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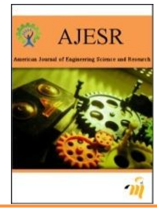

AN EXPERIMENTAL STUDY ON THE TRANSMISSION GEAR TOOTH RUNOUT

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ABSTRACT

Runout is a characteristic of gear quality that results in an effective centre distance variation. In other words, the amount a gear or wheel moves in and out away from its true centre as it is rotated. Runout causes backlash in gears, accumulated pitch variation and noise during the transmission of gears in motion. The goal of our project is to reduce the runout in the speed gears of the input and output shafts. The solution is achieved by analysing the machining line of the gears and the problems are narrowed down by using of the tools of quality. The problems faced are resolved with the implement of new solutions. The budding face width of the basic wear part called flange is increased to have a higher stability which reduces the vibration. A collet is introduced in the main bunk to have a firm grip for the work piece. The implementation of these solutions results in the reduced runout in gears which enables the quality of the gears to reach closer to the specification.

INTRODUCTION

A gear is a rotating machine part having cut teeth, which mesh with another toothed part to transmit torque, in most cases with teeth on the one gear being of identical shape, and often also with that shape on the other gear. Geared devices can change the speed, torque, and direction of a power source. Helical or "dry fixed" gears offer a refinement over spur gears. The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling causes the tooth shape to be a segment of a helix.The hand of helix is designated as either left or right.Most of the transmission gears are helical gears since higher strength compared with a spur gear, more effective in reducing noise and vibration when compared with a spur gear.Gears are produced generally by the following machining processes. [1]

GOVERNING PROCESSES

Gear Hobbing:

Gear hobbing is a machining process in which gear teeth are progressively generated by a series of cuts with a helical cutting tool.

Gear Shaving:

Primarily gear shaving is a finishing operation in which the deburred gear is machined to get a smooth surface that meets required specification.

Gear Deburring:

After hobbing operation the next step in gear manufacturing is gear deburring. In this process bur produced during hobbing operation is removed using required machine.

Gear deburring process is a one that deals with the outer edges of the gears and has nearly zero effect on the gear runout problem. Hence the main problems are dealt with the hobbing machine and gear shaving machine. The gears are tested immediately after the machining process of each stage using the gear comparators. These comparators are generally called as gear runout comparators. The main problem may be in the gear hobbing or shaving machine hence the above mentioned method is used to narrow down to the machine. Now these causes are detailed, studied and finally rectified to improve the quality of the gear. [3]

MAJOR CAUSES:

The possible causes for the OBD RUNOUT defect are being observed with the help of the cause and effect diagram or the fishbone diagram.

VALIDATION OF CAUSES USING CHECK SHEET

The major causes for the OBD runout were analysed and the root causes for the runout were validated using check sheet. These are listed as follows:

From the above check sheet it can be observed that the problems were found in machine and measurement of various parts like wear parts, tool and work piece.[5]

First the various machines involved in production were validated using data collection and then analyzed using Statistical Process Control Study. Next step is inspecting the wear parts of the machine.

STATISTICAL PROCESS CONTROL STUDY OF HOBBING MACHINE

The below chart shows that manufacturing of gear in hobbing machine is very poor. Thus control charts helps in finding the reasons for out-of-control of rejection of parts in 3rd PA Output Gear.

From the statistical process control study it is clear that the main problem is in the hobbing machine and action has to be taken in the hobbing process.

STATISTICAL PROCESS CONTROL STUDY OF SHAVING MACHINE

The above study ensures that the machining operation is in shaving machine is in a god state and hence the next stage of checking the wear parts is been carried out.The shaving machines statistical process control is within the range hence the wear parts of the hobbing machine and the shaving machine are validated for their quality and the the problem is analyzed. From then the checking process is carried out and then was found to be the accumulation of burs in the hobbing machine and shaving machine.[4]

SOLUTIONS

1. Here the reason for the misalignment in the hobbing machine is the accumulation of the burs from the previous machining operation. Hence these burs must be removed from base of the hobbing machine. For this purpose the pneumatic air blower is installed. Here the input for the air blower is obtained from the already installed compressor line which is used for the purpose of blowing the residual coolant in the machined work pieces.

