

Conceptual model of failure risk control on raw materials inventory system

Arief Suwandi¹, Teuku Yuri Zagloel² and Akhmad Hidayatno³

^{1,2,3}Department Industrial Engineering, Universitas Indonesia, Depok 16424, Indonesia

E-mail : arief.suwandi51@ui.ac.id

Abstract. In an effort to overcome the problem on raw materials for the production process in manufacturing highly complex and must be continuously strived to maintain the quantity and quality of production results so that the costs incurred due to problems in the procurement of raw materials can be pressed. Various difficulties in the risk control system in raw materials warehouse becomes an obstacle for the company to maximize its long-term profit. This research paper presents a conceptual model for risk control of failure in raw materials warehousing, which is influenced by various factors in the form of defective materials, materials deficiencies, delays and materials error. Whereas, each factor influenced by inspection variables, loading-unloading, allocated materials, retrieval, procedures, worker skills, and facilities. Conceptual modeling is done using the qualitative phase of system dynamic (SD) methodology on the network and Failure Mode and Effect Analysis (FMEA). The level of improvement in the conceptual model is given for the continuous improvement and improvement of the system of risk control in the raw materials warehouse.

1. Introduction

Technological developments in the manufacturing field so rapidly that the demand of every company continues to improve the quality of its products. Quality control becomes the absolute thing that must be done by the company especially in the field of raw material control so that there is no risk of material failure in the production process. The risk of not achieving process outcomes in key processes should be identified and reduced to achieve better results. The identification of risks involves defining the possible events that compromises the achievement of process outcomes and also the consequences of the occurrence of these events. (Sousa, Nunes, & Lopes, 2015).

Inventory inaccuracy has a significant negative impact on the performance of raw materials replenishment and production control. It usually leads to high inventory holding cost or large backlog penalty. To hedge against it, we investigate a replenishment and production control problems for a multiple machines and multiple product-types production/inventory system with inventory inaccuracy. (Li & Wang, 2017). Inventory inaccuracies can be found in the supply chain stages of raw material procurement, transportation and refilling of raw materials and control and distribution of final goods. Inventory overflow in the inbound supply chain is equally important to stock-out because inventory overflow causes the same impact of stock-out by making unloading operation impossible and then disruptions occur in production yield. (Lee, Cho, & Jung, 2014).



Based on previous studies, there are still many failure risks that are encountered on the procurement and handling of raw materials in manufacturing warehouse. The aim of this research was to create a conceptual model of handling the risk of failure in raw material warehouses.

2. Methodology

Dynamic system is a simulation modeling methodology used to understand complex system dynamic behavior in order to analyze and solve complex problems with focus on analysis and policy design (Poles, 2013). Forrester (1961) created system dynamics methodology to design enterprises by treating the time-varying (dynamic) behavior of industrial organizations. The methodology is a powerful approach to obtain insights into dynamic complexity problems (Sterman 2000). It is designed for long-term, chronic, dynamic management problems (Barlas 2002). Additionally, it is the proper method to encounter the systems with dynamic and full of feedback (Sterman 1991).

Briefly, the entire process is divided into two analyzing phases, namely qualitative and quantitative. In the qualitative phase, it starts with the observation of the systems under consideration before identifying the model objectives. Then, systems approach and analysis are applied to the observed systems by selecting properly all relevant entities and variables to the objectives in order to have a simplified and well-defined system. In the next step, a causal loop diagram is developed which is then transformed into a stock and flow diagram. During the quantitative phase, the stock and flow diagram is translated to a simulation program using SD software for developing dynamic models. Once the initial models are gathered, they are iteratively verified and validated to obtain sufficient models (Rasjidin, Kumar, Alam, Road, & Barat, 2014).

Furthermore, the improvement on each loop is done by using FMEA (Failure Mode and Effect Analysis) method that is calculated by Risk Priority Number which obtained from multiplication of three input variables Severity, Occurrence and Detection. The smaller the RPN value will be the better and vice versa the higher the RPN value will get worse. FMEA is a methodology used to evaluate failures occurring in a system, design, process, or service. Identification of potential failures is done by scoring or scoring each mode of failure based on the occurrence, severity, and detection rate. (Stamatis, 1995). The FMEA is used to analyse concepts in the early stages before hardware is defined (most often at system and subsystem). It focuses on major failure modes linked with the proposed functions of a concept proposal (Shivakumar, Hanumantharaya, & A, 2015).

