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Design and Development of Fault Detection System in Production Line Monitoring at UJAS Electrical Private Limited

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Abstract: The goal of this research is to provide a method for analyzing process efficiency that uses a combination of Petri nets and Flexsim software to resolve a typical discrete event in a workshop production system. This study, in particular, use Petri net theory to represent the event, followed by the usage of Flexsim software to interactively simulate the Petri-net based model, providing the system bottleneck intuitive and visible. Furthermore, it achieves the goal of increasing the efficiency of the system process by upgrading the system objects. In comparison to the previous way, the simulation results suggest that new method can immediately identify potential system faults. The efficiency is considerably increased as a result of this strategy. This research improves the efficiency of production line by reduction in idle percentage and improvement in processing percentage.
Keywords: Petri Nets, Flexsim Software, production line, idle percentage, optimization

I. INTRODUCTION

Today's manufacturing lines are complex combination of material processing, assembling and individual cells. The success of such a system is heavily reliant on each unit's fault-free and reliable operation. Productivity is harmed when things aren't as they should be. As a result, continuous monitoring is essential for producing quality products to ensure that the functionality is maintained.

A structure for developing a supervisor in Balanced Automation Systems (BAS) was presented, which considers failure detection and treatment. The method relies on Distribute Petri Nets (DPN), which are used to connect numerous graphs that represent operational modules in manufacturing systems. [1] A model (central-PN) is used in the methodology to express the techniques for controlling, analyzing, and monitoring industrial systems. This methodology can use previously analyzed nets to represent systems without taking into account for abnormal situations.

In Ujas Electricals, the manufacturing line of tool powder coating is responsible for delay in target production due to its present time-consuming structure. It is important to solve these problems in order to achieve efficient Production. The analysis for tool powder coating manufacturing line is one kind of typical random discrete event system. Analytical method is unable to study and optimize such system completely. Nevertheless, simulation technique can show precise status which also, gives a detail explanation about real process and information and discover the bottleneck and idle resource of the system. Now specialists mostly focus on the inventory layout of distribution center, picking strategy on simulation of logistics system.

This paper initially examines the procedure of a tool powder coating manufacturing line by modeling, simulation theory and Flexsim software. then builds a simulation model for improvements in manufacturing line. Secondly the paper gets the efficiency of key equipment and workers by using Flexsim so that the preliminary output is analyzed. Finally, the paper finds out the idle as well as bottleneck resource and makes several corrections to improve the operation efficiency for powder coating manufacturing line.

II. METHODOLOGY AND MODELLING

A. Petri Nets

A methodology and modelling Petri net is a type of suitable technique directed network that is populated by three different sorts of object. Locations, transitions, and directed arcs connecting places to transitions and transitions to places are the items in question. Places are represented by circles and transitions are represented by bars or boxes. A location is an input location for a transition if a directed arc connects it to the transition. A place is indeed an output place of a transition if the transition and the place are connected by a directed arc. A Petri net can be described in its simplistic definition by a transition and its input and output locations.

This basic net can be used to represent a number of different elements of the studied systems. Input (output) locations, for example, could indicate pre - conditions (postconditions), a transition, or an event. The availability of resources, the shift to their usage, and the release of resources are all possible inputs and outputs. As a result, the quantity and distribution of tokens in a Petri net control the execution of the Petri net. One can investigate the dynamic behavior of the modelled system by determining the distribution of tokens in areas, which may represent the occurrence of events or the implementation of actions. Transitions are fired in a Petri net to make it work. The flow of tokens is governed by two rules.

1) *Enabling Rule:* If respectively input place p of t holds at least the number of tokens equivalent to the weight of the directed arc joining p to t, then a transition t is said to be enabled.
2) *Firing Rule:* Only transitions that have been enabled can be fired. When an enabled transition t is fired, it eliminates the number of tokens equal to the weight of the directed arc linking p and t from each input p. It also places the same number of tokens from each output point p as the weight of the directed arc between t and p.

So, based on the firing transition rules, the system transfer transition node from its initial state to next state.

