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Value Stream Mapping and Work Standardization as Tools for Lean Manufacturing Implementation: A Case Study of an Indian Manufacturing Industry

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Abstract: ***Lean Manufacturing is becoming a vital backbone of production system of manufacturing sector. It has wide variety of tools to treat all kinds of problem faced by an industry, it also helps in making cost effective product and satisfies both customer and manufacturer. Value Stream Mapping (VSM) and Work Standardization are key tools used in lean manufacturing and lean transformation; it makes the process more smooth it helps in reduction of lead time and ultimately increasing productivity. Line balancing on other hand ensures optimum utilization of resources reducing the idle time. This paper displays a case study on how a VSM, standardization and line balancing has to be carried in shop floor consisting of different types of Computer Numerical Controlled (CNC) machines arranged in cells. Work Standardization is carried upon both cycle time and setup time of the process. Video analysis tool is used for time study. Effective man utilization is seen through line balancing. Results and benefits show the capability of lean tools over CNC production lines.***

KEYWORDS: **Value Stream Mapping, Work Standardization, Line Balancing, Video Analysis, Time Study.**

I. INTRODUCTION

Industries these days have realized the importance of lean manufacturing and lean transformation, as they have witnessed increased productivity, operational availability and better overall efficiency of the production line through successful implementation of lean and its tools in their facility. The current scenario of the market is very competitive and demand is highly flexible, thus manufacturers are opting to reduce machine down time. Many manufacturers these days invests huge amount in sophisticated CNC machines [1], which produces wide variety of products, thus making them to meet varied and flexible demand. Lean here plays a vital role in reducing setup time and cycle time through standardization and line balancing. This paper is based on lean transformation of gearbox manufacturer, whose facility is located in India. The manufacturer has already been using lean tools and have implemented cellular manufacturing concept in their production line. They have also installed state of the art CNC machines on their lines. The case study focuses on two specific lines of planetary gearbox, one manufacturing gears and the other gear shafts. Due to continuous improvement of the process through kaizens and other inventions, standard time of the processes recorded previous to improvement has become absolute, hence resulting in variation in cycle time across operators due to previous records. A brainstorming session was conducted which included plant head, team leaders, shop floor managers and operators to discuss upon this issue and it was concluded to perform VSM and work standardization to know the present actual time of the processes. It was also decided to do a line balancing to ensure that its operations are within takt time and maximum work utilization is attained.

II. REVIEW OF LITERATURE

Manufacturing Organizations faces an a Problem in reduction of cost and efficiency Challenges in their manufacturing Operations. To Stand up in today's Globalization world, Manufacturers need to find ways to reduce Production time and cost in order to improve operating performance and Product quality. Setup time reduced by SMED. It is normally possible to greatly reduce the setup times and extraordinary results can be Possible through better teamwork, good order, Planning and Simple modifications. The reduction in setup times can be done with help of a SMED Methodology. Each type of Industries can apply the SMED System to reduce their setup times. Single Minute Exchange of Die (SMED) is the approach to reduce Output and Quality losses due to Changeovers.[2] SMED is one of the lean production techniques for reducing waste in a manufacturing process. The Single-Minute Exchange of Die (SMED) methodology and other Lean Production tools were applied to reduce the setup time. As a result, the process setup time was significantly lowered (from 52 to 24 minutes). [3]

Value stream mapping will help industrial engineers, managers who still support gross manufacturing techniques of lean manufacturing. VSM is the removal of waste in manufacturing, production and business process by separating and eliminating non value added steps. VSM frames the current and future state of production process in an organization The non-value-added steps are known by their waste of resources and era. The process must be estimated to reduce and simplify the necessary actions needed. By reducing excess of time can get the proportional value added time in the process. The redesigned process is more effective and efficient than the previous one [4]. The moderate to large manufacturing industry depends on a long and integrated supply chain, consisting of inbound logistic, conversion process and outbound logistic. Integrated line balancing is minimization of cost for inbound and outbound logistic subsystems. The generic approach has been developed for linking the balancing of the line of production in the conversion area with the customers' rate of demand in the market and for configuring the related stock chambers [5] . A headlong rush to reduce lead time by becoming lean has created urgency for researchers and practitioners to apply new tools and techniques for dictating wastages. This research addresses the application of value stream mapping in garments industry to implement lean manufacturing. Value stream mapping is different than conventional recording approaches as it helps in the visualization of Material Flow, Information Flow, cycle times and utilization of resources. Assurance of effective integration and communication, lean systems can be achieved with better efficiency [6] .

