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A Case Study on Reducing Cycle Time and Improving Productivity in Leading Gear Manufacturing Company

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1. ABSTRACT

The purpose of the paper is to reduce the time and cost of production by using real-time data which is collected in manufacturing unit by using stopwatch. The time study and operation charts are the techniques that are used to calculate the deviations between present and proposed method. Here proposed method means the timing which is revised from the existing method for better production. We observed the cycle time of spur gear, pinion and drive gear. The sample data has been collected from the employees' who involved in manufacturing process to find out their satisfaction in the work environment. The descriptive and analytical method is the research design used for the study. Convenient sampling method is used to collect data from the employees'. The objectives for the study is to find out the feasibility of reducing the manufacturing time and cost and also to study the employee satisfaction. The results obtained from the study, if company establishes the machineries which the company takes the product for external operations that can be reduce the operation time per product, transportation cost and the labour cost. The employees' satisfaction towards the company is related with some of the factors such as work schedule, benefits offered by the company and work life balance are more satisfied for employees.

Keywords: Productivity, Time study, Cycle time and Employees' satisfaction.

2. INTRODUCTION

India produced 22.65 million automobiles in FY21, with 13 million of those built between April and October. In calendar year (CY) 2021, all divisions enjoyed growth, with overall sales climbing 5.8% to 18.49 million units, up from 17.47 million units in January-December 2020. Significant vehicle companies in India are expected to make India a global leader in the two-wheeler and four-wheeler markets by 2022. **(India brand equity foundation, 2020)**. Gear is the important product in the automobile industry which cannot be neglected at any cost. So the gear manufacturers pushed into the responsibility to increase the productivity of gears.

Productivity = Output/Input

The term "productivity" can be used to assess or quantify how much data can be recovered from a given input. The ratio of output to total resources utilized to manufacture a product is known as productivity **(Shital, 2020)**. Operational efficiency is a metric that measures how well a company uses resources including raw materials and supplies, people, land, buildings, machines, equipment, and energy. Understanding the efficiency level of other inputs, as well as observing trends of these inputs under various conditions and changing one or more of these inputs to change their quality or quantity, allows businesses to achieve maximum output through the optimal input combination. A work study's purpose is to analyze how an activity is carried out, simplify or modify the mode of operation to reduce unneeded or extra effort, as well as inefficient resource use, and create a time standard for completing that job. Work studies can be divided into two categories: method studies and work measurement. It's used to analyses and improve human working methods in a systematic way, taking into consideration all factors that influence productivity and working conditions. **(Cengiz duran, 2015).**

3. REVIEW OF LITERATURE

(Md. Shakil, 2013) The main goal of this study is to learn more about the Jute milling process and factor analysis. A

process flow chart can be used to explain how processes work as well as to design and document complicated processes or programs. This method may clearly reveal bottlenecks and losses in jute mills, which can cause operations to be disrupted. It aids in the identification of the manufacturing process's most significant and critical dependencies. Because a range of factors might influence jute mill production, it's necessary to maintain track of a variety of aspects inside the mills in order to achieve the target output rate. They have six manufacturing facilities and generate 215 metric tons of yarn every day. A lot of factors influence the yarn productivity of a jute mill's production unit, both intrinsically and extrinsically. If these aspects can be proven to be effectively used, they will surely assist the Akij jute mill enhance yarn productivity.

(Hayes, 2019) According to the author of this study, the legacy of the coal mining and manufacturing industries has linked regional working-class identities and attitudes to shared experiences of hazardous and stigmatized dirty work. Simultaneously, this country's manufacturing sector is becoming more reliant on computerized technology, systematized cleaning techniques, and multinational alliances. This study examines cleaning and contamination practices in a multinational auto parts manufacturing factory in Appalachian Kentucky, an area whose labour history is entwined with ideas about dirt, class, and moral rehabilitation. Workers negotiate their sense of belonging and class identification at work by embracing or avoiding filth and practicing cleaning skills and identities, according to the research. The authors say that lean manufacturing cleanliness standards and their negotiation in Appalachia and the US South are linked to broader debates. I suggest that in Appalachia and the US South, lean manufacturing cleanliness criteria and their negotiation combine with larger discourses about dirty labour to maintain local ideologies and symbolic categories of class distinction.