B. Flexsim Software for Modelling and Simulation

Flexsim software is a collection of 3-D image processing, simulation, artificial intelligence, and data management capabilities for computers. Flexsim is well-suited to manufacturing, storage, and delivery, as well as other sectors. Original data, modelling, and an operating model are all provided by Flexsim in order to carry out simulation experiments and optimize the system. [11][12] The Process of modelling in flexsim are as follows:

1) Determine simulated targets after the survey.
2) Gather the system's basic information. There are two components to collecting simulation data. One is that the data is collected in accordance with the simulation aims in order to keep the system operational. The other is that the data includes the system's beginning conditions and internal variables.
3) Create a system model. Discrete events should use a flow chart or network diagram to precisely define the system's constituents. The flowchart is divided into three sections: arrival model of temporary entities, queuing discipline, and service model.
4) Create a simulation model. The procedure entails confirming the model and data storage format, as well as selecting a software development platform and programming language based on the mathematical model and system features.
5) Validation of the model Determine whether the simulation model and computer language can accurately depict each component of the system (system composition, system organization, and parameter assumptions)
6) Simulation and running. In order to forecast actual moving principle of the system, it is important to understand the output response with different inputs and different simulation mechanism. g) Outputs and analysis of the simulation results.
7) Simulation and execution. It is necessary to comprehend the output response with various inputs and simulation mechanisms in order to foresee the system's actual movement principle.
8) Outcomes of the simulation and its analysis.

The powder coating manufacturing line contains the tool storage, powder coating and oven. Workers are responsible for raw tool handling of material to the production line. There is currently one production line in the plant for powder coating the tools. After the process of coating the finished tool sorted for defects and then tested in the inspection area. The flow chart of the process is given in fig 1.

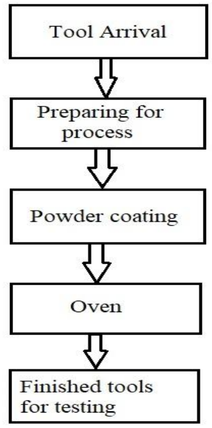

Fig -1 Process flow of production line

III.SIMULATION STUDY

The work schedule of Ujas electrical Private limited is from 10 am to 6 pm which is 8-hour shift. So, the length of simulation time is set to be 28800 sec. The parameters of powder coating process and oven has maximum 1000 content capacity. One operator is working on loading tool on production line and another for collecting finished tools. The petri net model of the current tool powder coating production is given in fig 2. Table 1 contains the description of entities designed in flexsim software. Table 2 contains the numbers and description of places in petri nets model. Table 3 contains the number of Transients and their descriptions.

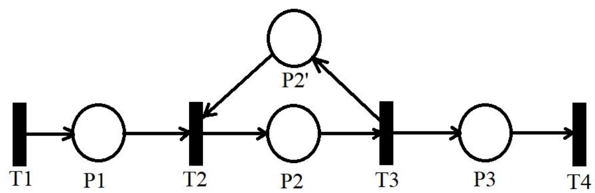

Fig -2 Petri net model of tool powder coating production line

Table -1 Flexsim model essential entity

Entity Name	Number	Description
Source	1	Generate The Tools to Be Powder Coated.
Queue	2	Staging For Tools Arrival and Another for Finished Powder Coated Tool
Processor	2	Production Line of Powder Coating and Oven Process
Conveyor	1	For Convey the Tool from Start to Finish
Operator	2	One For Loading Tool on Production Line and Another for Collecting Finished Tools
Sink	1	Total Finished Product

Table -2 places in petri nets and their description

Places	Description
P1	Tools Storage
P2	Powder Coating Process in Production Line
P3	Oven

Table -3 Transition in petri nets and its descriptions

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Transition	Description
T1	Arrival of Tools
T2	Workers Handling Tools
T3	Prepare for Oven
T4	Finished tool for Testing

IV. RESULT AND DISCUSSION

The table 4 contains statistics of powder coating and oven working status, After, running the simulation for 28800 sec. from the simulation its is observed that the percentage idle of powder coating 40.90% with processing percentage of 43.20%. it is also observed that the waiting time for transport is 15.92%. The percentage of idle is almost half of the processing percentage and needed to be optimized. The waiting of operator is 26.46% which is also, factor of consideration for optimization as it can be utilized for better time utilization. In case of Oven, the processing percentage is 43.10% and the percentage of idle is 29.90% which needed to be optimized.