After each machining operation the air blow gun is used around the working arbor. The burs formed during the previous hobbing machine process are accumulated around the arbor and this makes the seating of another work piece to be in a misaligned position. So to overcome this newly installed air gun is used around the arbor to remove the accumulated burs.[6]

2. In shaving machine for proper contact of work piece with flange, an increase in budding face is recommended. Thus by increasing the budding face, there will be more contact between the work piece and the flange. Increase in budding face of a flange is recommended at both right and left flange.

Here it is the old model design of the flange that is in existence in the machine which comes in the direct contact of the work piece and the contacting width with that of the work piece is minimum so that there will be vibrations during the machining process. To reduce this, the width of the budding face is being increased to a level where the width will provide extra firmness that will overcome the defect due to vibration. The width increased is checked with the dimensions of the work piece also since excess width must not be provided.

Thus it is concluded that by increasing the budding face of the right flange and left flange exact mating between the work piece and the flange will occur. This reduces the stress and the any misalignment between the work piece and the flange during machining process.

3. For any misalignment of work piece during machining operation due to vibration is reduced by using a collet.[7]

A collet is a holding device specifically, a subtype of chuck that forms a collar around the object to be held and exerts a strong clamping force on the object when it is tightened, usually by means of a tapered outer collar. It may be used to hold a work piece or a tool.

The details are as follows:

Hence here the collet provided is a round collet which gives a firm grip to the work piece when the machining operation is done. The work piece when it is placed the strong gripping force of the collet makes sure there is zero movement during the machining operation ofthe gears. Thus using collet, the misalignment due to movement during the machining operation is arrested. And also the rejection of gears due to OBD runout is reduced.

Fig 1. Cause and effect diagram or the fishbone diagram

The possible causes for the OBD RUNOUT defect are being observed with the help of the cause and effect diagram or the fishbone diagram.[8]