(Clark Li Ke You, 2010) According to the study, businesses can achieve effective business performance by building cultural traits like involvement, mission, consistency, and adaptability. The research suggests that in the Australian vehicle industry, there is a correlation between corporate culture and company performance. Adaptability has the biggest impact on company performance when compared to other cultural qualities. Customer happiness was deemed the most important non-financial metric among the non-financial and financial company performance measures analyzed. When it comes to predicting firm performance, consistency and mission are major indicators of profitability, whereas adaptability and mission are important determinants of mission.

(Jon-Chao Hong, 2014) This study looks at everyone who works for a monetary benefit, including welfare recipients. Companies that had created employee benefit programs were given questionnaires. To understand how employee benefits affect employee happiness and productivity. Employee benefit packages, according to this study, have a greater impact on job motivation than on productivity. Executives and employees alike hold monetary benefit schemes in high regard. There is a cognitive disconnecting between management and employees when it comes to the usefulness of employee benefit programs. Benefit demands change according to gender. Employee perks have a higher influence on unmarried employees than on married ones. Employee perks are viewed differently by employees with different levels of education and jobs.

(Simion Nyakwara, 2014) This research looked into how employee welfare facilities and working conditions influenced Mumias Sugar Company's industrial unrest intervention tactics and overall performance. The comparative approach focused on economic and social-political systems, whereas mobilization theory focused on workers' decisions to participate in labour disputes. Closed-ended surveys were used to collect quantitative data, while open-ended questionnaires, document analysis, and interview schedules were employed to collect qualitative data. Frequencies, Chi-squares, and percentages were used to present data on the variable responses. Strikes were determined to be the most common type of industrial disturbance encountered by MSC, with inflexibility of employment terms and conditions being the main cause.

(Sakthivel Rania, 2011) The aim of this study is to learn more about the link between employee happiness and work/life balance. Career potential, recognition, job duties, salary, benefits, superior subordinate relationship, employee satisfaction, and work/life balance are the constructs examined in this study. For the survey, respondents in the IT industry were polled. Employee satisfaction and work/life balance are two separate research streams that have been combined in this study. The findings point to a strong link between job task and employee satisfaction, with work-life balance serving as a mediating factor.

(Masso, 2012) Employee control over work schedules and processes has long been regarded as a crucial aspect of job quality, with research from a variety of social science disciplines supporting this claim. Research has usually concentrated on the effects of control rather than the diversity of employee control. The current study develops a theoretical framework for calculating employee job control. The framework provides valid reasons for selecting and grasping both organizational and employee-level drivers, based on past theoretical and empirical studies. The proposed theoretical model is put to the test using a nationally representative connected study of businesses and their employees. The findings reveal significant disparities in employee work control, which can only be explained by considering both individual and organizational

characteristics. Employee work schedule and work method control were found to be explained by job design and characteristics, skills and competencies, and managerial practices.

(Gorji, 2011) The goal of this paper is to determine the impact of empowerment implementation in a telecommunications company by taking into account factors like delegation, participation management, encouragement, and reward, as well as the priority and importance of each factor's impact on employee performance improvement. The research method was descriptive and causal comparison, with data, two surveys, and existing records on employee performance rate in two time periods before and after Empowerment implementation as the statistical sample. Employee performance improved significantly before and after Empowerment adoption, with Empowerment implementation stressing variables such as delegating, participating management, and supporting and rewarding employees.

4. OBJECTIVES

1. To study the feasibility of reducing production time and cost.
2. To study the employee opinion about Manufacturing process and work environment.

