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Productivity Improvement in Clutch Friction Disc (CFD) Manufacturing by Doing Automation

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Abstract: ***For any industrial firm, the most important thing is 'Productivity'. Everyday tasks are aimed at sustaining and increasing it. After all, it is productivity that determines the profit of the firm. It is also crucial for the economic progress of the country. High productivity refers to doing the job in the shortest possible time with minimum inputs and wastage but without sacrificing quality. This is where productivity improvement comes into the picture. This thesis aims to do a useful analysis in clutch friction disc manufacturing which will help in determining the improved methods to perform the required activities.***

Keywords: Clutch Friction Disc, Productivity Improvement, Cause and Effect Analysis, Why Why Analysis, Kaizens

1. Introduction

A clutch is a machine member used to connect a driving shaft to a driven shaft so that the driven shaft may be started or stopped at will without stopping the driving shaft.

2. Multi-Plate Clutch

In 2 wheeler vehicles like bikes and scooters there is a problem of packaging due to their small size, so to fulfil the need of required torque output, instead of a large single plate clutch, a multi-plate clutch having small clutch plates is used to transmit power between engine shaft and the transmission shaft

Figure 1: Clutch Assembly

2.1 Types of Multi-plate clutch

2.1.1 Spring Type Multi Plate Clutch
2.1.2 Diaphragm Type Multi-Plate Clutch
2.1.3Hydraulic Operated or Automatic Clutch

2.2 Components of Multi plate clutch

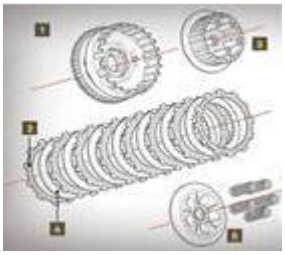


Figure 2: Components of Clutch

2.2.1 Clutch Outer Assembly
2.2.2 Clutch Friction Disc
2.2.3 Steel plates / Clutch plates
2.2.4 Inner Hub / Center
2.2.5 Pressure Plate
2.2.6 Lifter & Springs

2.2.1 Friction plates / Clutch friction disc / CFD
Friction plates or clutch friction disc or CFD receives power from outer assembly. Friction plates transmit power to steel plates or clutch plates. Friction plates have lugs in outer diameters which get fit in outer grooves. Processes involved in manufacturing CFD will be discussed in coming sections in detail

Figure 3: Friction plates / Clutch friction disc / CFD

2.3 Advantages of Multi plate clutch

- Increase the amount of torque to be transmitted.
- Decrease the pedal effort to operate the clutch.
- Decrease the pedal effort to operate the clutch.
- Decrease the moment of inertia of the clutch.
- Increase in better acceleration.

2.4 Disadvantages of Multi plate clutch

- Heavy
- Too Expensive

3. Problem Formulation & Methodology

3.1 Problem Statement

For any industrial firm, the most important thing is 'Productivity'. Everyday tasks are aimed at sustaining and increasing it.

3.2 Motivation / Need for Research

In this research work, I have tried to increase productivity of Clutch friction disc (CFD) manufacturing section. I analyzed the process flow chart of that section. I picked higher cycle time processes & worked in improving those. I did thorough study of these processes by doing cause and effect analysis. I captured all possible causes resulting in lesser productivity. I personally verified all possible causes to find out the potential cause. I did validation of all potential causes. For this I used 5 Why tool. After finding the root causes I did number of kaizen to improve root causes.

3.3 Methodology

3.3.1 Select the higher cycle time processes using flow chart.
3.3.2 Doing cause and effect analysis to find possible root causes.
3.3.3 Validation of potential root causes.
3.3.5 Why Why analysis of all potential causes to find exact root cause of the problem.
3.3.6 Kaizens to improve root causes

3.4 Measuring instruments & machines used

Vernier Caliper; Micrometer; Temperature meter; Surface table; Depth dial gauge; Hydrometer; Slit Jig for bend inspection; Flatness checking gauge; Weight machine; Kneader machine; Roller machine; Klinker machine; Adhesive machine; Sand blast machine; Moulding machine; Deflusher machine; Grinding machine; ID deburring machine; Brushing machine; Packing machine

