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Conversion of Regular Assembly Line into Cellular Manufacturing Layout

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Abstract: - The main aim of any industry is to increase the profit by maximum utilization of resources. Industries develop and adopt new technologies and new designs to improve their productivity by considering their various limitations such as workers, machine utilization, etc. Productivity is a ratio of production output to the resources required to produce it (inputs). The measure of productivity is defined as a total output per one unit of a total input. Productivity can be increased by reducing non value adding process which can be identified through seven wastes (defects, inventory, motion, waiting, over processing, overproduction, transportation) and through work study. (Work study is a scientific analysis and improvement of work in all its aspects and is a very useful technique of increasing productivity. Work study results in improvements in plant layout, material handling system, process design and standardization, working conditions, etc.) These in turn help to minimize defective work and waste. Nowadays industries are trying to adopt cellular layout for flexible production process with maintaining production rate. Cellular layout is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in design and production. Cellular manufacturing is an integral part of lean manufacturing and is based upon the principles of Group Technology. The objective of lean manufacturing is the aggressive minimization of waste, called muda, thereby improving efficiency of resources. This paper presents the application of work study and seven wastes of lean manufacturing for the optimization of cellular manufacturing layout of relay assembly in an industry.

Index Terms:- **Cellular Manufacturing, Lean Manufacturing, Productivity, Seven Wastes (Muda), Work Study.**

I. INTRODUCTION

Nowadays competitiveness decides the industry leader in all over the world. The objective of all industries is to increase the efficiency through improved productivity. Industries are trying to adopt lean manufacturing practices to help address concerns about their bottom line. Cellular manufacturing is an integral part of lean manufacturing. Cellular manufacturing is the type of layout in which a variety of products can produce with as little waste as possible. A cell consists of group of workstations, machine tools, sometimes material handling systems, etc. Families of different parts are processed progressively from one workstation to another in a cell without waiting for a batch to be completed. The major benefits of cellular manufacturing are efficient layout designs [1]. Cellular layout is worked upon the principles of Group Technology, in which similar parts are processed through a cell through standardization. In process layout the machines are not arranged according to a particular product sequence, there is an assembly of similar operations or similar machines in each department. This layout is more resistant to machine breakdowns. In a product layout, the workstations and equipment are located along the line of flow of the work units, but the layout can only produce less flexibility products with high production rate. The major advantage of cellular layout is that reduces the distance travelled by materials, inventory and lead times. Cellular Manufacturing reduces setup time and gives the workers the tools to be multiprocessing, operating different processes at the same time, and multifunctional that led to quality improvements, simple machine maintenance and waste reduction. This help worker to easily self-balance within the cell and reduce lead times, resulting in the ability for the industries being able to manufacture high quality products at a low cost, in a flexible way and on time. The goal of lean manufacturing [3]-[4] is the aggressive minimization of waste called ‘muda’ to achieve maximum efficiency of resources. Properly trained and implemented cells are more flexible and responsive than the traditional mass-production line, and can manage scheduling, equipment, maintenance processes, defects, and other manufacturing issues more efficiently.

A. Seven wastes of lean manufacturing

There are seven wastes in lean manufacturing, which are at the root of all unprofitable activity within your organization. It is important to eliminate waste to increase profitability in manufacturing and distribution businesses. To eliminate waste in the production process, it is important to identify exactly which waste is and where it exists. The typical wastes found in manufacturing environments of industries are quite similar. The Japanese automobile manufacturer, Toyota, identified seven wastes for eliminating in manufacturing processes.

Seven wastes are,

1. Overproduction: is to produce more than demanded or to produce it before it is needed.
2. Transportation: Each time a product is moved it stands the risk of being damaged, delayed, lost, etc. As well as being a cost for no added value. Transportation does not make any value to the product.
3. Motion: of the workers, machines, and transport (e.g. Due to the inappropriate location of tools and parts) is waste.
4. Waiting: The advantage to eliminate waste is either to maximize the utilization/efficiency of the worker or to maximize the utilization of the machines.
5. Over processing: Over-processing occurs any time more work is done on a product than the actual requirement of the customer. All unnecessary processing (non value added) steps should be eliminated.