5. RESEARCH METHODOLOGY

This study utilized a descriptive and analytic research design. Both primary data and secondary data are used for this research. Primary data was collected from employees in the company, using a structured questionnaire contain 5 scale questions and demographic questions. The cycle time of process is collected through observation by using stopwatch. Secondary data obtained from the journals, literature and the various websites. The Sampling size is the total number of employees, who are all involved in the process of manufacturing gears. Sampling procedure is a convenience sampling. The Tools and Techniques used for analyzing data are Time study, Operation chart, Percentage analysis, Regression analysis.

6. ANALYSIS

6.1 Time study for spur gear

Elements	cycles					summary			
	1	2	3	4	5	Sum	Mean	Rating	Normal
Cutting	4	4	4	4	4	20	4	1	4
Drilling	1	1	1	1	1	5	1	1	1
Normalizing	30	30	30	30	30	150	30	1	30
CNC finish turning	7	7	7	7	7	35	7	1	7
Broaching	3	2.67	2.73	3.27	2.9	14.57	2.914	0.8	2.3
Teeth cutting	7.79	7.83	7.7	7.83	8	39.15	7.83	0.8	6.3
Heat treatment	15	15	15	15	15	75	15	1	15
Id hard turning	1	1	1	1	1	5	1	0.8	0.8
								Total	66.4

Labor standard= Normal time / (1-Allowance rate)

= 66.4 / (1-0.167)

= 66.4/ 0.833

= 79.7 min per job

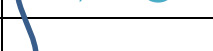
From the above chart explains there are 8 operations to produce a Spur gear and explains to be calculated a Labour cost there are five cycle times to be noted and Rating indicates the performance of the worker basically 0.8 Means the worker done the job lately and 1 indicates the worker done the job correctly and 1.2 indicates the worker performed extra-ordinarily with the help of this Normal time will be calculated. There was a sequence of operations which are taken for production.

6.2 Present method for manufacturing Spur gear

From the above chart, it is inferred that there are 8 operations for the particular product for the complete manufacturing process. The major problems are delay time and transport times are there in between the operations. Basically it starts from cutting the raw material and there is normal delay waiting for production and then outsourcing done for Heat Treatment.

No.	Dist. Time (Min)	Worker Time(Min)	Symbols	Description
1.		4		Raw material cutting
2.		600		Waiting for the batch
3.	45			Transport by vehicle
4.		1		Drilling the metal piece
5.		30		Normalizing the batch
6.		7		Finish Turning process
7.		750		Waiting for the batch
8.	45			Transport by vehicle
9.		2.91		Broaching the job
10.		7.83		Teeth cutting (Hobbing)
11.		1174.5		Waiting for the batch
12.	45			Transport by vehicle
13.		15		Heat treatment for the batch
14.	45			Transport by vehicle
15.		1		ID hard turning

6.3 Proposed method for manufacturing Spur gear

No.	Dist. Time (Min)	Worker Time(Min)	Symbols	Description
1.		4		Cutting the Raw Material
2.		600		Waiting for the batch
3.		1		Drilling Process
4.		150		Waiting for the batch
5.		30		Normalization
6.		7		CNC Finish Turning
7.		2.91		Broaching Process
8.		7.83		Teeth Cutting Process
9.		1174.5		Waiting for the batch
10.		15		Heat Treatment Process
11.		1		ID Hard Turning

By the proposed method suggests that the manufacturing process can be re-arranged in a correct manner there is a chance to fast production of gears. Among those there is a normal delay will occurs for next batch. There is a lot of products still in waiting position. Finally saving time and reduce cost is a big motive for this method.

