Productivity Improvement Through Flexibility Creation In Disk Pad Module

Nithyanandhan Kamaraj, S.Ranjithkumar, N.Dhavaneeswaran

Abstract: The proposed are various methods and alterations in the Disk Pad Module (DPM) to improve the module productivity. The disk pad module has several processes which are performing, curing, baking, painting grooving, grinding, inspection printing and packing and has their corresponding men and machines working. But the customer demand for recently increased number of models could not be met with the current equipment and features as they need additional time and labor to change the machines to suit them. The area of study is selected and is evaluated based on the work study technique which brings out the processes to be improved. Various suggestions are made based on the results of the study to improve productivity.

Index Terms: Disk Pad Module (DPM), Increased customer demand, Improve productivity, Work study method.

1 Introduction

Productivity improvement is one of the important strategies towards efficient and effective production of goods. Over the years the use of automobiles has seen a constant hike and a corresponding hike in the demand and demand for its spares. One of the major spares that has an increased demand is the brakes for the vehicles, especially the disc pads whose use are high. To meet the increasing demand for disk pads the existing processes and resources needs to be managed, improved and modified effectively to meet the current demands. Predicting the demands could be tedious job, yet the improving the existing process would mean a lot in terms of productivity and the net outcome of the production module. Various methods and principles should be employed in estimating the current productivity, various factors that affect the former and effective ways to improve the productivity. Productivity is defined as the ratio between output of the wealth/products and the input of resources that are used in the process of production. Productivity usually compares the output and input by means of productivity index.

$$\text{Productivity} = \frac{\text{OUTPUT}}{\text{INPUT}}$$

Productivity is one of the most widely used tool to have a view of performance and quality of a company [8,12]. It also denotes the company's utilization of the available resources in producing its goods and services. At national level, productivity has its own effects on the costs of the produce goods and services. An increased productivity will lead to a reduction in price of the goods and services and a reduced productivity will lead to a corresponding increase in the costs of goods and services.

2 Literature Review

The improvement of productivity in an organization is by the proper use of work study technique that is combined with the motion and time study in the activities of manufacturing.

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productivity could also be measured by means of the productivity index where physical and monetary units were used [2]. The work study method has been used in the production line of an automotive industry where the method is used to evaluate, measure and conclude on the parameters that were to be improved. The work measurement technique was extensively used [3,7,10]. Every manufacturing line in any plant will have a maximum capacity which is often not utilized. The full capacity is the attainable level of output that can be reached under normal output conditions without the lengthening of standard working hours and the period for usual vacations and maintenances should be allowed. These principles should be used in terms of utilization of the capacity and the resources [4]. The productivity is measure of a nation's economy and the various factors which hinder its growth must be identified and removed [5,6,9]. Among the various methods that were studied, the work study is the major method that was highlighted as a mean to measure the productivity and the factors that affect it.

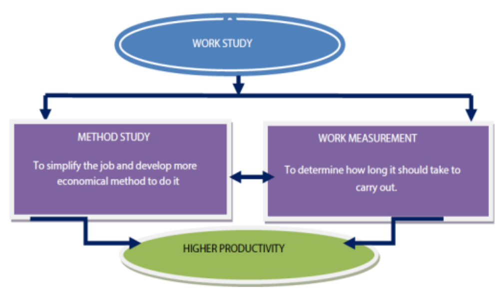


Fig 1

3 Methodology

Work study is a method by which the performance of a company could be evaluated and the obtained results are analysed and the data are used to manage and optimise the use of various resources like men, machine and materials that are already available in the organization. The concept of work study has two major segments which are the work measurement and method study. The study basically aims at optimising the use of various resources rather that to waste them. To have a better look at the relationship between productivity and work study, it is highly important to examine more closely and to evaluate and find various factors that significantly affect the working efficiency and conditions. The work measurement which deals with the measurement of time in which the work is being carried out in the production line. The time for completion of various processes are recorded and analysed for any possible improvements. The possible measures to reduce the time consumption are then suggested and implemented in the production line.