III. PROCESSES FLOW CHART

This case study focuses on processes after heat treatment in other words finishing operations, shafts and gears are two broader classification of product variety and they are manufactured in two distinct production lines - gear line and shaft line. The components considered for the study and their processes are shown in Figure 1.

GEAR LINE

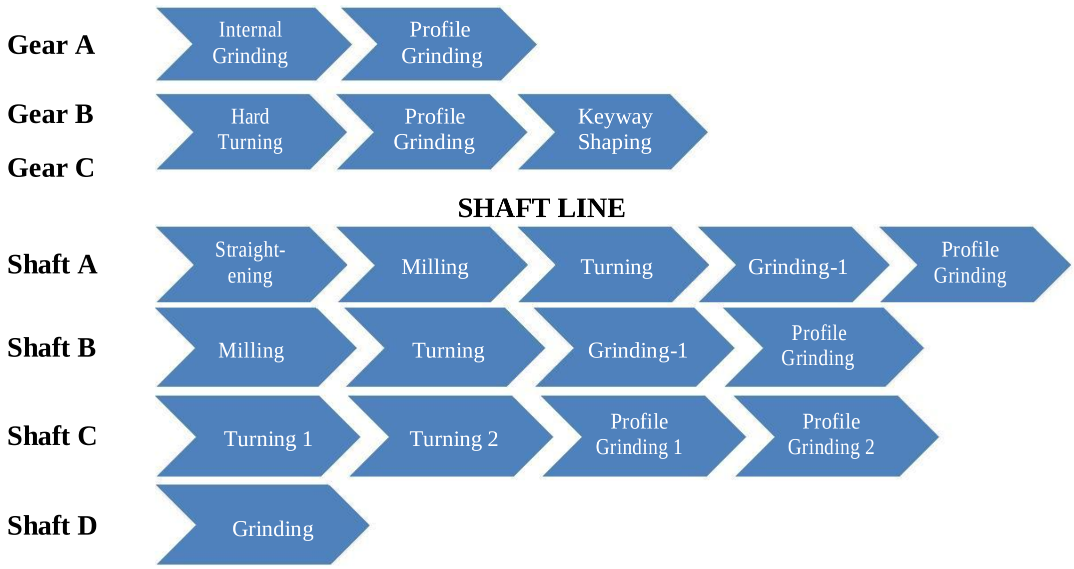

Fig 1. Process Flow of selected Components

IV. CURRENT STATE VALUE STREAM MAPPING

A. Current state VSM

To map the process, it is necessary to collect the various relevant data regarding each process such as cycle time, setup time, change-over time, work-in-process inventory, machine availability and number of operators involved in the machine is collected. Figure 2 shows the VSM resulting from the analysis of the current manufacturing situation of low speed wheel. Similar VSM analysis reveals that the percentage value addition is 34% and other observations are summarized in Table 1. To generate ideas for improvement, the Gemba Kaizen is conducted. The participants are shop floor engineers and experienced operators. Work standardization and line balancing are the suggestions made after brain storming sessions at the workplace. Work Standardization and line balancing are the two major steps performed in this case study. standardization of the processes the actual cycle time and setup time is known and the data Obtained is further used for line balancing of the gear line and shaft line, following the methodology as shown in Figure 3.Work Standardization is carried for both cycle time and

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setup time of the operations, the methodology followed for the standardization processes are illustrated in Figure 4.

