Productivity Improvement in Foundry By Using Process Chart Method

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Abstract- *India's production of castings is anticipated to grow at a compound annual growth rate of 12.7% from 2018 to 2023. Since most of the casting manufacturing units limit the market strength which falls under small and medium scale foundries in which some foundries don't use work study methods. The huge barrier for the small-scale industries to grow further is the ability to not supply high quality goods to the international market and failing to meet domestic demand for castings. This study focuses on the productivity improvement in Foundry which produces final cover drive by using Process Chart Method. The Process Chart is a work study tool which is used in this study. Through the study, the data has been collected for 6 months which is about the production of the final cover drive. Based on the data collection it seems the production is low due to the lack of the process flow and unavailability of basic automations. The delay in the production is identified in the areas of Scrap Discharging and Knockout Area. So, a Process Chart is developed for the existing process followed in the Foundry and a Process Chart has been proposed further in the industry which improves productivity.*

Keywords- Productivity, Foundry, Process Chart, Scrap Discharging, Knockout.

I. INTRODUCTION

Casting Foundries face low production due to the lack of proper work system. The project is carried out in the foundry called Manis Foundries Pvt Ltd., which is located in Dindigul,Tamilnadu. For industries such as power plants, railways and all type of valves, this foundry specializes in creating castings such as steel, high alloy and low alloy. In this work the project is all about the product final cover drive. Final cover drive which acts as a cover for gear boxes are used in the defense vehicles. The production of the final cover drive is about 30 metric tons per month while the expected production of the final cover drive can be upto 50 metric tons, which is only 60% of the target achieved. So, this work focuses on using the process chart tool to improve the productivity in foundry. The process is delayed in the areas of scrap discharging, knockout and heat treatment. These delays should be controlled by using the suggested automations for the process

II. LITERATURE REVIEW

The following has been revealed via a literature review of the corpus of extant knowledge.The comprehensive summary of the previous research on the topic of improving productivity in foundry by using process chart method is summarized below.

The problems and defects in the process are identified and analyzed which produces a proper solution for the process involved.

Ashish Kalra et al., (2016) in their papersaid it reflects on the paint assembly line which is considered for the two conditions before and after. The time of the workers in the paint assembly line is decreased by 163 seconds by adding trolley kits to the production process before painting.

Ashok Kumar and Jitendra, (2021) in their work exclaimed that the process of the gear manufacturing plant the researchers (, 2021) researched that the existing processes are examined by the method study and the layout technique. After the implementation of the ideas for the improvement the productivity is increased by 27.77%.

Bupe and Charles,(2016) in theirstudyproposed that the employee should be trained especially on the programs to increase production and develop skills of the worker. The brewing company requires the material handling systems which is used for further improvement.

Cengiz Duran et al., (2015) in their work proved that the productivity is improved by utilizing the work and time research method for the manufacturer of the earth energy glass. The efficiency is increased by 53% as a result of comparing the actual and standardized times.

Chandra, (2013) in theirpaper said that itfocuses on the productivity enhanced by work study techniques mixed along with the modern soft skills. Men utilization is

considered for every process undergoes in the manufacturing unit. To increase production, method and time study are applied systematically.

Gyanendra and Prem, (2014) in their study analysed that in the forging section the productivity improvement is done by using the work study techniques, gang process chart and suggestions of automations which includes hydraulics and process control system.Thus, the cycle time is reduced, and the number of workers is reduced.

Kumar and Mahto, (2013) in their study approved that the optimizing process in the assembly line in packaging industries is done by the process of minimizing the number of workstations which leads to the output rate being maximiszed. These are the most typical objectives that should be executed to increase productivity.

MP Singh and Hemant, (2016) in their work said that the smallscaledindustries in which the time study approach has been used to recommend changes in the process that reduces process time, labour costs and cost of prodcution. The flow process charts and new devices suggested for the process is used in process improvement.

Malashree et al., (2018) in their study said that work study methods include the study of motion and time in the activities of the manufacturing process. A new model is created and specified in relation to the process, after which the new technique must be implemented and maintained in order to increase productivity on production related tasks.