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6. Inventory: Main Inventory of industries are raw materials, work in progress (WIP) and finished goods. Any of these three items not being actively processed to add value is waste.
7. Defects: Making defective products is pure waste. Whenever defects occur, extra costs are incurred reworking the part, rescheduling production, etc. Focus on preventing the occurrence of defects instead of finding and repairing defects.

Work study is activity timing and method study are an important part of lean manufacturing implementation if the wish is to design manufacturing cells or balance and improve existing flow lines and cells. Traditional work study usually involves the use of an industrial engineer standing over an operator with a stop watch to time the operations involved in producing a product to measure standard times for costing and payment. These standard times would be used to estimate costs for products and to set production targets that could be used to either reward or penalize the workforce. Methods used within a lean manufacturing try to avoid some of the problems associated with these traditional methods by including the workforce in taking these measurements and using them to help drive continual improvement.

II. PROBLEM IDENTIFICATION

The industry produces relays and switches used in the electronic industry for application in communications, industrial controls, instrumentation, automotive, strategic and consumer electronics. Relays are electro magnetically operated switches. Relays are used along with switches to regulate the flow of current. Typical applications for relays include laboratory instruments, computer interfaces, domestic appliances, air conditioning and heating, telecommunication systems, automotive electrics, lighting control, traffic control, building control, control of motors and solenoids, business machines, tooling machines, electric power control, production and test equipment. Several months ago, the industry followed the regular assembly flow with high inventory. To analyze the process, the case study is concentrated to one relay series line. In this relay line, more than ten designs of manufacturing and assembly carried out based on the demand of different customers. The designs of the relay line are listed in the table 2. The process was carried out with a high inventory of about 33,409 numbers (table 1). Besides that from one station to another, work in progress products need more transportation time because the process stations are arranged one in front of others and so on. Due to this arrangement floor space is much higher at 89.5m². This arrangement can produce an average of 3000 relays per day by the utilization of 28 operators.

Table 1: Total Inventory before Cell Implementation

Work In Process With In The Cell					
Sl.No	**Operation**	**Components**	**In**	**Within The Cell**	**Out**
1	Coil Pin Insertion	Bobbin	50	4	100
2	Winding		200	4	4566
3	Dipping		82	1	2615
4	No Contact Staking	Contact	1325	1	3260
5		Terminal	500		
6	Nc Contact Staking	Contact	1684	1	4226
7		Terminal	630		
8	Mvg Contact Staking	Contact	1100	1	2200
9		Mvg Spring	1030		
10	Armature Staking		1500	1	3664
11			1128		
12	Yoke Pre Cal		504	1	80
13	Braided Wire And Ter-30 Welding		60	1	40
14	Braided Wire Welding On Yoke Ter-30assy		38	1	150
15	Y.C.C.S	Coil	960	1	45
16		Yoke Terminal-30	500		
17	Base Coil Staking	Y.C.C.S	85	10	10
18		Base Terminal Assy	150		
19	Resistor Fixing		10	10	10
20	Resistor Soldering		10	10	30
21	Cleaning		10	10	80
22	Armature				

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	Welding				
23	Final Welding		160	1	320
24	Dynamic Air Cleaning		40	8	120
25	Calibration		40	1	30
		Total Wip	11796	67	21546

The movement of a batch of relays takes one day for the next process and so cycle time of one relay took several days. The quality of the process in the average months of study (from March to June) is 95.37%. This value is high in normal cases, but in the case of relays this must be above 98%. This is because the selected relay is used for automotive applications of large automotive industries in the area of horn control, indicator, security systems, and radiator fans, etc. Minute problem of any relay is significant- sometimes cause fetal death, For example if the relay used in indicator has a problem that will affect the resulting automotive indicator and that cause accidents. So quality procedure has a very important role in the case of relays.

Table 2: Different Designs of Selected Relay Line

DESIGN NO:	CUSTOMER
1	TATAMOTORS
2	TME
3	TATAMOTORS
4	MAHINDRA
5	ASOK LEYLAND
6	DAIMLER INDIA(BENZ CUSTOMER)
7	JCB
8	VILLOTECHNOLOGY
9	YAZAKI(FORD)
10	HYUNDAI

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III. CELLULAR LAYOUT IMPLEMENTATION

When implementing cellular layout Management must deal with many issues including: cell design and set up, teamwork training, team design and placement, employee training, and other company functional issues. A project team should consist of management and production employees to handle the changes of layout. Before implementing cellular layout, the time needed for each processing station (fig. 1) of the selected relay line is noted using a stop watch and takt time is measured.

