Preventive Scrap Analysis of Crankshaft Ovality in Grinding Process

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ABSTRACT

A crankshaft is an important part of an engine. It is the heart of an automotive vehicular system. A crankshaft in an internal combustion engine which converts the linear motion of the piston in to rotary motion of the flywheel. This converted rotary motion is used to drive automobile or any other device. In that main function of crankshaft is there any ovality on pin and journal part of crank shaft causes the improper power transmission, fluctuation and large noise and vibration production in engine. We have studied the production process of crankshaft having 5 journal and 4 pin on the centerless automatic grinding machine (like JUCRANK, JUMAT and OIL).
It is an important part in various types of engines like aerospace, reciprocating. A crankshaft contains two or more centrally-located coaxial cylindrical ("mains") journals and one or more offset cylindrical crankpin ("rod") journals. The crankshaft main journals rotate in a set of supporting bearings ("main bearings"), causing the offset rod journals to rotate in a circular path around the main journal centres, the diameter of which is twice the offset of the rod journals.
In BFL1 we observe various types of defective crankshaft are manufactured during various forging and cutting process. Mainly the problem occurs in manufacturing line consist of various automated machine line. Defect produce due to pin width oversize, ovality, undersize, unclean patch, diameter run out, flange boss diameter over/undersize, etc. these defects are mainly produced due to defects in grinding operation.

Keywords: BFL-Bharat Forge Ltd.1 etc.

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1. INTRODUCTION

A crankshaft is a main component of an engine. A crankshaft in an internal combustion engine which converts the linear motion of the piston in to rotary motion of the flywheel. This converted rotary motion is used to drive automobile or any other device. It can be manufactured by various method but we mainly concentrate the forging technic for manufacturing.

Great care must be observed in the manufacture of the crankshaft since it is the most important part of the engine. The journals and the crank pins are ground to exact size after turning. Most crankshafts are ground at the journals and crankpins. In some cases, grinding is followed by hand lapping but in mass production it is done by some automatic grinding machines like centre less grinding machines (JUCRANK, JUMAT and OIL).Crankshaft used in high production automotive engines may be either forged or cast. Forged crankshafts are stronger than the cast crankshaft, but they are more expensive.

Forged Crankshaft: Forged crankshafts are generally made from SAE 1045 or a similar type of steel. The crankshaft is formed from a hot steel billet form earlier through a series of forging dies. Each die changes the shape of the billet slightly. The crankshaft blank is finally formed with the last die. The blanks are then machined to finish the crankshaft. Forging makes a very dense, tough crankshaft with a metal's grain structure running parallel to the principle direction of stress.