Md Abdul Moktadir et al., (2017) in their workanalysed that the method study which is a work study technique is used to improve the productivity. Applying work measurement to the production line enhances the leather products industry production system. The process is improved by 12.71 percent.

PR Akkoni et al., (2019) in their paper proved thatthe increase in the productivity in the manufacturing of the valve industry is done by applying the work study procedure and the flow process chart is suggested. The flow process chart was used to analyze the method which already existsand to make a new suggestion for increasing productivity.

Parthiban and Raju, (2014) in their work said that the shoe making industry focuses on the improvement in productivity by using the method study. This is possible by consolidating the activities, minimizing the number of workstations and decreasing worker fatigue.

Prathamesh et al., (2014) in their study proposed that minute to minute bottle neck analysis is made and implementation of 5S tool also improves the productivitywith critical lean tools, the proper results are made and as well as the profit margin is obtained.

Prathamesh, (2014) in their paper said that the goal is to provide an overview of the process for increasing productivity using lean deployment. The most popular and efficient methods for reducing waste are the tools which are used in lean manufacturing.

Rishab Nehra, (2015) in their paper proved that the productivity is improved by using the method study principles such as reducing the cycle time of the product in which the product is carried from injection molding machine to the trolleys instead of using the pallets which is to be proceeded in the paint shop department.

Sajjanwar and Choudhari, (2018) in their work said that it implies on the inventory reduction, labor utilization and effective space utilization which results in the cost saving. The various tools used in the work are single piece flow, Just in time and Kaizen. Production rate is increased in the number of cables in which the movement of the cable is reduced from 4 stations.

Shantideo and Achal, (2018) in their study said that the multiple activity charts and flow process charts which are the work study methodused in the manufacturing industry to improve the productivity. It reduces the worker's fatigue and increases the productivity by 11% and also improves the quality.

Singh Md et al., (1992) in their paper said that the improvement in the work process is done by combining the work process which leads to decrease in the production time and space used. The company which manufactures Francis Turbine stay vane is concentrated on this study. The total time after making the design fixture and using the work study methods for the stay vane is reduced.

Sujay et al., (2016) in their work implies that the Ergonomics which is study of people's efficiency in the working environment and usage of work study techniques improves the productivity. The analysis of the flow process chart is made in the work pro software and the results are obtained by improving the productivity by 27%.

Vinayak and Ravikumar, (2014) in their study stated that The RULA (Rapid Upper Limb Assessment) and the REBA (Rapid Entire Body Assessment) are the tools which is

video work study technique used for the productivity improvement at assembly station. By recommending a suitable order of operations for the process, the ineffective time associated with the assembly process has been decreased.
As concerning the previous journals that are suggested for the task of using process chart technique in the productivity improvement of a foundry, the project is done in the productivity improvement. After the literature review methodology of the work is to be proceeded in which how the work is done is explained in a detailed manner in the methodology section.

III. METHODOLOGY

The methodology includes the problem definition which is the low production of the final cover drive due to the lack of the process.

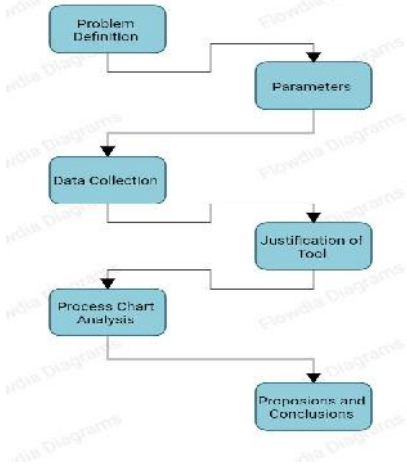

Fig1. Methodology of the Project

The parameters of the problem definition include the delay in the scrap discharging and in the process of knockout. Then the data collection of the production of final cover drive for about a month and the data collection of overall production of the foundry is noted down. From the data collected the Process Chart tool can be used which is a suitable method for the improvement in productivity andit is very easy to project in a understandable way. This makes the process chart tool justified. Then the process chart analysis is carried out by contrasting the current method and the suggested method. The method which is proposed is need to be improved from the existing method so that the productivity is increased. Then from inference of the process chart proposions and conclusions are made which is the final stage of the methodology process followed in this work is mentioned in Fig.1 which is the methodology of the project.Thus, this methodology is carried outfor the work of productivity improvement in foundry by using process chart method.