Takt time = (the available work time per shift) / (customer demand per shift)

= 7.33 x 60 x 60 / 3000

= 8.796 Sec.

Takt synchronizes pace of production with the pace of sales. Takt time is based on customer demand. We cannot change customer demand. But, we can change Takt time by

- Changing available production time (number or length of shifts)
- Changing the number of end items produced in the cell
- Changing number of work cells making the end items

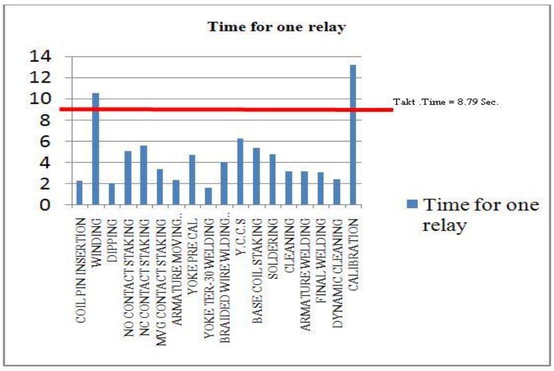

Fig. 1: Time Required For Each Operation before Cell Implementation

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From the above graph the average talk time is 8.79 Sec. This means one relay needs to be produced every 8.79 Sec. to meet customer demand. The change of a company production layout into the cellular manufacturing layout without analysis makes more costly and time-consuming. So in the first stage, main process of the selected relay line is taken for analysis. The process starts from yoke coil and core staking (Y.C.C.S) to final calibration (fig. 1). The layout is changed in cellular layout only after the successful implementation of main processes. The main processes of the relay are analyzed using method study and seven wastes tool (Muda). Method study is the part of work study, which is concerned with the reduction of work content and establishing the best way of completing a job whereas work measurement is concerned with investigation and reduction of ineffective time associated with the job and establishing time standards for an operation carried out as per the standard method. Analysis of YCCS is taken as an example. By using method study YCCS operation (table 3) is divided into elements and each operation has two cycle time. They are element cycle time and machine cycle time. Element cycle is the time required for non machine operation and the machine cycle is the time required on machines. In the case of Y.C.C.S (table 3), one non value added operation is detected in terms of motion and that can eliminate by

- Place the staked part direct to tray instead of the surface of the press (element two)
- Reduce the size tray used for coil carrying (element one and five)

All processing stages of selected relay line are analyzed in this way and determine to eliminate non value adding process and maximum utilization of resources bring to achieve (fig. 2 and fig. 3). Each color (fig. 3 and fig. 4) of graph in Y.C.C.S (table 3) shows a work element (1 to 5 (table 3)) and the time needed for each operation before and after applying method study and eliminating waste.

Table 3: Table of YCCS for Eliminating Waste

Process study work sheet	YCCS			7 wastes		
Process steps	Work element	Element cycle (sec)	Machine cycle (sec)	Sl no.	Waste	Problem identified
1	Pick coil and yoke T.30 assembly and assembling	1.53		1	Delay	
2	Pick staked assembly and place on the surface of the press	0.16		2	Over production	
3	Place the one in to the tool	0.58		3	Waiting	
4	Operate the press	0.54	1.5	4	Over processing	
5	Staked the assembly to tray	0.52		5	Transportation	
				6	Inventory	
				7	Motion	1. Placing the staked assy. On the surface of the press before placing new assy. To the tool 2. Movement to pick the coil and place the staked part to the tray.

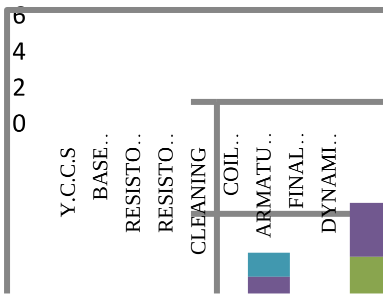

Fig. 2: The Selected Relay Line Main Processes Before Applying Method Study and 7 Wastes