4. Experimentation & Analysis

4.1 Flow Chart of CFD manufacturing processes with cycle time of each process

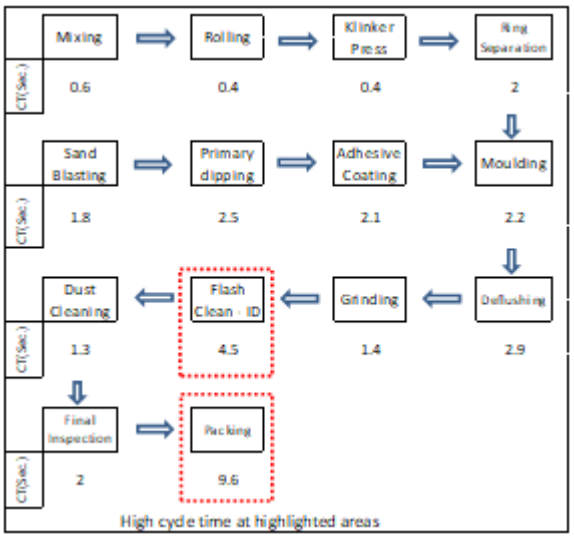


Figure 4: Flow Chart of Processes with cycle time

4.1.1 Mixing

In mixing, first, fresh compound is made using rubber, cork and mixing agents. Rubber is used to provide elasticity and to absorb heat. Cork grains offer strength and mixing agents are used for proper mixing. This process is carried out in a machine called mixer. After the fresh compound is made, the left-out sheets from pressing are mixed with 15% fresh compound in the mixer to prepare the final material to be used for rolling. This is done because the material loses its strength every time it is recycled. So this ensures the durability of the friction lining.

4.1.2 Rolling

After the mixed powder is created, they are rolled to form sheets in the rolling machine. The machine comprises of two parallel rolls in between which powder is poured. The sheets are rolled three times in machine.

4.1.3 Klinker Press

The rolled sheets are then folded four times and kept under the pressing machine die to obtain cork ring.

4.1.4 Ring Separation

Since rolled sheets are folded four times, after pressing, four get stuck together which need to be separated. This process is done manually by workers, and it involves a lot of rejection because rings break during separation.

4.1.5 Sand Blasting; Primary Coating

It involves forcibly propelling a stream of abrasive material against a surface under high pressure to make rough surface on core plates. After this, the plates are dipped in a primer for coating. Then, the plates are checked whether they are flat or bend. If they are irregular, then they are made flat.

4.1.6 Adhesive coating

The plates are then coated with an adhesive so that friction lining can be attached to them. This is done in an SPM (Special Purpose Machine). Around 26 plates go at a time into the machine and get dipped into an adhesive container. Then they are heated inside it for drying purpose and then taken out.

4.1.7 Hot Moulding

This is an essential process in the moulding shop. The adhesive coated plates and friction lining are attached in the machine at a temperature around 180 – 200°C and pressure 100 MPa to obtain a CFD with Inner Diameter (ID) and Outer Diameter (OD) flashes. After Hot moulding, the worker also deflashes the ID using knife. Three platen moulding die is used for this operation having total 27 cavities. Finally dispatches it into the OD deflashing station.

4.1.8 OD Deflashing

Here, the worker first puts the plates in a polycarbonate shot blasting machine which removes 90% of the flashes, after which he performs the deflashing manually using a filer. If flashes remain in the CFD's , it will result in accidents during next grinding process. From here, the plates are taken into the grinding section.

4.1.9 Grinding

This process is done to maintain the thickness of CFD using double disc grinder.Auto pusher is used to put CFD in grinder. One CFD is passed at one time in between the grinders. Dust generated in this process is collected by using dust collector. Dust is highly inflammable so quencher is

placed on top of machine to absorb sparks generated during process. From here, CFD is passed to the reaming station.