Table1. Process Chart of Existing Method

Process Chart of Existing Method			
Description	Distance (metres)	Time	Symbol
Storage of Molding Sand			
Molding Sand Mixng and Rammering	40	30 mins	
Mold and Core Making	10	30 mins	
Mold Closing		5 mins	
Storage of Scrap		2 sec	
Scrap Discharging by Trolleys	**50**	**60 mins**	
Metal Tapping		20 mins	
Metal Pouring	10	10 mins	
Mold Curing		8 hours	
Quality Assurance		1 hour	
Knockout and Decoring	**50**	**8 hours**	
Heat Treatment	10	3 hours	
Fettling		2 hours	
NDT Inspection		1 hour	
Machining Division	30	2 hours	
Final Inspection		30 mins	
Dispatch and Packing	40	20 mins	
Storage of Final Cover Drive Product	10		

The objective of this study is to improve productivity by identifying the delays in the areas of the process involved in the production of the final cover drive.

The work has been done in four stages, the third section which follows the introduction part and the literature review focuses on the use of the process chart tool in the existing sequence and to provide a new order of sequence which improves the productivity.

The work has been done in three phases:

Phase 1: Identifying the Process followed in the Final Cover Drive Production

The process followed in the process of producing the final cover drive involves Planning. The Planning stage includes thethree basic processes such as methoding, molding and the melting. The production planning is made before the sample heator the bulk production of the product. Before the bulkproduction of heat, a sample is to be tested in the lab and

the analysis results are produced. After the melting process, the metal pouring is to be carried out. Then Fettling which is a process of removing excess material from the casting is done. Fettling process includes knockout, decoring, runner and riser cutting. Then the casting undergoes heat treatment which is then followed by NDT inspection and sent to the machining division is mentioned in the Fig2.

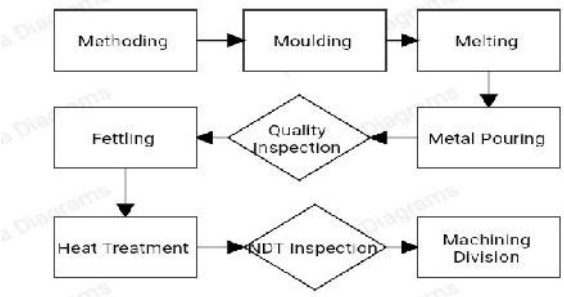

Fig2. Process in Production of the final cover drive

According to the data gathered it has been found that the melting process and the fettling process are where the final cover drive is produced.The melting process include scrap discharging and melting of the scrap which is then proceeded to sample testing.The fettling process includes knockout and decoring process which is followed by heat treatment process.
It was decided to study the delay in theseprocesses using the process chart method.

Phase 2: Study of the Process of the Existing Method using the Process Chart

In this the existing methods they have been studied with the help of using the process chart method. The process chart is a type of diagram that shows the action taken on the work system throughout the operation in graphic and symbolic form.

The existing process starts from the storage of the molding sand to the storage of the final cover drive product. Before the storage of molding sand and marketing which include the quotation and purchase order of the product.

- Indicates the stage of the process occurred.

From Table 1, it is seen that the delays are occurred in the areas of scarp discharging through trolleysand knockout and decoring which is done manually. The duration of the scarp discharging and the manual knockout process are 1 hour and 8 hours respectively. Scrap discharging is done in the transport stage and knockout is done in the operation stage.

The improvement in these areas can be done by using the process chart for proposed method which results in the productivity improvement in the product of the final cover drive.

Phase 3: Proposed Improvised Process Chart Method for final cover drive production.

In this Table.2 a process chart is proposed for the final cover drive production. This proposed method improves the productivity of the final cover drive.