Table -4 statistics of powder coating and oven working status

Object	Output	Percentage idle	Processing percentage	Waiting for operator	Waiting for transport
Powder coating	1245	40.90%	43.20%	0	15.92%
oven	1244	29.90%	43.10%	26.46%	0.00%

From the percentage idle and processing percentage of powder coating and oven respectively, the change in the structure of the production line needed. The performance of production line can be improved by adding one more powder coating processor with the conveyor so that processing percentage can be improved. From the above investigation of simulation results, it shows that the utilization rate is lower for workers and equipment. The several actions are essential to improve the performance of powder coating production line. The fig. 3 shows optimized structure of production line. one more powder coating processor is added to fully utilize the process. And table 5 shows the Statistics of Optimized powder coating production line.

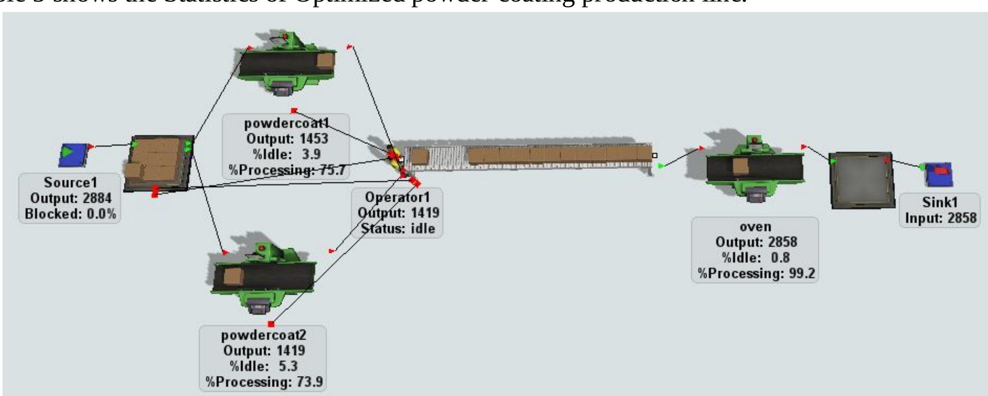

Fig -3 Optimized model of powder coating production line

Table 5 shows the Statistics of Optimized powder coating production line.

Object	Output	Percentage idle	processing percentage	waiting for operator	waiting for transport
Powder coating1	1453	3.9%	75.7%	0	18.24%
Powder coating2	1419	5.3%	73.9%	0	19.03%
oven	2858	0.80%	99.2%	26.46%	0.00%

From the table 4 the total output from powder coating 1 and 2 is 2872, average percentage idle is 4.6%, average processing percentage is 74.8% and waiting time average is 18.63%. The table 6 shows the improvements of two simulations.

Table 6 the improvements of two simulations.

Object	Name of entity	before optimization	after optimization	Percentage Improvement
Powder Coating	idle	40.90%	4.6%	36.3%
	processing	43.20%	74.8%	31.6%
Oven	Idle	29.90%	0.80%	29.82%
	Processing	43.10%	99.2%	56.1%

From the table 6 it is observed that idle percentage has been significantly improved upto 36.3% after adding additional powder coating processor. Also, the percentage of processing has been also improved upto 31.6%. Similarly in case of Oven, the idle and processing percentage improved 29.82% and 56.1% respectively. This improvement measures are good for increasing productivity and better efficiency.

V. CONCLUSION

The powder coating production line in Ujas electrical has been analyzed. This paper analyzed the present process of production line. The flexsim software is used to build the model for finding out idle and processing percentage of the equipment. Finally, the paper provides improvement measures to minimize the idle positions and improve the processing percentage for improving productivity.

