Implementation of Lean Production System in Steering Manufacturing System

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Abstract-*In the present scenario manufacturing industries are facing a greater competition in the market. Because of this, they try to improve and increase both quality and productivity continuously. One way to increase the productivity is to increase the availability of existing machines. The main objective of this paper is to understand the concept of Lean production system and the various associated tools. While understanding these tools, it also aims on how to use them in the process of implementing the Lean Production System. The company has assigned the work for TAFE Rocker shaft line which is working on the concept of the lean production system. The work involves the study of all the existing concepts, practices and tools of the lean production in the TAFE Rocker shaft cell. After studying the existing practices of the cell, the scope for improvement like Inventory reduction and setting time reduction has been identified.*

It is identified to reduce the "MUDA"(Waste) from 7 Kinds of waste in the TAFE Rocker shaft cell, the inventory in turning operation is reduced by reducing the setup time through Eliminate Combine Reduce Simplify (ECRS) technique and the concept of Single minute exchange of dies(SMED) for quick change over of setup is implemented.

Keywords-Lean Production system, Inventory reduction, Setup time reduction, ECRS (Elimenate, Combine, Reduce, Simplify) technique.

I. INTRODUCTION

Many of the concepts in Lean Manufacturing originate from the Toyota Production System (TPS) casing were identified and the experiments were designed as per full factorial and have been implemented gradually throughout Toyota's operations beginning in the 1950's. By the 1980's Toyota had increasingly become known for the effectiveness with which it had implemented Just-In-Time (JIT) manufacturing systems. Today, Toyota is often considered one of the most efficient manufacturing companies in the world and the company that sets the standard for best practices in Lean Manufacturing. The term "Lean Manufacturing" or "Lean Production" first appeared in the 1990 book The Machine that Changed the World.

Lean Manufacturing has increasingly been applied by leading manufacturing companies throughout the world, lead by the major automobile manufactures and their equipment suppliers. Lean Manufacturing is becoming an increasingly important topic for manufacturing companies in developed countries as they try to find ways to compete more effectively against competition from Asia.

"A systematic approach to identifying and eliminating waste (non-value-added activities) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection."

Lean Production, also known as the Toyota production system, means doing more with less- less time, less space, less human effort, less machinery, less materials- while giving customers what they want. The basis of the Toyota Production system is the absolute elimination of waste. The two pillars needed to support this system are:

- Just-In-Time
- Automation

Just-in-time means that, in a flow process, the right parts needed in assembly reached the assembly line at the time they are needed and only in the amount needed. A company establishing this flow can approach zero inventories.

Automation is known as automation with a human touch. An operator is not needed to stand by just to see that the operations are being performed properly. The machine has a built in capability to distinguish between normal and abnormal conditions. Only in case of an abnormality would the machine require human intervention. Thus one operator can look after several machines.

II. LITERATURE REVIEW

The history of the Lean Production system traces back to the late nineteenth and the early twentieth century when the production system began with the craft production followed by the mass production. The craft producers were highly skilled in a particular area and used simple and flexible tools to produce one item at a time according to the customer requirements. These custom produced components were too expensive for everyone to afford. The Mass production uses narrowly skilled professionals using expensive single-purpose machines to design standardized products in a very high volume. To assure smooth production, mass production demands extra workers, extra supplies and extra space. Because changing over to a new product costs even more, the mass producer keeps standard designs in production for as long as possible. The result: the consumer gets lower cost but at the expense of variety.

The Toyota Production system evolved out of need. Certain restrictions in the market place required the production of small quantities of many varieties under conditions of low demand, a fate the Japanese automobile industry had faced in the post-war period. These restrictions served as a touchstone to test whether Japanese car manufacturers could establish themselves and survive in competition with the mass production and mass sales systems of an industry already established in Europe and in United States. The Toyota Production system was conceived and its implementation began soon after World War II. The most important objective of Toyota system has been to increase production efficiency by consistently and thoroughly eliminating waste.

Ir. W. de Kogel et al. [1] state that the application of the Lean philosophy during the design of a new production system might result in a production system which is leaner from the beginning and needs less improvement during its life time. In this paper, a design support tool for new lean production systems is presented. It combines the theory on lean and production system design. The design support tool consists of three elements with a strong interaction. The first element of the tool prescribes the steps in the design of a production system in general. The second element illustrates the flow of different types of information during the design process. The third element consists of guidelines for lean design. The goal of this project was to design a support tool for Lean production systems.