Table.2 Process Chart of Proposed Method

Process Chart of Existing Method			
Description	**Distance (m)**	**Time**	**Symbol**
Storage of Molding Sand			▽
Molding Sand Mixing and Rammering	40	30 mins	
Mold and Core Making	10	30 mins	
Mold Closing		5 mins	
Storage of Scrap		2 sec	▽
Scrap Discharging through magnetic scrap discharging	**10**	**10 mins**	
Metal Tapping		20 mins	
Metal Pouring	10	10 mins	
Mold Curing		8 hours	
Quality Assurance		1 hour	▽
Knockout and Decoring using Knockout Machines	**10**	**2 hours**	
Heat Treatment	10	3 hours	
Fettling		2 hours	
NDT Inspection		1 hour	▽
Machining Division	30	2 hours	
Final Inspection		30 mins	▽
Dispatch and Packing	40	20 mins	
Storage of Final Cover Drive Product	10		▽

⧖ - Indicates the stage of the process occurred.

From Table.2 it is seen that the delays are rectified by using the magnetic scarp discharging instead of using trolleys for scarp discharging results in the reduction of 50 minutes from the existing process. The knockout in the existing

process is about 8 hours which is reduced to 2 hours that is 75 % of the process is improved.InFig.3, the time consumption of the existing method is shown. The processes are listed in the x axis and time taken in hours is pointed in y axis.The time consumption for every process is plotted.

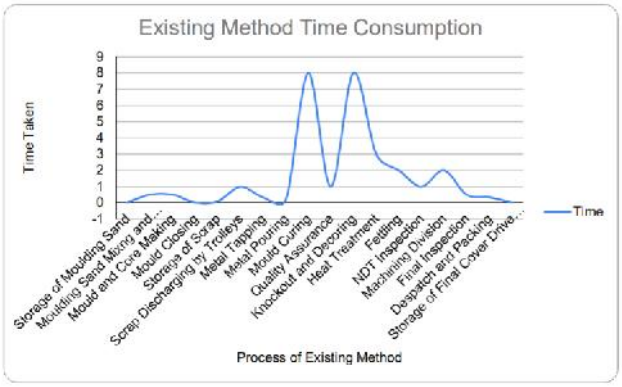

Fig3. Existing method time consumption

InFig.4, the time consumption of the proposed method is shown. The processes involved in the proposed method are listed out in the x axis and the time taken in hours is pointed out in the y axis. The time consumption for all process in the proposed method is plotted.

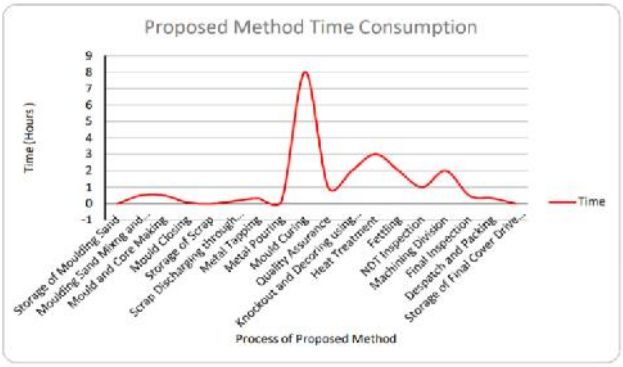

Fig4. Proposed method time consumption

In Fig.5, the time consumption of the existing and the proposed method are compared in which the processes ae listed in the x axis while the time taken is plotted in y axis. The reduction in the graphindicates the time reduction by using the proposed method from the existing method. The reduction in the time also interprets the improvement in the productivity.

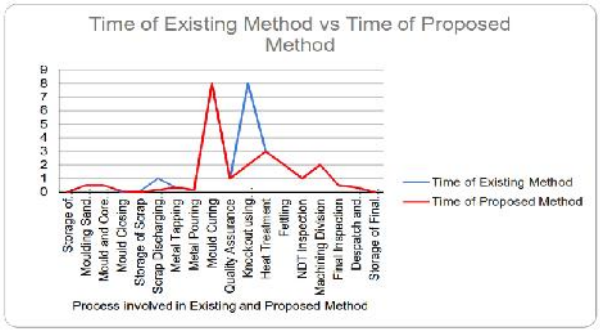

Fig5. Time of Existing and Proposed methods.