Table 1. Current state *VSM* – observations

Wheels		Shafts	
Customer's demand	18 units / day	Customer's demand	6 units / day
Working days	5 days /week	Working days	5 days /week
Customer's takt time	240 min	Customer's takt time	240 min
Target cycle time	204 min	Target cycle time	204 min
Tolerance time	188 min	Tolerance time	188 min
Overall Equipment Effectiveness	85%	Overall Equipment Effectiveness	85%

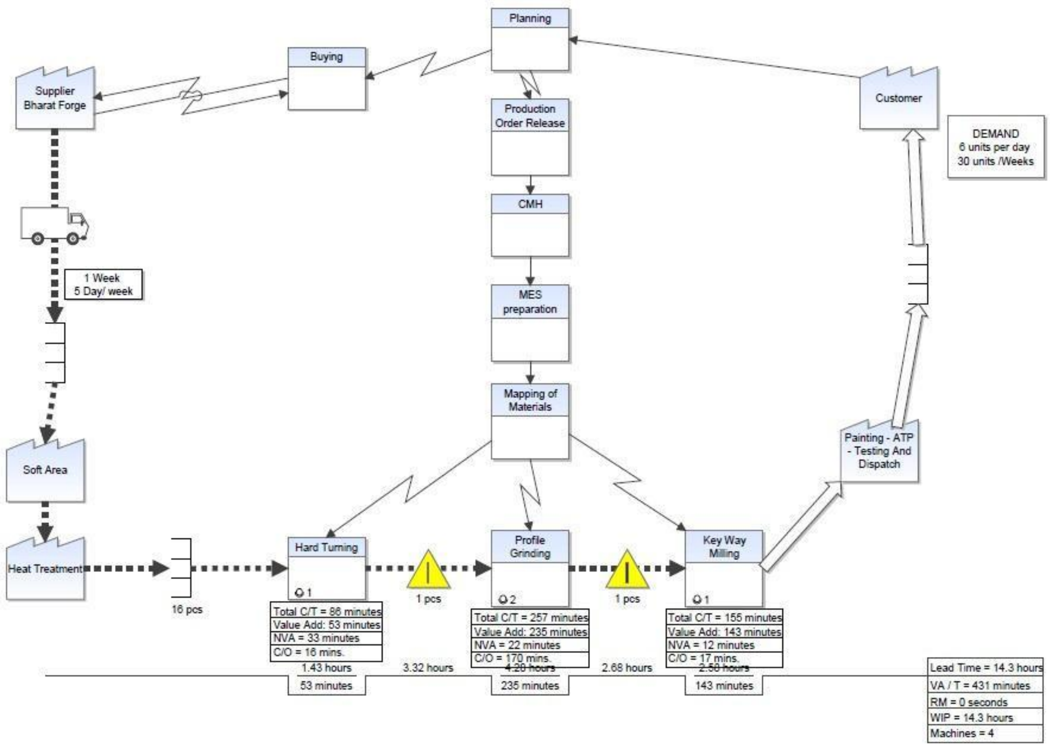

Fig 2. Current state VSM – Low speed wheel

B. Non Value Added Activities

The Existing process is first thoroughly understood by monitoring and its data is collected simultaneously. A report is generated with time taken for operation, setup time, Overall Equipment Effectiveness, operators involved to get a clear knowledge of the facility. Based on the obtained cycle time and setup times from the report, number of trial to be taken for the operation is obtained through conventional standard table [1], and it is again validated statistically by the Equation 1. The cycle time and setup times are captured using a video camera; these videos are given subtitles corresponding to the operations performed. Thus time of each activity is obtained from the subtitle file generated. These activities are analysed carefully and grouped under three classifications: (i) Value Added Activity (VA) (ii) Non-Value Added Activity (NVA) (iii) Necessary Non-Value Added Activity (NNVA). In the next step the NVA is eliminated completely and NNVA is reduced with possible improvements.

The setup elements are further classified as Internal and External elements, and are categorized into critical components such as movement, documentation, control, adjustment, mechanical change over, cleaning,

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transport and waiting. The setup elements are processed using Eliminate, Combine, Reduce, Simplify (ECRS) concept to obtain reduced setup time. It is a technique employed to improve processes in operational as well as office management practices.

