International Journal of Electrical, Electronics and Mechanical Controls

ISSN (Online) : 2319-7501

Volume 4 Issue 2 May 2015

Manuscript ID : ISSN23197501-V4I2M1-052015

IMPROVEMENTS IN THE ASSEMBLY LINE STOPPAGE USING HONEYBEE BASED METAHEURISTIC APPROACH

Sukh Dev Sharma

M.Tech. Research Scholar

Department of Mechanical Engineering

Shree Siddhivinayak Group of Institutions

Shahpur, Haryana, India

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, a finished product can be assembled faster and with less labor than by having workers carry parts to a stationary piece for assembly. Assembly lines are the common method of assembling complex items such as automobiles and other transportation equipment, household appliances and electronic goods. In this research task, an effective algorithm for avoidance in the assembly line stoppage is designed and implemented using honeybee algorithm. The Bees

Algorithm is a population-based search algorithm which was developed in 2005. It mimics the food foraging behaviour of honey bee colonies. In its basic version the algorithm performs a kind of neighbourhood search combined with global search, and can be used for both combinatorial optimization and continuous optimization. The Artificial Bee Colony algorithm is a swarm based meta-heuristic algorithm that was introduced by Karaboga in 2005 for optimizing numerical problems. It was inspired by the intelligent foraging behavior of honey bees. The algorithm is specifically based on the model proposed by Tereshko and Loengarov (2005) for the foraging behaviour of honey bee colonies. The model consists of three essential components: employed and unemployed foraging bees, and food sources. The first two components, employed and unemployed foraging bees, search for rich food sources, which is the third component, close to their hive. The model also defines two leading modes of behaviour which are necessary for self-organizing and collective intelligence: recruitment of foragers to rich food sources resulting in positive feedback and abandonment of poor sources by foragers causing negative feedback. In the proposed and implemented research task, the assembly line stoppage is reduced by identifying the critical points or simply root causes of the breakdowns in the assembly line.

Keywords - Root Cause Analysis of Assembly Line, Manufacturing Assembly Line, Production Assembly Line

INTRODUCTION

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.

Assembly line methods were originally introduced to increase factory productivity and efficiency. Advances in assembly line methods are made regularly as new and more efficient ways of achieving the goal of increased throughput (the number of products produced in a given period of time) are found. While assembly line methods apply primarily to manufacturing processes, business experts have also been known to apply these principles to other areas of business, from product development to management.

Henry Ford designed his first moving assembly line in 1913, and revolutionised the manufacturing processes of his Ford Model T.

This assembly line, at the first Ford plant in Highland Park, Michigan, became the benchmark for mass production methods around the world. It was Henry's intention to produce the largest number of cars, to the simplest design, for the lowest possible cost. When car ownership was confined to the privileged few, Henry Ford's aim was to "put the world on wheels" and produce an affordable vehicle for the general public. In the early days, Ford built cars the same way as everybody else – one at a time. The car sat on the ground throughout the build as mechanics and their support teams sourced parts and returned to the car to assemble it from the chassis upwards. To speed the process up, cars were then assembled on benches which were moved from one team of workers to the next. But this was not fast, as Ford still needed skilled labour teams to assemble the 'hand-built' car. So production levels were still low and the price of the car was higher to cover the costs of mechanics.

Toyota's method of production and assembly helps address that problem. Toyota factories in Japan are designed to be happy places, where automated delivery cars play cheerful songs as they go by. If a worker spots a problem, he or she is encouraged to stop the production line and fix it -- even though stopping and starting the line is very expensive. Also, as a group, employees exercise together and workers are continually invested in and given a stake in the company. After seeing Toyota's success, other car makers have started using some of the same principles.

Some car companies have never really applied the production line process to their product -- their cars remain entirely hand-crafted. High priced cars from automakers like Aston Martin and Ferrari are hand-built to their customer's specifications. In some cases, car makers will even custom mold the driver's seat to the buyer's shape.

Other cars are built using a combination of these two techniques. The Chevrolet Corvette, for example, has a hand-built engine, but other parts of the car are assembled on the production line.

PROBLEM FORMULATION

The existing methods of cost reduction or optimization are not effective and should be processed using specialized algorithms of metaheuristic techniques. Metaheuristics are used to solve Combinatorial Optimization Problems, like Bin Packing, Network Routing, Network Design, Assignment Problem, Scheduling, or Industrial Manufacturing Problems, Continuous Parameter

Optimization Problems, or Optimization of Non-Linear Structures like Neural Networks or Tree Structures as they often appear in Computational Intelligence.