Table.3 Process Chart Conclusion Table

Process	**Duration of Existing Method**	**Duration of Proposed Method**
Operation (7)	12 hours 40 mins	6 hours 40 mins
Delay (2)	11 hours	11 hours
Inspection (3)	2 hours 30 mins	2 hours 30 mins
Transport (3)	1 hour 25 mins	1hour 40 mins
Total Time	27 hours 35 mins	20 hour 45 mins
Total Time	27 hours 35 mins	20 hour 45 mins

From Table.3, it is seen that the total duration of the existing method is about 27 hours and 35 minutes while the duration of the proposed method is about 20 hours and 45 mins, nearly 7 hours of the time of the overall process have been reduced.

PRODUCTIVITY CALCULATIONS

Reduction in time = Duration of Existing Method – Duration of Proposed / Duration of Existing Method.

= (1655 mins – 1245 mins) / 1655 mins

= 24.78 %.

Thus, the time is reduced by 24.78 % percent in the production of the final cover drive product.

Table 4 shows the data collection of the final cover drive and overall production over afive-month period.

Table4. Data collection of Final Cover Drive and Overall Production

S No	Month	Final Cover Drive Production (MT)	Overall Production (MT)
1	January	30	60
2	February	32	61
3	March	28	59
4	April	31	62
5	May	29	61

Productivity = Output / Input

= (Duration of the Proposed Method / Durationof the Existing method) * 100

= (1245/1655) * 100

= 75.22 %.

Thus, the productivity improvement is about 75.22% in the production of final cover drive.

For Example, Considering January month,

Existing Production of Final Cover Drive = 30 MT

Existing Overall Production = 60 MT

Estimated Production of Final Cover Drive = Existing Production of Final Cover drive * Productivity Improvement

= 30 * 0.752

= 52.6 MT.

Table 5.Estimated Data Collection after Improvement.

S No	Month	Existing Production of Final Cover Drive (MT)	Estimated Overall Production (MT)
1	Month 1	52.6	105
2	Month 2	56	107
3	Month 3	49	103
4	Month 4	54	109
5	Month 5	51	106

Estimated Overall Production = Existing OverallProduction * Productivity Improvement

= 60 * 0.752

= 105 MT.

Thus, the estimated production of final cover drive and the overall production after the productivity improvement considering the month of January is about 52.6 MT and 105 MT respectively.

The estimated production results for a five-month period are obtained and shown in Table 5.

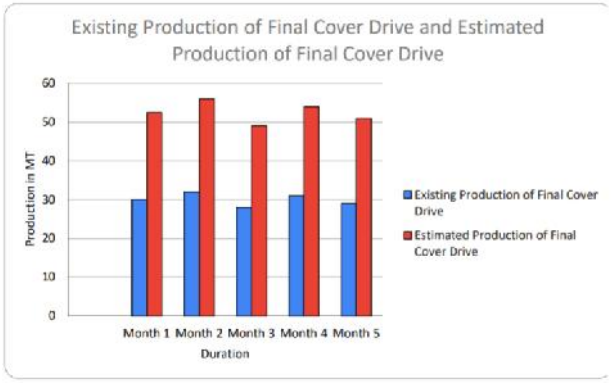

Fig.6 Existing & Estimated Production of Final Cover Drive

In Fig 6, the existing and estimated production of final cover drive is shon as a graph in which the production of the final cover drive is in metric tonnes. The duration is listed out in the x axis while the production in metric tons is plotted in the y axis.

In Fig.7, the existing and estimated overall production of the final cover drive is shown in the graph where the production is in metric tons.The production in metric tons is plotted in the x axis while the duration of the production is listed in the y axis.

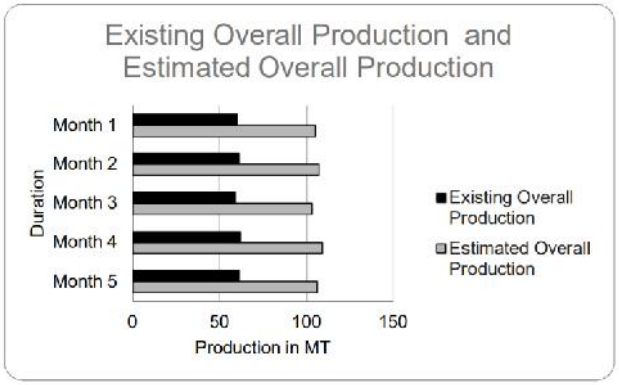

Fig.7 Existing and Estimated Overall Production

Final Cover Drive Calculation,

Individual weight of Final Cover Drive = 200 kg

Existing Final Cover Drive Production = 30 MT

No of Final Cover drives produced for month 1 = Existing Production of Final Cover Drive / Individual weight of Final Cover Drive.