It consists of carrying out in sequence the following phases:
- Eliminate useless operations
- Combine such operations liable to be done together
- Rearrange, whether profitable and feasible, the operations' sequence
- Simplify the remaining operations.

$$n = \left[\frac{20\sqrt{n' \sum x^2 - (\sum x)^2}}{\sum x} \right]^2 \qquad \text{--------------------------------- (1)}$$

This process shown in Figure 4 is continued for several cycles as determined by Equation 1 and conventional standard table. Thus all NVA is eliminated and results in optimized standard time. Documentation is made on every cycle. Allowances are added to the optimized standard time, here 92% operator efficiency is considered as per the company's employee data.

C. Line Balancing Methodology
Line balancing here is based on allocation of operator to the machines and ensures maximum productivity from the machine and the operator. The basic line balancing operation has four steps as shown in Figure 3. As we start Line balancing from optimized standard time it is not necessary to perform step (i) and (ii). The main objective of the line balancing in this case study is to effectively use man power, without much compromise in machine utilization and output.

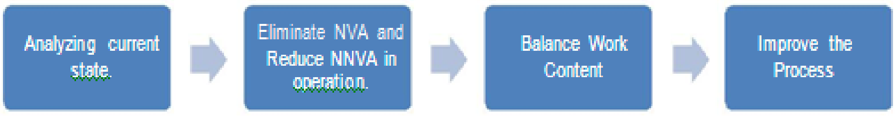

Fig 3. Line Balancing Methodology

D. Work Standardization
Standardization of the operations is carried out as per the methodology mentioned earlier. Three cycles are performed for time study. A cumulative of 170 improvement ideas and kaizens were identified and implemented during the process. Reduction of about 118 minutes in cycle time and 290 minutes in setup time is achieved through standardization. The gear cycle time and set up time results are shown in Figure 5 and Figure 6. Standard operating procedure is then drafted and is validated. A controlled copy of the standard operating procedure is placed on all machines of the line for easy access of the operator.

