Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2016, 3(11): 62-67

Research Article ISSN: 2394 - 658X

Identifying Root Causes of Assembly Line Stoppage Using Metaheuristics Approaches

Ashish Shrivastava and Gitesh Vijay

Department of Mechanical Engineering, Rajathan Technical University, Kota, Rajasthan, India
ashish.shri414@gmail.com

ABSTRACT

An assembly line is a manufacturing process or simply a progressive assembly in which the components are added as the semi-finished assembly moves from work station to work station where the parts are added in sequence until the final assembly is produced. By mechanically moving the parts to the assembly work and moving the semi-finished assembly from work station to work station, there may arises a problem of sudden stoppage of assembly line due to failure of some machine parts because of many reasons. In this research task, an effective algorithm for avoidance in the assembly line stoppage is designed and implemented using ant colony and firefly approach to get the root cause of stoppage of assembly line and thereafter a comparative study is done to find out the better approach among them.

Key words: Preventive Maintenance, Metaheuristics, Firefly Approach

---

INTRODUCTION

In today's competitive environment of business world, the companies throughout the world are trying to improve their profit without increasing the sale price of their products. This can only be done by minimizing the manufacturing cost of the products by increasing the productivity and reducing losses during production. Automation has played a great role in increasing productivity but it fails if the equipment is not maintained properly [1]. An assembly line is a manufacturing process in which interchangeable parts are added to a product in a sequential manner to create an end product. In most cases, a manufacturing assembly line is a semi-automated system through which a product moves. At each station along the line some part of the production process takes place. The workers and machinery used to produce the item are stationary along the line and the product moves through the cycle, from start to finish [2].

The motivation of this particular thesis project was derived from the study that if the root causes for stoppage of assembly line is identified by some approach, then it will be easy to eliminate or decreased it as much as we can. So that, no interruption is occurred while production, as a result of these, maintenance cost as well as production cost is decreased. These thesis work comes under Preventive Maintenance program. Preventive Maintenance (PM) is a maintenance program which involves a newly defined concept for maintaining production plants and equipment [3]. The goal of the PM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction.

LITERATURE REVIEW

Assembly lines or essentially fabricating related assembly is straightforwardly connected with the consecutive association of devices laborers, machines and the mechanical parts [1]. In his self-portrayal Henry Ford (1922) notices a few advantages of the assembly line including [4]:

- Workers do no truly difficult work.
- No halting or twisting over.
- No exceptional preparing required.
- There are employments that just about anybody can do.
- Provided livelihood to outsiders.

Sharma [5] shows the improvement in the assembly line stoppage using Honeybee based metaheuristics approach. In this work, The Classical Greedy Method is compared with the Proposed Metaheuristics Method which shows the better results than before. Cusumano [6] studies several distributed and represented that in the 1980s Japanese firms, drove by Toyota, have accomplished the most elevated amounts of assembling proficiency on the planet vehicles industry. It likewise reflects how viably they diminish the quantity of parts and semi-finished products; these add to working expenses and regularly conceal wasteful practices or process mistakes. Calvo et al [7] contemplates the utilization of worth stream mapping (VSM) as an apparatus in incline fabricating usage and a structure of change exercises, specifically for a productive presentation of kanban and milkrun procedures. Bautista [8] studies a variation of the blended model sequencing issue on assembly lines which the one is proposed by Yano and Rachamadugu in 1991. They consider time windows in workstations and the work over-burden idea—total of contrasts between genuine culmination time in the workstation and due dates, which relies on upon the time window esteem. This paper proposes a few strategies for taking care of the issue, and contrasts them and others taken from writing utilizing two computational investigations. Fliedner et al [9] studies that Assembly lines are stream line generation frameworks which are of incredible significance in the modern creation of high amount institutionalized items and all the more as of late even picked up significance in low volume generation of redid items. Thus, open exploration difficulties are distinguished and the specialist is furnished with insights on the most proficient method to single out suited adjusting strategies for his sort of assembly framework.