= 30000/200

= 150.

Therefore 150 final cover drives are produced per month approximately.

After Productivity Improvement,

Estimated Final Cover Drive Production = 52.6 MT

No of Final Cover drives produced for month 1= Estimated Production of Final Cover Drive / Individual weight of Final Cover Drive

= 52600/200

= 263.

Therefore 263 final cover drives are produced per month approximately after the productivity improvement.

In Table.6, the existing and the estimated number of finalcover drives produced per month are obtained and listed out. This is calculated by using the estimated final cover drive production for a month and the individual weight of the final cover drive.

Table.6 Existing and Estimated Number of Final Cover Drives Produced.

S No	Month	Existing No of Final Cover Drives Produced	Estimated Final Cover Drives Produced
1	Month 1	150	263
2	Month 2	160	280
3	Month 3	140	245
4	Month 4	155	270
5	Month 5	145	255

In Fig.8, the existing and the estimated number of final cover drive produced is shown in the graph. The duration is listed out in the x axis while the number of final cover drives produced is plotted in the y axis for both existing and the estimated production.

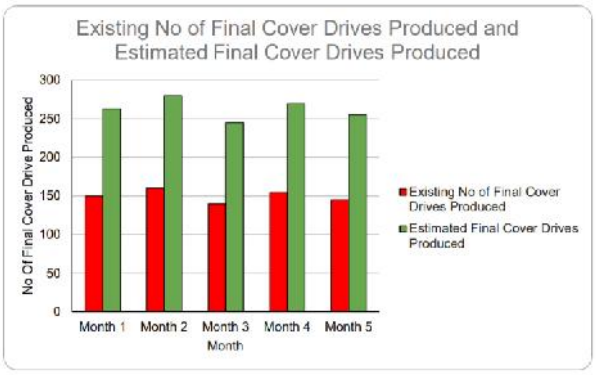

Fig.8Existing and Estimated No of Final Cover Drives Produced.

IV. CONCLUSIONS

From the calculation of the productivity of the final cover drive it is seen that the productivity is increased about 75.22percent by using process chart method. The calculation of the time reduction is about 24.78 percent by using the process chart method.The individual weight of the final cover drive is about 200 kg. By using the individual weight of the final cover drive and the production of a final cover drive for a month, the existing production of final cover drive is about 140 to 160 cover drives per month which is about 30 MT per month. After using the process chart method now 255 to 280 cover drives are produced per month which is about 50 MT per month.Thus, productivity is improved in foundry by using process chart method.

V. SCOPE OF FUTURE WORK

This project can be expanded in the areas of delay in thesand storage, mold preparation and mold conveying. These processes can be improved further by using automatic pumping sand system, mold continuous mixer and motorized roller conveyor.

REFERENCES

[1] Ashish Kalra, Sumit Sharma, Sachin Marwah, Virender Narula, 2016, "Increasing Productivity by Reducing Cycle Time in Assembly line of an Automotive Industry using Work Study Techniques", International Journal of Engineering Research & Technology (IJERT), Vol. 5 Issue 02, pp 272-275.

[2] Ashok Kumar Ghodki, Jitendra Pandey,2021,"Productivity Improvement in Manufacturing Industry Using Work Study Technique", International Journal of Science, Engineering and Technology, 9:1, e-ISSN:2348-4098, p-ISSN: 2395-4752.

[3] Bupe.G.Mwanza, Charles Mbohwa, 2016, "Application of work study for productivity improvement: a case study of brewing company", Proceedings of the International Conference on Industrial Engineering and Operations Management, pp. 296-305.