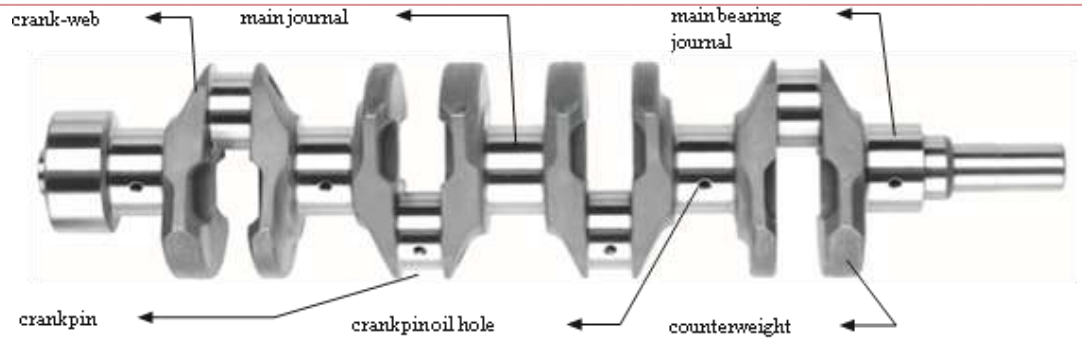


Fig-1: ActualCrankshaft

1.1 Processes FlowIn BFL CL1 Line for Crankshaft Production:

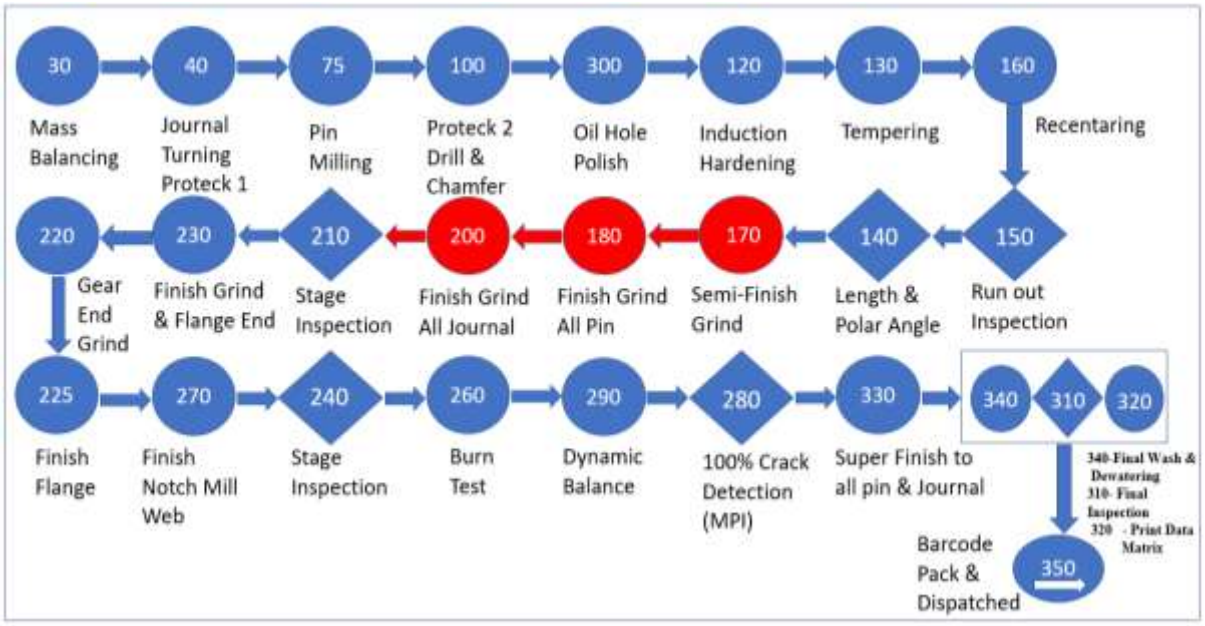


Fig-2: Process Flow Line for CL 1 Line of BFL

As we observe the production of crankshaft involves so many processes, so for easy analysis we divide above processes in three modules which as follows

MODULE-I & II: Turning, Milling, Deburring, Tempering, Hardening etc.
MODULE-III: All sort of grinding processes.
MODULE-IV: Balancing, Super finishing, Crack detection, Washing, Packing etc.

- **Mass Balancing:**
  Mass Balancing is the first process done in the CL1 Line. In this Machine, the forged crankshaft is balanced so that it is free from vibration and stress.
- **PROTECK I & II:**
  In Proteck I & II the crankshaft Machining operation is performed i.e. the turning operation of Crankshaft to form the specific of Pin and Journal. In Proteck I first the journal in the crankshaft is turned and in the Proteck II the pin turning process take place.
- **RGFM Mill:**
  In this Machine, the Pin Milling operation is performed. A Multi tooth milling cutter is fed on the crankshaft so the milling operation is performed on the crankshaft. The cutter also run at an extreme speed.
- **EMAG Drill Chamfer Oil Hole:**
  In this Machine Drilling operating on crankshaft is performed. Drilling at an angle of 45 degree and 90 degree are performed on the crankshaft. This operation is done as to reduce the weight of the crankshaft.

