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A Line balancing of the Welding Machine Assembly Line Using ARENA Simulation Software: A Case Study of a Manufacturing Industry

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ABSTRACT

In production management, customer requires fast delivery, low costs and to survive increase in production has prime importance. The Company has to find out best alternative for increase production without overloading the resources, avoiding equipment errors and health problems of the operators in the line balancing. The aim of this paper to explore the ARENA simulation model for layout changing and worker assignment problem. This paper deals with implementation of results by simulation on ARENA a model to design assembly line for performances improvement and increase production rate. The empirical case study analysis of assembly line of welding machine manufacturing organization is conducted to illustrate the use of proposed model for determine bottleneck operation as well as worker assignment, analyze and reduce Cycle time of welding machine The proposed simulation model solve the worker assignment as well as production related problem effectively.

Keywords: MTM, Kaizen, NVA, Fixtures, ARENA

I. INTRODUCTION

Nowadays people wanted high quality with less price, no one from the society willing to pay the high price on waste. In order to be stay in business environment companies need more reduce non value added activities for product with greater quality, lower costs, and cycle times should minimum which are provided to customers [Denis and Ferreira1,2009]. For compete with other companies and the ever increasing costumers demand, the increase in the importance of the workers about their work to the final product for increase the production rate where high productivity and minimum cycle time has prime importance[Zurek and Cieslak,2009].For line balancing three techniques are used like MTM, worker assignment and kaizan for continuous improvement of performance. MTM is time measurement technique which is developed by Manyard in 1948,which consider all basic moment and behavior of workerand when it applied on current line which help to make standard time for each activity and identification of non -value added activities.5s and kaizan were used for reduce non value added activities and continuous improvementThus, it is necessary the development and application of techniques that allow the best utilization of the available resources. In order to increase productivity, this work proposes the use of the Methods Time Measurement (MTM) methodology in different companies [Bures and Pivodova, 2014].Fixture, storage trolley, hardware trolley were developed for increase performance. The track is also

designed and implemented to reduced non value added activities and waste of time. In this article ARENA simulation is used for line balancing problem and MTM used for time measurement.

1.1. Research motive

Till now most of industries used stopwatch method for time measurement for each activity on assembly line in manufacturing industry. MTM gives standard time for each activity. Simulation of welding machine assembly line layout on arena which gives practical results and help to identify bottleneck operations and production rate.

1.2 Research Goal

An aim of this paper to explore idea of using ARENA simulation software for line balancing and worker assignment problem and for standardization of time for each activity using MTM method.

This article is divided into five sections. Section II consists existing methodology for solving line balancing problem. The application of MTM methodology shown in chapter IV and chapter V contains application of simulation software and analysis of results. Chapter VI concludes with summary.

II. LITERATURE REVIEW

Denis and Ferreira1 represents the application of this MTM methodology in manufacturing companies considering the current developments of time tables, which are not wide spread in many companies. However, in this work the MTM methodology will not be applied in an isolated way, but in combination with other techniques. Paper concluded that the MTM methodology is a useful tool for the planning and organization of operators´ working processes, and that combined with other applied methods it can generate a significant increase in productivity.

Zurek et.al, evaluates the practical perspective for methods of research of cycle time analysis for workers each activity of worker by MTM and MOST, during assembly of spindle machine. For precise and reliable time study MTM and MOST is preferable.

Vylen, et.al, shown that their target was to redesign the assembly process flow by elimination of material wastage. They use value stream mapping walk to find out source of material wastage, though there is no value addition on the part. The result shows a drastic improvement in productivity, reduction in the rejections, reduction in the manufacturing lead time and also the manufacturing cost.

Bures,et.al,The paper focuses on mutual comparison for time standardization. For comparison they compared methods of REFA methodology and two predetermined time systems MTM-1 and Basic MOST. Mutual comparison of results obtained by means of those 3 methods was performed. The main goal of the research was to demonstrate reliability, mutual accuracy and deviations of selected methods. Findings about time demands for performing the analysis according to selected method

LI et al.This paper provides a practicable method to solve thestochastic *MMALB* problem.The *ARENA* simulation model results will provide some decision support and point out the bottleneck process in details to improve the efficiency of *MMALB*. Based on the simulation results, some necessary assistants along the lines are needed.