Tom Drews et al. [2] have explained lean principles are the central core of many industrial companies for improving their production system. In order to be able to optimize their manufacturing and logistics processes, companies have to choose the most suitable lean principles to solve problems or to reach their target state. To solve this decision problem, it is important to identify objectives based on values of the decision-maker and to determine effects of lean principles and objectives. They presents a value-focused thinking driven identification of objectives and a system dynamics approach for understanding the interdependencies and dynamics of lean principles and objectives. This provides a transparency and better understanding for these interactions for the decision-maker in the decision-making process. Based on this knowledge, the most effective lean principles for the design of the production system can be chosen and successfully applied.

M.Laxman et al. [3] have reduced set up time, by increasing production in company and the profit through mass production. Some techniques were used to reduce setup time and increase productivity by converting the internal set up activities to external set up by carrying out number of iterations. The problematic area was the Vertical Machining Centre (VMC), Chiron, where the setting changeover was taken once in a week for machining two different part numbers as per customer schedule. Due to this frequent setting change the losses were more.

The set-up time was brought down to 113 minutes from 498minutes.This was possible by applying the Single Minute Exchange of Die (SMED) techniques. Still there is scope for further reduction by fine tuning the process. In the above case the major share of time was consumed for removing the fixture and again mounting the required one. Hence by applying the SMED technique by a systematic way they have reduced the set up time.

Chompoonoot Kasemset et al. [4] in their study aimed to apply ECRS concept and simulation technique in efficiency improvement of a paper package factory in Thailand. A simulation model was built for target product and process to identify and improve the bottleneck. One specific type of paper packages was selected as the target product due to its high and continuous demand. The first step was to collect general data of the target product and its process. Then, collected data were analyzed using input analyzer before they were used in the simulation model development. Results from simulation and actual data analyzed using ECRS concept were used to propose improvement solutions to reduce the total time of the target process. Three procedures were evaluated via simulation tests. Finally, the results from the simulation model showed the reduction in total process time from 4.99 hours to 3.49 hours that was 28.06% reduction.

ECRS and simulation techniques were applied in efficiency improvement of one paper package production line. Consequently, to improve the bottleneck, ECRS can be applied to conduct the improvement solutions.

Shweta V. Nagarale et al. [5] have focused on improving the operator productivity in the metal cutting department. Various industrial engineering tools and techniques were used for analyzing the manual activities in metal cutting department. Man-machine chart and ECRS technique gave an optimum solution to improve productivity and reduce the waste elements. We could reduce the manpower and thereby improve productivity which resulted in a cost saving benefit to company.

Gaurav J. Pawaret al. [6] state that Single minute exchange of dies (SMED) along with ECRS can be used efficiently to reduce setup time. They have suggested an analysis of current changeover methods of bearing ring grinding machine in a manufacturing plant having line layout. The total setup time is reduced by implementation of SMED and ECRS principles on the setup procedure in the bearing manufacturing plant from an initial time of195 minutes to 114 minutes, saving 81 minutes i.e. 41.53%of total time. This indicates that SMED along with ECRS is an effective tool to reduce production loss in a similar batch manufacturing plant having a line layout.

III. IMPLEMENTATION OF LEAN PRODUCTION SYSTEM

Product detail

RANE (Madras) Ltd Manufactures the Manual Steering gear for Tractor and Farm Equipment (TAFE). This steering gear is used to convert the rotary motion to linear motion. Steering gear works on mechanism of inter meshing of the gears of primary & secondary rocker shafts. The direction or rotation given by the driver will transfer to the inner column & movement transfers to the rocker shaft & drop arm connected to rocker shaft oscillates & drop arm is connected to the wheels of the vehicle with the help of tie rod. This mechanism is used to change the direction of vehicle

TAFE Rocker Shaft Cell Layout

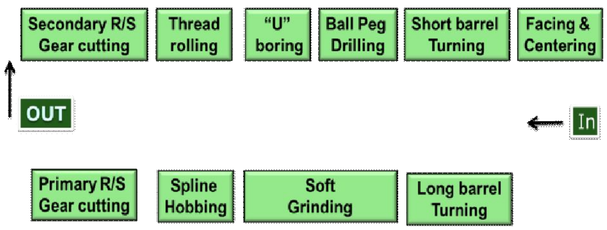

Fig.1

TAFE Rocker Shaft cell is lean production cell which consist of 10 machines. This cell is dedicated to manufacture only TAFE Rocker Shaft. Cell is used manufactures two different components i.e. Primary Rocker shaft & Secondary Rocker shaft. The cell is operated with 6 man power with multi machining concept. All the machines in the cell are conventional & special purpose machines (SPM).