4 PROPOSED WORK STUDY MODEL

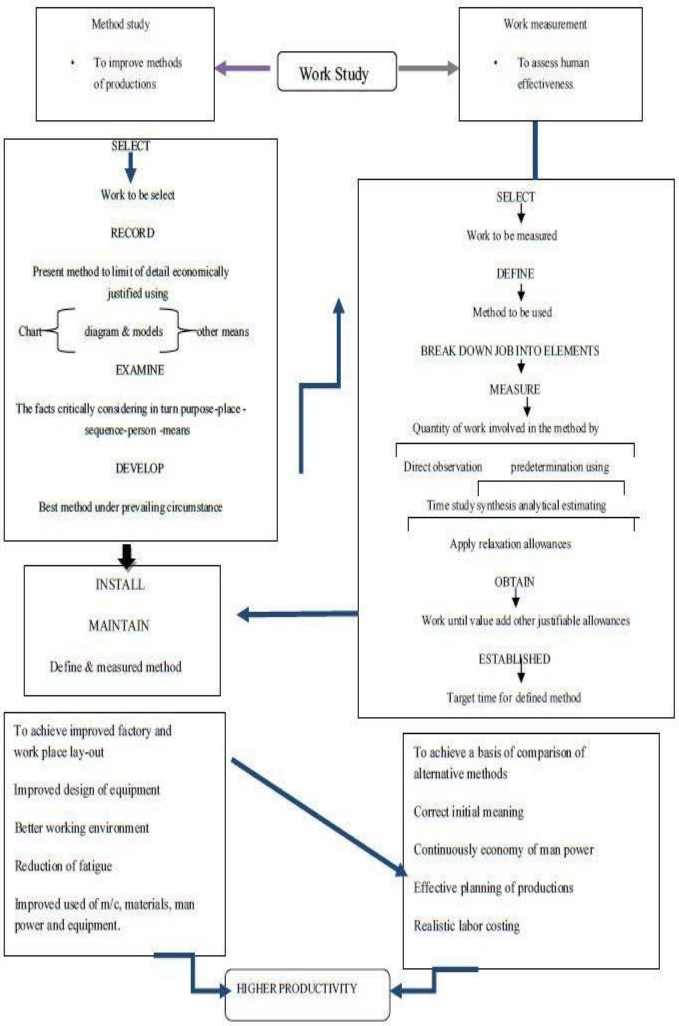


Fig 2

The proposed work study model that is as suggested from [10]. This model has proved to be highly effective in the case of work study. The below model extensively shows the steps involved in the work measurement and method study and finally with improvement in productivity.

5 Measurement parameters

5.1 Observed time
The time that is directly measured to complete the specified operation or combination set of operations.

5.2 Selected time
A time that is represented in place of a group of times for a work by calculating mean, median and mode.

5.3 Performance rating
The performances of workers who operate the respective machines are noted to corresponding to the standard pace. The commonly used scale of performance is below.

TABLE 1

RATING SCALE	*DESCRIPTION*
0	*No Activity*
50	*Very slow, clumsy, fumbling movements, operative appear half-asleep, with no interest in the job*
75	*Steady, deliberate, unhurried performance, as of a worker not on Piecework but under proper supervision, looks slow, but time not being intentionally wasted while under observation*
100	*Brisk. Business-like performance, as of an average qualified worker on piecework, necessary standard quality and accuracy standard rate achieved with confidence*
125	*Very fast, operative exhibits a high degree of assurance, dexterity and co-ordination of movement, well above that of an average works.*
150	*Exceptionally fast, requires intense effort and concentration and is us-likely to be kept up for long periods, a performance achieved only by a few outstanding workers*

5.4 Base Time
It is the minimum theoretical time that is required to complete a single unit of output. The term base time is given as

$$\text{Base time} = \frac{\text{observed time} * \text{observed rating}}{\text{Standard rating}}$$

5.5 Standard time
Standard time is the time that is required to do a job at standard performances.

Standard Time = Basic Time + Allowances

Considerations - Relaxation allowance – 15%

Contingency allowance – 3%

5.6 Relaxation allowance
This is the time that is allocated for the operating personnel to recover from the physical and mental fatigue that they go through while working and also to allow them for their personal needs. This time is usually taken as 15% of the base time.