Metaheuristics are generally applied to problems for which there is no satisfactory problem-specific algorithm or heuristic; or when it is not practical to implement such a method. Most commonly used Metaheuristics are focused to combinatorial optimization problems, but obviously can handle any problem that can be recast in that form, such as solving Boolean equations.

PSEUDOCODE FOR THE BEES ALGORITHM

```
1 for i=1,…,ns
   i  scout[i]=Initialise_scout()
   ii flower_patch[i]=Initialise_flower_patch(scout[i])
2 do until stopping_condition=TRUE
   i   Recruitment()
   ii  for i =1,…,nb
        1 flower_patch[i]=Local_search(flower_patch[i])
        2 flower_patch[i]=Site_abandonment(flower_patch[i])
        3 flower_patch[i]=Neighbourhood_shrinking(flower_patch[i])
   iii for i = nb,…,ns
        1 flower_patch[i]=Global_search(flower_patch[i])}
```

In the initialisation routine ns scout bees are randomly placed in the search space, and evaluate the fitness of the solutions where they land. For each solution, a neighbourhood (called flower patch) is delimited.

In the recruitment procedure, the scouts that visited the nb≤ns fittest solutions (best sites) perform the waggle dance. That is, they recruit foragers to search further the neighbourhoods of the most promising solutions. The scouts that located the very best ne≤nb solutions (elite sites) recruit nre foragers each, whilst the remaining nb-ne scouts recruit nrb≤nre foragers each. Thus, the number of foragers recruited depends on the profitability of the food source.
In the local search procedure, the recruited foragers are randomly scattered within the flower patches enclosing the solutions visited by the scouts (local exploitation). If any of the foragers in a flower patch lands on a solution of higher fitness than the solution visited by the scout, that forager becomes the new scout. If no forager finds a solution of higher fitness, the size of the flower patch is shrunk (neighbourhood shrinking procedure). Usually, flower patches are initially defined over a large area, and their size is gradually shrunk by the neighbourhood shrinking procedure. As a result, the scope of the local exploration is progressively focused on the area immediately close to the local fitness best. If no improvement in fitness is recorded in a given flower patch for a pre-set number of search cycles, the local maximum of fitness is considered found, the patch is abandoned (site abandonment), and a new scout is randomly generated.
As in biological bee colonies, a small number of scouts keeps exploring the solution space looking for new regions of high fitness (global search). The global search procedure re-initialises the last ns-nb flower patches with randomly generated solutions.
At the end of one search cycle, the scout population is again composed of ns scouts: nr scouts

produced by the local search procedure (some of which may have been re-initialised by the site abandonment procedure), and ns-nb scouts generated by the global search procedure. The total artificial bee colony size is n=ne•nre+(nb-ne)•nrb+ns (elite sites foragers + remaining best sites foragers + scouts) bees.

Applications

The Bees Algorithm has found many applications in engineering, such as:

- Optimisation of classifiers / clustering systems
- Manufacturing
- Control
- Bioengineering
- Other optimisation problems
- Multi-objective optimisation

Using MATLAB, the implementation of proposed algorithm designed is accomplished with the better and effective results for improvements in the assembly line stoppage.