[4] Cengiz Duran, Aysal Centindere,Yunus Emre Aksu, 2015, "Productivity Improvement by Work and Time Study Technique for Glass Manufacturing Company",Procedia Economics and Finance, Volume 26, Pages 109-113, Doi: 10.1016/S2212-5671(15)00887-4.

[5] Chandra PV, 2013, "An Effort to Apply Work and Time Study Techniques in a Manufacturing Unit for Enhancing Productivity",International Journal of Innovative Research in Science, Engineering and Technology,2: 4050-4058.

[6] Gyanendra Prasad Bagri, Prem Raushan,2014,"Productivity Improvement of Forging Section Using Work Study and Automation in ExistingAxle Manufacturing Plant", International Journal of Mechanical and Production Engineering, 2(6), pp1-4.

[7] Kumar N, Mahto D,2013,"Productivity Improvement through Process Analysis for Optimizing Assembly Line in Packaging Industrie", Global Journal of Researches in Engineering Industrial Engineering, Vol.13 Issue 03, pp 1-17.

[8] M.P.Singh, Hemant Yadav, 2016, "Improvement in process industries by using work study methods: A case study", International Journal of Mechanical Engineering and Technology,7(3),pp.426-436.

[9] Malashree P, Vinayak N Kulkarni, N. Gaitonde, Sahebagouda M, 2018, "An Experimental study on Productivity using Work study and Ergonomics", International Journal of Darshan institute on Engineering Research and Emerging Technologies, Vol 7, No.1, pp. 31- 36.

[10] Md Abdul Moktadir, Sobur Ahmed, Fatema-Tuj-Zohra and Razia Sultana, 2017, "Productivity Improvement by work study technique: a case on leather products industry of Bangladesh", Industrial Engineering and Management, 06(01). DOI: 10.4172/2169-0316.1000207.

[11] P.R Akkoni, V.N Gaitonde, Vinayak N Kulkarni, 2019, "Applications of work study techniques for improving productivity at assembly workstation of valve manufacturing industry", IOP Conference Series: Materials Science and Engineering Volume 561. doi:10.1088/1757-899X/561/1/012040.

[12] Parthiban.P, Raju.R, 2014, "Productivity improvement in shoe making industry by using method study",IOSR Journal of Mechanical Engineering and Civil Engineering,e-ISSN: 2278-1684, p-ISSN: 2320-334X, pp.-01-08.

[13] Prathamesh P. Kulkarni, Sagar S. Kshire, Kailas V. Chandratre, 2014, "Productivity Improvement through Work Study Methods", International Journal of Research in Engineering and Technology, 03(02):429-434.

[14] Prathamesh P. Kulkarni,2014,"Productivity Improvement Through Lean Deployment & Work Study Methods",Volume: 03 Issue: 02, e-ISSN: 2319-1163, p-ISSN: 2321-7308. DOI:10.15623.

[15] Rishabh Mishra 2015,"Productivity improvement in Automobile industry by using method study", International Journal of Scientific Engineeering and Applied Science, 1(4), 361-363.

[16] Sajjanwar.S.W,Choudhari.C,2014,"Implementation of Performance Improvement Techniques - A Industrial Case study", International journal of Engineering Science and Reaserch Technology, 7 (1), 267-273.

[17] Shantideo Gujar,Achal S.Shahare, 2018, "Increasing in Productivity by Using Work Study in a Manufacturing Industry", IRJET, Vol: 05, Issue:05.

[18] Singh MD, Saurabh KS, Sachin BP, Rahul BP, Ankit PP ,1992, "To Improve Productivity by Using Work Study & Design A Fixture in Small Scale Industry", International Journal on Theoretical and Applied Research in Mechanical Engineering 1: 75-81.

[19] Sujay Biswas, Abhijit Chakraborty, Nabanita Bhowmik,2016, "Improving Productivity Using Work Study Technique",International Journal of Research in Engineering and Applied Research, Vol: 06, Issue:11, pp. 49-55.

[20] Vinayak Kulkarni, Ravikumar Kamble, 2014, "Productivity Improvement at assembly station using work study techniques", International Journal of Research in Engineering and Technology, Vol:03, Issue: 09.