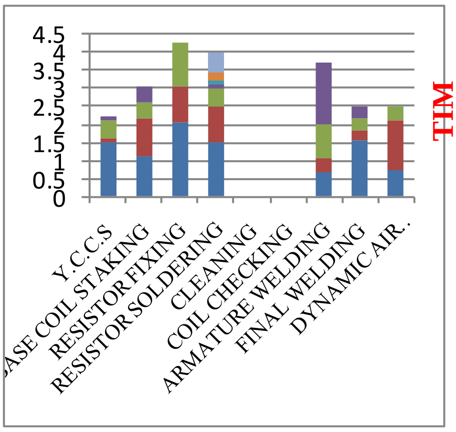

Fig. 3: The Selected Relay Line Main Processes After Applying Method Study and 7 Wastes

After eliminating non value adding operation in each process, the main processes of the relay line are implemented in one line as a cell and optimization of a cellular layout using lean manufacturing is started.

A. Optimization Of Cellular Manufacturing

From the implementation analysis, main process from the relay process (fig. 1) is first implemented in the following order in new cellular layout (fig. 4). The main process starts from yoke coil and core staking (Y.C.C.S) to final calibration (Hypot checking) (fig. 1). Optimization of each process is carried out based on text time (8.79Sec.) and seven wastes. Operation time for each process must less than takt time. In the initial stage of cellular manufacturing, processing of relay assembly progresses (fig. 4) With four relays of one batch and at that time waiting time in some stages of operations were detected. Workers only start operations after getting four relays in each stage. So labor utilization cannot use its maximum. To avoid that instead of the four relays, one relay is processed in each stage and operation time is taken. In this method, waiting time came to a minimum, almost becomes zero. To maintain almost the same operation time for all processes (fig. 4) either adding more operations (from previous operations) to processes which have low operation time or reduce some operations (provide to next or previous operations) from processes which have more operation time based on takt time, For example (table 4), Y.C.C.S need more operation time compared to other

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operations. Besides other processing stages depend on the operation time of Y.C.C.S. If the operation time of Y.C.C.S is less, then more relays can be produced and vice versa. In order to maintain almost the same time, one of the operation (coil staking) of Y.C.C.S is given to the next processing stage (Base staking and cap insertion) and time is taken for each processing stage (table 5) using a stop watch.

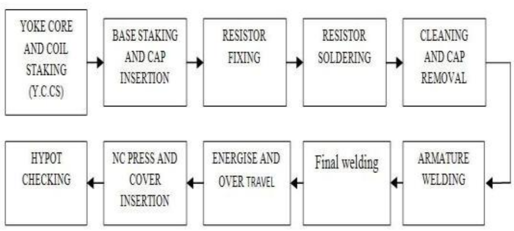

Fig. 4: Processing Order of Main Process of Selected Relay Line in First Cellular Layout

Table 4: Time Needed For Each Processing Stage In Selected Relay During Cell Implementation In Sec.

PROCESSING STAGES	TIME FOR ONE RELAY IN SEC.
Yoke core and coil staking (Y.C.C.S)	8.05
Base staking and cap insertion	5.21
Resistor fixing	4.62
Resistor soldering	3.26
Cleaning and cap removal	4.36
Armature Welding	3.03
Final Welding	4.02
Energise and over travel	4.72
NC press and cover insertion	5.23
Hypot checking	2.73

Table 5: Time Needed For Each Processing Stage In Selected Relay After Rearrangement In Sec.

PROCESSING STAGES	TIME FOR ONE RELAY IN SEC.
Yoke and core staking(Y.C.S)	6.52
Base and coil staking and cap insertion	7.32
Resistor fixing	4.7
Resistor soldering	3.26
Cleaning and cap removal	4.59
Armature Welding	2.24
Final Welding	3.45
Energise and over travel	4.28
NC press and cover insertion	5.81
Hypot checking	2.69

After time is taken for each station using a stop watch, found that Y.C.S time has reduced and base and coil staking and cap insertion processing time is increased (table 5) compared to table 4, but time for processing stages are under takt time. So one more operation (core insertion) (fig. 6) Adds to Yoke and core staking (Y.C.S) and time is taken for each processing stage (table 6). By adding core insertion (one operation) from previous station (not include in main processes), the previous processing station can be eliminated and thereby eliminate one operator utilization from the whole cell. After time taken for each processing station, all processing time is compared with takt time graphically (fig. 5) And determined that all processes are under takt time and operating time for all processing stations are within the limited range (table 6).