Wirabhuana,et al. In this paper layout design developed using simulation model of ARENA, The solutions is designed based on four approachesand principles that cater how to minimize imbalance workloads in assembly line, to improve material handling capabilities through facilities re-layout, and to automate the processes. The initial model has been developed in term of process logic, animation and interfaces using ARENA version 7.1 Simulation application package.

III. METHODOLOGY

Methodology for this study is investigation of current layout and process through time study on each activity for which study of cycle time. The proposed work is focused on detection and reducing non-value activity from assembly line life cycle process by using lean tools like a Kaizen and 5S for make the more enhancements in processes and also quality of the product. MTM method is in efficiencies in line, Non-valued added activities are analysed and for simulation purpose ARENA is used .which shows bottleneck operations and area of improvement as well as production rate. Simulation models were developed using ARENA version 7.1 while Microsoft Excel were used for statistical analysis

IV. CASE STUDY

Case study conducted in manufacturing company.

Background of Company:

The welding machine manufacturing company XYZ which is producing mix model welding machine. The assembly line of mix model welding machine line, which have mix model welding machine assembly line and manufacturing various type of welding machine as well as consumables.

The existing layout of assembly line is as shown in fig.1 which contains 5 subassembly stations and 2 main assembly stations. Subassembly stations have five workers and main assembly have three workers.

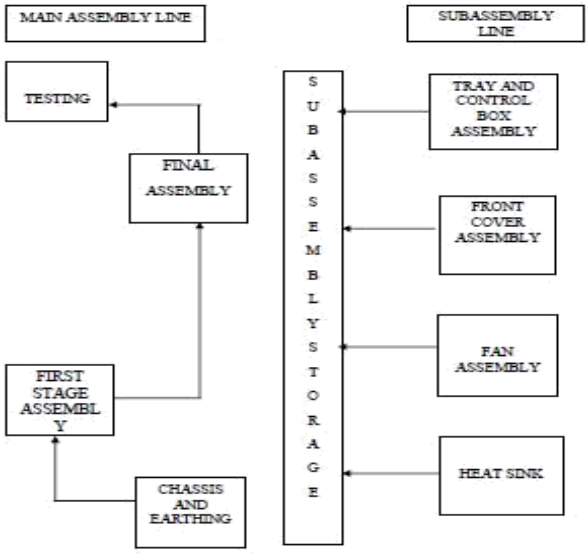

Fig. 1 The existing layout of assembly line

4.1. MTM Method

MTM defines the MTM methodology as an instrument to describe structure, configure and plan work systems through defined process modules, seeking to be an efficient pattern of production systems. It can be used anywhere where it is necessary to plan, organize and accomplish a human task seeking its effective execution. Basically the method determines its time. When used for planning issues the MTM methodology would justify the premise presented by MTM, which is to avoid costs instead of reducing them, that is, a correctly planned process can be executed since the beginning without the extra costs associated with the inefficiencies of the process. .MTM is a methods time measurement methodology. MTM gives values for the fundamental motions of: reach, move, turn, grasp, position, disengage, and release. One TMU is defined to be 0.00001 hours, or 0.036 seconds. MTM studies provided the following kinds of information.

- Developing effective work methods prior to production
- Improving existing methods to increase production and decrease labor cost per unit
- Establishing time standards as basis for wages and incentive plans

- **MTM time study for making of control box**

Control box has following activity

1. Taking base plate
2. Place 4 stud and align it
3. PCB mount on stud
4. Casing
5. Hardware making and tight

Time required for placing base plate on workstation is as shown in table 1.which shows time required for taking plate from 40cm apart from hand and place it in on station. Time measured in terms of TMU unit.

Table 1 Base Plate

Left hand	TMU	Right hand	Motion
	15.6	R40B	Reach
	7.3	G4A	Grasp
	15.8	M40C	Move
	16.2	P2AP	Position
	2	RL1	release
	43.4		Stand

	192		Walk
	29		Bend
	31.9		Bend arise
	34.7		Sit
Total	387.9		

4.2. MTM time study of existing Thyrolux assembly line

Table 2 shows for total cycle time for completion of one machine is 198 min by MTM method, which shows time required for each subassembly as well as main assembly stations.