Rocker shaft process flow diagram

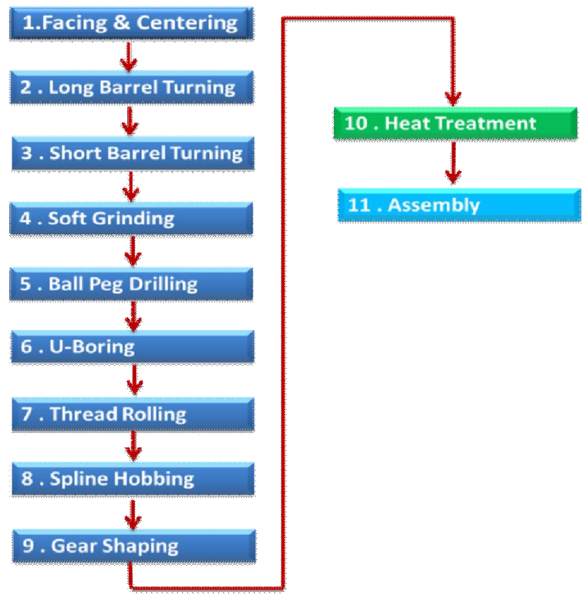

Fig. 2

Value steam mapping (current state mapping)

It is used to determine the value adding and non-value adding activities in a cell. Value stream mapping plotted for the TAFE rocker shaft line.

Value steam mapping (VSM) is done to cell for current conditions. The VSM plotting was done from supplier to customer end. It is found that the value adding time is 169.3 seconds I.e. total processing time of the product & non value adding time is 10467 seconds. Through VSM it's observed that the inventory in the turning operation was high compared to other operation. The entire cell running with the single piece flow except the turning operation every time 252 No's will be present at this stage. Team decided to investigate the reason for the inventory at turning operation.

Reason for inventory in turning operation

The TAFE steering assembly consists of Primary & secondary Rocker shaft, both rocker shaft are manufactured in the same cell. For both Primary & Secondary gear shaping machine material has to be feed from the single set of copy turning machine. To feed the material to gear shaping machine frequent setting has to be changed frequently between primary & secondary Rocker shaft.

The Setting required in short turning operation is 42 minutes & 47 minutes in long barrel turning, totally 89 minutes is required for changing the setting between primary & secondary. For this reason inventory is maintained in the turning operation & doing the batch production. Since the INVENTORY is one of the waste in the Lean production system (LPS), team decided to take the project to reduce the inventory in the turning operation.

TIMWOOD

Transportation
Inventory
Motion
Waiting
Over processing
Over production
Defects

Problem Identified in the TAFE Rocker shaft cell are as follows

1. High Inventory in turning operation.
2. High Setting time in turning operation is 89 minutes.
3. Batch production in turning operation.

IV. OBJECTIVES

After the VSM study & data collection team has identified the projects as mentioned below.

1. Reduce inventory in turning operation.
2. Eliminate setting time in turning operation.
3. Change over from Batch production to lean production.

V. PROBLEM ANALYSIS

A. Rocker Shaft cell layout

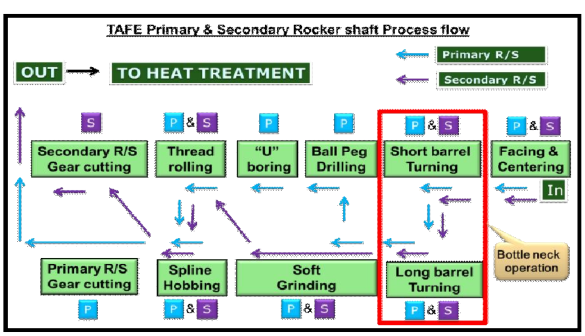

Fig. 3

The figure shows the cell layout of TAFE Rocker Shaft & product flow of primary & secondary rocker shaft. The Blue line represents the primary rocker shaft & purple line represents the secondary rocker shaft. Chart shows that flow of Primary rocker shaft through all the machines in the cell & secondary rocker shaft flows through only few machines in the cell. As shown in the flow chart only few machines are common for primary & secondary rocker shaft, few machines are dedicated in the cell. As explained in the previous setting detail sheet the turning operation common for both the rocker shaft & having the highest setting time in the entire cell. Because of the high setting time in the turning operation running the batch production & having the higher inventory. Setting change takes place at every shift start & runs for 252 No's & again setting changes for the other pattern, average time required for changeover per set up is 89 minutes.