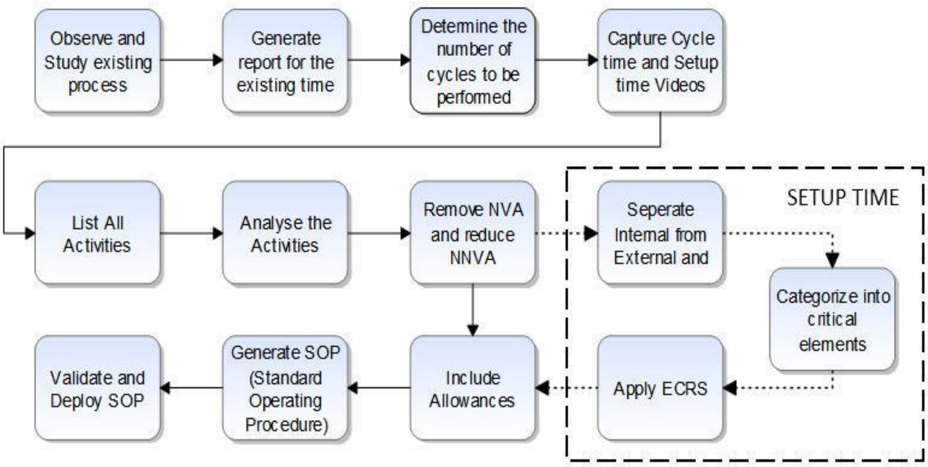

Fig 4. Work Standardization Methodology

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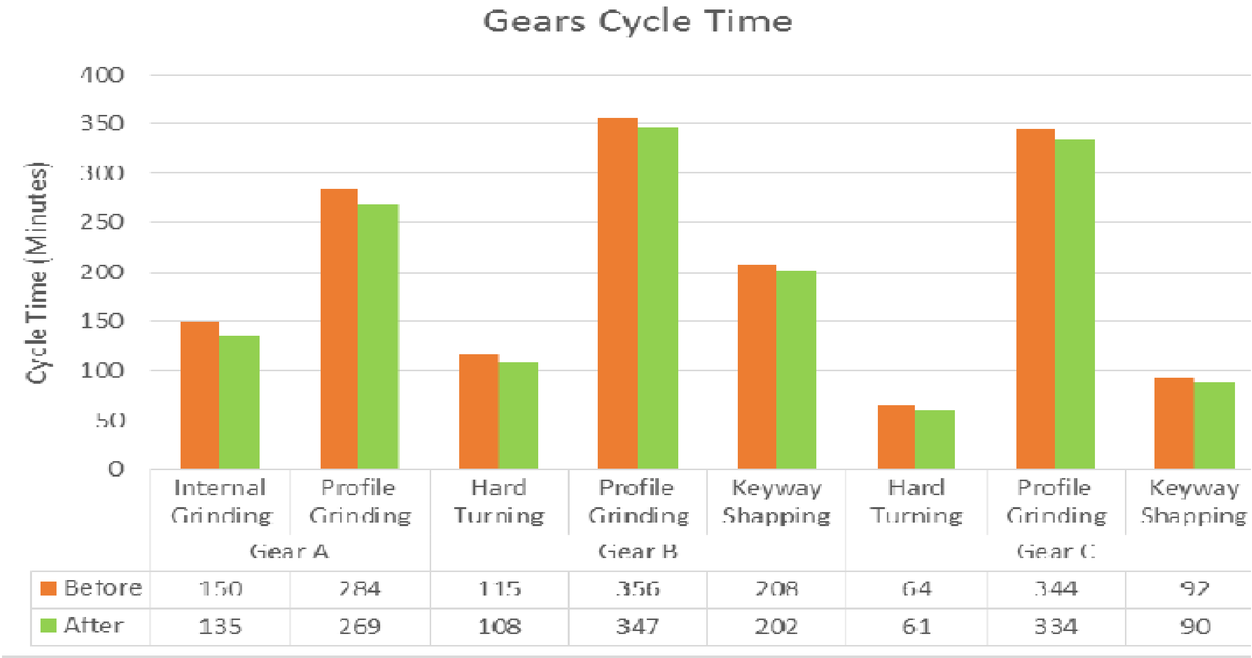

