Effectivity analysis for poultry feed production using system simulation

Faraz Mueen Mulla*, Vinayak N Kulkarni, Sanjay V Kulkarni, V N Gaitonde, B B Kotturshettar

School of Mechanical Engineering, KLE Technological University, Hubballi, Karnataka, India

E-mail: farazmueen@hotmail.com

Abstract: Organizations constantly work towards process improvements in their day to day activities. Material and information flow in the process is to be controlled to successfully manage and control any process in the organization. Information flow in the production process is a key area to focus on effectivity analysis and performance improvement. Considering a poultry feed production process of a poultry firm that produces commercial broiler chicken. Poultry feed is required to feed the chickens. Several ingredients are required to produce poultry feed, which includes maize, soya, fats, essential nutrients, and medicines. Feed manufacturing requires skills and experience in the areas of nutrition, medicine and disease control. The paper introduces to the general continuous poultry feed manufacturing practices and the use of tools to analyse the process, later in the paper is process analysis which includes present analysis of the production process. The effectivity of the processes is also discussed in the paper with the use of generic simulation software. The experimentation of the processes is done using by creating models of the system, these models are created to increase the production efficiency and decreasing the non-value-added activities. Finally, giving the output as results in the conclusion. The paper also includes the gap in the processes involved which can be studied further by the researchers.

Keywords: Enterprise Systems, Feed Production Process, Poultry, Supply-Chain.

1. INTRODUCTION

The production process management is a powerful yet critical business activity in any size of an industry or an organization as it involves transactions concerning the enterprise resources. The business processes involve value-added and non-value-added activities in the fulfilment of the customer requirement[1]. Because the enterprise resources are the most valuable assets of any organization but the information of those assets are also equally important[2]. Management of the processes is a critical task in day to day operations as well as recording the information of that process is also equally challenging[3]. To study or to analyse any process in a system it is required to have a proper understanding of the system and its behaviour when inputs are given. The system consists of components that are working towards the intended goal[4]. The components contribute to the overall system performance and the behaviour of the system is analysed. The production process simulation in any generic simulation software requires a proper understanding of terminologies of the system engineering at a basic level at least because a system such as feed production has a flow of product (raw material) and information which is especially carried out by a sequence of activities. The production process is the execution of those activities in an organized manner to fulfil the desired output with less utilization of resources and elimination of formulation errors so that the firm or the organization should not face losses. Simulation software is a decision-making tool built to analyse the mathematical and statistical models of a system. The software package is built on mathematical and
statistical principles to give results in analytics. The practitioner has to be skilled to work with the
generic simulation software because results given by this generic simulation software are properly
analysed by a skilled practitioner to obtain the experimental results. The methodology of the system
analyses using simulation is a series of organized activities that are often performed by practitioners to
achieve good results out of experimentations [5]. This involves a solid problem identification
 technique such as fishbone diagram and Pareto analysis to identify the problem in the system, based
on the results of the initial analyses practitioner then forms a problem statement. The problem
statement defines the actual area to be focused for analysis, with a proper understanding of the
problem statement practitioner defines the objectives of the experiments and draws a line of scope to
the study[6]. After compiling the prerequisites to define the problem, it is now required to analyse the
information flow in the process, the points of interest in the process where the ration of the raw
material and ingredients could be compromised. To understand the proper flow of activities and to get
the concrete idea of the system behaviour a high-level flow chart is created, which shows the
information flow as well as the activities or tasks to be carried out in the sequence by the system to
fulfil the desired output. The high-level flow chart is not a brainstorming map to describe the system;
it is a systematic standard chart to demonstrate the activities of the system[7]. A high-level flow chart
aims to guide the practitioner to build the simulation models which are mathematical, statistical and
analytical. The simulation models are logical models purely made up of mathematical functions and
equations, these models help to calculate the inputs and gives the required outputs. Simulation models
are built for experimentation to reduce cost, time and other valuable enterprise resources. The
simulation models can run in no time comparing to the actual physical system operations, which are
most often require a physical system interaction for the experimentation plus it consumes a lot of time
and resources. Resources of the system being physical which do not allow the practitioner to
experiment on it; a logical replica of the physical system is created in a virtual environment to
study and analyse the system[8].

A poultry feed manufacturing industry which produces different types of commercial broiler feeds
and breeders’ feeds categorising in livestock feed formulation standards; production process for the
raw material of poultry feed is studied[9]. This study aims to analyse the ongoing as-is process where
the material flow is weak and manipulative. The management of the firm is interested in redefining
the process with high effectivity and high efficiency to streamline the process with proof of records
and eliminate any non-value-added activities. The paper contains as-is and to-be analyses based on
high-level flow charts and simulation models that are properly run and studied for a desired amount of
time. The roles and functions of the process are discussed and also show the before and after analyses
report wherein the results and conclusions can be justified further.