Table 1 – Execution Time from the SampleSize of the Defects in Assembly Line

SampleSize	**Execution Time**
100	0.344
200	0.84223
500	1.02323
800	1.42323

1000	1.555

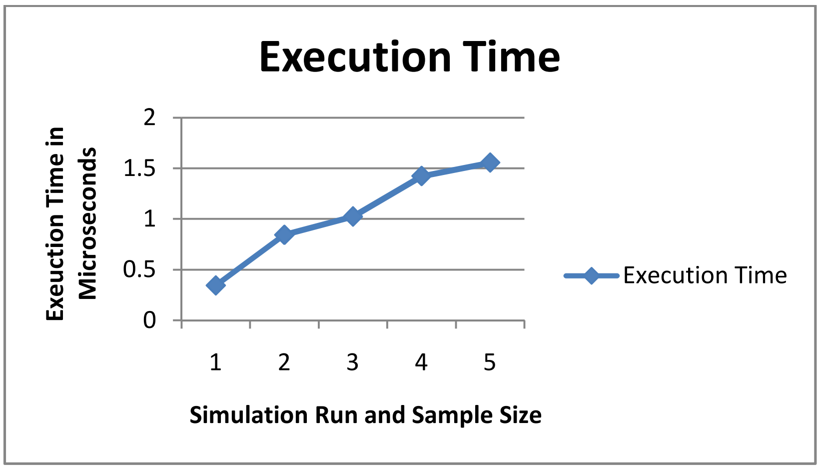

Figure 1 – Execution Time Pattern in the identification of Root Cause

International Journal of Electrical, Electronics and Mechanical Controls

ISSN (Online) : 2319-7501

Volume 4 Issue 2 May 2015

Manuscript ID : ISSN23197501-V4I2M1-052015

Table 2 – Root Causes Identified from the defect datasheet

Size of DataSheet	Issues (Defect Points)	Root Causes Identified
50	10	3
100	30	8
200	29	10
500	40	12
800	130	20
1000	300	40

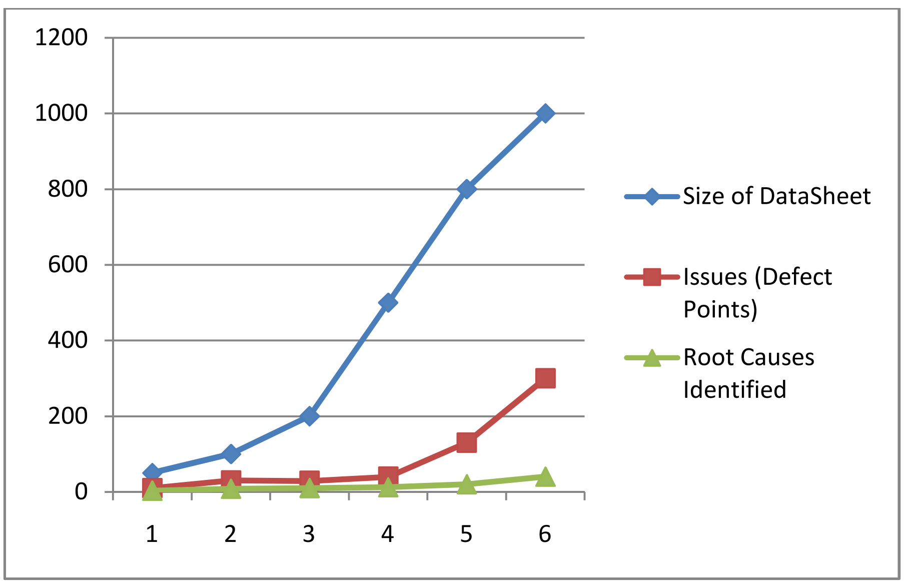

Figure 2 – Pattern of Root Causes Identified from the defect datasheet

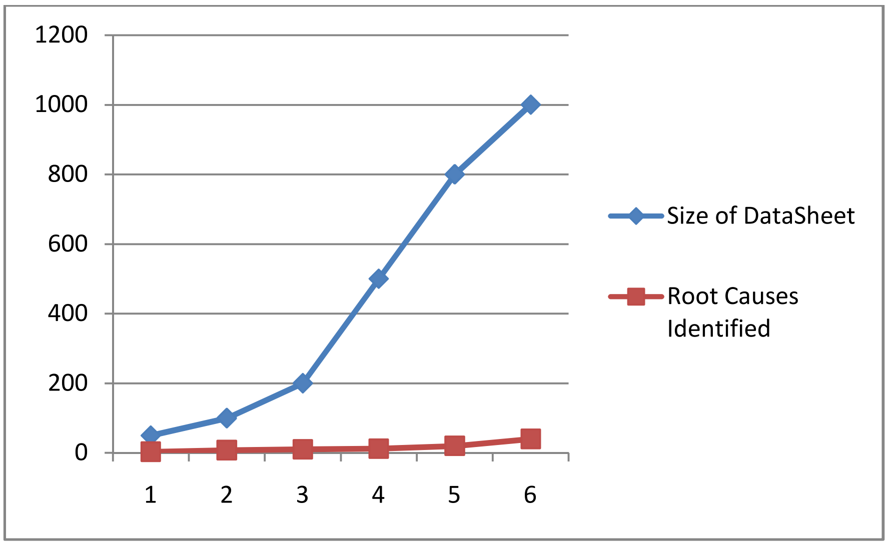

Figure 3 - Pattern of Root Causes and Size of the DataSheet Identified from the defect datasheet

Table 3 – Comparison of Overall Efficiency of the Assembly Line

Classical Approach	**Proposed Approach**
70	98
60	78
80	97
40	60
50	78
89	99
30	59