- **DeburringRobot:**
  The Deburring Robot Machine does the work of removing the burr formed on the crankshaft. It is automated robot working under set parameters.
- **Pyro-Tempering & Hardening:**
  The tempering principle is simple: tempering of crankshaft at high-temperature and cool them quickly to keep their new form to modify their chemical aspect. An Automated Hardening Machine is used to increase the temperature on the journal and pin of the crankshaft and reduce the temperature.
  Induction hardening is used to selectively harden areas of a part or assembly without affecting the properties of the part as a whole.
- **JUMAT Semi Finish Grinder:**
  JUMAT external cylindrical grinding machines can be used in individual or combined grinding operations in the straight or angular in feed process to grind: Crankshaft.
- **Jucrank Journal Finish:**
  Jucrank grinding machines solve practically every grinding task in crankshaft grinding. Main bearings (cylindrical, concave, and convex) and pin bearings (cylindrical, spherical, concave and convex) can be ground in a single clamping.
- **Toyoda End Operation and FE Grind:**
  The toyoda grinding machine the Face End of Crankshaft is grind and the end grinding operation is done.
- **Dynamic Balancing:**
  An Automated dynamic balancing Machine balance the forces present in the crankshaft it ensures that the shaft is completed out of stresses.
- **Super finishing:**
  Super finishing to all the pin and journal is done on the crankshaft. The checking of the crankshaft is also done by using various type of radiation. It also is last turning process after this process the crankshaft is washed and packed.

1.2 Scrap History:

We adopt following to solve the ovality problem occurs in BFL MCD II department of CL1 line. And Collect the Month wise Scrap Data from Quality Assurance Division for JAN'16 to AUG'16 and plot Pareto by using MINITAB.

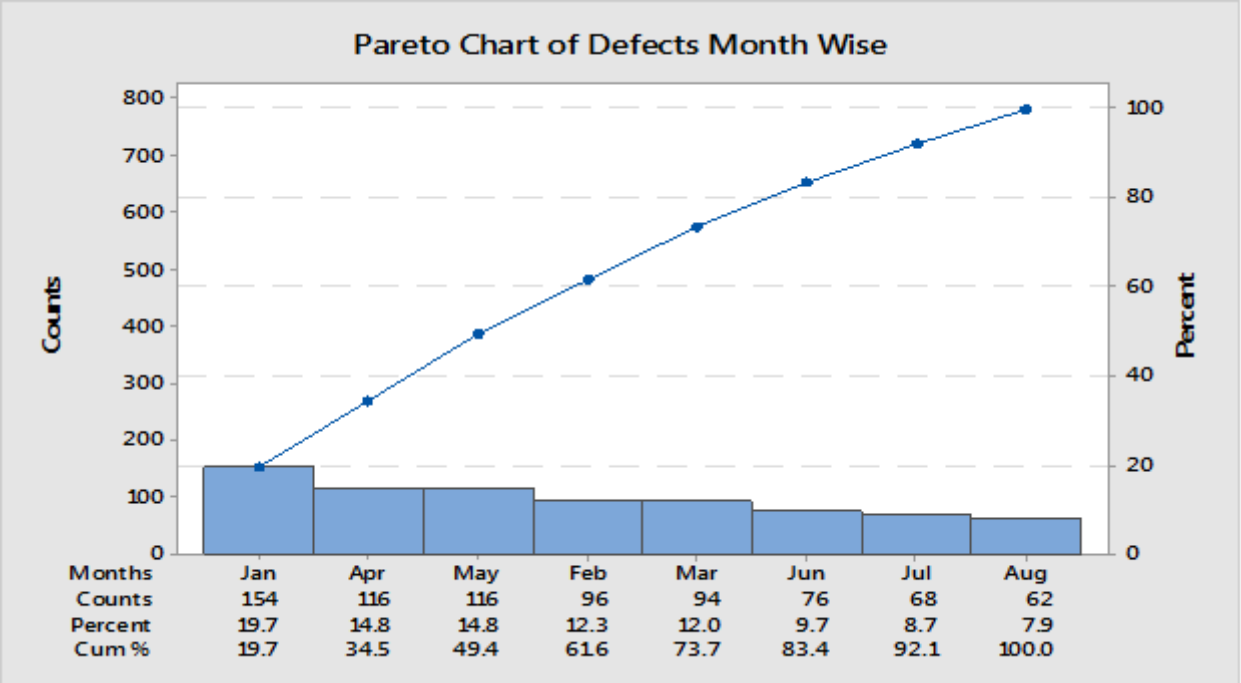


Fig-3: Month wise Pareto of BFL CL1 line in MINITAB

HereStudy of some important processes which is contributing to scrap as follows in MCD II for the manufacturing of crankshaft.