5.7 Contingency allowance
The time that is required or allocated for the events that may or may not happen is called contingency allowance. It is usually a small amount of time that will be included in standard time for

time study. The default contingency time will be 3% of basic time.

5.8 Efficiency

= Output in minutes / Input in minutes

5.9 Increase in efficiency

= The efficiency of proposed line – present efficiency / Present efficiency

5.10 Increase in productivity

= Proposed standard output – Existing output / Existing output

6 CASE STUDY

6.1 Data collection

The disc pad module of Disc manufacturing company brake lining limited is selected for the purpose of data collection for the study. The company has been in joint venture with the Japanese friction manufacturer Nisshinbo to be updated in technology and quality. The selected plant being the mother plant, the one that was started first has a comparatively older tech and machines in the production line. For the study, the finishing line and the preforming are selected and the time for various processes are observed. The methods for production are also evaluated

OPERATION	OBSERVED TIME IN SECONDS										MANUAL/MC
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	
FIX PAD IN GROOVING	54	52	55	60	54	45	65	62	49	62	MANUAL
GROOVING	63	60	64	67	68	66	71	62	69	72	MC
PICK UP THE PAD FROM GROOVING TABLE	15	12	14	24	25	15	12	14	19	11	MANUAL
STACK THE PADS IN GRINDING TABLE	33	34	32	27	29	36	35	29	32	33	MANUAL
GRINDING	45	43	39	46	38	48	35	47	42	40	MC
PICK UP THE PAD FROM GRINDING MACHINE	21	15	18	22	25	19	17	24	27	21	MANUAL
STACK IN TRAYS	46	45	38	47	39	45	44	41	40	50	MANUAL
AIR WASHING	**125**	**114**	**115**	**109**	**122**	**125**	**119**	**127**	**123**	**114**	**MANUAL**
PICK UP PAD FROM TRAY	8	9	12	14	10	8	13	14	8	10	MANUAL
STACK INTO CHAMFERING BED	38	32	31	36	40	42	44	40	38	39	MANUAL
CHAMFERING	**34**	**32**	**35**	**40**	**28**	**36**	**40**	**44**	**33**	**31**	**MC**
PICKUP FROM CHAMFERING FIXTURE	12	13	20	16	17	13	14	18	22	20	MANUAL
STACK INTO TRAY	42	45	36	27	45	29	37	44	42	34	MANUAL
INSPECTION	56	52	49	60	63	57	46	59	61	55	MANUAL
PREFORMING FOR SINGLE LAYER PADS	**30**	**32**	**26**	**32**	**33**	**41**	**31**	**38**	**37**	**30**	**MC**

TABLE 2

The above table shows the list of timings that are observed to be taken by the men or machines during the operation. All of the timings were observed by trained personnel using precise and calibrated stopwatch.

TABLE 3

CHAMFER LENGTH	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	AVG
Less than 15mm	34	32	35	40	28	36	40	44	33	31	35.3
Greater than 15mm	55	55	48	60	56	49	56	52	51	47	52.2