Fig 5. Results of cycle time - Gears

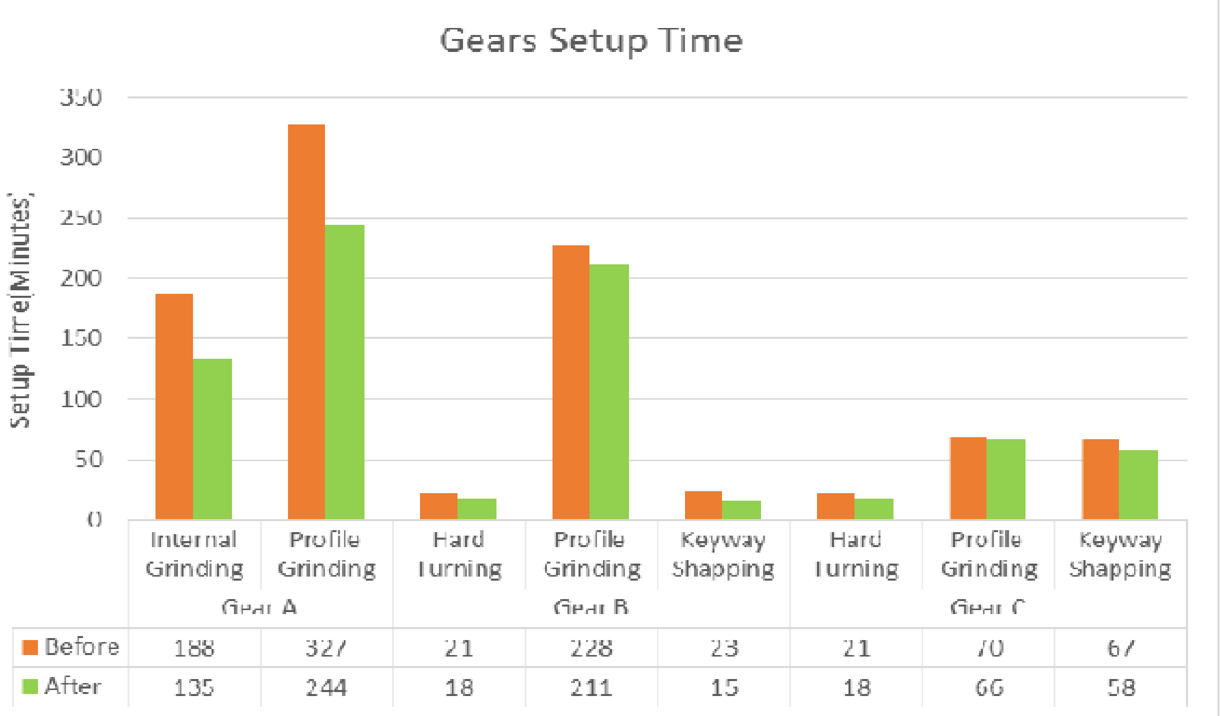

Fig 6. Results of set up time – Gears

E. Line Balancing

Based on the data obtained from the standardization existing layout and man movement is obtained as shown in Figure 7. The improved layout and man engagement is shown in Figure 8. The comparison between the actual and the improved layout is shown in Table 2. In the improved layout, man power is reduced from 3 to 2 without any change in the output.

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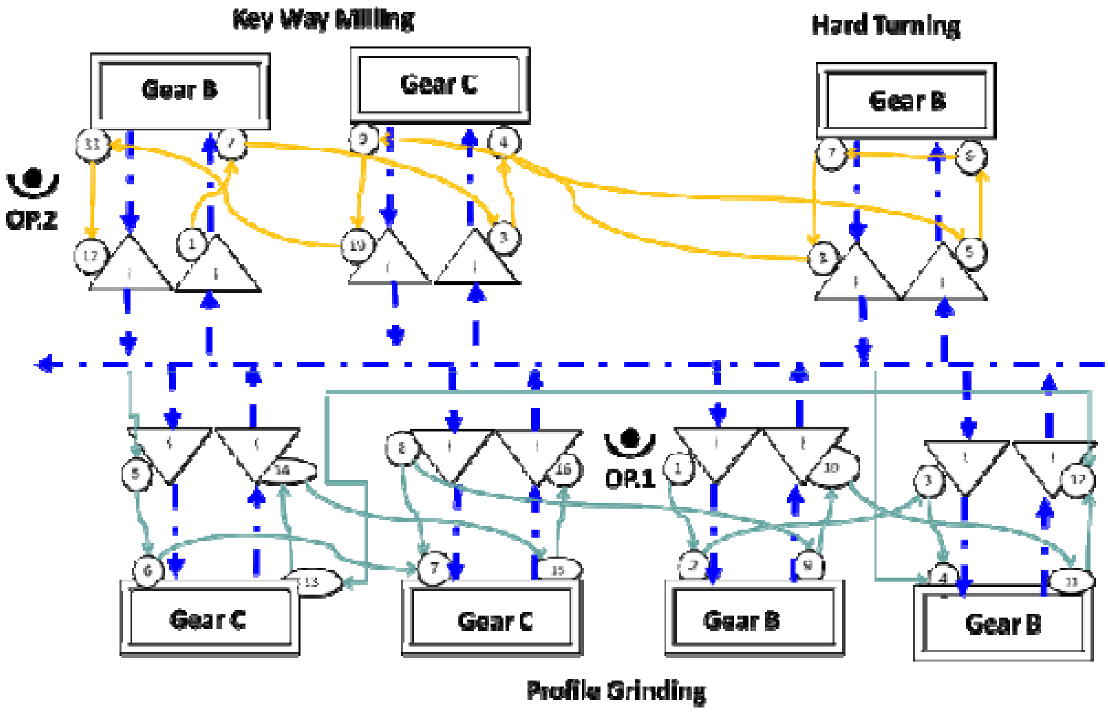