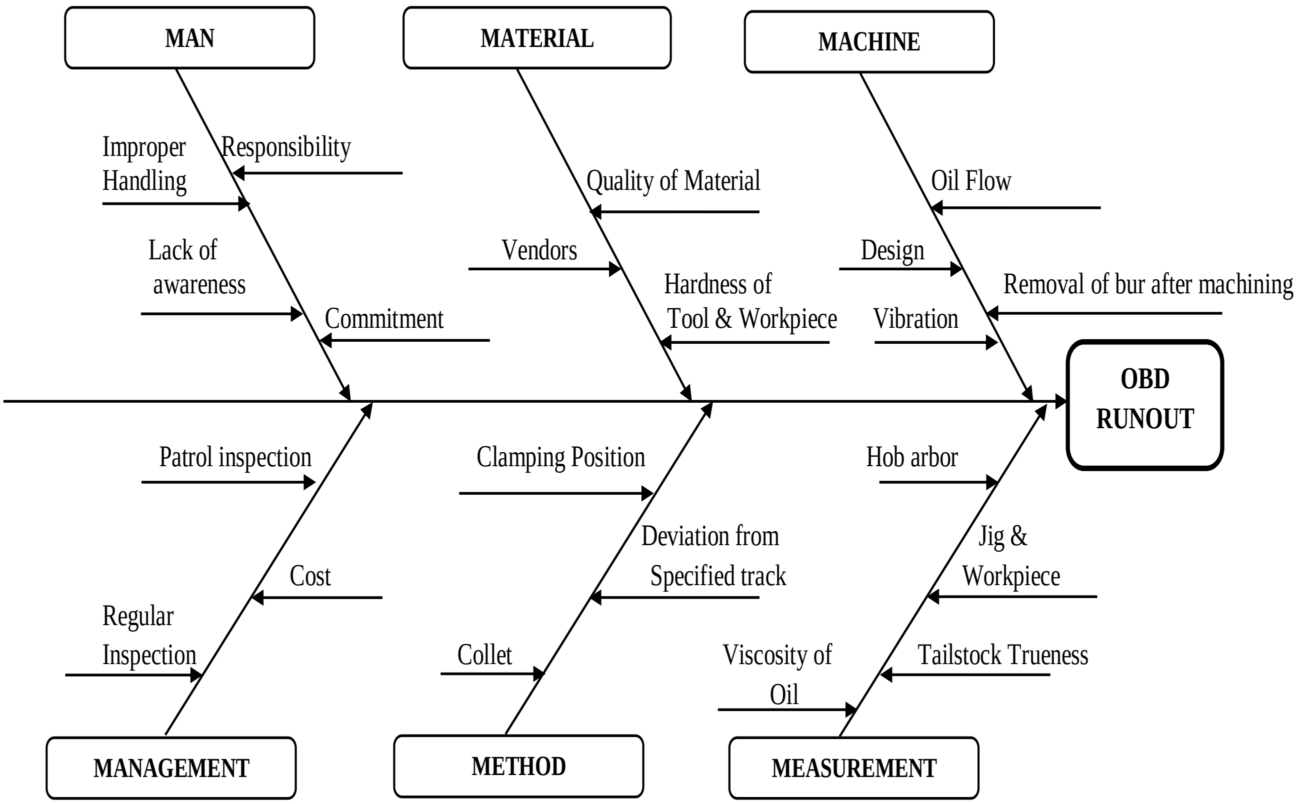


Table 1.Validation Of Causes Using Check Sheet

Category	Reason	Technique used	Valid	Invalid
MACHINE	Design	Inspection	✓	
	Vibration	Observation	✓	
	Oil Flow	Observation		X
	Removal of bur after machining	Observation & Inspection	✓	
METHOD	Clamping Position	Observation & Inspection		X
	Deviation from specified track	Data Collection		X
	Collet	Inspection	✓	
MEASUREMENT	Hob arbor	Inspection	✓	
	Viscosity of oil	Inspection		X
	Tailstock trueness	Inspection	✓	
	Jig &workpiece	Inspection	✓	

From the above table it can be observed that the problems were found in machine and measurement of various parts like wear parts, tool and work piece.First the various machines involved in production were validated using data collection and then analyzed using Statistical Process Control Study. Next step is inspecting the wear parts of the machine [9].