2. EXISTING PRODUCTION PROCESS ANALYSIS

The analysis of the production process is a skilful task where the proper understanding of the flow of
material, information and other resources is very important. The generation of the requirement of raw
material and the information associated with it should be properly managed, because a small deviation
in the information and the actual requirement may lead to the improper process flow that eventually
leads to loss of control over the process[10]. The flow of material information is very important in
modern enterprise tools such as ERP systems as it is an enterprise information management system
that deals with enterprise resources.

Figure 1. is a high-level flow chart of the feed production process which clearly describes the different
stages of the production process; input of raw material using hoppers to fill the raw material storage
bins for maize and soya seeds. The raw materials are later fed into batch-bin as per the required feed
formula. The batch raw material is fed to the hammer mill using bucket elevators after hammer
milling the crushed raw material is mixed with other medicines, toxin binders and fats in the mixer;
the mixing process requires a fixed amount of time for proper mixing. After the successful mixing of
the feed, it is lifted to a finished feed storage bin for packaging.

The as-is analysis is the first analysis to go for any business process analysis in any organization's business process reengineering. The as-is analysis is the result of the orientation phase of the study where the practitioner physically visits the facility and study the business process. This analysis is defined as the current analysis of the process which is running in a firm or company. Most of the companies rely on solid processes to effectively and efficiently meet target objectives. But without effective and efficient processes companies always faces productivity issues which further leads to loss of resources and eventually cutting the profits.

Figure 1. High-level flow chart for feed production

Figure 2. Process stages

Figure 2 represents the floor process stages at the firm which starts from the input of raw materials in the production line from hoppers, with the help of bucket elevators the feed is moved into the storage bins for maize and soya respectively. The storage bins release the raw materials using the formulation
ratios and feed them to the hammer mill. The feed production is a continuous production process where the agricultural raw materials such as maize and soya are converted into poultry feed with medicines and other essential ingredients containing nutrients toxin binder and oils and fats.

**Table 1. Data distribution table**

| Processing stages | Processing time (sec.) | Delay time (sec.) | Breakdown time (sec.) |
|-------------------|------------------------|-------------------|-----------------------|
| 1                 | 120 ±10                | 0                 | 0                     |
| 2                 | 180±20                 | 40±20             | 1800±120              |
| 3                 | 480±60                 | 60±20             | 1800±480              |
| 4                 | 240±40                 | 120±20            | 1800±120              |
| 5                 | 120±20                 | 60±20             | 1800±60               |
| 6                 | 120±40                 | 0                 | 0                     |

Table 1 shows the distributed data collected in the as-is process analysis of the feed production and is later used in the simulation software for the initial pilot run.

**3. SIMULATION STUDY**

The simulation information regarding processing time, delay time and breakdown time of all the stages have been noted at the beginning of the study. These values were used as input data for building a simulation model. Organizations are working towards continuous improvements to increase the process effectiveness, efficiency, and productivity whilst reducing the overall lead time. The management wants to reduce the production process time for every batch and to have more control over the flow of raw materials, that being the reason for redefining the simulation. To have better control over the process information flow is very important, any misinformation in the production planning and resource planning leads to delay in production.

![Figure 3. Simulation model of the process stages](image)

Figure 3 indicates simulation model of the overall process and Table 2 represents the data for 1 ton of feed production, based on which three scenarios are created to study the different outcomes in the process to reduce the processing time and delays with possibilities of reducing machine breakdowns.

**Table 2. Stage wise congestions observed**

|               | RMI | Storage in Bin | Milling | Mixing | FF in Bin | Packaging | Total       | Avg. Prod. |
|---------------|-----|----------------|---------|--------|-----------|-----------|-------------|------------|
| Avg. no in queue (ANQ) | 0   | 180            | 480.81  | 270.18 | 120.45    | 124.67    | 1176.11     | 1.0        |
| Avg. waiting time (AWT)   | 0   | 180            | 480.61  | 290.37 | 127.83    | 30.31     | 1109.32     | 1.0        |

The average number in queue as shown in table 2 represents the queuing of raw material in the process which is affecting the raw material for the delay. The first scenario is focused on increasing the speed of the process by increasing only the hammer mill speed. The second scenario is focused on increasing the mixer speed as well as hammer mill. The third scenario is focused on increasing the packaging time. The speed of stage 2 i.e. storage of raw materials in the bin cannot be increased.
significantly because of the elevator buckets size and motors attached to it. As there is aim for just tweaking the existing process instead of changing radically the components of the system.