4.1.10 Flash Clean ID

After grinding, reaming operation is carried out to clean the ID. This process involves a single point cutting tool which rotates about an axis and cuts the flashes across the ID. Flashes should not remain inside CFD's. Extra cutting is also NG. So proper cutting of cutter is done to prevent it. From here, the plates go into the air brushing machine.

4.1.11 Final Inspection

The plates are passed through a slit gauge to check the size. If it passes, the plate is accepted otherwise it is rejected. Then the plates are checked for visual defects. Thickness NG ; chip off; Bend ; Groove depth NG ; Ring off are some types of defect. After this Ok CFD's are marked by specific color for identification purpose.

4.1.12 Packing

In last final packing of CFD is done using auto pusher & tape dispenser machine. Packing standard is given by customer. Then material is kept in finished goods area. From FG area material is dispatched to the customer as per requirement.

4.2 Cause and effect analysis to find possible causes

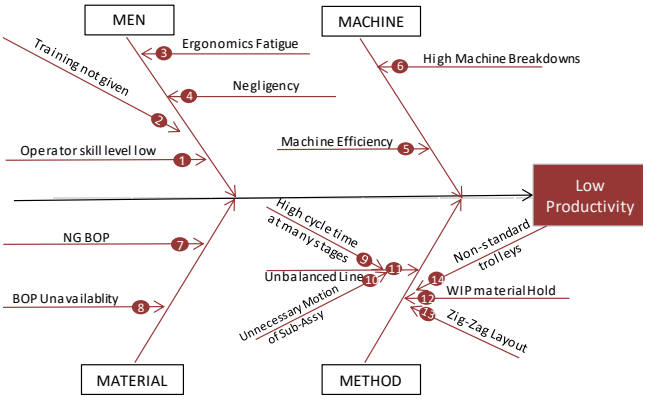


Figure 5: Cause and Effect Analysis (Possible Causes)

I checked all aspects involved to decide whether this cause is potential one or not.

1) Operator Skill Level Low

Verification Method	Result
Verbal Questions & Skill Matrix	Ok

Skill Matrix

2) Training Not given

Verification Method	Result
Training Record & Training Matrix	Ok

Monthly training record available & training plan made

3) Ergonomics Fatigue

Verification Method	Result
Work activities view	Not Ok

I did not found any activity related to reduction of ergonomics fatigue. Some operations were highly fatigable which are as below.

Flash clean ID operation was one. Tight grip of both hands was required to clean ID effectively. So in eight hour shift operator's wrists were getting totally tired. Operators were not willing to work on this operation. Attrition rate was also high on this operation. If operator grips parts loosely while doing cleaning, rejection was produced. If operator uses knife with loose hand to clean part ID, rejection was produced. This operation was CTQ.

On final packing operation, operators had to put four CFD's in one packing box at high speed to meet customer demand. Also cycle time of this operation was highest amongst all operations involved in CFD manufacturing. Short quantity customer complaints were coming frequently. Mental stress was very high on this operation. No automatic mechanism was there to relieve operators stress. Thus this possible cause found Not Ok.

4) Negligence

Verification Method	Result
Poison Test	Not Ok

Flash clean ID & final packing stations were manual operation. Negligence cases observed on both operations. Operators were not removing NG part produced in the process. They were keeping these parts in Ok material. On final inspection process, these NG parts were getting identified. There were chances of skipping of NG parts on final inspection operation also. This possible cause found Not Ok.

5) Machine Efficiency

Verification Method	Result
Machine cycle time, working condition, Preventive maintenance record.	Ok

All machines preventive maintenance on time so working perfectly.

6) High Machine Breakdowns

Verification Method	Result
Machine breakdown data	Ok

Machine breakdowns very less, No major breakdowns impacting productivity & Quality

7) NG BOP

Verification Method	Result
BOP inspection record & Line complaint record	Ok

After verification of BOP inspection & line complaint record there is no major & regular problems observed at line.

8) BOP Unavailability

Verification Method	Result
Line stoppage due to BOP unavailability	Not Ok

No line stoppage due to BOP unavailability.