Fig 2. Increase in budding face of left flange

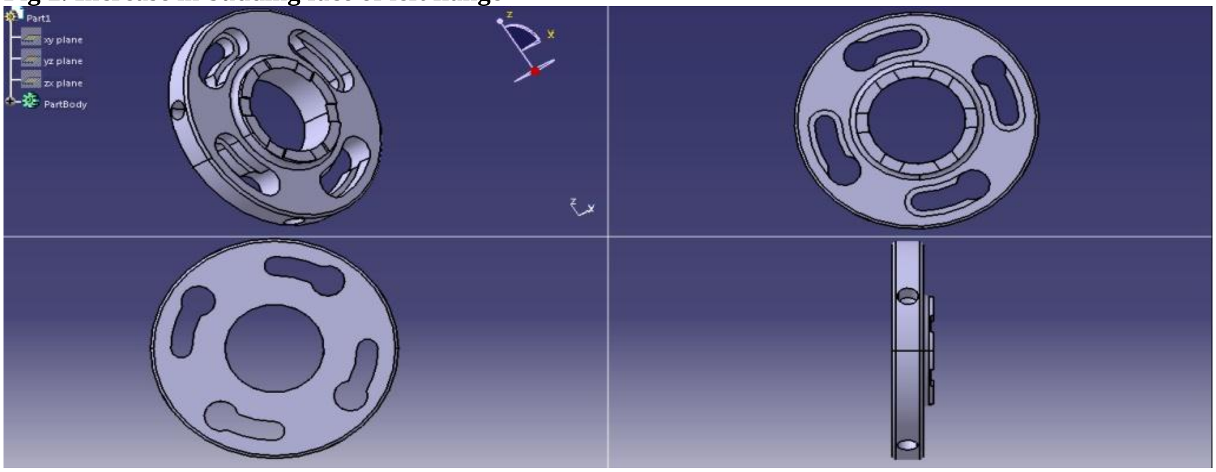


Fig 3. Increase in budding face of right flange

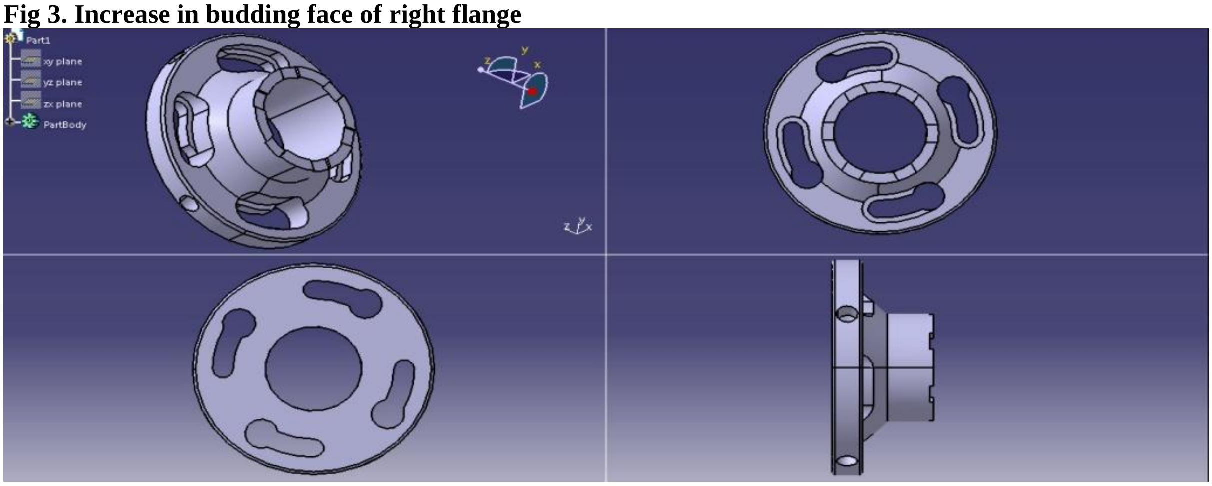


Fig 4. Collet in the shaving machine

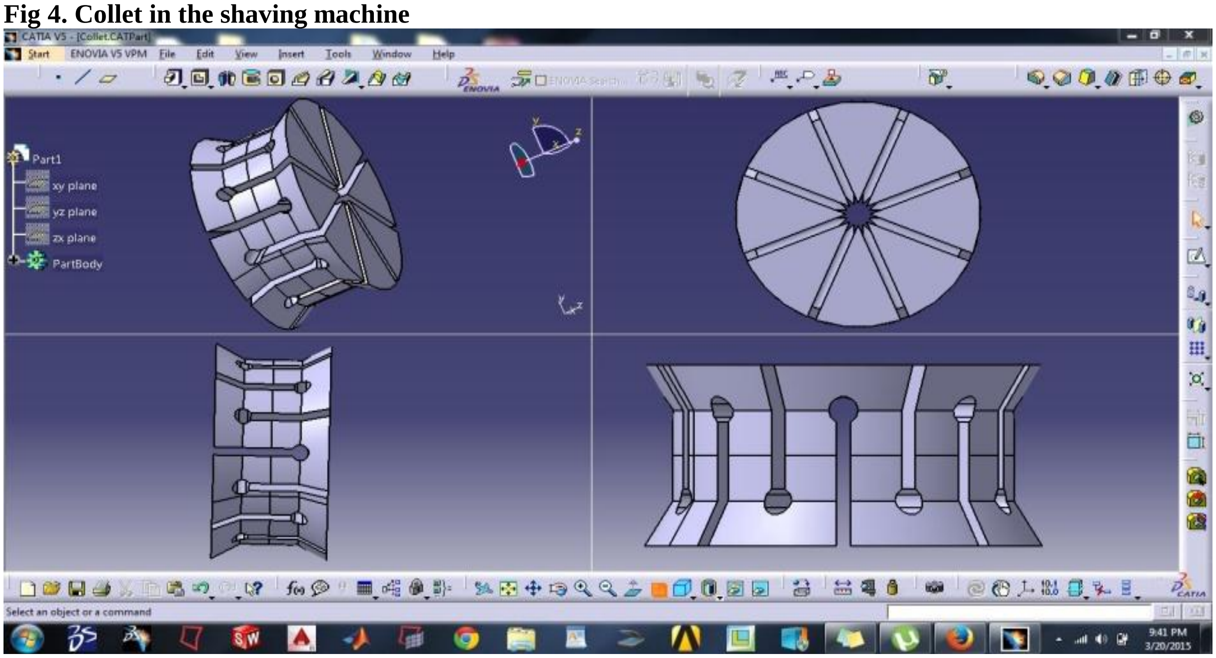


Table 2. Statistical process control study of hobbing machine:

STATISTICAL PROCESS CONTROL STUDY

PART NAME:	**PA- 3rd OP SPEED GEAR**	INSTRUMENT:	**COMPARATOR**	L.COUNT:	**0.001**	LINE	**345 OP GEAR LINE**
PART NO:	**43263-02610**	SPEC:	**0.033**	OPRN.NO:	**40**		
SAMPLE SIZE:	**50**	OPERATION:	**HOBBING**				

