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Assessing Incoming Inspection Performance Using System Dynamics Modelling

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Abstract: An incoming inspection verifies the quality of purchased raw materials based on predetermined set of acceptance criteria. It is performed by quality assurance personnel in the incoming inspection laboratories of a manufacturing facility to resolve any quality issues before production. Since incoming inspection of raw materials coming from vendors is one of the important targets in a company's efforts to improve overall quality performance, it is important to have a system in place to measure the performance of incoming inspection laboratories. There are various factors effecting the incoming inspection performance. These are; internal customer satisfaction, inspection errors, inspection wait times, re-inspection rates, etc. In this research we will present a generic system dynamics model for assessing the performance of an incoming inspection laboratory considering these factors under different demand and resource deployment scenarios.

Keywords: Incoming Inspection, Performance Assessment, Quality Inspection

1. Introduction

Recently, the use of zero defect policy for incoming materials has been growing among the manufacturers. With this policy an incoming lot from supplier is accepted only if no defect is found in the samples selected for inspection. (Schilling and Neubauer, 2009) The general procedure for such procedure, also called acceptance sampling procedure, is to take a random sample from each lot and determine whether the lot will be rejected or accepted based on the inspection result of the random sample taken. Acceptance sampling procedures are preferred because a 100% inspection is usually not desirable when the inspection is destructive, time consuming, or expensive. (Squeglia, 2008)

All incoming lots from supplier are inspected at Incoming Inspection Laboratory (IIL), which constitutes a major element of a company. IIL is associated with the processes and the facilities that production utilizes. Thus, it is important to have a system in place to measure the performance of an IIL to ensure proper service and support is provided to the production. In this study, we will model the dynamic nature of incoming inspection laboratory system of a production company using system dynamics (SD) modelling approach. We intend to utilize this dynamic model to assess the performance of the laboratory under different scenarios.

The Incoming Inspection Laboratory system in this company is as follows: Incoming raw materials (routine materials) are received from the supplier as different lot sizes. Acceptance sampling procedures are applied to these lots based on the quality performance history of the supplier. Acceptance sampling is used to differentiate good lots of received material from not acceptable lots so that such lots do not enter production. Then the required sample size to be inspected are listed on a waiting list before they are received to the incoming inspection laboratory. The routine sampled materials coming from a waiting list is inspected on a first come first served basis. There is a variability on the routine inspection time. As many materials as possible are after inspection directly released to production, if they pass the inspection. About 1% of the materials needs to be retested due to inspection error and are listed on the waiting list for re-inspection. The technicians working in the laboratory are fully trained on operating all inspection equipment. When a lot is rejected due to not meeting technical blueprint requirements, suppliers receive a non-conformance report and need to take immediate action. Good (pass the acceptance criteria) inspection results are also sent to supplier for feedback and to maintain good supplier-customer partnership. In addition, the incoming inspection department is required to accept all necessary emergency inspections (coming from the production and need immediate action). It can be assumed that any overflow emergency inspection can be sent to another laboratory for inspection, though the company will have to pay for the cost of inspection whenever this happens. The admission policy as stated before is that all emergencies must be given priority, and any spare operators and equipment are used for routine inspections.

Taking into account all attributes of an incoming inspection laboratory, to perform effective performance assessment, it is important to utilize a decision-support model. Thus, in this study we will conduct an introductory research analysis to study

the performance of an incoming inspection laboratory under different demand and resource deployment scenarios, and we will construct a generic system dynamics (SD) model for this purpose.

2. Modelling Approach and Model Design

There are various factors effecting the incoming inspection laboratory performance. These are; internal customer satisfaction, inspection errors, inspection wait times, re-inspection rates, etc. System dynamics modelling approach is selected for the development of the incoming inspection laboratory performance assessment model due to the need to address these factors for a generic tool. System dynamics approach provides a framework to understand the operations of complex dynamic systems and present the effect of any decision on the entire system. It presents a holistic view of system components and the analysis of their interdependencies. (Bala, et al, 2017)

System dynamics modelling starts with problem definition, followed by causal loop diagram and stock- flow modelling. Casual loop diagram (CLD) and stock flow diagram are two main components of SD model. Casual loops are important to represent the feedback loops or casual relations between the variables of a SD model in a conceptual manner. (Bala, et al, 2017) Stock flow modelling is the identification, mapping and interpretation of the stock and flow networks of a system. Unlike CLD, stock flow modeling provides the model system with memory, delays and disequilibrium dynamics. Stocks are defined as the accumulations of physical/abstract elements and characterize the state of the system while generating information upon which decisions and actions are based. Flows are defined as an action or process that transforms "information" by directly adding to, or subtracting from the accumulation of a Stock, hence forming the Inflow and Outflow, respectively. (Sterman, 2000)

Based on system dynamics representation notation (Forrester, 1994; Sterman, 2000), the laboratory will be illustrated as a stock-flow diagram using three building blocks:

- stocks (rectangles), which represent the state of a process, e.g., raw material accumulation in queue for inspection,
- flows (pipes), which represent the rate of change of this state,
- converters (circles) which hold information about the system and affect the rate of the flow

For the case of the material arriving to the incoming laboratory, the inspection process is shown in Figure 1. The tested raw material is released from the inspection area and proceed to the production. The inspection process is completed based on the capacity of the lab (Number of inspectors and equipment availability) and the associated inspection rate. Materials passing the inspection can proceed to the production. However, a percentage of material fail inspection and have to be re-inspected. If a queue has been formed they wait, and then get re-inspected. Again, the inspection process at the re-inspection depends on the number of the available technicians, equipment and the associated re-inspection rate. In addition, production may request certain percentage of material to be inspected if they see any necessity. such cases are treated as emergency cases and given priority for inspection. If they cannot be inspected due to lack of capacity at the laboratory, they are sent to another laboratory for inspection. The process ends when all raw material, after being inspected for all necessary requirements, are processed and accepted fully in production.

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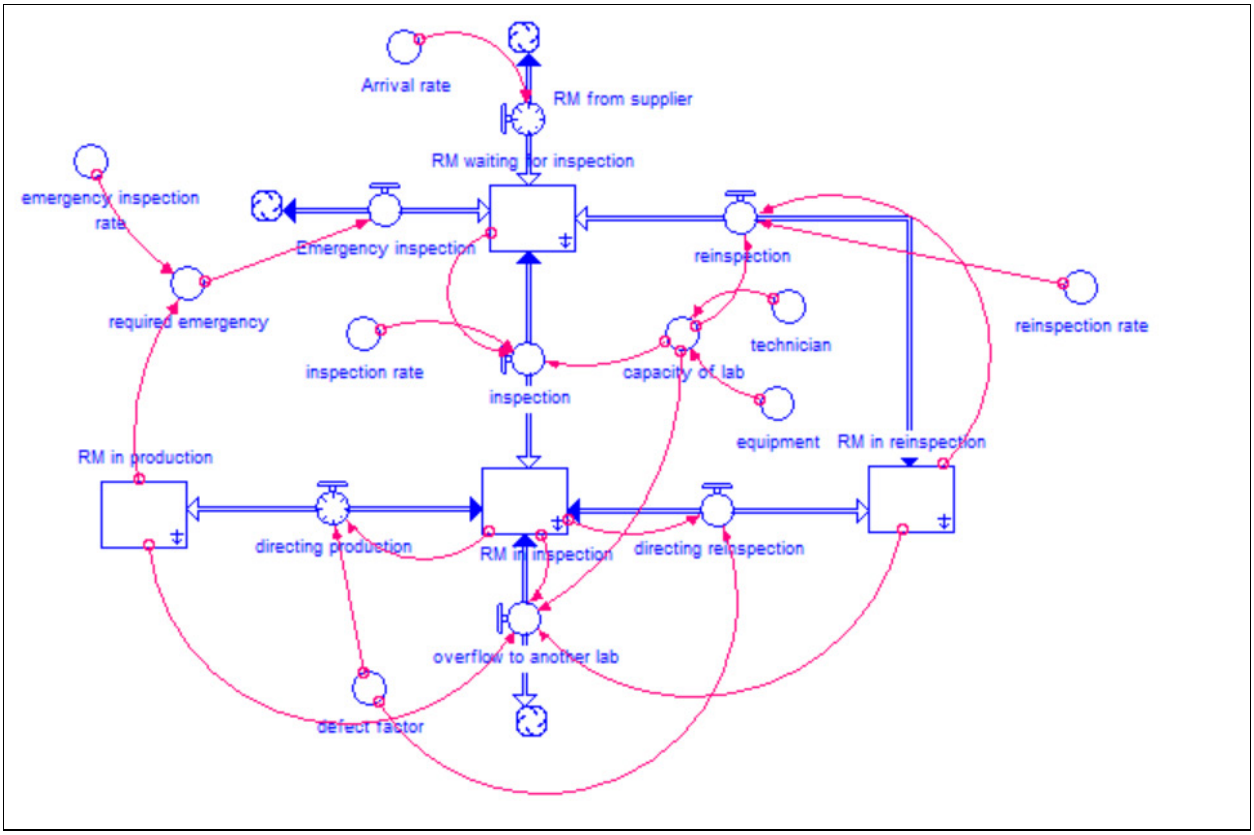

Figure 1. Incoming Inspection System Model

3. Conclusion

A system dynamics model for incoming inspection laboratory has been presented. This preliminary proposed model supports effective decision-making, providing the capability of conducting impact analysis with respect to laboratory performance measures, such as capacity, waiting times, technician and equipment utilization, material accumulations at various stages, etc. The major strength of the proposed model is that it is generic and can be easily used to represent any other laboratory conditions. Furthermore, it allows for a holistic evaluation of laboratory performance, realizing important interactions and trade-offs among the various laboratory activities.

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