PROBLEM FORMULATION

The dataset is taken from live industry using assembly line for manufacturing. The steps showing how the Data Set is taken from the Live Assembly Line as follows: -

- The difficulty level of the assembly line issues is ranked between the range (0, 1, 2). This range or ranking approach is fetched from the live industry of automobile industry as well as the scientific instruments production and assembly line. As shown in Table 1.
- Using a huge dataset of this type, the analysis and prediction can be done on the aspect that which particular point of failure is most critical. As shows in Table 2.
- For each cause of issue and its related downtime is associated with a specific difficulty level which the engineers and assembly line operators face in their routine experiences. As shown in Table 3.
- After frequency analysis of the correlation of cause, downtime and difficulty level, the future issues can be avoided in the assembly line.
- Using the generated results, a detailed comparative study is done using three approaches i.e. honey bee, ant colony, and firefly approach.

Table 3 shows the sample datasheet of the dataset considered for the research work. There are overall set of 500 records in the dataset mention in the appendix and following is the sample sheet. The dataset then imported in the MATLAB software to analyze by the different approaches.

The **objectives of proposed work are**

- The classical work was done using honey bee algorithmic approach.
- The classical work is improved using ACO and Firefly Metaheuristics approach.
- The reduction in assembly line stoppage and prior analysis is optimized using ACO and firefly algorithms.
- A comparison study is done using cost factor and reliability factor for comparing the three approaches.

Table- 1 Code for Difficulty Levels

Code	Description
0	Easy Issue
1	Intermediate (Solvable in Finite Time)
2	Difficult

Table-2 Sample Datasheet

Day	Cause	Downtime	Difficulty Level	Cost Factor
1	10	1	0	0.03699593
3	9	6	0	0.222057735
3	2	9	2	2.333827893
4	6	3	2	2.111648679
6	7	9	2	2.335320417
8	8	4	2	2.14953271
10	9	7	0	0.26207413
11	8	8	2	2.3003003
12	5	3	2	2.112951807
12	4	1	2	2.037693178

Table-3 Assembly Line Breakdown Cause Code and Description

Cause	0	1	2	3	4	5	6	7	8	9	10
Description	Temperature	Humidity	Technical	Human Error	Overload	Damage	Over Heat	Equipment Failure	Scheduling Fault	Warnings Ignored	Machine Overrunning

Table-4 Frequency Analysis

Cause	Total Downtime (Minutes)	Frequency
Temperature	183	28
Humidity	291	49
Technical	384	10
Overload	70	4
Damage	87	19
Overheat	120	10
Equipment Failure	190	18
Scheduling Fault	104	13
Warnings Ignored	68	9
Machine Overrunning	67	10

Table-5 Root Cause Extracted from Frequency Analysis

Implementation Scenario ID	Data Set Analysed	Total Log Records Issues (Root Causes or Key Defect Points)	Root Causes Identified
1	50	16	5
2	100	28	9
3	200	50	12
4	300	69	18
5	400	90	22
6	500	130	33