6.4 Comparison of present and proposed methods of manufacturing Spur gear

Comparison factor	Present method	Proposed Method	Estimated Savings
No. of Operation per product	8	8	8
No. of Inspection per product	-	-	-
No. of Delays per product	3	3	3
Minutes per product	2524.5min(42.075hrs)	1993.24min(33.22hrs)	531.36(8.86hrs)
Labor cost per product (40rs per hour)	1683Rs	1329Rs	354Rs
Annual labor cost per year (3008nos. per year)	5062464Rs	3997632Rs	1064832Rs
Vehicle traveled per product	180min(63.93km)	-	-
Vehicle cost per km (include labour cost per km= 12.35Rs)	790Rs	-	790Rs

From above table, proposed method reduces the cost and time to the company by avoiding the transportation than the present method. The time difference between the present and the proposed method is 8.86 hours. By this the company might produce 7 products approximately and also can reduce the labor cost (354Rs) per product. The company could earn profit approximately up to 1064832Rs per year. And also it may reduce transport time (180 min).

6.5 Time study for drive gear

Elements	cycles					summary			
	1	2	3	4	5	Sum	Mean	Rating	Normal
Cutting	7	7	7	7	7	35	7	1	7
Rough turning	0.75	0.7	0.78	0.75	0.73	3.71	0.74	1	0.74
Normalizing	30	30	30	30	30	150	30	1	30
Finish turning	1	1	1	1	1	5	1	1	1
Hobbing	2.4	2.33	2.45	2.55	2.42	12.15	2.43	0.8	1.95
Teeth chamfering & punching	1.17	1.2	1.18	1.12	1.18	5.85	1.17	1.2	1.4
Shaving	1	1	1	1	1	5	1	0.8	0.8
Case hardening & sandblas	27	27	27	27	27	135	27	1	27
Id honing	1.83	2	1.83	2.2	2	9.86	1.97	0.8	1.58
								TOTAL	71.47

Labor standard= Normal time / (1-Allowance rate)

Normal time= 71.47 min (1.2 hrs.)

Labour standard = 71.47 / (1-0.167)

=71.47/ 0.833

= 85.8 min per job (1.43hrs)

From the above table explains there are 9 operations to produce a Spur gear. Rating indicates the performance of the worker basically 0.8 Means the worker done the job lately and 1 indicates the worker done the job correctly and 1.2 indicates the worker performed extra-ordinarily with the help of this Normal time will be calculated.

6.6 Present method for manufacturing Drive gear

No.	Dist. Time (Min)	Worker Time(Min)	Symbols	Description
1.		7		Cutting the Raw Material
2.		1050		Waiting for Transport
3.	45			Transporting the Material by Vehicle
4.		0.74		Rough Turning Process
5.		30		Normalization process
6.		1		CNC Finish Turning Process
7.		150		Waiting for Transport
8.	45			Transporting the Material by Vehicle
9.		2.43		Hobbing Process
10.		364.5		Waiting for Transport
11.	10			Transporting the Material by Vehicle
12.		1.17		Teeth Chamfering and punching Process
13.		175.5		Waiting for Transport
14.	10			Transporting the Material by Vehicle
15.		1		Shaving Process
16.		150		Waiting for Transport
17.	45			Transporting the Material by Vehicle
18.		27		Case Hardening Process
19.	45			Transporting to plant 1 by vehicle

From the above chart, major problems are delay time and transport times are there in between the operations. The bottle neck of this production process is outsourcing the normalizing and heat treatment process. And some other operations are done in other plant of company.

6.7 Proposed method for manufacturing Drive gear

No.	Dist. Time (Min)	Worker Time(Min)	Symbols	Description
1.		7		Cutting the Raw Material
		1050		Waiting for batching
2.		0.74		Rough Turning Process
		111		Waiting for batching
3.		30		Normalization Process
4.		1		CNC Finish Turning
5.		2.43		Hobbing Process
6.		1.17		Teeth Chambering and Punching Process
7.		175.5		Wait for Transportation to Plant 2
8.	10			Transport to Plant By Employee
9.		1		Shaving Process
10		150		Waiting for batch
11	10			Transporting jobs to hardening
12		27		Case Hardening and Sandblas
13		1.97		ID Honing