Table 2 shows total cycle time for completion of one machine is 198 min by MTM method and 229.4min by Stopwatch. There is difference of 20 min between stopwatch and MTM method. The gap was because of human tendency, efficiency of work done and working condition. As shown in table.3 existing assembly line is unbalanced because time for each station and worker is not same and Tact tim+e for 15 machine production is 30min.and from fig come to know that time distribution for 1st stage and final assembly stage is maximum and for heat sink ,fan and control box assembly it is very less. So have to balance the current assembly line and distribute same time for all worker r s and the simulation is carried out on ARENA model which is shown as below fig.2. Simulation shows total production for existing assembly line and work in process inventory and machine utilization by each worker.

Table 2.Comparision between MTM and stopwatch time study

STATIONS	MTM TIME(min)	STOPWATCH CYCLE TIME
Front cover	25.33	30
Shunt assembly	2.02	4
Tray assembly	8.63282	12
Heat sink	8	10
Fan assembly	3.45	5

Control box	3	4.4
Chassis assembly	10.75	14
1st stage assembly	35	40
Final assembly	100	110
Total time	198	229.4

4.3. Simulation of existing Thyrolux welding machine assembly line using ARENA

Animation of proposed layout is as shown in fig below the proposed model is run for modified worker assignment means which is run for three operators for subassembly stations and five operators for main assembly stations and used reduced cycle time of each station after improvements. Firstly, to collect and analyze data scientifically, get the probability distribution and put it into the model; Secondly to set the simulation parameters and run the model. To analyze simulation results and data, to find the sensitive workstations. Finally to improve the balancing results and simulate there are many possibilities to manipulate the developed simulation model, in this model two major decision options. The first option is manipulating the model with more effective work canters to avoid the bottlenecked process and increase the system output. The second one is to develop different alternatives of improving the existing labor utilization, assuming that the operators are worked in two or more work centers.

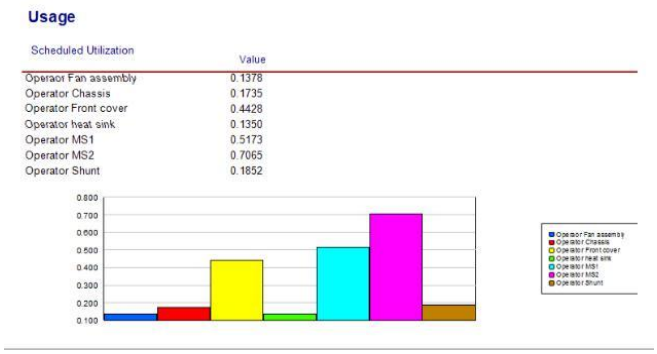

Fig4.Arena Animation Simulation For Existing Assembly Line

Fig 3. Shows flow chart for Thyrolux assembly line and segment line required for simulation .From arena simulation for existing assembly line layout for 460min shift and worker assignment total production rate is 13 machines complete and 4 work in process inventory. Also know about bottleneck operations, waiting machine

time and idle workers as well as idle operations and where need of improvement and identification of non -value added activities and how to reduce its which all analysis done by this arena simulation.

Fig 4.shows machine utilization by each worker for existing assembly line. Maximum utilization of machine is done for MS1 worker and minimum is done by heat sink worker. Up to completion of ms1 operation other worker remain idle so need of balancing assembly line

4.4. Design of fixture for Improvements on sub assembly stations

Before:

At existing state, for making heat sink operator has moment to go to storage rack pick up and again position it, then put fixture on it and then paint and after roving fixture kept aside and do further operations, so waste of time to place and remove the fixture

Proposed:

For that the fixture for heat sink was designed in such a way that all the three models heat sink will be done on the same fixture. In this the total movement of the part will be restricted by providing the locking system at one side against the direction of force applied. In this system after use of fixture worker only have to lock it and do further operations. The designed heat sink locking fixture as shown in fig.5 which reduces the time required for placing and removing fixture. Fixture is designed considering all the dimensions as well as height required for worker to comfortably work.