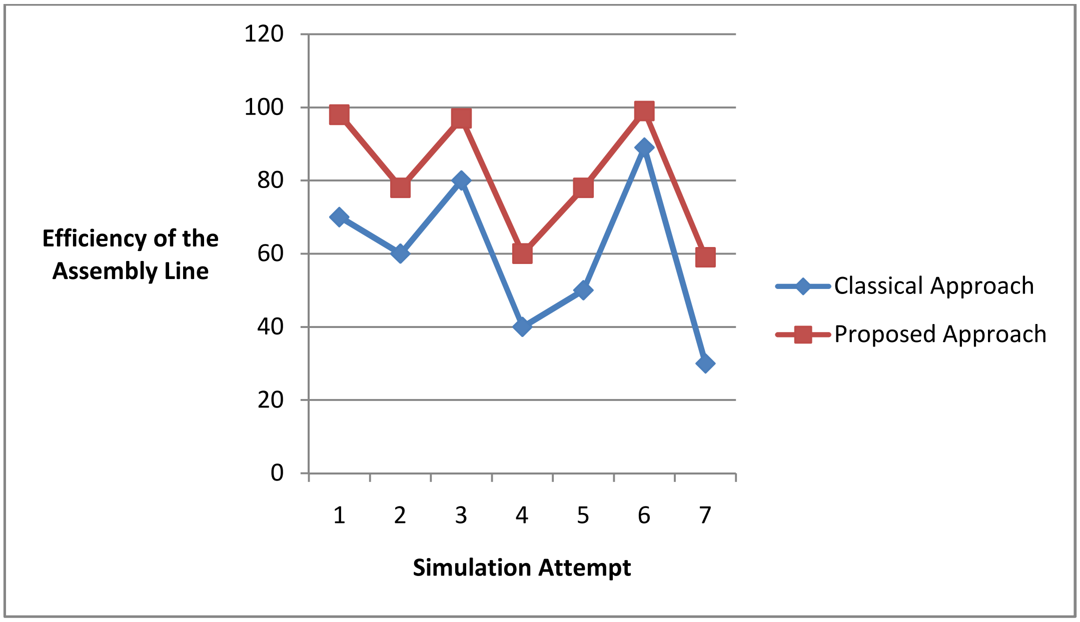

Figure 4 – Pattern of Root Causes and Size of the DataSheet Identified from the defect datasheet

CONCLUSIONS AND FUTURE SCOPE

The proposed algorithm for the assembly line stoppage is providing effective and better results, still the usage of techniques including ant colony optimization, genetic algorithm, and neural networks can give optimal results in terms of greater accuracy and integrity. In the results, it is evident that the honeybee based implementation is effective as compared to the classical approaches of assembly line root cause analysis, prediction and avoidance.

REFERENCES

[1] Arnot, Chris. "When the wheels came off the dream." The Guardian. Feb. 25, 2009. (March 9, 2009) http://www.guardian.co.uk/society/2009/feb/25/ford-dagenham

[2] Álvarez, R., Calvo, R., Peña, M. M., & Domingo, R. (2009) Redesigning an assembly line through lean manufacturing tools. The International Journal of Advanced Manufacturing Technology, 43(9-10), 949-958.

[3] Boysen, N., Fliedner, M., & Scholl, A. (2008). Assembly line balancing: Which model to use when?. International Journal of Production Economics, 111(2), 509-528.

[4] BusinessWeek.com. "Taking A Page From Toyota's Playbook." Aug. 22, 2005. (March 10, 2009) http://www.businessweek.com/magazine/content/05_34/b3948443.htm

[5] Bowen, D. E., & Youngdahl, W. E. (1998). “Lean” service: in defense of a production-line approach. International Journal of Service Industry Management, 9(3), 207-225.

[6] Bautista, J., & Cano, J. (2008). Minimizing work overload in mixed-model assembly lines. International Journal of Production Economics, 112(1), 177-191.

[7] Bartkowiak, T., & Gessner, A. (2014, July). Modeling Performance of a Production Line and Optimizing Its Efficiency by Means of Genetic Algorithm. In ASME 2014 12th Biennial Conference on Engineering Systems Design and Analysis (pp. V003T10A004-V003T10A004). American Society of Mechanical Engineers.

[8] Cusumano, M. A. (2013). Manufacturing innovation: lessons from the Japanese auto industry. Sloan Management Review, 29.