S.NO	1	2	3	4	5	6	7	8	9	10		
1	0.0250	0.0600	0.0800	0.0250	0.0350	0.0550	0.0400	0.0350	0.0550	0.0450	**U.T.L**	0.033
2	0.0550	0.0550	0.0700	0.0330	0.0380	0.0650	0.0350	0.0400	0.0520	0.0550		
3	0.0450	0.0540	0.0650	0.0340	0.0400	0.0400	0.0620	0.0450	0.0540	0.0600		
4	0.0170	0.0450	0.0450	0.0550	0.0650	0.0300	0.0450	0.0550	0.0450	0.0480	**L.T.L**	0
5	0.0650	0.0300	0.0400	0.0450	0.0700	0.0350	0.0550	0.0600	0.0450	0.0500		
X_{LARGE}	0.0650	0.0600	0.0800	0.0550	0.0700	0.0650	0.0620	0.0600	0.0550	0.0600	X_{MAX}	0.0800
X_{SMALL}	0.0170	0.0300	0.0400	0.0250	0.0350	0.0300	0.0350	0.0350	0.0450	0.0450	X_{MIN}	0.0170
RANGE	0.0480	0.0300	0.0400	0.0300	0.0350	0.0350	0.0270	0.0250	0.0100	0.0150	**R-BAR**	0.02950
AVG	0.0414	0.0488	0.06	0.0384	0.0496	0.045	0.0474	0.047	0.0502	0.0516	**X-BAR**	0.048

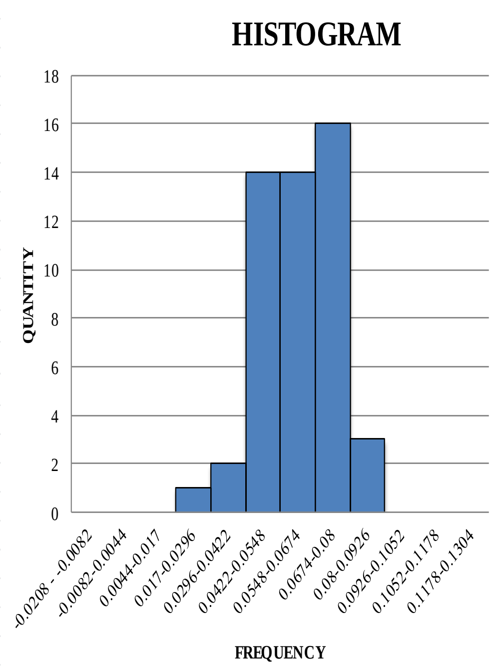
SAMPLE	D2	A2	D4
1	1.123	2.56	3.27
2	1.128	1.88	3.27
3	1.693	1.02	2.57
4	2.059	0.73	2.23
5	2.326	0.59	2.11

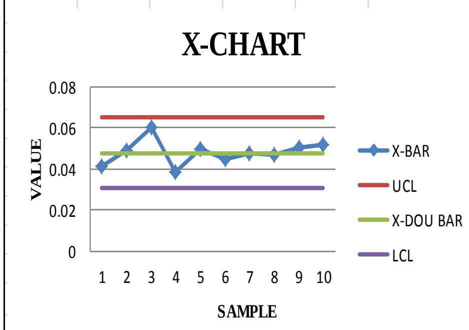
NO. OF NON CONFORMANCE PART =	44
NO.OF PARTS ABOVE U.T.L =	44
NO OF PARTS BELOW L.T.L =	0

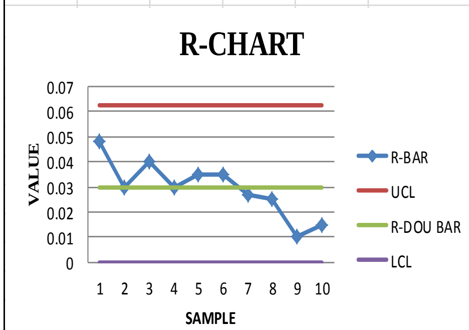
Process Width(P)=	0.0630	Specification Width(S)=	0.0330	Index(K)={2*(D-XBAR)/S)=	1.9031
Design Centre(D)=	0.0166	Interval =	0.0126	Selecting no of classes =	5
Starting Point =	0.0170	No. of Readings =	50	Shift of 'X-BAR' from 'D'=	0.031400