- Journal turning of Proteck 1
- Pin Milling
- Proteck 2
- Drill & Chamfer
- Hardening & Tempering
- All Grinding and Super finishing processes

In that of most scrap contributing process is Grinding.Three stages of inspection are mainly done, first Run-out inspection after induction hardening second one is after grinding stage and third one is after super finishing stage.

As the above Pareto chart show the amount of defective crankshaft from the month January to the August. These total amounts of defective crankshaft are produce on the Crankshaft line 1 in all the machines and the modules.

- From Fig-1 process flow diagram, we sort out following some process which most contributed in rejection of the job.
  - Semi-finish Grind
  - Finish Grind (All Pin)
  - Finish Grind (All Journal)
- In that we plot a machine wise scrap pattern and observed the JUCRANK, JUMAT & OIL as critical machines.
- Which fall under Module-III contains these machines as critical level of scrap production need to reduce them.

Collect last 8 month's scrap data and observes following points:

1. Jan have pin ovality as top 5 defects in that month.
2. Feb, April and May has second highest defects of pin ovality.
3. In the period of observation total 30% of job has been rejected due to pin ovality.
4. April and may has maximum numbers of job rejection due pin ovality.
5. It is especially in module III defects (pin ovality) belongs in grinding section.
6. Generally, JUCRANK, JUMAT and oil has great contribution in ovality defects.