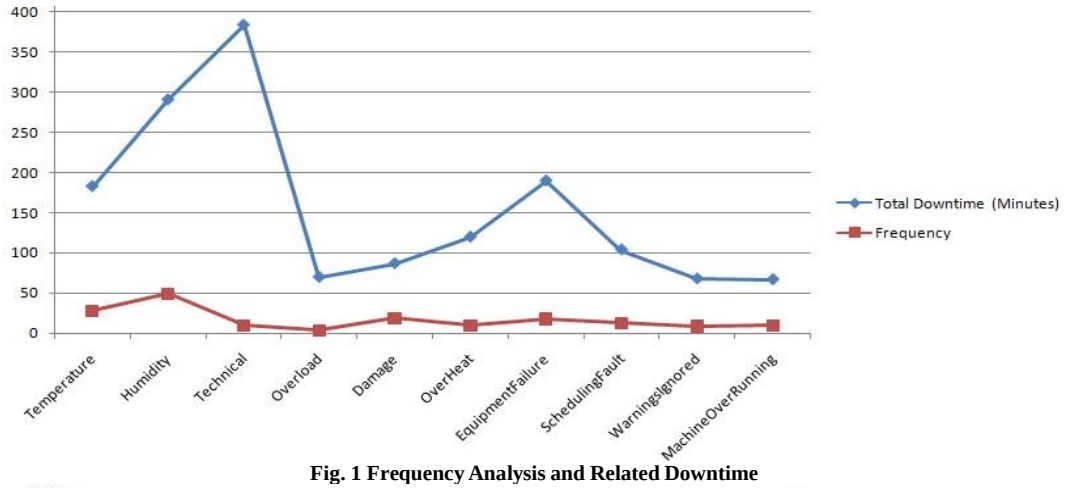

Fig. 1 Frequency Analysis and Related Downtime

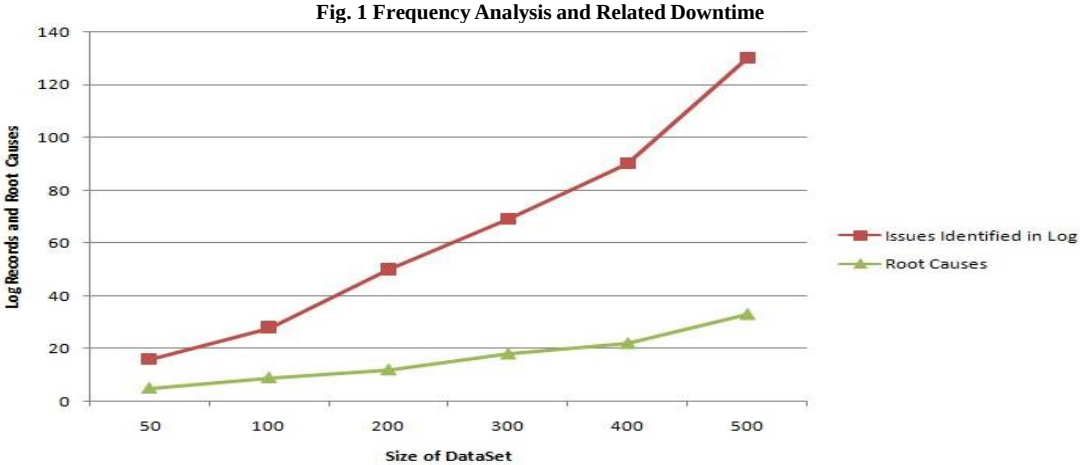

Fig. 2 Root Cause Identified in Data Set

RESULTS

Using MATLAB, the implementation of proposed algorithm designed is accomplished with the better and effective results for improvements in the assembly line stoppage. Table -4 Shows the Results of the Frequency Analysis of the Causes Extracted from the Dataset by the Approach. Fig.1 describes a graph showing the 'Cause' of root cause on x-axis and 'Frequency' associated with it on y- axis. It shows the relation between the Total Downtime identified in the log and Frequency of causes identified. Table -5 shows the root cause extracted from the dataset by using the approaches, in which the column 2 analyzed the data set in different sample size like 50, 100, 200 etc. In column3, the total log record shows the total number of downtime logged/recorded in the assembly line. Out of these total log records, approaches are applied to measure the root causes.

In first record, total dataset is 50. In this dataset, it is found that 16 times there was downtime (system failure/stoppage) in the assembly line. After analysis using the approaches, it is found that there are 5 key points (root causes) which repeatedly affecting the performance of assembly line. Likewise, there are 6 sample id is there which are analyzed. Different approaches are used for fetching the root cause but the main goal is to calculate which approach is taking minimum time in getting the root causes. The root causes are same in all the approaches but their performance in terms of time is different. In these work, the different time spans are logged / recorded. Based on time, the cost and complexity are calculated because time is directly proportional to complexity and cost. If any function is taking more time, then it will consume more resources which means more complexity and more cost. The reliability / efficiency / performance are inversely proportional to cost / time.