Table 3. The outcome of each scenario after experiments by simulation.

| Scenario | RMI | Storage in Bin | Milling | Mixing | FF in Bin | Packaging | Total | AP |
|----------|-----|----------------|---------|--------|-----------|-----------|-------|----|
| 1        | ANQ | 0              | 180     | 270.37 | 120.45    | 120.65    | 1131.63 | 1.01 Tones |
|          | AWT | 0              | 180     | 290.18 | 127.83    | 121.32    | 1159.73 |    |
| 2        | ANQ | 0              | 180     | 140.37 | 120.45    | 120.65    | 1041.63 | 1.02 Tones |
|          | AWT | 0              | 180     | 120.18 | 127.83    | 121.32    | 989.74  |    |
| 3        | ANQ | 0              | 180     | 270.18 | 120.45    | 60.23     | 941.21  | 1.01 Tones |
|          | AWT | 0              | 180     | 290.37 | 127.83    | 61.28     | 942.26  |    |

AP: Average production, ANQ: average number in queue, AWT: Average waiting time. Table 3 represents the outcome of the experimentation scenarios or simulation runs.

Figure 4. Average no. of queue vs simulation runs

Figure 4 represents the average number of queue vs simulation runs where we see that by changing the scenarios, gives the ability of the experimentation on the processes without actually running it on the physical shop floor gives an insight into the future decisions that can be made and also to evaluate the process performance.

Figure 5. Average waiting time vs simulation runs
Figure 5 represents the average waiting time vs simulation runs which helps to identify the actual waiting time of the process by changing the scenarios for the simulation runs.

Figure 6 represents the total production observed after simulation runs for the different scenarios of experiments.

4. RESULTS ANALYSIS

The results in table 3 show clearly that the impact of change in speeds on the processes at different stages gives different outcomes after simulation. The change in hammer mill speed gives an output of approximately 100 KGs more feed production. The change in the mixer speed gives approximately 200 KGs more feed production. By changing the packaging speed of the production doesn’t help with the production but decreases the packaging time that might affect in the later processes for the dispatching of goods against orders.

5. CONCLUSION

Simulation is one of the best decision-making tools for organizations. Focuses on the processes to improve the efficiency and effectivity the simulation is used at every stage of the operations in the process. The feed production process in the firm is studied using generic simulation software that helped to derive the results and effects on the system by changing the scenarios of the process ideas. The strategic objectives for planning and dispatching can be solved using the proposed techniques.

The scope of research can be done in the value chain system of such organizations to study the operations capabilities, resource optimization management, and corporate governing activities in the near future for optimization and innovations.

REFERENCES

[1] Tyre, M.J. and Hauptman, O., 1992. Effectiveness of organizational responses to technological change in the production process. *Organization Science, 3*(3), pp.301-320.
[2] Liang, C. and Li, Q., 2008. Enterprise information system project selection with regard to BOCR. *International Journal of Project Management, 26*(8), pp.810-820.
[3] Weske, M., 2012. Business process management architectures. In *Business Process Management* (pp. 333-371). Springer, Berlin, Heidelberg.
[4] Megretski, A. and Rantzer, A., 1997. System analysis via integral quadratic constraints. *IEEE Transactions on Automatic Control, 42*(6), pp.819-830.
[5] Pattar, M.V., Kulkarni, V.N., Kulkarni, S.V. and Kotturshettar, B.B., 2020. A Study on Implementation of Simulation at Operational Level in Manufacturing System. In Emerging Trends in Mechanical Engineering (pp. 115-121). Springer, Singapore.

[6] Ilie, G. and Ciocoiu, C.N., 2010. Application of fishbone diagram to determine the risk of an event with multiple causes. Management research and practice, 2(1), pp.1-20.

[7] Kammann, R., 1975. The comprehensibility of printed instructions and the flowchart alternative. Human factors, 17(2), pp.183-191.

[8] Pattar, M.V., Kulkarni, V.N. and Gaitonde, V.N., 2019, October. Simulation study and analysis of plant layout in tin container industry. In IOP Conference Series: Materials Science and Engineering (Vol. 561, No. 1, p. 012034). IOP Publishing.

[9] Hellin, J., Krishna, V., Erenstein, O. and Boeber, C., 2015. India’s poultry revolution: implications for its sustenance and the global poultry trade. International Food and Agribusiness Management Review, 18(1030-2016-83092), pp.151-164.

[10] Killingsworth, P.S., 2006. An Exploratory Parametric Analysis of Production Cost Improvement in the Aerospace Industry. The Journal of Cost Analysis & Management, 8(1), pp.15-36.