B. Process detail

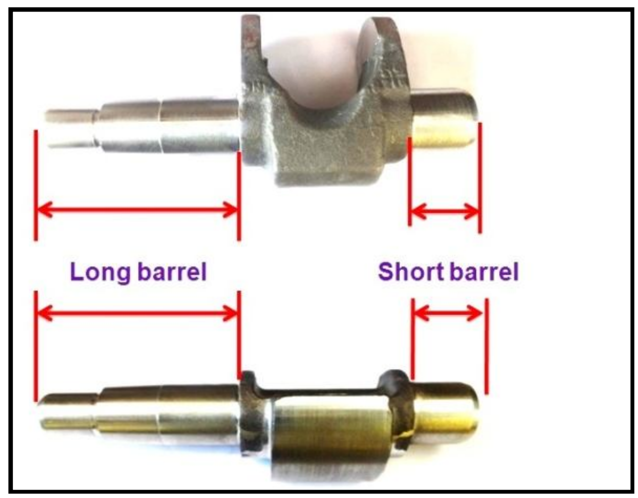

Fig. 4

The above figure shows the primary & secondary rocker shaft, as discussed in the earlier both the rocker shaft manufactured in the cell & both rocker having the two ends I.e. long barrel & short barrel. Both ends of the rocker shaft are turned in the copy lathe. Both the rocker shafts having different shapes, but both rocker shafts are similar up to the barrel end.

VI. SOLUTIONS

List of ideas / Measures

As the team decided that to reduce the inventory through the elimination off setting between the primary & secondary rocker shaft, team listed out the ideas through ideas the brain storming.

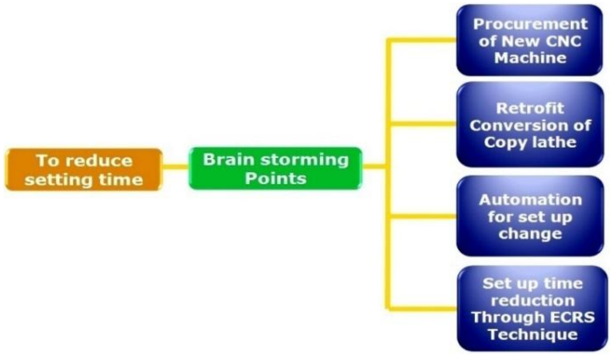

Fig. 5

A. Measure -1: Procurement of New CNC Machine

Fig. 6

Procurement of New CNC Machine requires an initial investment of Rs40 lakhs and Lead time is 4 months.

Result: Procurement of New CNC Machine NOT FEASIBLE

B. Measure-2: Retrofit Conversion of Copy lathe

Fig. 7

Retrofit Conversion of Copy lathe machines requires an initial investment of Rs18 lakhs and lead time is 6 months. Alternate machine must be released for conversion.

Result: Retrofit Conversion of Copy lathe Machine NOT FEASIBLE

C. Measure-3: Automation for set up change

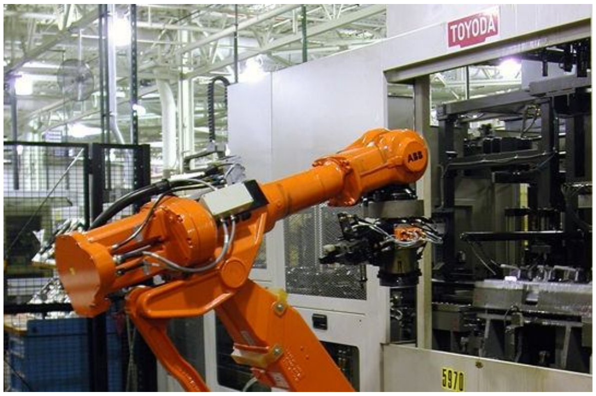

Fig. 8

Automation for set up change requires an initial investment of Rs 6 lakhs and high lead time of 12 months. Alternate machine is required during conversion.