By the proposed method suggests that the manufacturing process can be re-arranged in a correct manner there is a chance to fast production of gears. Among those there is a normal delay will occurs for next batch. Finally saving time and reduce cost is a big motive for this method

6.8 Comparison of present and proposed methods of manufacturing Drive gear

Comparison factor	Present method	Proposed Method	Estimated Savings
No. of Operation per product	9	9	-
No. of Inspection per product	-	-	-
No. of Delays per product	5	4	1
Minutes per product	1952min(32.5hrs)	1558.81min(26hrs)	393.19min(6.7hrs)
Labor cost per product (40rs per hour)	1301Rs	1036Rs	265Rs
Annual labor cost per year (2800 per year)	3642800Rs	2900800Rs	742000Rs
Vehicle traveled per product	200min	20min	180min
Vehicle cost per km (include labour cost per km)	876Rs	88Rs	788Rs

From above table, proposed method reduces the cost and time to the company by avoiding the transportation than the present method. The time difference between the present and the proposed method is 6.7 hours. By this the company might produce 5 products approximately and also can reduce the labor cost (265Rs) per product. The company could earn profit approximately up to 742000Rs per year. And also it may reduce transport time 200min to 20min.

6.9 Time study for pinion gear

Elements	Cycles					Summary			
	1	2	3	4	5	Sum	Mean	Rating	Normal
Cutting	1	1	1.33	1.35	1.35	6.03	1.206	1	1.20
Semi& cnc finish turning	1	1	1	1	1	5	1	1	1
Flat milling	1	1.20	1.22	1.24	1.24	5.9	1.18	1.2	1.42
Drain hole drilling	0.33	0.4	0.6	0.6	0.6	2.53	0.506	0.8	0.4
External octogon milling	1	1.15	1.16	1.18	1.20	5.69	1.138	0.8	0.9
Internal octogon milling	3	3.20	3.30	3.35	3.30	16.15	3.23	1	3.23
External gear cutting	2	2	2	2.20	2.20	10.4	2.08	1	2.08
Od grinding	6	6.20	6.20	6.22	6.20	30.82	6.164	1	6.16
Plating	1.5	1.5	1.5	1.5	1.5	7.5	1.5	1	1.5
								Total	17.89

Labor standard= Normal time / (1-Allowance rate)

= 17.89 / (1-0.167)

= 17.89 / 0.83

= 21.55 Min per job

From the above table there are 9 operations to produce a pinion and we observe cycle time of each operation at 5 times by using stopwatch and Rating indicates the performance of the worker basically 1 for normal skill worker, 0.8 is a lazy worker and 1.2 for effective worker.

6.10 Present method for pinion gear

No.	Dist. time (Min)	Worker time (Min)	Symbols	Description
1.		1.2		Cutting the Raw Material
2.		180		Waiting for Transport
3.	45			Transporting the Material by Vehicle
4.		1		Semi& CNC turning Process done Outsourcing
5.		150		Waiting for Transport the Material
6.	45			Transporting the Material by Vehicle
7.		1.18		Flat Milling Process
8.		0.51		Drain Hole Drilling Process
9.		1.138		External Octogon Milling Process
10.		3.23		Internal Octogon Milling Process
11.		2.08		Teeth cutting process
12.		6.16		OD Grinding Process
13.		924		Waiting For Transport the Material
14.	45			Transporting the Material by Vehicle
15.		1.5		Plating Process done Outsourcing
16.		225		Waiting For Transport the Material
17.	45			Transporting the Material by Vehicle

From the above chart, major problems are delay time and transport times are there in between the operations. The bottle neck of this production process is outsourcing the some operation to manufacturing gears.