Fig. 2 describes the graph showing 'Size of Dataset' on x-axis and 'Log Records and Root Causes' on y-axis. It shows the relation between the Issue identified in the log and Root causes identified.

COMPARATIVE RESULTS OF APPROACHES

Here are the results of comparison of all approaches based on some factors and parameters. The Factors and Parameters Evaluated for comparison of different approaches are-

Reliability

Reliability is the ability of an apparatus, machine, or system to consistently perform its intended or required function or mission, on demand and without degradation or failure [10-11].

$$R = (((1 / C_F) *100) + R_n) – E_{OV} \quad (1)$$

$$Reliability = (((1 / Cost\ Factor) *100) + random\ Noise) – Expected\ Optimization\ Value \quad (2)$$

The above equation 1 and 2 shows the equation on which the simulation work is done of all approaches to get the reliability factor of all the process. Here, during implementation the approaches uses all the factors like random noise, cost factor, optimization value etc. The Matlab code uses this equation and find out the accurate and correct compared result.

Figure 3 shows the Weibull probability plot which is useful in the investigation and analysis as it is the key aspect by which the maintenance and downtime of any machine or system is evaluated. In any assembly line, it is mandatory to check and evaluate whether a particular machine or system is having maintenance downtime at the current instance. Using Weibull distribution, the current status of any system or machine or simply assembly line can be evaluated [12]. It is clear from the figure 4 that Firefly is better approach in terms of reliability which is one of the important aspect and performance parameter of assembly line.

Cost factor

Cost Factor of the process is directly proportion to the process time. If time is more, the cost factor associated will be more. During simulation / implementation, the execution time / evaluation time of the root causes identification is measured and logged in the file system.

The cost factor is one of the key parameter that is taken into the performance evaluation because it is very important to check the optimization time [10-11].

$$C_F = ((TS_i - TS_{i-1}) * O_f)/D_S \quad (3)$$

$$Cost\ Factor = ((Time\ Stamp\ by\ the\ Root\ Causes\ Identification\ using\ Metaheuristics\ Approach - Initial\ Time\ Stamp) * Overall\ Optimization\ Factor) / Data\ Sets\ in\ Analysis \quad (4)$$

Here, Fig. 5 shows the comparison graph of all approaches considering cost as the factor in which x -axis shows 'span of time' and y -axis shows 'cost factor'. The four points indicate the simulation attempts in MATLAB. It means that the code is executed four times and the proposed approach is better in all these four attempts / implemen-

tation run. For getting the results accurate, we have to run the code many time on the same dataset. That's why to defend the work effectively, the code is executed four times and then it is verified that in all the attempts (span of time), the output of proposed approaches are better than the classical approach. Here, the span of time is the advancement of time or simply sequence in which the code is executed. Suppose we run a code 10 times. In this case, there will be 10 time spans.