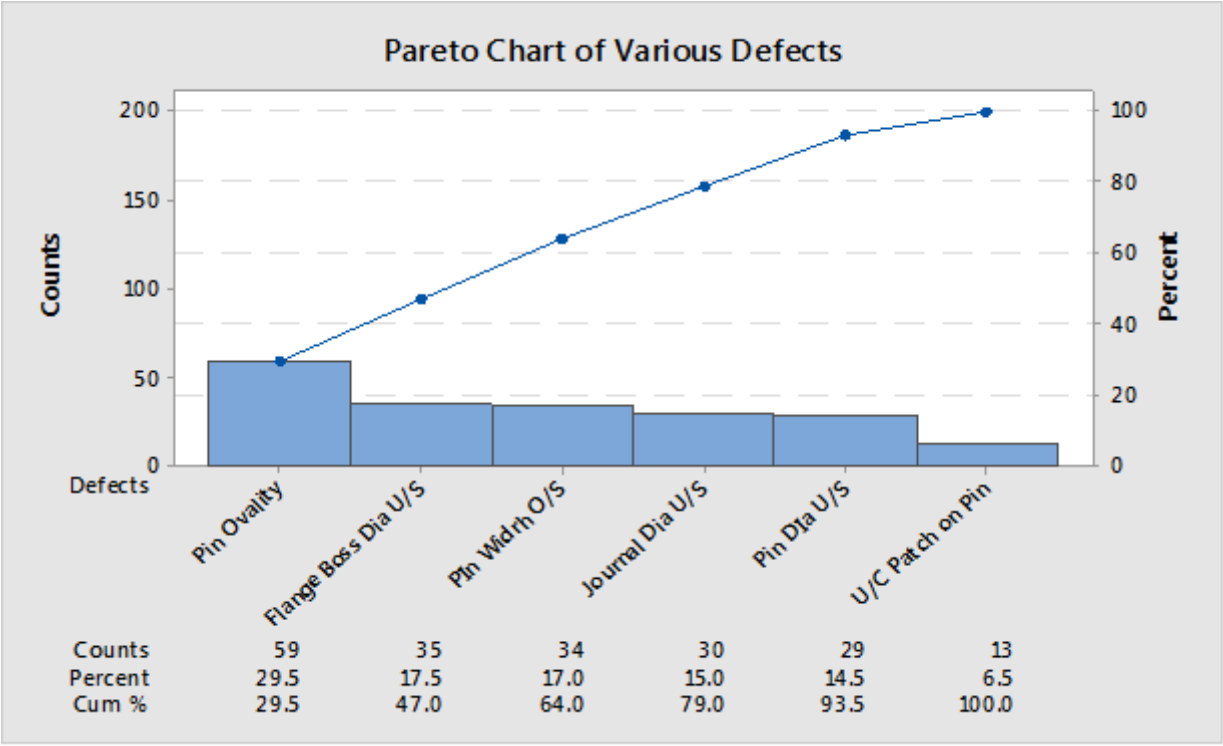
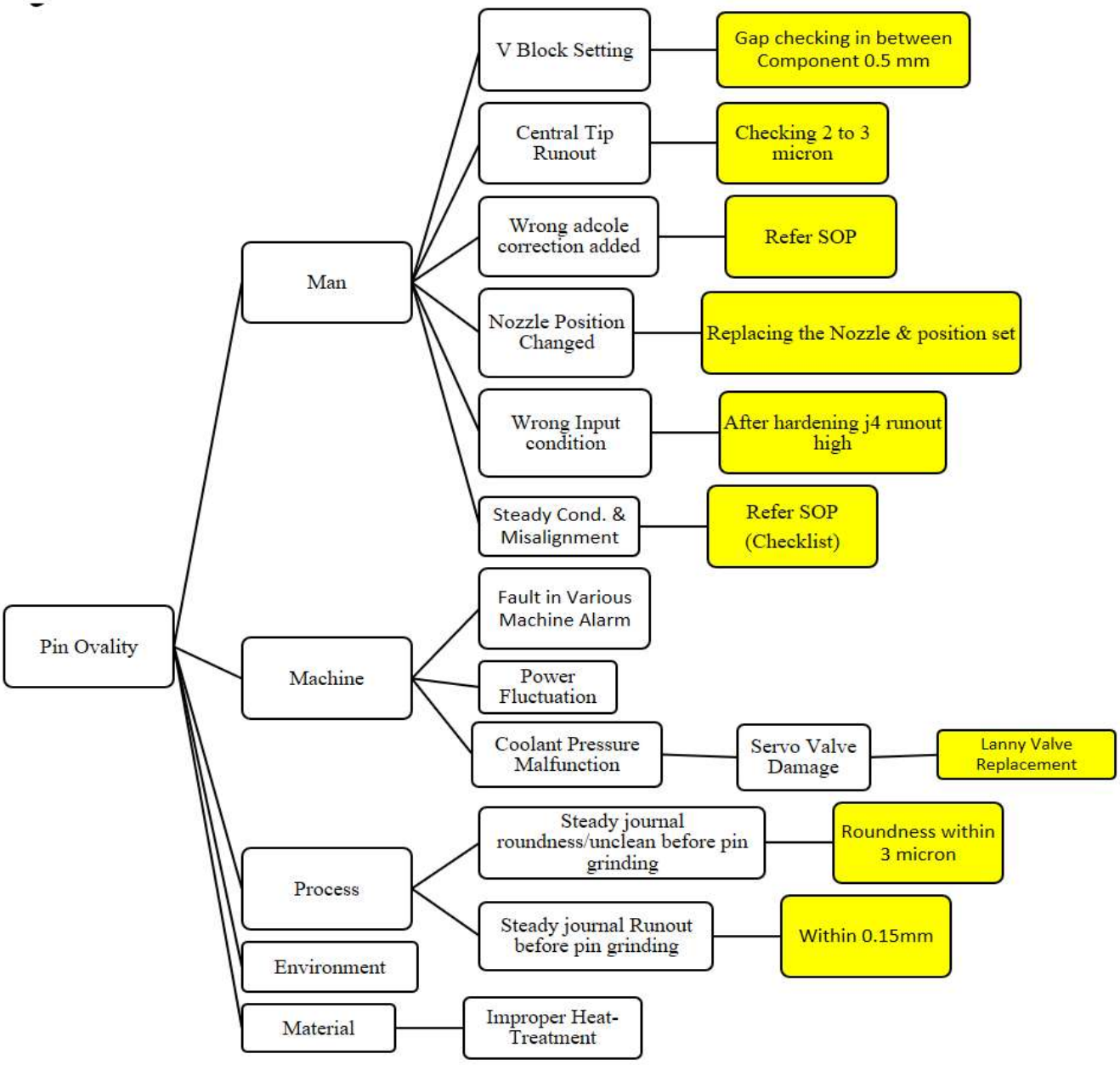


Fig-4: Defect wise Pareto of BFL CL1 Line

As the above Fig-2 & fig-3 chart show that around about approx. 30% of the defect in the crankshaft are due to the Pin Ovality. To reduce the reduction rate in the crankshaft it is important to reduce the Pin Ovality defect. This Pin Ovality defect come always in the grinding section in the CL 1 Line.