INTERVALS		FREQ.	CU. FREQ
-0.0208	0.0082	0	0
-0.0082	0.0044	0	0
0.0044	0.017	0	0
0.017	0.0296	1	0
0.0296	0.0422	2	0
0.0422	0.0548	14	0
0.0548	0.0674	14	0
0.0674	0.08	16	0
0.08	0.0926	3	0
0.0926	0.1052	0	0
0.1052	0.1178	0	0
0.1178	0.1304	0	0

UCL $_{X\text{-}BAR}$ =	0.065405
LCL $_{X\text{-}BAR}$ =	0.030595
UCL $_{R\text{-}BAR}$ =	0.062245
LCL $_{R\text{-}BAR}$ =	0
Std.Dev 'σ'	0.01268
Cp = (S/6σ) =	0.43366
Cpk = {(1-k)*Cp} =	0.39164







RESULT	PROCESS IS VERY POOR TAKE IMMEDIATE ACTION

Table 3. Statistical process control study of shaving machine:

STATISTICAL PROCESS CONTROL STUDY

PART NAME:	**SPEED GEAR**	INSTRUMENT:	**COMPARATOR**	L.COUNT:	**0.001**	**TABLE VALUES**
		SPEC:	**0.033**			
SAMPLE SIZE:	**50**	OPERATION:	**SHAVING**			

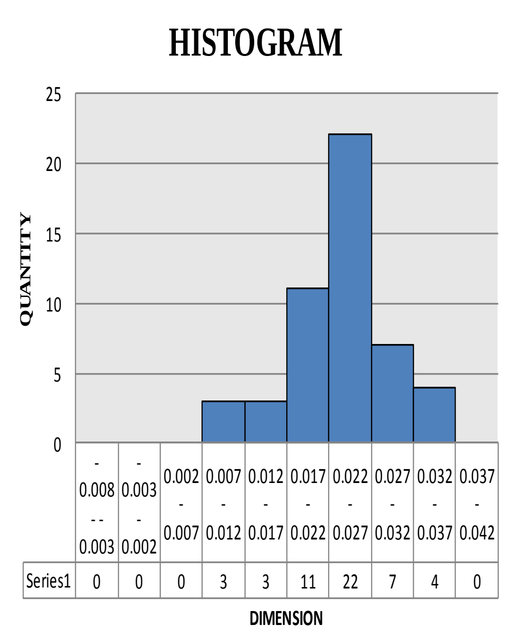
S.NO	1	2	3	4	5	6	7	8	9	10			SAMPLE	D2	A2	D4
1	0.019	0.02	0.026	0.022	0.023	0.015	0.019	0.017	0.02	0.026	**U.T.L**	0.000	1	1.123	2.56	3.27
2	0.014	0.015	0.02	0.007	0.008	0.014	0.017	0.031	0.032	0.015			2	1.128	1.88	3.27
3	0.019	0.009	0.019	0.021	0.018	0.025	0.02	0.02	0.028	0.021			3	1.693	1.02	2.57
4	0.007	0.023	0.021	0.008	0.015	0.02	0.018	0.031	0.015	0.024	**L.T.L**	0.033	4	2.059	0.73	2.23
5	0.022	0.026	0.02	0.007	0.017	0.02	0.02	0.022	0.02	0.017			5	2.326	0.59	2.11

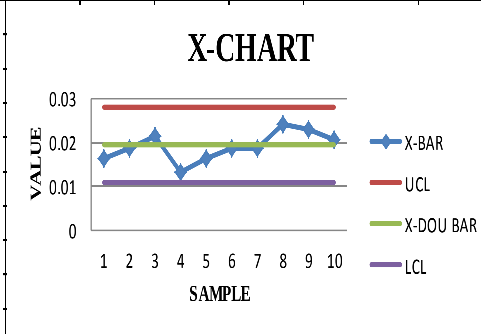
X_{LARGE}	0.022	0.026	0.026	0.022	0.023	0.025	0.02	0.031	0.032	0.026	X_{MAX}	0.032	NO. OF NON CONFORMANCE PART =	0
X_{SMALL}	0.007	0.009	0.019	0.007	0.008	0.014	0.017	0.017	0.015	0.015	X_{MIN}	0.007		
RANGE	0.015	0.017	0.007	0.015	0.015	0.011	0.003	0.014	0.017	0.011	**R-BAR**	0.0125	NO.OF PARTS ABOVE U.T.L =	0
AVG	0.0162	0.0186	0.0212	0.013	0.0162	0.0188	0.0188	0.0242	0.023	0.0206	**X-BAR**	0.01906	NO OF PARTS BELOW L.T.L =	0