TABLE 4

OPERATION	SELECTED TIME	STD RATING	OBSERVED RATING	BASIC TIME	STANDARD TIME	MANUAL/MC	MANPOWER	CAPACITY
FIX PAD IN GROOVING	55.8	100	77	42.966	50.69988	MANUAL	1	9642
GROOVING	66.2	100	85	56.27	66.3986	MC		
PICK UP THE PAD FROM GROOVING TABLE	16.1	100	80	12.88	15.1984	MANUAL		
STACK THE PADS IN GRINDING TABLE	32	100	71	22.72	26.8096	MANUAL		
GRINDING	42.3	100	88	37.224	43.92432	MC		
PICK UP THE PAD FROM GRINDING MACHINE	20.9	100	75	15.675	18.4965	MANUAL		
STACK IN TRAYS	43.5	100	80	34.8	41.064	MANUAL		
AIR WASHING	**119.3**	**100**	**81**	**96.633**	**114.02694**	**MANUAL**	1	14647
PICK UP PAD ROM TRAY	10.6	100	79	8.374	9.88132	MANUAL	1	5667
STACK INTO CHAMFERING BED	38	100	78	29.64	34.9752	MANUAL		
CHAMFERING	**35.3**	**100**	**84**	**44.436**	**52.43448**	**MC**		
PICKUP FROM CHAMFERING FIXTURE	16.5	100	80	13.2	15.576	MANUAL		
STACK INTO TRAY	38.1	100	76	28.956	34.16808	MANUAL		
INSPECTION	55.8	100	80	44.64	52.6752	MANUAL	1	9809
PREFORMING FOR SINGLE LAYER PADS	**33**	**100**	**86**	**28.38**	**33.4884**		1	2880

The table 4 is filled up with the timing values like standard time, base time and selected time which are calculated with the values from the first table. These values directly show the performances of the finishing line and the employees who work in it.

TABLE 5

OPERATION	GROOVING ELEMENT WISE	TIME(S)
GROOVING FIXTURE CHANGE	Getting grooving parts	10
	Picking up the tools	15
	Removing old fixture	253
	Place the fixture in rack	13
	Picking up the next fixture	25
	Installing the grooving fixture	167
	Adjust the grooving height	153
	Getting approval from QAD	222
	TOTAL time (s)	**858**

This table shows the time that is required to change a fixture in the grooving machine and setting the machine for the next part.

6.2 Data analysis

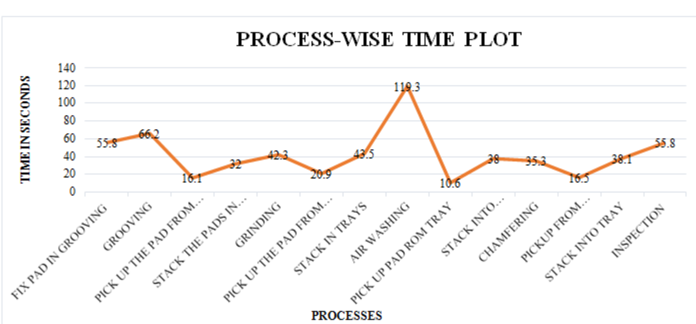


Fig 3

It is evident from the above plot that the AIR WASHING operation consumes more time than any other operations that are taken into study

Fig 4

The chamfering time for the pads with chamfer length more than 15 mm is very high when compared to those with length less than 15 mm.

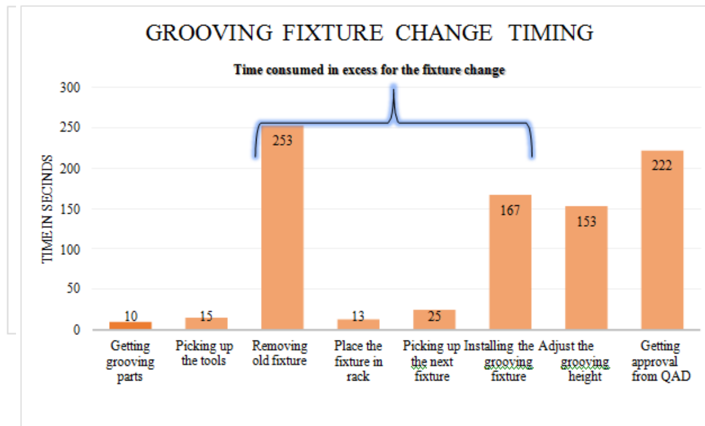


Fig 6

From the Fig 6, it could be inferred that most time in the above process is consumed for the removal of the fixture and installing the fixture

6.3 Findings

1. The time consumption for the "air washing" process is very high at 119.3 seconds which should be reduced or eliminated.
2. The time taken to chamfer the pads with longer chamfer length i.e. greater than 15mm is high and should be reduced.
3. The pads with less chamfer length require more output from the chamfering machine, i.e. the productivity should be increased.
4. The time required to change the grooving fixture is very high.