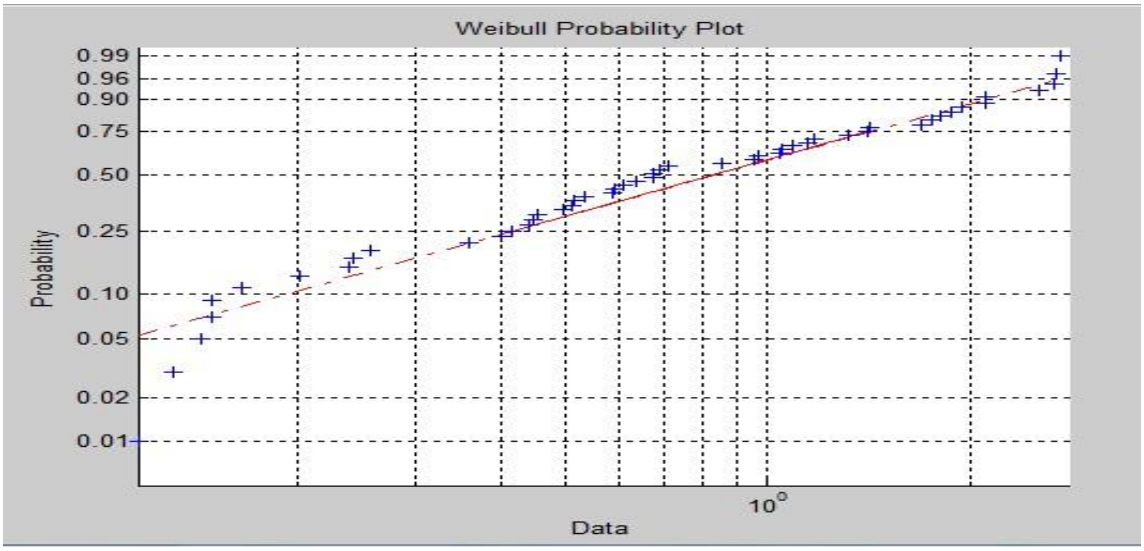

Fig. 3 Weibull Probability Plot

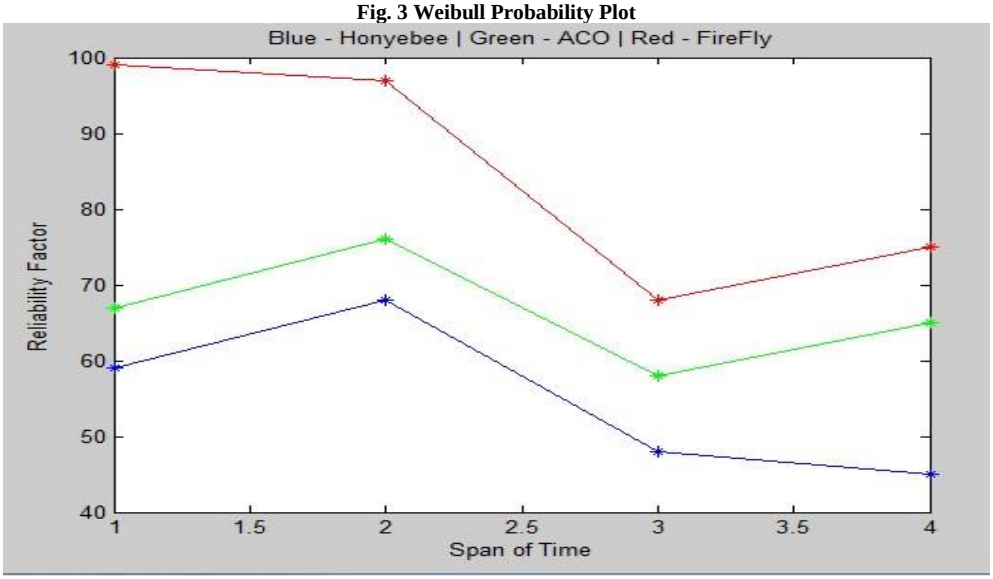

Fig. 4 Reliability Factor

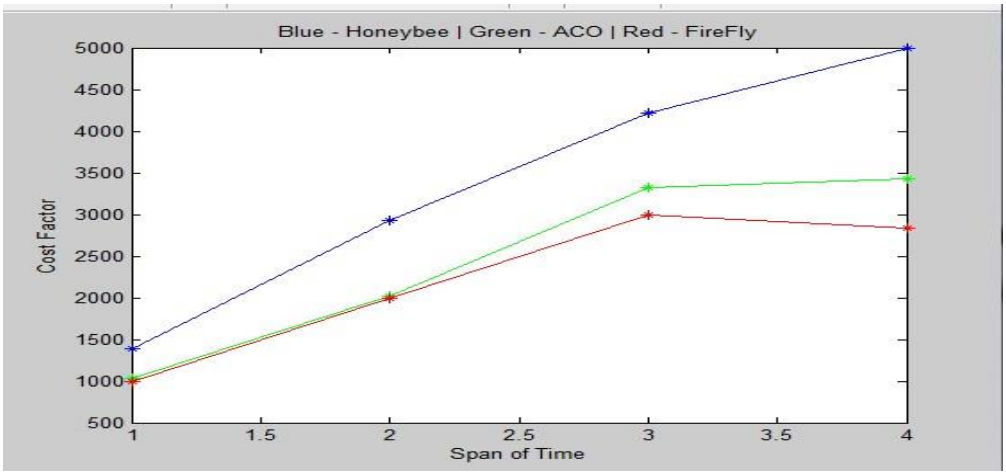

Fig. 5 Cost Factor

It is clear from the results that Firefly is better approach in terms of reliability and cost factor. In the earlier implementation of phase-1, the ant colony optimization is performing better than honeybee. In phase-2 of implementation, another Metaheuristics approach firefly is implemented and found that it is performing and giving better results than ACO and Honeybee approach of optimization.

CONCLUSION

In this work an attempt is made to find out the root causes for stoppages of Assembly line by implementing different Metaheuristics Approaches *i.e.* Honey bee colony technique as existing approach, and Ant colony approach and Firefly approach as proposed approaches. The proposed approach is implemented in MATLAB with the integration of Ant colony and Firefly Algorithm. With the use of the results, a comparison is made with taking cost factor and reliability as factors and found that firefly approach is working better than ant colony and honey bee approach. This study can be very helpful in industries as the maintenance cost is high as compare to before it and if a study of common cause of stoppages in Assembly line is done, it will decrease the maintenance cost as well as overall production cost.

REFERENCES

[1] Michael Kanellos, *Inside Toyota's Hybrid Factory*, CNET News, Oct.10, **2006** [online]. Available:http://news.cnet.com/Inside-Toyotas-hybrid-factory/2100 11389_36124334.html. March 9, **2009**.