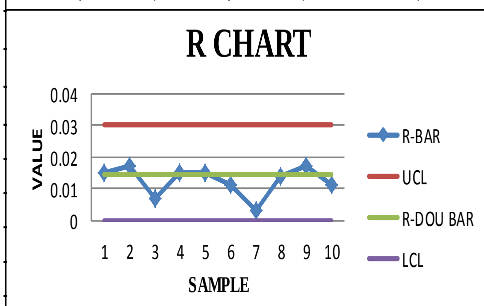
Process Width(P)=	0.025	Specification Width(S)=	0.0330	Index(K)={2*(D-XBAR)/S}=	0.1491
Design Centre(D)=	0.0166	Interval =	0.005	Selecting no of classes =	5
Starting Point =	0.007	No. of Readings =	50	Shift of 'X-BAR' from 'D'=	0.031400

INTERVAL		FREQ	CU. FREQ
-0.008	-0.003	0	0
-0.003	0.002	0	0
0.002	0.007	0	0
0.007	0.012	3	3
0.012	0.017	3	6
0.017	0.022	11	17
0.022	0.027	22	39
0.027	0.032	7	46
0.032	0.037	4	50
0.037	0.042	0	50

$UCL_{X\text{-}BAR}$ =	0.027857
$LCL_{X\text{-}BAR}$ =	0.010983
$UCL_{R\text{-}BAR}$ =	0.030173
$LCL_{R\text{-}BAR}$ =	0
Std.Dev 'σ'	0.005374033
Cp = (S/6σ) =	1.023439938
Cpk = {(1-k)*Cp} =	0.870845043







RESULT	PROCESS IS GOOD

CONCLUSION

In the hobbing machine the additional provision of the pneumatic air gun blower which has the input from the main compressor line is used to remove the bur accumulated in the arbor. This reduces the misalignment in the seating position of the workpieces along with the flange which reduces the runout. In shaving machine for proper contact of work piece with flange, an increase in budding face is recommended. Thus it is concluded that by increasing the budding face of the right flange and left flange exact mating between the work piece and the flange will occur. This reduces the stress and the any misalignment between the work piece and the flange during machining process. The collet provided is a round collet which gives a firm grip to the work piece when the machining operation is done. The work piece when it is placed the strong gripping force of the collet makes sure there is zero movement during the machining operation of the gears. Thus using collet, the misalignment due to movement during the machining operation is arrested. And also the rejection of gears due to OBD runout is reduced by using the recommended solutions.

REFERENCES

1. Tamura H., Liu. Z. (1997). Measurement of helical gear using coordinate measuring machine. *Journal of Japan Society of Mechanical Engineering*, 63, 252–258.
2. Smith JD. (1987) Gear Transmission Error Accuracy with Small Rotary Encoders. *SAE Technical Paper*, 874773.
3. Kohler K and Regan R. (1985). The Derivation of Gear Transmission Error from Pitch Error Records61/85.
4. Kato S, Yonekura K, Omori T. (1996). Analytical Procedure for Gear Tooth Surface Modification Reducing Gear Noise, SAE Technical Paper 852273.
5. Umezawa K. et al. (1985). Vibration of Power Transmission Helical Gears (The effect of contact ratio on the vibration). *Bulletin of JSME*, 28, 238-18.
6. Honda S. (1995). Rotational Vibration of a Helical Gear Pair with Modified Tooth Surfaces. *JSME International Journal Series C*, 38.
7. Smith JD. (1994). Helical Gear Vibration Excitation with Misalignment, C08293.
8. Lorea A, Morra G, Ruspa G. Advanced Statistical Methods for the Correlation Between Noise and Transmission Error in Gears, Fiat Research centre. (SAE Technical Paper 865144).
9. Flodin A. Wear of Spur and Helical Gears, Royal Institute of Technology, Stockholm, Doctoral Thesis, 2000.
10. Modler KH, Lovasz EC, Bar GF, Neumann R, Perju D, Perner M. (2009). Mărginean,General method for the synthesis of geared linkages with non-circular gears. *Mechanism and Machine Theory*, 44, 726-738