2. ROOT CAUSES AND REMEDIES:

With the help of expertise in BFL and Past Scrap Data we categories the root carouses from Scrap List and We shows it in to Tree Diagram of various defects and their solution in yellow in blocks. The classification of defects is done using Man, Machine, Process, Environment and Material. The defects produced due to the Environment and Material are neglected. Main area of occurrence of defects is lying under Man, Machine and Process.



2.1 Trial on Machine:

As we observe the result of pin ovality from previous result we prepared the check-sheet for pin ovality in grinding machine. And give it to machine operator for follow the instruction as per check-sheet. And result are plotted as follows from moth of October to November, which is development stage and effective changes was observe in the month of December, January and February.

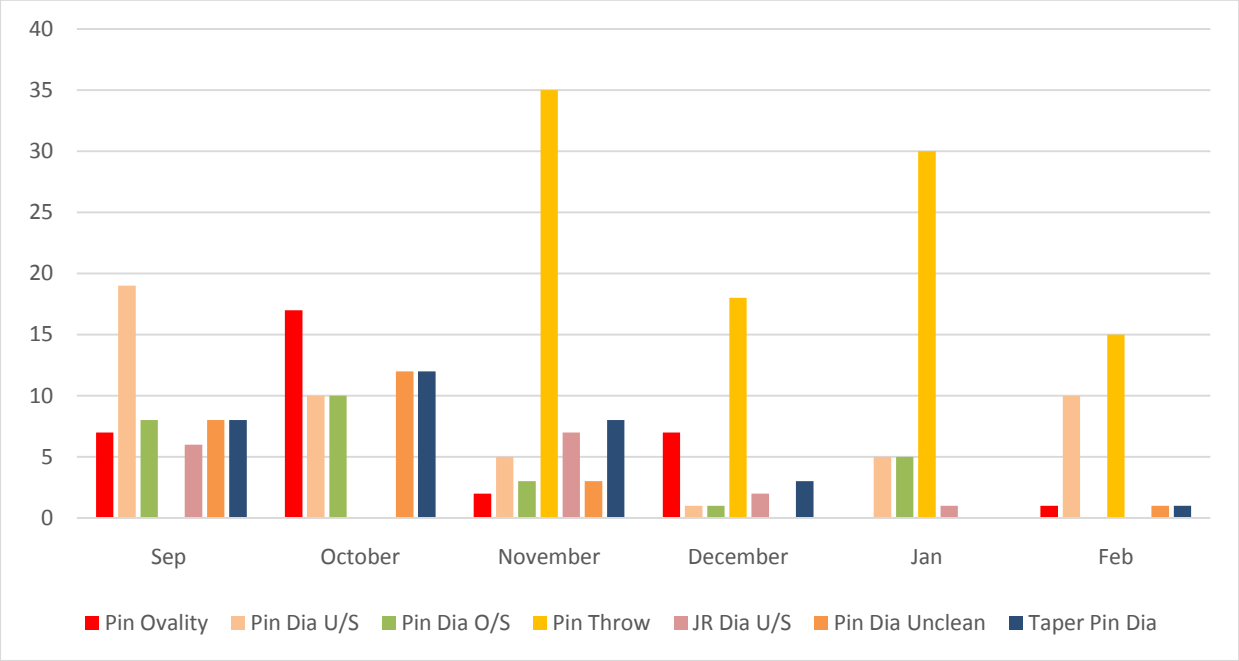


Fig-5: Month wise Trial Result on SCRAP of BFL CL1 line

3. FINAL CHECK SHEET AND MACHINE PARAMETER:

From the fig-4 Data we conclude that the prepared sheet is just in the acceptable tolerance of any normally functioning industry shows bellow