9) High cycle time at few Stages

Verification Method	Result

Cycle time study sheet	Not Ok

As shown in flow chart earlier, line balancing is not ok. Some processes like Flash clean ID; Final packing had very high cycle time as compared to other processes. Both operations were manual operation & critical to quality. Efforts for getting more production were resulting in higher rejections & customer complaint. Thus this possible cause found Not Ok.

10) Un-necessary Motion of Sub-Assy

Verification Method	Result
Gemba observation	Ok

Found no un-necessary motion in operations

11) Unorganized Space

Verification Method	Result
Gemba observation	Not Ok

Due to variation in cycle times of processes line balancing in department was not fine resulting in unorganized working. Cycle time at SPM ID & Packing stations was very high. Inventory levels before these operations usually remain high & vice versa for the next operations. Packing station was last station before dispatch. During high dispatch schedule mental pressure on this station was remaining high. Due to this customer complaint was also coming due to wrong packing. Thus this possible cause found not ok.

12) WIP Material Hold

Verification Method	Result
Gemba observation	Ok

No WIP material observed at operations.

13)Zig Zag Layout

Verification Method	Result
Gemba observation	Ok

No Complexity observed in layout.

14)Non Standard Trolleys

Verification Method	Result
Gemba observation	Ok

Standard size trolleys were available for material handling.

4.3 Validation of potential causes

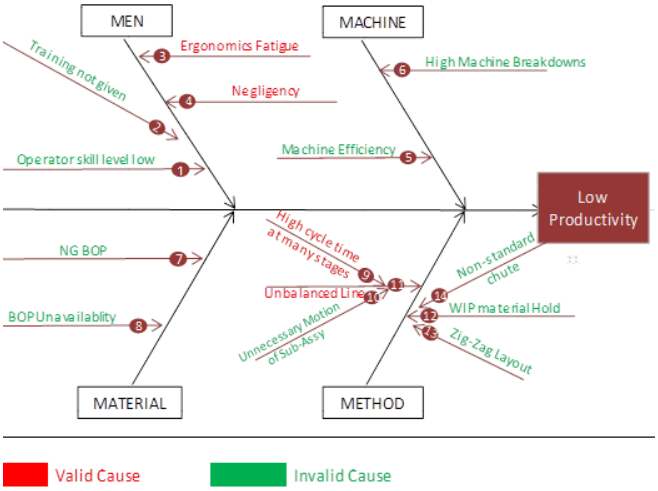


Figure 6: Cause and Effect Analysis (Potential Causes)

4.3.1 Validation No 1 – Ergonomics fatigue

To validate this cause we checked working of operators on Flash clean ID operation. Operator has to clean internal diameter of CFD using knife. Both hands tight gripping is required in this operation which is creating Ergonomic fatigue.

Figure 7: Flash Clean ID operation

Why- Why Analysis

Why-1	Why-2	Why-3	Why-4
Ergonomics fatigue at Flash clean ID operation	Continuous tight gripping of parts by hand	It is manual operation. Operation is part of process.	No fixture/ SPM for this operation.

4.3.2 Validation No 2 – Negligence

To validate this cause we checked working of operators on Hero SPD packing stations. In this operator has to put four numbers CFD in one box. First operators count 4 numbers CFD then puts in packing box. Due to negligence operator usually puts 3 or 5 CFD. We usually got short quantity complaint from customer also.

Why- Why Analysis

Why-1	Why-2	Why-3	Why-4
Operator Negligence	Short quantity problem reported by customer	Manpower dependency	No automation for critical stations

4.3.3 Validation No 3 – High cycle time at many stages / unbalanced line

As shown in flow chart earlier, line balancing is not ok. Some processes like Flash clean ID; Final packing had very high cycle time as compared to other processes. Both operations were manual operation & critical to quality. Efforts for getting more production were resulting in higher rejections & customer complaint. Due to variation in cycle

times of processes WIP level in department was high resulting in unorganized working.

Why- Why Analysis

Why-1	Why-2	Why-3
High cycle time	Totally man dependent operation	No automation for critical stations.