Table 6: Time Needed For Each Processing Stages After Cell Implementation In Sec.

PROCESSING STAGES	TIME FOR ONE RELAY IN SEC.
Core insert and yoke and core staking(Y.C.S)	7.11
Base and coil staking and cap insertion	7.41
Resistor fixing	4.82
Resistor soldering	3.06
Cleaning and cap removal	4.72
Armature Welding	2.61
Final Welding	3.84
Energise and over travel	4.59
NC press and cover insertion	5.97
Hypot checking	2.87

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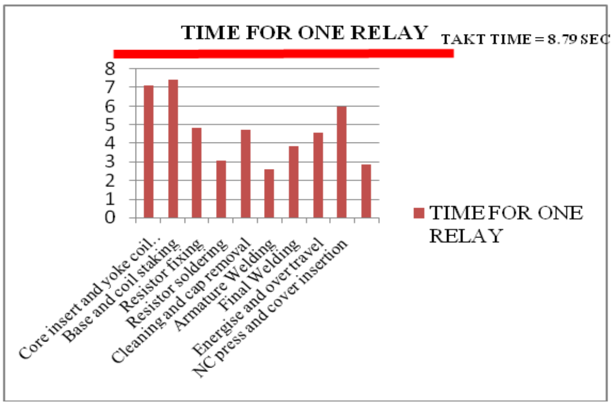
Fig. 5: Graphical Representation of Time Required For Each Operations



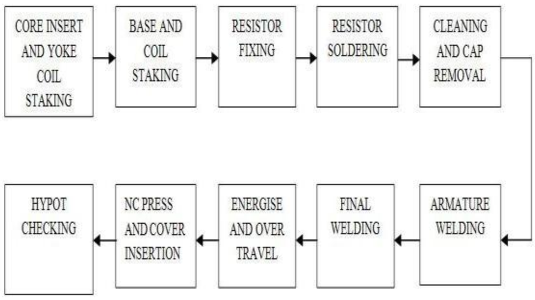


Fig. 6: Final Processing Order of Main Process of Selected Relay Line in First Cellular Layout

B. Productivity Improvement After Cell Implementation

In the regular assembly line the productivity was 43.28%. After cell implementation, productivity improvement is calculated as follows.

- Productivity before cell implementation

= pieces/operator/shift
= 34625 (monthly)/ (16x25x2)
= 43.28 %

- Number of operators before implementing the cell

= 13

- Number of operators at present in the cell = 10

Pieces per operator before cell implementation

= 3000/13
= 230.77

- Pieces per operator at present

= 3500/10
=350

- Productivity improvement

= (350-230.77)/230.77
= 51.67 %

Productivity improvement after cell implementation is determined as 51.67 %. That means the industry now has a productivity of 65.64 %.

IV. CONCLUSION

The goal of cellular manufacturing is having the flexibility to produce a high variety of low demand products and maintaining the high productivity of large scale production. Cell designers develop this through modularity in both process design and product design. After implementing and optimizing of cellular layout, productivity of relays is improved by 51.67% and the industry can now produce 3500 relay/day instead of 3000 per day. All designs of selected relay for various customers can make in one cell without rearranging machines. Besides this, inventory is reduced close to zero. In this cellular layout, lead time of one relay is 70 Sec and floor space for this assembly process is only 13.25m². Concentrating work study on the first two processes (fig. 5) (core insertion and yoke coil core staking and base and coil staking) productivity can be improved and a higher production rate with maximum resource utilization can be achieved.

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REFERENCES

[1] Massoud Bazargan-Lari., Layout designs in cellular Manufacturing Original Research Article European Journal of Operational Research, Volume 112, Issue 2, 16 January 1999, Pages 258-272.

[2] Miltenburg, J., 2001. One-piece flow manufacturing on U-shaped production lines: A tutorial. IIE Transactions 33, 303–321.

[3] Morris, S.J., Tersine, R.J., 1990. A simulation analysis of factors influencing the attractiveness of group technology cellular layouts. Management Science 36 (12), 1567–1578.

[4] Atul Agarwal., Partitioning bottleneck work center for cellular manufacturing: An integrated performance and cost model. Department of Business, Kettering University, 1700 W Third Avenue, Flint, MI 48504, USA.