Result: Automation for set up change NOT FEASIBLE.

D. Measure-4: Set up time reduction through ECRS Technique

Fig. 9

Advantages

- Setting time reduction can be done through ECRS (Eliminate, Communize, Reduce, and Simplify) technic of the existing setting procedure.
- The cost for the ECRS will much lower compared to all other measures.
- Productivity can be improved by reducing or eliminating the setting.
- Lead time will be much low compared to the other measures
- Investment will be less.
- Scope for the learning will be more.

Result: Set up time reduction through ECRS Technique is SELECTED.

E. Time Study Using ECRS approach (Elemental Study)

Setting procedure elemental study done & identified the elements for the ECRS. Six elements identified for elimination & six elements identified for reduction.

Table.1 Time Study Using ECRS approach

Turning setting time details				
SL NO	Elements	LBT	SBT	ECRS
1	Loosening drive plate the Allen screws (6Nos)	120	120	E
2	Removing the Drive plate	10	10	E
3	Replacing the drive plate	60	60	E
4	Tightening the drive plate Allen head screws (6nos)	180	180	E
5	Loading & unloading of master component	30	30	R
6	Drum card setting	450	300	R
7	Dry run checking	180	180	R
8	Facing unit setting	600	600	E
9	Facing unit adjustment	600	600	E
10	Trial component	300	120	R
11	Component Inspection	120	120	R
12	Length & diameter adjustment	300	300	R
	Total time (sec)	2830	2500	
	Total time (Min)	47	42	

E-Eliminate C-Combine R-Reduce S-Simplify

VII. METHODOLOGY

A. Action 1: Design & manufacture of drive plate

As seen in the elemental study the drive plate is been changed for both primary & secondary rocker shaft during the setting change. This drive plate is used for rotating the component in between centers. Drive plates are different according to the shape of the component To eliminate this drive plate changing common drive plate designed for the both rocker shaft with different driving pins.

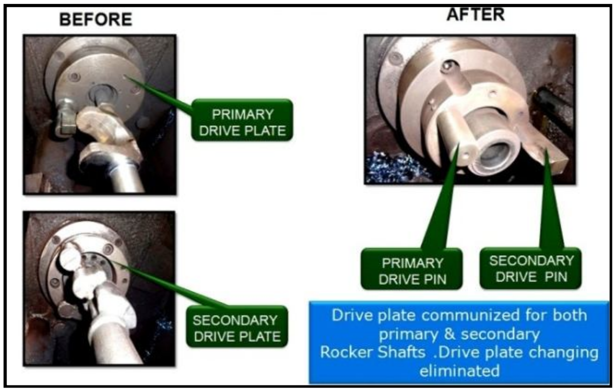

Fig. 10

By common drive plate for both primary & secondary able to eliminate the drive plate changing. This action has resulted drastic reduction in the setting change time. The same actions have been done for both the long barrel & short barrel turning operation.

B. Action 2: Separate drum card regions for primary and secondary Rocker shaft

The function of drum card is to control the travel of the tool travel. The primary & secondary rocker shafts having the different shapes & different tool paths needs set the drum card during every set up between primary & secondary rocker shaft. In the existing practice the same region is been used for the both rocker shaft. The drum card setting is done for the both the machines.

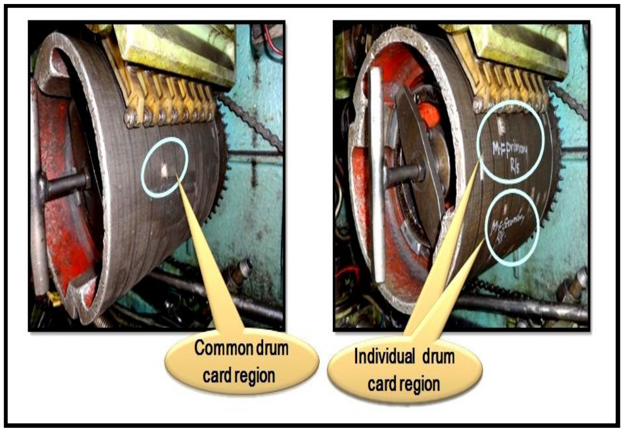

Fig. 11

To reduce the drum card setting time different regions provided with the identification for primary & secondary rocker shaft. The action has given the reduction in setting time to the greater extent.