6.11 Proposed method for pinion gear

No.	Dist. time (Min)	Worker time (Min)	Symbols	Description
1.		1.21		Cutting the Raw Material
2.		1		Semi& CNC turning Process done Outsourcing
3.		1.18		Flat Milling Process
4.		0.51		Drain Hole Drilling Process
5.		1.14		External Octogon Milling Process
6.		3.23		Internal Octogon Milling Process
7.		2.08		Teeth cutting process
8.		6.16		OD Grinding Process
9.		1.5		Plating Process

From the proposed method, if we buy the new machinery instead of outsourcing we can reduce or negligible transport and delay time as well as cost of transport and inventory cost of product.

6.12 Comparison of present and proposed methods of manufacturing pinion gear

Comparison factor	Present method	Proposed Method	Estimated Savings
No. of Operation per product	9	9	-
No. of Inspection per product	-	-	-
No. of Delays per product	4	-	4
Minutes per product	1496 Mins (24.09hrs)	198.01 Mins (3.3hrs)	1297.9Mins (21.63hrs)
Labor cost per product (40rs per hour)	999.2Rs	Rs.132	Rs.867.2
Annual labor cost per year (11111nos. per year)	Rs.11102111.2	Rs.1466652	Rs.96,35,459.2
Vehicle traveled per product	180min	-	180min
Vehicle cost per km (include labour cost per km= 12.35Rs)	Rs.789	-	Rs.789

From above table, proposed method reduces the cost and time to the company by avoiding the transportation than the present method. The time difference between the present and the proposed method is 21.36hours. By this the company might produce 60 products approximately and also can reduce the labor cost (867Rs) per product. The company could earn profit approximately up to 9635459Rs per year. And also it may reduce transport time (180min).

6.13 Employees' opinion

By the below table, the data shows the employee opinion about the company.

(5- Strongly Agree, 4-Agree, 3-Neutral, 2-Disagree, 1-Strongly Disagree)

NO.	PARTICULARS	AVERAGE	RANK
1.	Are you satisfied with your work schedule	3.94	1
2.	The benefits offered by the company are good	3.78	2
3.	I can able to balance my work and personal life	3.75	3
4.	I am satisfied with the cleanliness on the work place	3.69	4
5.	The amenities provided by the company are good	3.50	5
6.	Company encourages new ideas	3.50	6
7.	My company culture suits me	3.06	7
8.	I feel I have autonomy in decision making	1.91	8

From the above table, it is inferred that almost all the employees are satisfied with their work schedule framed by the company followed by that employees agree that benefits offered by the company are good, at the same time it is seen that employees remark that they do not have autonomy in decision making in their company.

6.14 Overall satisfaction about manufacturing plant

The figure and the table shows the overall satisfaction of the workers in the company,

Overall satisfaction	Percentage
Strongly Agree	6%
Agree	44%
neutral	28%
Disagree	22%
Strongly Disagree	0%

From the above table Show that there are 44% of Employees agreed overall satisfaction of workers working in manufacturing plant.

7. CONCLUSION

The purpose of this study is to suggest ways to reduce cycle time and increase Productivity of spur gear, pinion and drive gears. Time study is used to calculate the labour standard time of producing one job. If the company establish CNC machines instead of semi-automatic machines the cycle time could be reduced in gear manufacturing process. Process chart is the technique to represent the flow of operations clearly. The present method indicates current operation followed by the company. The important problem of the present method is outsourcing some operations of spur gear, pinion and drive gears. The company can neglect the outsourced operations by installing some of the machines in their own plant. From that the company can reduce the time which are used for external operations that leads the company to gain profits and also reduce the labour cost.

When the employees' are satisfied with the work place, there will be a chance to increase their efficiency of work. The overall job satisfaction of employees' towards work schedule, benefits, work – life balance, cleanliness, amenities, company culture, empowerment had a significant impact on the overall satisfaction. Hence it can be concluded that if the opinion of employees on variables empowerment, Work culture, and encouraging new ideas increases then their overall job satisfaction increases.

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