4.4 Counter measures

Effect	Identified Causes	Countermeasures	Resp.	Target	Status
Less Productivity	Higher cycle time at critical packing operation.	Auto pusher mechanism implementation done for cycle time reduction	Shakti Malik	MAR18	Done
		Tape dispensor & cutting machine automation done for cycle time reduction & tape saving.	Shakti Malik	MAR18	Done
	Higher cycle time at Flash clean ID operation.	SPM drill machine implemented for Flash clean ID operation.	Shakti Malik	FEB18	Done
	Ergonomics fatigue at Flash clean ID operation.				
	No automation for critical packing station	Automation poka yoka implemented on packing station to avoid short quantity problem.	Shakti Malik	FEB18	Done

4.5 Kaizens

4.5.1 Kaizen No 1

Auto pusher Automation on critical packing station

Before | After

In manual packing, operator has to count 4 CFD before putting them in box.After this opeartors were checking weight of box to ensure required quantity.

Auto pusher m/c installed. It ensures pushing of 4 CFD at one time. So requirement of counting 4 CFD & weighting of box. Cycle time reduced.

Benefit : 1) Cycle time of packing operation reduced from 9.6 second to 4 second.
2) Short quantity customer compaint solved

4.5.2 Kaizen No 2

Weighting station removal on critical packing station

Before | After

In manual packing, operator has to count 4 CFD before putting them in box.After this opeartors were checking weight of box to ensure required quantity.

Auto pusher m/c installed. It ensures pushing of 4 CFD at one time. So requirement of weighting boxes is removed. Cycle time reduced.

Benefit : 1) Cycle time of packing operation reduced from 9.6 second to 4 second.
2) Short quantity customer compaint solved

4.5.3 Kaizen No 3

Tape dispensor & cutting machine Automation on critical packing station

Before | After

In manual tape dispensor machine, operator manually pulls tape & cuts it. Cycle time is more & tape consumption is high.

Automatic tape dispensor & cutting machine installed. M/c automatically pulls tape ; cuts it & sticks on rotary plate. Cutting tape length is optimized & cycle time is reduced.

Benefit : 1) Cycle time of packing operation reduced from 9.6 second to 4 second.
2) Tape consumption reduction by 50%

4.5.4 Kaizen No 4

SPM ID machine for Flash clean ID operation

Before | After

Both hand tight grip is required in this operation which is resulting in Ergonomic fatigue & high cycle time.

SPM machine installed. Parts gripping is done by pnuematic fixture & cleaning operator is done by cutter attached to drill machine. Ergonomics fatigue removed & cycle time increased.

Benefit : 1) Cycle time of Flash clean ID operation reduced from 4.5 second to 1.2
2) Edge Damage internal rejection reduced.

5. Results & Conclusion

5.1 Tangible Benefits (Quantitative)

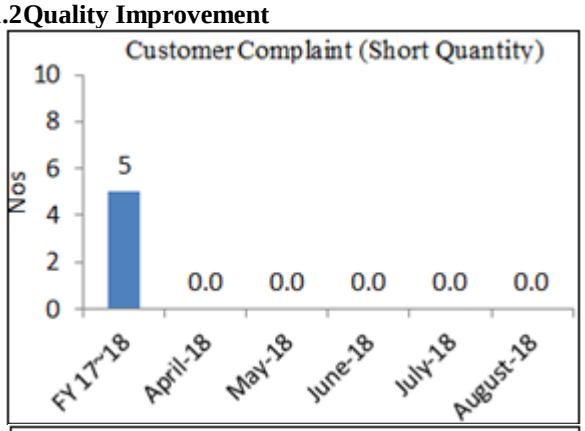
5.1.1Productivity Improvement

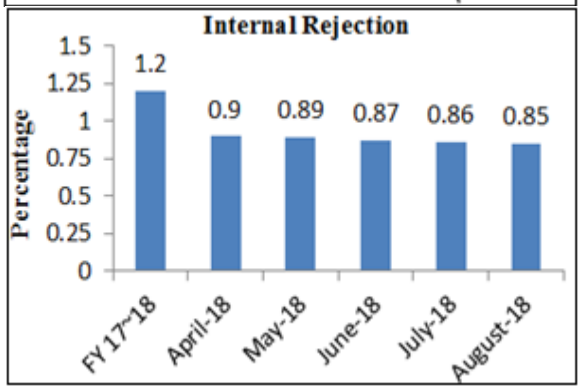
In FY 17~18, productivity of CFD shop was 77.7%

On Packing station cycle time reduced from 9.6 sec to 4 sec. Auto pusher & Tape dispenser machine installed on this operation.