C. Time Study (After completion of actions)

After completion all the actions again setting time study done and compared with the initial, observed that setting time has reduced from 89 minutes to 23 minutes.

Table.2 Time Study

Turning setting time					
SL	Elements	PHASE -1		PHASE -2	
		Existing		ECRS	
		LBT	SBT	LBT	SBT
1	Loosening drive plate the Allen screws (6Nos)	120	120	0	0
2	Removing the Drive plate	10	10	0	0
3	Replacing the drive plate	60	60	0	0
4	Tightening the drive plate Allen head screws (6nos)	180	180	0	0
5	Loading & unloading of master component	30	30	30	30
6	Drum card setting	450	300	120	60
7	Dry run checking	180	180	120	120
8	Facing unit setting	600	600	0	0
9	Facing unit adjustment	600	600	0	0
10	Trial component	300	120	120	120
11	Component inspection	120	120	30	30
12	Length & diameter adjustment	300	300	300	300
	Total time (sec)	2830	2500	720	660
	Total time (Min)	47	42	12	11

The actions of the ECRS abled to reduce the setting time from 89 minutes to 23 minutes. But the target of the project to bring down the setting time to zero and reduce the inventory from 252 to 1 number. After the actions still it is not able to achieve the single piece flow. Further team decided to find alternate solution for eliminating the setting.

E. Alternate Solution:

Similarity analysis done between primary and secondary rocker shaft I.e. the dimensions of the both primary and secondary rocker shaft are similar up to the barrel end on the both long barrel and short barrel rocker shaft only the gear blanks are having different dimensions.

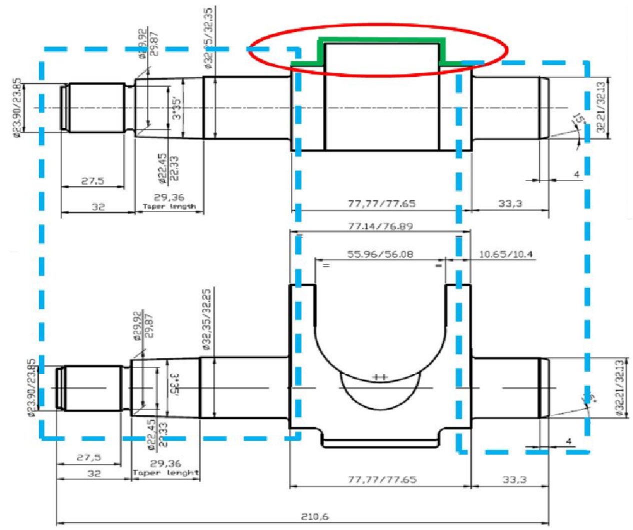

Fig. 12 Similarity analysis

The blue circled ends are similar and gear blank are different. By analysis found that if the gear blank turning is eliminated for secondary rocker shaft setting can be eliminated.

As discussed earlier that the rocker shafts are similar up to the barrel ends and also analyzed that the primary tool path will match the secondary tool path with the small modification in the secondary rocker shaft dimension. If the setting kept constant for primary in the copy tool and facing tool the both primary and secondary rocker shafts can be machined in the single set up. It has decided to do the trails of the common setting idea.

After completion of the trials secondary rocker shaft turning done without any setting change, the primary rocker shaft tool path has been given to the secondary rocker shaft. The primary rocker shaft complete machining done all the dimensions maintained as per the requirement, but the secondary rocker shaft machining done only up to the barrel end the gear blank kept un-machined.

VIII. CONCLUSION

The implementation of ECRS (Eliminate, Communize, Reduce, Simplify) technique on the setup procedure of turning operation in primary and secondary rocker shaft has able to reduce the setting time from 89 minutes to 23 minutes. After the actions, still it is not able to achieve the single piece flow. Further it was decided to find alternate solution for eliminating the setting. The setting elemental study done and found no setting is done for primary and secondary rocker shaft turning. After implementation of the common tool path for both primary and secondary rocker shaft setting time made zero with the gear blank turning elimination. Finally, the setting time get reduced from 89 minutes to ZERO minutes and WIP (Work In Process) reduced from 252 no's to 1 no. by enabling the alternate piece turning of primary & secondary rocker shaft. Change over from batch production to lean production.

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