The number of preform cakes per day is 2880 which requires an improvement that could be done in the preform machine.

6.4 Suggested improvements or changes

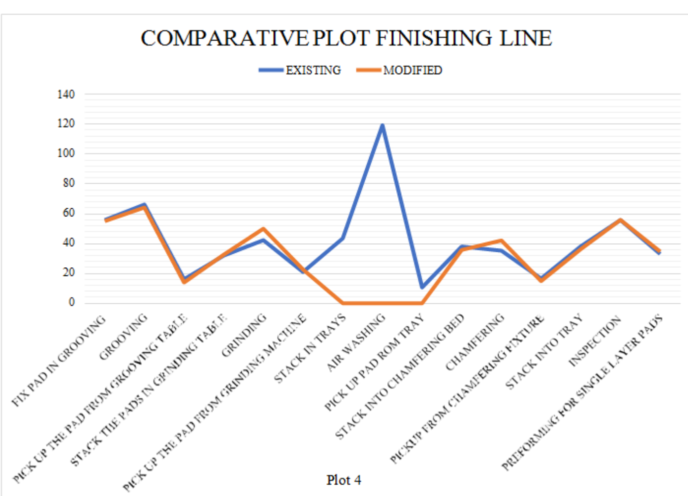
1. The separate air washing unit should be removed and the process should be integrated in the grinding process. Separate air nozzles should also be provided in the grinding machine apart from the one for air washing.
2. Positive chamfer i.e. the chamfer is provided in the punch of the preforming and curing machines for the pads with chamfer length higher than 15mm.
3. The usual output 5667 from the chamfering

machine for smaller pads should be increased by increasing the fixture and magnetic vice lengths i.e. the number of cavities in the fixture should be increased.

4. The grooving fixture should be altered to support more than one product so as to reduce the fixture change timing.
5. The number of cavities could be increased from two to three in the preform moulds for pads with single layer friction material.

7 Implementation

1. As per the findings of the study, the operation of air washing was found to consume about 19.13% of the whole 623.4 seconds required for a disk pad to pass through the finishing line. Hence the process of air washing is suggested to be integrated with the final grinding process in the finishing line. A row of nozzles was fitted to the end of the grinding machine where the grinded pads will pass through during the cycle. With the integration of the air washing in the grinding process.
2. The disk pads with chamfer length more than 15 mm consume a greater time than those with less chamfer length. Hence it was suggested to avail a punch with positive chamfer or the chamfer provided in the punch itself to get the chamfered edge without separate process
3. The chamfering process for the pads with chamfering length less than 15mm could be more effective chamfered in the machine. But the fact that the current fixture supports only a sum of 4 pads at a time. Hence this could not keep up with the demand from the customer. With the implementation of the above change in the chamfering process, the usual output of four pads per chamfer cycle is doubled with just a small increase in cycle time of 2 seconds.
4. The grooving process is one which requires a change in the grooving fixture every time a different model pad is to be grooved. This changing of grooving fixture almost takes 858 seconds. With the modified fixture being installed in the grooving machine, the productivity of the grooving by reducing the time consumption to change the grooving fixture.
5. The preform mould for the pads with single layer of friction material consists of two cavities as the pads with more layers do. But the output of dual cavity moulds in preforming process in not enough for the current demand. Hence the number of cavities in the mould has been increased by a number from two to three which takes the output up by 50%.