On SPM ID station cycle time reduced from 4.5 sec. to 1.2 sec. Pneumatic fixture & SPM drill machine installed in place of manual cleaning.
Both automations resulted in improvement of productivity from 77.7% to 88.7%
Total 14% productivity improved against target of 10%
Sustenance of improvement is also achieved as shown in graph above.

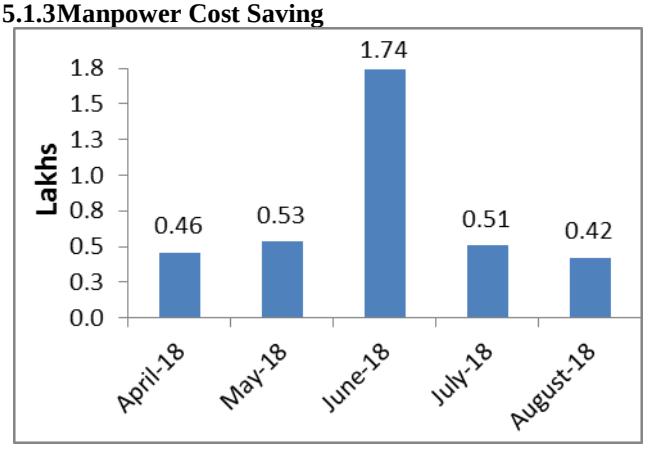
5.1.2Quality Improvement





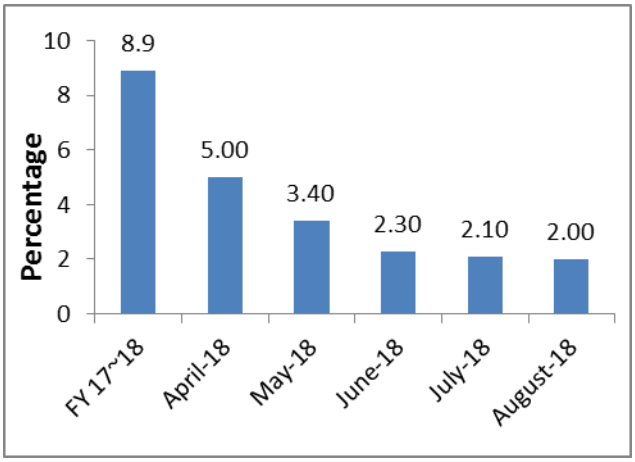
Customer complaint of short quantity eliminated completely from 5 to 0.
Customer quality rating improved.
Internal rejection reduced from 1.2% to 0.85%.
Edge damage rejection in Flash clean ID operation was highest amongst all rejection types. After starting SPM ID machine for this operation, this rejection was completely removed. This operation removed from CTQ operations.

5.1.3Manpower Cost Saving



3.66 lakh manpower cost saving done from April-18 to August-18 & to be continued.

5.1.4Attrition Rate of Workers



Workers attrition rate reduced from 8.9% to 2% by doing improvement in ergonomics fatigue.

5.2 Intangible Benefits (Qualitative)

Productivity Improvement / Customer Satisfaction	1) Presentation skill improved
	2) Analysis knowledge improved
	3) Brain storming skill improved
	4) Communication skill improved
	5) 5S improved
	6) Self-confidence improved
	7) Morale improved & innovative consciousness

6. Future Scope

In this thesis I have covered only clutch friction disc (CFD) manufacturing. In future there is scope of doing such types of improvement in

- Clutch plate
- Outer clutch
- Center clutch
- Lifter
- Pressure plate

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