3. The Proposed System Description

Control of raw material inventory in manufacturing aims to reduce the risk of raw material failure for the production process, so that production goes according to plan. The physical flow of the raw material inventory system presented in Figure 1 shows that the supplier sends raw materials to the company to the raw material warehouse. Inspection is done in the warehouse by taking into account the suitability of administrative documents with physical material that is by looking at the specifications, quantities, types, and quality of materials.

Next, unloading the raw materials to ensure the level of material quality, type and quantity of available materials. Handling is done for the allocation of raw material materials in the warehouse for easy in finding and finding the type of raw materials that will be used in the production process. Retrieval material is the process of selecting raw materials for production use, by unloading of material placement followed by handling activities to move and transport raw materials from warehouse to production.

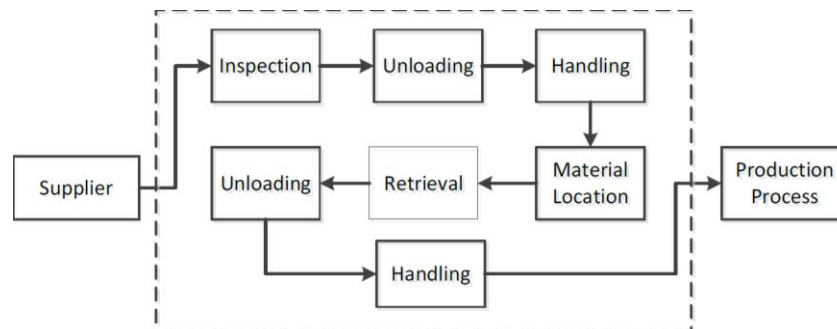


Figure 1. Physical Flows of Raw Materials Inventory System

The inventory system of raw materials by maintaining good quality is crucial for production quality. Therefore, there is a need for risk reduction system of raw material in manufacturing warehouse. The sequence of activities in the raw material inventory system for risk reduction is described in the following system scheme:

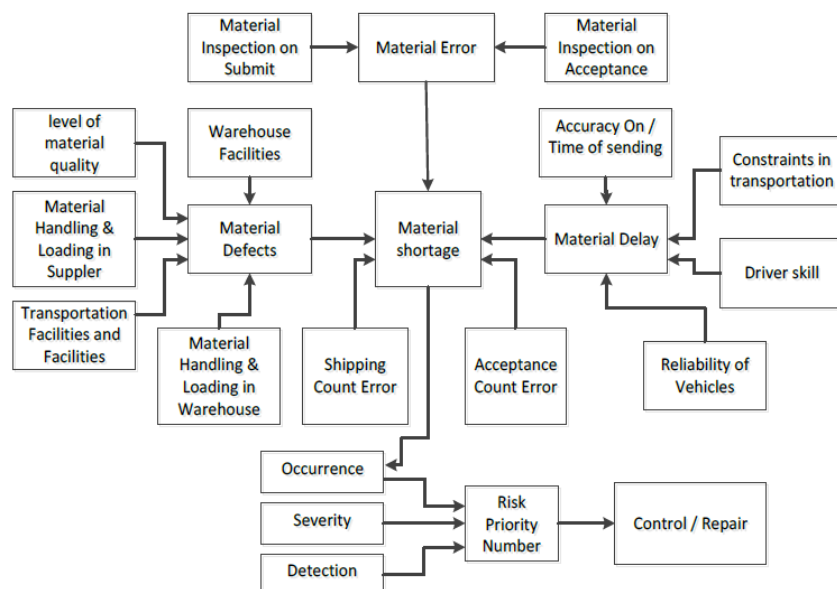


Figure 2. The series of inventory system activities in reducing risk of failure

Risk of raw material inventory system failure arises from various things including the material shortage in the warehouse will result in the risk of failure in the production process, so the process will run not according to the production plan because of the material shortage. The cause of the material shortage is the miscalculation of the delivery, miscalculation at the time of receipt of raw materials in the warehouse, the existence of defective material is also the cause of the raw materials shortage in the warehouse, in addition to material errors and material delay is the cause of material deficiencies in the warehouse.

Material defects that occur in raw materials caused by various factors, among others, is the level of material quality where the low quality level will easily occur defective materials, as well as material handling and loading systems in suppliers, transportation facilities and facilities, material handling systems and loading in the warehouse, and raw material warehouse facilities.

Material delays in raw material warehouses are caused by the following factors, including inaccurate timing of material delivery, constraints in transportation, driver skill or lack of skilled drivers will result in delays in material acceptance of warehouse, and vehicle reliability.

Furthermore, the material shortage in the raw material warehouse becomes a risk of failure for the production process. The frequency of occurrence of material deficiency will give the occurrence value (how often the occurrence) where the more frequent occurrence of material deficiency will impact the

high occurrence value, then along with the severity and detection value can be generated RPN (Risk Priority Number). RPN value is what will give the company to make improvements on the value of a large RPN, so that with the level of repair is well managed then the company can control the risk of failure in raw materials.