Fig 7. Line Balancing: Existing Layout

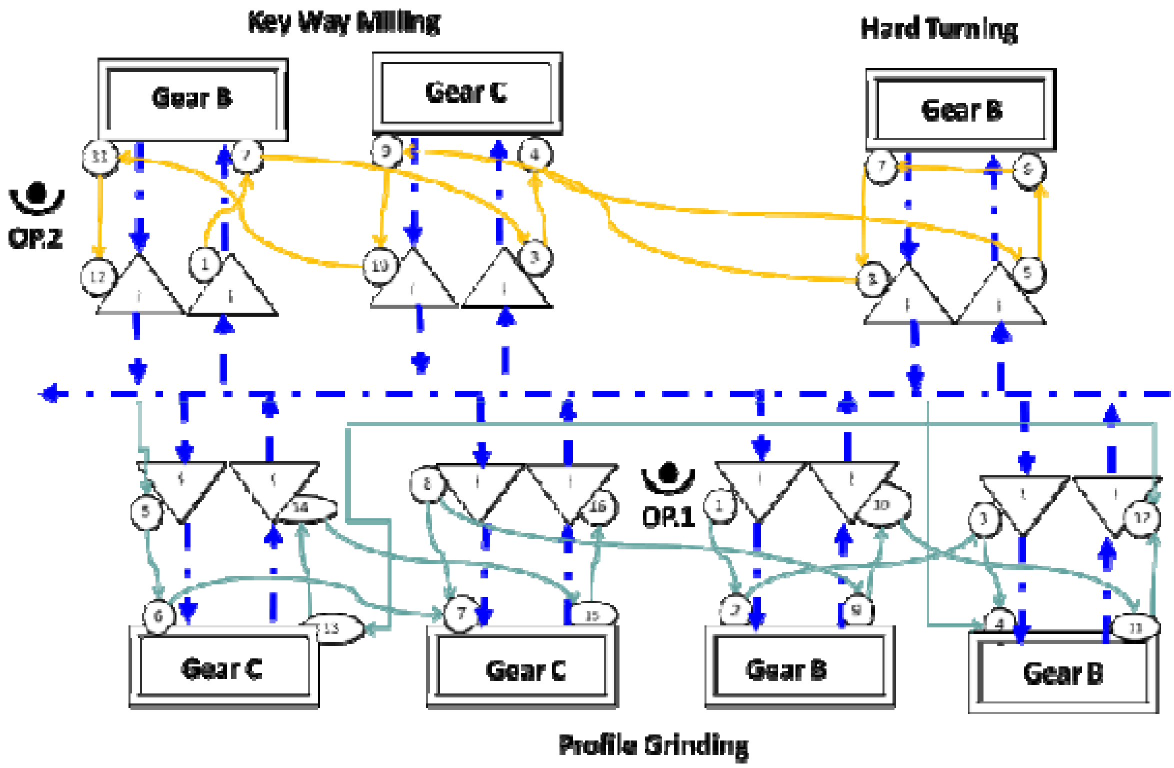

Fig 8. Line Balancing: Improved Layout

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Table 2. Results of Line Balancing

Operation	Before				After			
	Man Power	M/c Utilization	Man Utilization	Output / Shift	Man Power	M/c Utilization	Man Utilization	Output / Shift
Gear B – Profile Grinding		88.9%		1.2		88.9%		1.2
Gear B – Profile Grinding	1	82.29%	44.38%	1.1		82.3%	55%	1.1
Gear B – Keyway		65.21%		3.4		89.4%		2.0
Gear C– Profile Grinding		88.9%		1.2	2	75.9%		1.1
Gear C – Profile Grinding	1	82.29%	40.6%	1.1		68.2%	64.8%	0.9
Gear C – Keyway		83.75%		1.8		76.2%		3.9
Gear B – Hard Turning	1	57.3%	49.1%	3.2		47.5%		2.8
Total	**3**	**78.3%**	**44.7%**	**12.9**	**2**	**77.8%**	**60%**	**12.9**

V. CONCLUSIONS

In summary, the conclusions reached from this work are the following: (i) standardization and line balancing gave appreciable results upon implementation over CNC machine cells (ii) standardization gave a setup time reduction of 290 minutes and a reduction of about 118 minutes in cycle time (iii) the process has become smooth without any mismatch between planned time and production time, enabling hazel free work atmosphere (iv) kaizens made for standardization made it easy for operators to work freely without any stress (v) line balancing approach of effective man power utilization resulted in manpower reduction without affecting output.

VI. FUTURE WORK

1. To build the Lean Team for continuous improvement of manufacturing process
2. Introducing Pull System for better customer satisfaction

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