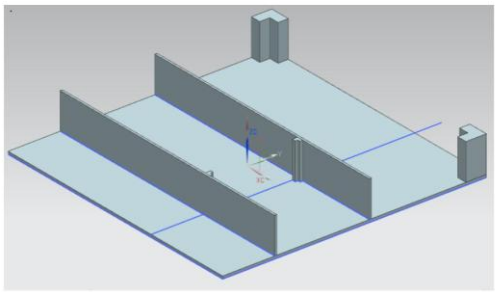

Fig.5.Fixture for heat sink mounting and holding the painting fixture

At each station, no all materials as well as hardware and tools available so there were maximum moment for taking the material from storage rack from distance and come back and place it or use it.

After: For that component trolley and hardware trolley should be provided at each work station, it reduced transportation time. Component trolley was designed as shown in fig.8.during designing the trolley all the component required for each station.

Before:

At existing state, for making tray operator has moment to go to storage rack pick up and again position it, then put fixture on it and then making subassembly of tray by fitting various stud and after roving fixture kept aside and do further operations, so waste of time to place and remove the fixture

Proposed:

For that the fixture for tray was designed in such a way that all the three models tray will be done on the same fixture it's a modular fixture. The designed tray fixture as shown in fig.6 which reduces the time required for placing and removing fixture. Fixture is designed considering all the dimensions as well as height required for worker to comfortably work.

After: After implementing the fixture time for tray making gets reduces and also reduces time of pick up and drop heat sink which is used as base for supporting the tray. And also reduces material handling time **.**For that component trolley and hardware trolley should be provided at each work station, it reduced transportation time. During designing the trolley all the component required for each station.

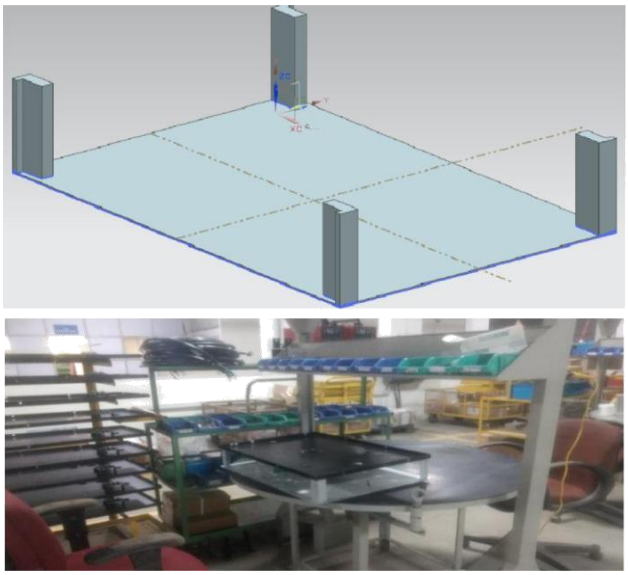

Fig.6.Fixture for holding tray

After modification calculated time for each activity which reduces the time by MTM method time for each activity is as shown in table which gets reduced .an worker assignment and new sundered time for each activity.

Table 4.MTM time after modification

STATIONS	MTM TIME(min)
Front cover	21.33
Shunt assembly	2.02
Tray assembly	7
Heat sink	7
Fan assembly	3
Control box	3
Chassis assembly	8.25
1st stage assembly	30
Final assembly	92

As per modification worker assignment and work distribution should be done and for that time calculated using MTM method which is modified MTM time for respective task or activity which is done by worker. Modified worker Assignment and MTM time is as shown in Table 5.This table shows time reduced for each activity due to improvement as well as due to reduce in non -value added activities.

Table 5.Worker assignment and mtm time

WORKSTATIONS	workers	CYCLE TIME IN MIN
FrontC	w1	21.33
SHT	w2	16
FCbCh	w3	14.25
ms1	w4	24
ms2	w5	27
ms3	w6	25

ms4	w7	23
ms5	w8	25

Fig.7 shows 5 stages track for assembly line which creates in line production in which every station provided with hardware and component trolley and with well tools required for operation which deceases maximum moment and reduced wasting as well as waiting time for tool and for hardware making. This track helped in reduction of material handling time as well as human effort to loading and unloading machine on stations. Due to all required material available at each station on track cycle time reduced. Also human safety has prime importance and this track is built considering human safety.