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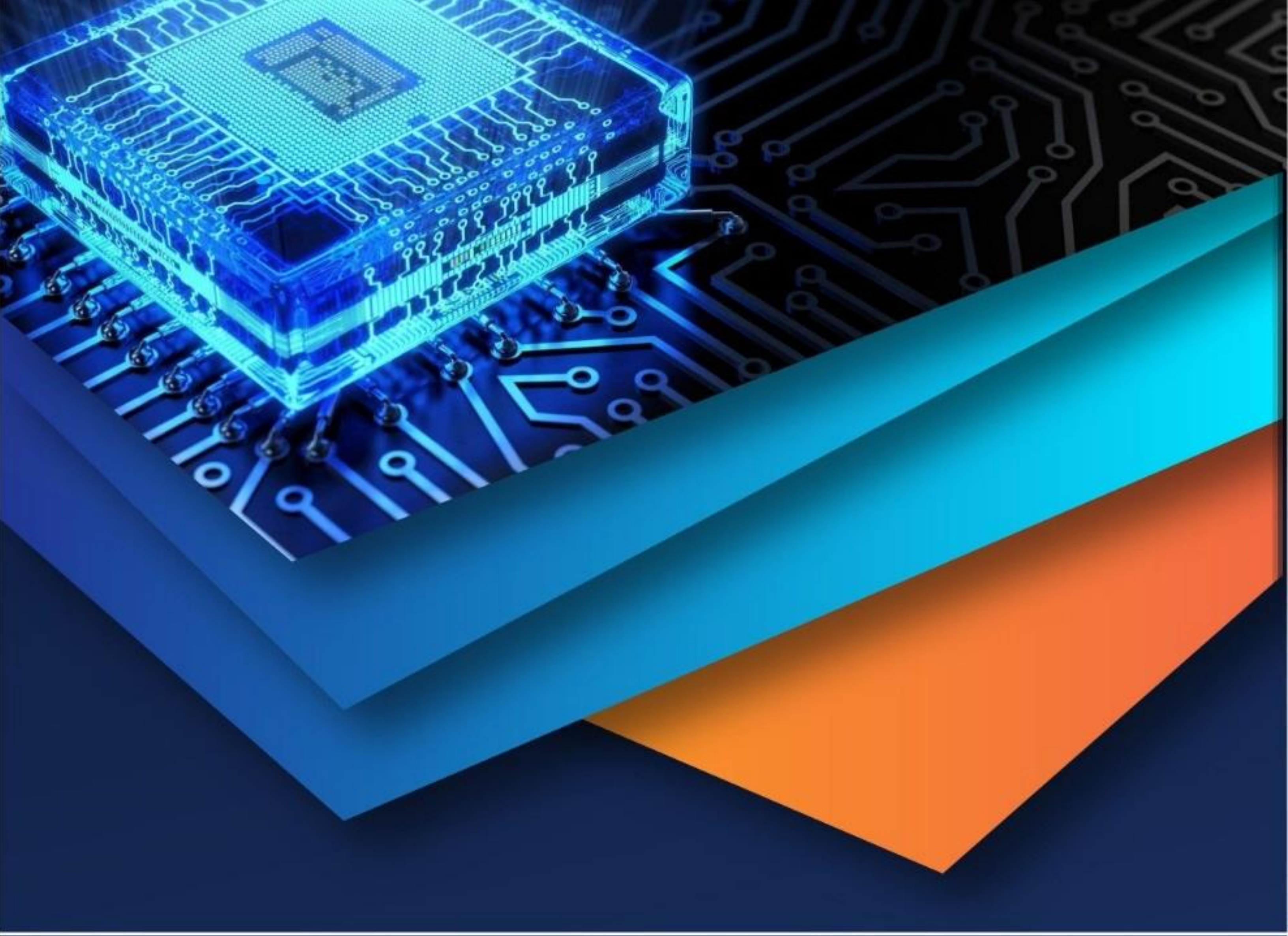

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