[9] Charles Sorensen's account can be found in: Sorensen, Charles, E., My Forty Years with Ford (1956); Banum, Russ, The Ford Century (2002); Brinkley, Douglas, Wheels for the world: Henry Ford, his company, and a century of progress, 1903-2003 (2003).

[10] Chutima, P., & Naruemitwong, W. (2014). A Pareto biogeography-based optimisation for multi-objective two-sided assembly line sequencing problems with a learning effect. Computers & Industrial Engineering, 69, 89-104.

[11] Croci, F., M. Perona, and A. Pozzetti. "Work Force Management in Automated Assembly Systems." International Journal of Production Economics. 1 March 2000.

[12] Design Build Network. "BMW Car Production Plant, Leipzig, Germany." (March 10, 2009) http://www.designbuild-network.com/projects/bmw/

[13] Dove, Rick. "Custom Lines—Built Just in Time." Automotive Manufacturing & Production, August 1997.

[14] Fisher, M. L., & Ittner, C. D. (1999). The impact of product variety on automobile assembly operations: Empirical evidence and simulation analysis. Management science, 45(6), 771-786.

[15] Gustavson, Richard. "Software Guides Assembly Line Designers." Machine Design, 9 October 1997.

[16] Gann, D. M. (1996). Construction as a manufacturing process? Similarities and differences between industrialized housing and car production in Japan. Construction Management & Economics, 14(5), 437-450.

[17] Iida, K. (1993). U.S. Patent No. 5,255,197. Washington, DC: U.S. Patent and Trademark Office.

[18] MacDuffie, J. P. (1995). Human resource bundles and manufacturing performance: Organizational logic and flexible production systems in the world auto industry. Industrial & labor relations review, 48(2), 197-221.

[19] McMullen, P. R., & Frazier, G. V. (1997). A heuristic for solving mixed-model line balancing problems with stochastic task durations and parallel stations. International Journal of Production Economics, 51(3), 177-190.

[20] Michalos, G., Fysikopoulos, A., Makris, S., Mourtzis, D., & Chryssolouris, G. (2015). Multi criteria assembly line design and configuration–An automotive case study. CIRP Journal of Manufacturing Science and Technology.

[21] Maloney, David. "New Roots." Modern Materials Handling. October 2003.

[22] Nieble, Benjamin, and Andris Freivalds. Methods, Standards, and Work Design. July 2002.

[23] MacDuffie, J. P., Sethuraman, K., & Fisher, M. L. (1996). Product variety and manufacturing performance: evidence from the international automotive assembly plant study. Management Science, 42(3), 350-369.

[24] Miltenburg, J. (2001). U-shaped production lines: A review of theory and practice. International Journal of Production Economics, 70(3), 201-214.

[25] Koepfer, Chris. "Mass Producing Quantities of One." Modern Machine Shop, April 1998.

[26] Köhler, H. J., Nickel, U., Niere, J., & Zündorf, A. (2000, June). Integrating UML diagrams for production control systems. In Proceedings of the 22nd international conference on Software engineering (pp. 241-251). ACM.

[27] Kanellos, Michael. "Inside Toyota's hybrid factory." CNET News. Oct. 10, 2006. (March 9, 2009) http://news.cnet.com/Inside-Toyotas-hybrid-factory/2100-11389_3-6124334.html

[28] Rabbani, M., Sadri, S., Manavizadeh, N., & Rafiei, H. (2014). A novel bi-level hierarchy towards available-to-promise in mixed-model assembly line sequencing problems. Engineering Optimization, (ahead-of-print), 1-16.

[29] Samuelson, Robert J. "The Assembly Line." Newsweek 130, no. 24-A (Winter 1997).

[30] Saurin, T. A., & Ferreira, C. F. (2009). The impacts of lean production on working conditions: A case study of a harvester assembly line in Brazil. International Journal of Industrial Ergonomics, 39(2), 403-412.

[31] Umble, Michael, Van Gray, and Elisabeth Umble. "Improving Production Line Performance." IIE Solutions. November 2000.

[32] Whitfield, Kermit. "Assembly: How Standard Can You Get?" Automotive Design & Production. March 2004.

[33] PI International. "Automobile Production at OPEL, Bochum (Germany)." (March 10, 2009) http://www.profibus.com/pall/applications/casestudies/article/3043/

[34] Woodyard, Chris. "It's waste not, want not at super green Subaru plant." USA Today. Feb. 19, 2008. (March 10, 2009) http://www.usatoday.com/money/industries/environment/2008-02-18-green-factories_N.htm