Fig.7.Track for main assembly line

VI. RESULT AND DISCUSSION

Table 6: Cycle time

Variable	**MTM min**	**Stopwatch min**
Cycle time	198	229.4

As seen from Table 6 cycle time for completion of one machine is 198 min by MTM methodology and 229.4 min by average recorded time. MTM technique gives standard time for each activity because it considered all basic moments of worker for doing operation and helped to identify non-value added activities.

Table 7: Comparison chart

Variable		
Production	17	20

The ARENA simulation result for one replication is as shown in Table 7.This simulation consider worker assignment and cycle time for each work station .Result shows production rate increased by 17 machine to 20 machine after implementation kaizen activity as well as proposed model means simulation tool is best solution for line balancing problem to reduce cycle time and increase production rate.

VII.CONCLUSION

The time required for each activity is calculated by MTM methodology, which creates Standard time for each activity by considering all basic moments required to work and as shown in results, the cycle time is reduced by 13%. ARENA simulation result shows the area of improvement and layout with well line balanced with worker assignments problem and it helped to achieve reduced cycle time and ultimate production is increased by 17% by reducing non value added activites.

The advantage of MTM method and ARENA simulation were demonstrated by application of these methodologies in manufacturing industry case study. In this study cycle time reduced by implementing Kaizen activities. From empirical case study it is concluded that simulation model gives practical approach to solve line balancing problem.

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REFERENCES

[1.] Denis, L.,M. and Ferreira1, C. E. (2009) "Analysis of the Methods Time Measurement (MTM) Methodology through its Application in Manufacturing Companies",*Flexible Automation and Intelligent Manufacturing,1-9.*

[2.] Zurek,J and Cieslak,R. (2012) ,"Practical Evaluation of methods of research in assembly line consumption,archives of mechanical engineering and automation 32: 43 – 53

[3.] Vylen,R., Shashidhar, M.,and Rajesh,N.,(2012) "Redesigning the Assembly Process Flow through Lean Strategy" *International Conference on Challenges and Opportunities in Mechanical Engineering, Industrial Engineering and Management Studies* (ICCOMIM - 2012), 11-13.

[4.] Bures, M. and Pivodova, P. (2014) "Comparison of Time Standardization Methods on the Basis of Real Experiment" *Procedia Engineering* 100: 466 – 474.

[5.] Kitav,V., Zupan, H., Herakovic, N. (2015) "Production line balancing with discrete event simulation: A case study"

[6.] *IFAC (International Federation of Automatic Control* ,48-3: 2305–2311.

[7.] 6.Domingo, R., Alvarez, R. and Marta, M., P. (2007) "Materials flow improvement in a lean assembly line: a case study" *International Journal of Advanced Manufacturing Technology* 27:2,141–147.

[8.] Kitav,D., Matebu,A., and Tadesse,S.(2010) "Assembly line balancing using simulation technique",*Journal of EEA* , 17:1-12

[9.] Mokhtar, A. (2007) "Line Balancing and Optimization for Single Model Assembly Line at a Small Medium Industry (SMI)" *university technical Malaysia Melaka*

[10.] Penkała, P. andPłowaś,B., (2014)"The Influence Of Currant MMA Welding On The Tensile strength Of Joint", *Advances in Science and Technology Research Journal*,8:21, 43–48

[11.] Propster, M. (2015)"Validation of Line Balancing by Simulation of Workforce Flexibility" *Procedia, CIRP*, 33:93 – 98.

[12.] Sajjadi, S., Soroush, H. and Arabzad, S. (2014)"Efficiency analysis and optimisation of a multi-product assembly line using simulation" *Int. J. Productivity and Quality Management,* Vol. 13, No. 1.

[13.] Shadadal, V., and Babu, M.(2015) "Productivity Improvement in Sub-assembly lines of Electric car using Lean Layout Concepts" *International Research Journal of Engineering and Technology (IRJET)*,02: 05.

[14.] Zupan, H., Herakovic, N. (2015) "Production line balancing with discrete event simulation: A case study" *IFAC*

[15.] *(International Federation of Automatic Control* ,48-3: 2305–2311.

[16.] LI, Y., and SUN,Q.,"Study on Stochastic Mixed-Model Assembly LineBalancing Based on Arena"'IEEE'978-1-4244.