4. Results and Discussion

The proposed system dynamics conceptual model is utilized to measure determinated system performance. (Rasjidin, Kumar, Alam, & Abosuliman, 2012). The proposed system, described in the previous section, is then further developed to derive its conceptual model based on the Dynamic Systems approach. The resulting conceptual model is presented in the form of causal-loop and stock and flow diagram.

4.1. The Resulted Causal-Loop Diagram

The causal-loop of the proposed risk failure reduction on input of production system is presented in Figure 3. All variables involved in the causal loop are described in Table 1. The interactions among variables leading to dynamics in the system are categorized into two types of feedback loops, positive (or self-reinforcing) and negative (or selfcorrecting) loops. While the positive loops tend to reinforce or amplify whatever occurs in the system, the negative loops counteract and oppose change (Sterman, 2000).

Figure 3 has three balancing loops namely B1, B2 and B3 and the details of these loops are shown in Table 2. The first balancing loop has seven variables which are shortage of materials, occurrence, severity, detection, risk priority number, level of improvement, and material delay. There is only one negative arrow in the loop B1 that categorizes the loop as a balancing loop, where a negative arrow is shown from the level of improvement to the material delay.

B2 as the second balancing loop is built by seven variables, which are materials defect, materials shortage, occurrence, severity, detection, risk priority number, level of improvement. Loop B2 is categorized as a balancing loop indicated in the negative direction from the level of improvement to the materials defect.

Furthermore, the third loop balancing, B3 consists of seven variables such as materials error, material deficiencies, occurrence, severity, detection, risk priority number, and rate of improvement. The categorization of B3 as balancing loops is determined negative arrow from the level of improvement to materials error.

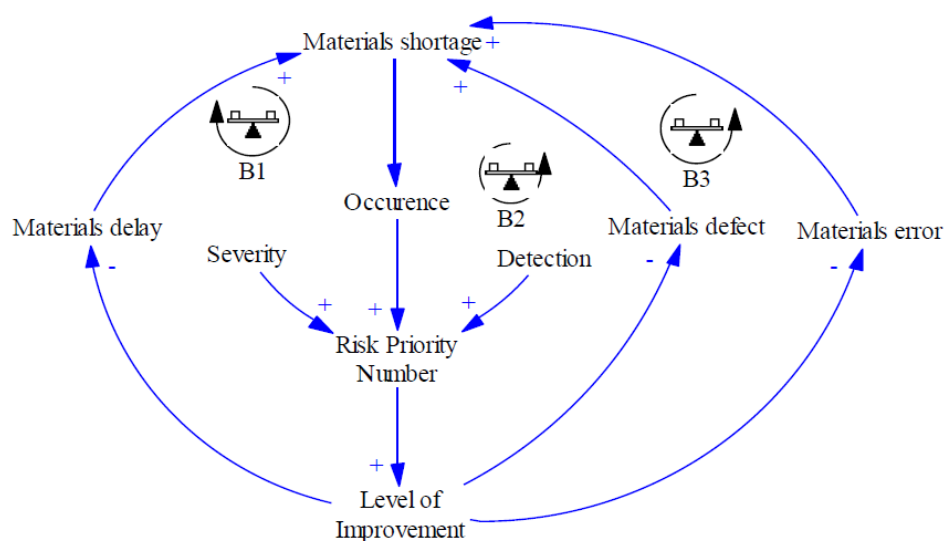


Figure 3. Causal Loop Diagram on Production Input

Furthermore, the variables used in the CLD are described in detail in the following table descriptions.

Tabel 1. Description of variables in the causal loop diagram

Variables	Description
Materials Delays	The materials condition is received in the late time
Materials shortage	The materials condition in warehouse is shortage
Occurrence	Events that cause the risk
Risk Priority Number	Priority value for risk handling
Level of improvement	Type of improvement of risk handling
Materials Error	The condition of the received materials does not match
Materials Defects	Materials condition is defective or not according to

Variables in loops have signs which show relationships and provide an overview on the loop identifier which is the loops on the part of the causal loop diagram in Figure 3.