Plot 4

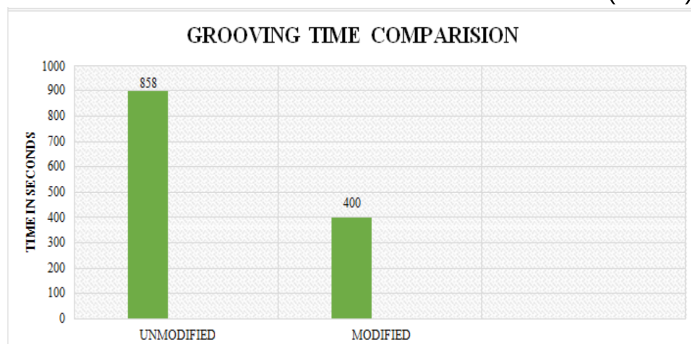
8 Results And Outcomes

It could be inferred from the plot that the post modifications in the finishing line has significantly reduced the overall line production time by about 150 seconds. Thus, the productivity is increased and also a man power is reduced

Fig 7

Fig 8

The Fig 8 shows the reduction in timings due to the modifications that were done on the grooving fixture. This modification thus has reduced about half the time (458 s)



required to change the fixture for another model pad thus increasing the productivity in the line. With the inclusion of the positive chamfer in the preform and curing moulds, the entire process of chamfering for the disk pads is eliminated in the finishing line. The pads with chamfer length greater than 15mm avail this feature in their preform and curing moulds. The useful man time of about 121 seconds could be saved.

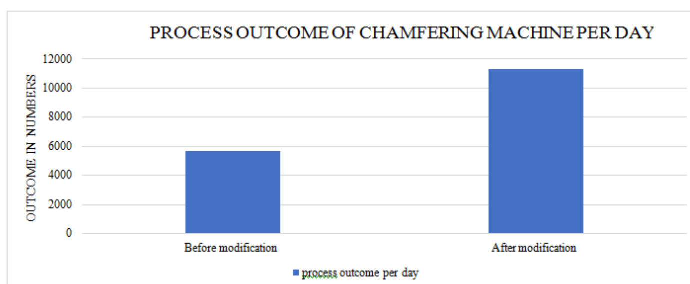


Fig 9

From the above Fig it is found that the increase in length of the chamfer bed and the chamfering fixture has noticeably doubled the output of the chamfering machine in the finishing line thereby improving productivity

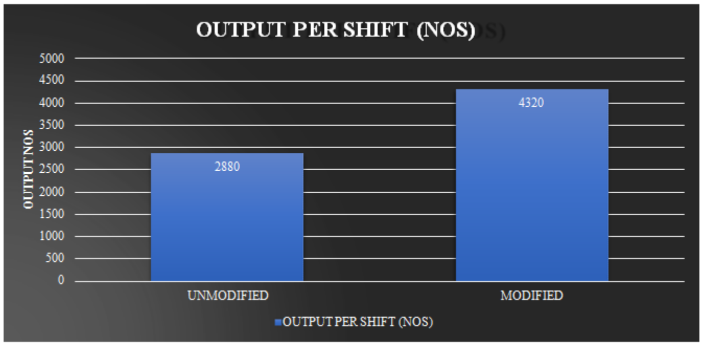


Fig 10

TABLE 6

OPERATIONS	BEFORE	AFTER	IMPROVEMENT
FINISHING TIME (S)	590.4	423.3	28.3%
GROOVING FIXTURE CHANGE TIME (S)	858	400	53.3%
POSITIVE CHAMFER (S)	121	0	18.9%
CHAMFER QUANTITY (Nos)	5667	11334	100%
PREFORM QUANTITY (Nos)	2880	4320	50%

9 CONCLUSION

The study being conducted is based on the work study technique which was suggested from the literatures. The work measurement, a kind of work study was successfully implemented on the finishing line of the Disk Pad Module. It was observed from the study, the various bottlenecks in the finishing line that tend to consume more time than other operations in the line. Hence, these found out bottlenecks were suggested with various modifications that were cost friendly and would also improve the productivity of the finishing line and the preforming process. Most of the production plants now are automated now which is a result of the former work studies that were conducted. Yet some of the companies still rely on the manual labour for their daily operations. Hence these are the potential areas where the productivity should be improved to meet the customer demands. The work study technique could thus be applied in any industry as done above to improve the productivity of the same.

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