[2] Robert J Samuelson, *The Assembly Line, Winter*, Newsweek 130, no. 24-A, [online], Available: http://www.newsweek.com/assembly-line-170026, **1997**.
[3] BS Dhillon, *Engineering Maintenance*, CRC Press, **2002**.
[4] J Miltenburg, U-Shaped Production Lines: A Review of Theory and Practice, *International Journal of Production Economics*, 2001, 70 (3), 201-211,
[5] SD Sharma, Improvement in the Assembly Line stoppage using Honeybee Based Metaheuristics Approach, *International Journal of Electrical, Electronic and Mechanical Control*, **2015**, 4(2), 121-136.
[6] ML Fisher and CD Ittner, The Impact of Product Variety on Automobile Assembly Operations: Empirical Evidence and Simulation Analysis, *Management Science*, **1999**, 45 (6), 771-786.
[7] MA Cusumano, Manufacturing Innovation: Lessons from the Japanese Auto Industry, *Sloan Management Review*, **2013**, 29 (4), 125-129.
[8] PR McMullen and GV Frazier, A Heuristic for Solving Mixed-Model Line Balancing Problems with Stochastic Task Durations and Parallel Stations, *International Journal of Production Economics*, **1997**, 51(3), 177-190.
[9] Chris Arnot, When the Wheels Came Off the Dream, the Guardian [online]. Available: http://www.guardian.co.uk/society/2009/feb/25/ford-dagenham, **2009**.
[10] JP MacDuffie, K Sethuraman and ML Fisher, Product Variety and Manufacturing Performance: Evidence from the International Automotive Assembly Plant Study, *Management Science*, **1996**, 42(3), 350-369.
[11] DM Gann, Maintenance in a Day to Day Work, *Construction Management and Economics*, **1999**,14(6) 437-450.