Tabel 2. Variables and signs in the balancing loops

Loop identifiers	Variables in the loop	Arrow direction sign
B1	Materials Delays	+
	Materials Shortage	+
	Occurrence	+
	Severity	+
	Detection	+
	Risk Priority Number	+
	Level of Improvement	-
B2	Materials Defect	+
	Materials Shortage	+
	Occurrence	+
	Severity	+
	Detection	+
	Risk Priority Number	+
	Level of Improvement	-
B3	Materials Errors	+
	Materials Shortage	+
	Occurrence	+
	Severity	+
	Detection	+
	Risk Priority Number	+
	Level of Improvement	-

4.2. The Resulted Stock-and-Flow Diagram

The cause-and-effect diagram shown in Figure 3 is then further developed to create the appropriate stock-and-flow diagram as shown in Figure 4. In this study, the development of stock-and-flow diagram is carried out by using a certain system dynamics software, VENSIM, which is similar to the tools in the studies of Tan and Kumar (2006), Gu and Gao (Qiao-Lun & Tie-Gang, 2011). Basically, stock-and-flow diagram is built using a particular diagramming notation, namely stocks, flows, valves and clouds. Stocks or levels are represented by rectangles or boxes (Rasjedin et al., 2014). Stock or level variables describe accumulations in the system. Flows or rates are represented by pipes. There are two types of flows which are inflows and outflows. Inflows are represented by a pipe (arrow) pointing into (adding to) the stock. Outflows are represented by pipes pointing out of (subtracting from) the stock. Flow controls are represented by valves. Clouds represent the sources and sinks for the flows. A source represents the stock from which a flow originating outside the boundary of the model arises; sinks represent the stocks into which flows leaving the model boundary drain. Sources and sinks are assumed to have infinite capacity and can never constrain the flows they support (Sternan, 2000).

Stock and flow diagrams are the detailed physical structures of the proposed system which show how the flow of materials flow from the supplier to the production floor consists of receiving incoming ordered materials, pre inspection, post inspection, allocated materials, and delivered materials. In the network of stock and flow diagrams described incoming material process ordered there is percentage of material error, which is an inflow of preinspection materials, and returned materials to supplier. In preinspection materials there is a measurement of level of materials quality which is an inflow of post inspection materials, and non conformity materials. Post inspection materials measures the level of materials handling reliability which is the inflow of the allocated materials at the warehouse, and the defect caused by materials handling / transportation, where the measurement of success rate of rework is an inflow of rework to be forwarded to the allocated materials at the warehouse, and inflow from scrap. At the outflow of the allocated material at warehouse, a level of materials deterioration measurement is the inflow of delivered materials to shop floor production. In addition, the deteriorated materials measures the success rate of treatment / repair that will be an inflow in the allocated materials at the warehouse.

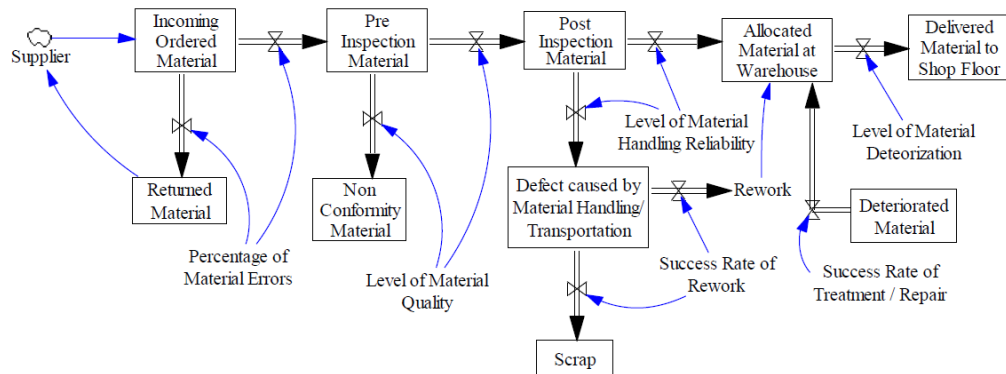


Figure 4. Stock and Flow Diagram (SFD) on Production Input

5. Conclusion

A conceptual model for risk reduction in manufacturing raw material warehouses has been built. The model formed consists of causal loops diagrams and appropriate stock-and-flow diagrams designed by the qualitative phase of the system dynamics methodology.

The proposed system structure represents the physical flow and information related to the regulation of raw material flow coming from suppliers to the raw material warehouse which is the inflow of the shop floor production through a certain network through various incoming ordered materials, pre-inspection, post inspection, allocated materials at warehouse, and delivered material to shop floor production. In incoming ordered material there is returned material to supplier, in pre-inspection there is non conformity material, also on post inspection there is activity of defect caused by material handling/transportation which is inflow from rework and scrap, and deteriorated material is inflow allocated material at warehouse. Further model development can be done by using the quantitative phase of the dynamic systems approach to the resulting conceptual model.

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