes shift work to cope with the disturbance can not be used again. The disturbance must be solved by making a change of action performed by the person responsible for carrying out the action. Table 4 shows disturbances response matrix that serves to determine what action to perform the implementing party. The preceding action for leaking tester trouble is with the shift break changes to cope with the disorder. But if the disorder is constantly repeated, then the action is done by meeting with the suppliers and as the executor is the head of the production department.

| No | Disturbance       | Cause                | PIC                      | Further action                  |
|----|-------------------|----------------------|--------------------------|---------------------------------|
| 1  | Delay caused by supplier | Trouble when delivering | Head of division or department | Changing level stock or meeting with supplier |
| 2  | Clamp pipe broken | Lifetime of the machine’s component | Head of department | Build a team to control the machine’s life time |
| 3  | Leak test         | Casting process      | Head of department | Meeting with supplier |
| 4  | Porous            | Casting process      | Head of department | Meeting with supplier |
| 5  | Misrun            | Casting process      | Head of department | Meeting with supplier |

**Sub Model of Safety Stock Determination**

Determination of the safety stock value begins by calculating the percentage of the influence of the disturbance to the percentage of safety stock values that change every day based on the disturbance that occurred. The percentage value of disturbance effect is obtained from the difference of effect of each disturbance divided by the number of disturbances per day. The percentage value of safety stock this period is obtained by summing the percentage value of safety stock last period with the percentage of influence of interference. On the 1st, the percentage of safety stock last year was 58.15% which was obtained from the safety stock percentage of last period of May. Value is added with the percentage of disturbance that is 1% so the percentage of safety stock this period is 59.15%. Implementation of the control model for safety stock calculation requires that the percentage of safety stock is within the prescribed control limit of 60 - 80%.

Forecasting requirement of this period is planning of cylinder head request which for assembly section for one month is averaged. Safety stock requirement planning is the result of multiplication of percentage value of safety stock of this period with value of forecasting requirement. Actual usage is the number of units shipped to AE, and the remaining inventory is obtained by summing up the last period's inventory value forecasting and subtracting it from actual usage. For example, in the period of June,14,2016 the percentage of safety stock which is (78.72%) and forecast value of this period is 788 units, so the value of safety stock is 566 units.

The result of safety stock calculation by using sub controlling control model at table 5 shows the safety stock value of cylinder head component which is smaller than company policy. For June data, Safety stock based on company policy has a very large range, which is between 200 - 1398 units. This range is very fluctuating compared to the safety stock score based on model of 0 - 630 units. If there are many safety stocks provided by the company, it will affect the achievement of KPI cost due to stockpiling. The design of the controlling model of disturbance at PT XYZ has been based on the KPI of the company, resulting in the design of sub-model which is more effective in controlling production system disruption at PT XYZ associated with the non-achievement of KPI.
Table 5. Calculating safety stock using disturbance control model

| Previous period stock | June,1, 2016 | June,2, 2016 | June,3, 2016 | June,6, 2016 | June,7, 2016 | June,8, 2016 | June,9, 2016 | June,10, 2016 | June,13, 2016 | June,14, 2016 |
|-----------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|                       | 2109         | 2097         | 1985         | 2073         | 2061         | 2049         | 2002         | 1875         | 1913         | 1901          |
| Forecasting for current period | 788         | 788         | 788         | 788         | 788         | 788         | 788         | 788         | 788         | 788           |
| Safety stock planning  | 473          | 481          | 489          | 495          | 501          | 507          | 517          | 528          | 559          | 566           |
| Actual usage           | 800          | 900          | 700          | 800          | 800          | 835          | 915          | 750          | 800          | 800           |
| Current period stock   | 2097         | 1985         | 2073         | 2061         | 2049         | 2002         | 1875         | 1913         | 1901         | 1889          |

4. Conclusion
The dominant disturbance in production process at PT XYZ as an automotive company comes from reject casting. The design of disturbance control model for the company consists of Sub Model of Disturbance Risk Level to know the level of risk of low, medium, or high disturbance, Sub Model Status done action to know whether the disorder requires immediate action or not or just monitoring, Sub Model of 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. Based on the results of analysis it is known that the range of safety stock based on disturbance control model is relatively more stable than the safety stock based on company policy.

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