GRINDING MACHINE CHECKSHEET PARAMETERS				
S.N	**PARAMETER**	**SPEC**	**FREQUENCY**	**CHECKING**
	After/ while Dressing parameters to be check			
1	Wheel width	46.5 mm Min	Daily	Check
	During component Machining			
	For Old wheel			
2	Travels	min wheel width 46.5 mm	Daily	Check
	For New Wheel			
3	Travels	wheel width 49.7 mm	Daily	Check
	Machine Condition			
4	steady deflection	Vertical = + 2 mic Horizontal= -6 mic	1/Month	Inspect/Adjust
5	Steady pad condition	No sharp edge/loose/crack	Daily	Check
6	Steady clamping pressure	14 to 22 bar	Weekly	Check
7	Marphoss Checking (Linkage, bolt etc.)	No Crack/ No loose / No Damage	Monthly	---
8	Marphoss rinsing	Active or deactive	Daily	Check
9	Marphoss cylinder forward and backward proxy setting	---	Weekly	Inspect/Adjust
10	Coolant temperature	26 to 30^{0}C at knoll unit	Daily	Check

11	V block setting and inspection	Gap checking in between Component 0.5 mm max and part receiver, bolts condition	Weekly	Inspect/Adjust
12	Centre tip run out	2 mic	Weekly	Inspect/Adjust
13	Clamping Jaw and bolt condition	Crack, wear out loose fiment etc.	Weekly	
14	Tailstock forward proxy setting	---	Weekly	Inspect/Adjust
15	Centre condition	No wear/step/crack/dent	Weekly	Check
16	Steady journal roundness/unclean before pin grinding	Roundness within 3mic & clean	Daily	Inspect/Adjust
17	Steady journal Run out after pin grinding	Within 0.15mm	Inspect/Adjust	Daily
18	Steady pad condition	No sharp edge/loose/crack	Check	Daily
19	Chuck bearing condition	free rotation/ No abnormal sound	Weekly	Check

Table-1: Grinding Machine Parameter

3.1 Standard Check Sheet:

From the reference and past experience we conclude the final check sheet for defect of ovality. And for ease of handling just we tabulate them as below.

Defect	**Method**	**Root Causes**	**Action Taken**	**Checking Frequency**
Ovality	Man	Wrong Correction Added	Refer SOP	……..
		Nozzle Position Changed	Nozzle PositionSetting	1/ week
		Wrong Input condition	After Hardening J4 run out high	1/5 parts
		V block setting and inspection	Gap checking in between Component 0.5 mm	Weekly / confirm
		Centre tip run out	5 microns	Weekly / confirm
	Machine	Fault in Various Machine Alarm		None
		Power Fluctuation	……..	……..
		Steady deflection	Vertical = + 2 microns Horizontal= -6 microns	1/Month
		Steady pad condition	No sharp edge/loose/crack	Weekly
		Steady clamping pressure	Should be between 15 to 20 bar	Weekly
		Coolant Press. Malfunction	Lanny Valve Replacement	Damaged
		Clamping Jaw and bolt condition	crack, wear out loose fiment etc.	Weekly
		Tailstock forward & reverse setting	Confirm positive stroke should be at least 8 to 10 mm & it should not clamp on chamfer.	1/setup
		Centre condition	No wear/step/crack/dent	Weekly
		Steady journal roundness/unclean before pin grinding	Roundness within 3mic & clean	1/ setup

		Work head & tail stock alignment	Should be within 0.03 to 0.05 mm	1/six months
	Process	Uneven Grinding cut	Should be within 3 micron	1/Set-up
		Steady journal roundness/ Unclean before pin grinding	Roundness within 3mic & clean	Daily
		Steady journal Run out after pin grinding	Within 0.15mm	Daily
	Material	Improper Heat-Treatment	None	Sample/Lot
	Environment	No Causes related to ovality	None	None

Table-2: Standard check sheet for ovalirty

4. CONCLUSION

Although the decision making criteria and co-ordination of process is quite for imposed challenging problem which however where welcome by us, Due to availability of good reference and expertise to very close tolerance and thereby minimizing the level scrap production specially in grinding due to ovality.
In this, we can do some machine wise changes and analyse so that it can meet the requirement of the people like automation and many other aspects. And we succeeded in that reduced the overall scrap from 59 count (last 8 months) approx. 29.5% to 1 per month in FEB approx. 2.9%.

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