ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Modification of crank shaft bearing in multi cylinder four stroke petrol engine

A.K. Nachimuthu*, P. Vineeth Kumar, S. Rugunath
SVS College of Engineering, Coimbatore, Tamil Nadu, India
***Corresponding author: E-Mail: sabari88mech@gmail.com**

ABSTRACT

This project takes up the module of Crankshaft main and sub journal bearing friction. In bearings wear due to friction is always undesirable. Thus the reduction of friction reduces the wear, noise and improves the smooth rotational behavior of the element. We have replaced the prolonged use of journal bearings with compact and improved design of needle bearing. Calculation of needle bearing and journal bearing are done and comparative results are shown. It is seen that the performance of needle bearing is higher than performance of journal bearing.

KEY WORDS: Design, Friction, Journal Bearing, Needle bearing, Performance, Wear.

1. INTRODUCTION

A bearing is used to constrain virtual motion and reduces friction between moving parts to only the preferred motion. The design of the bearing may for occurrence provide for free linear movement of the moving part or for free rotation around a fixed axis or it may prevent a motion by controlling the vectors of normal forces that bear on the touching parts. Many bearings also smooth the progress of the preferred motion as much as possible such as by minimizing friction. Bearings are classified mostly according to the category of operation, the motions permitted, or to the guidelines of the loads (forces) functional to the parts. Bearings are classified into two types based on their usage. The two basic categories of bearing are Plain bearing and Roller bearing.

Table.1. Wear test for Plain Bearing Material

Sample Material	Gunmetal
Sample Dimension	Diameter = 8mm; Length = 35 mm
Disk Material	EN 31 Steel
Disk Size	60 mm

Table.2. Mechanical and substantial properties of Bearing Materials

Resources	Density Kg/m^3	Poisson Ratio	Young's Modulus MPa	Co-efficient of Thermal expansion	Thermal Conductivity
Gunmetal	8719	0.33	95100	1.883e05/C	74.80W/m-K
SAE 21500	8750	0.29	21500	13.25e06/C	46.60 W/m-K

Table.3. Wear test for Gun metal of 5 Minutes duration

Weight (Kg)	Speed (rpm)	Frictional force (N)	Wear (Microns)
0.50	845	9.70	97
1	845	14.20	118

$$\text{Sliding Speed} = \frac{\pi DN}{60}$$

Where, D = Drag Diameter = 60 mm, N = beginning of disk = 845 rpm

Therefore, Sliding Speed = $\frac{\pi \times 60 \times 845}{60}$ = 2654.64 mm/minute

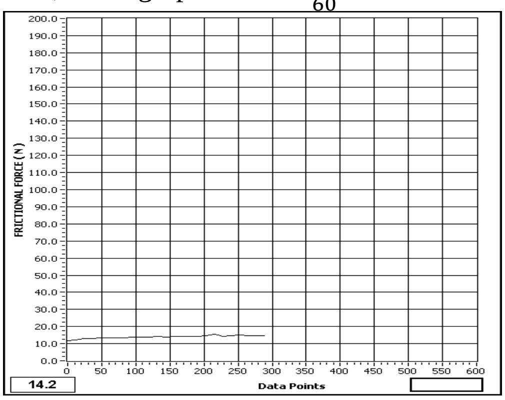

Fig.1. Exact frictional force at 1 Kg

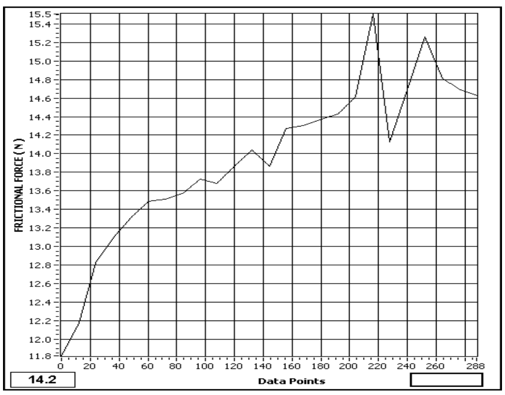

Fig.2. Magnified frictional force at 1 Kg

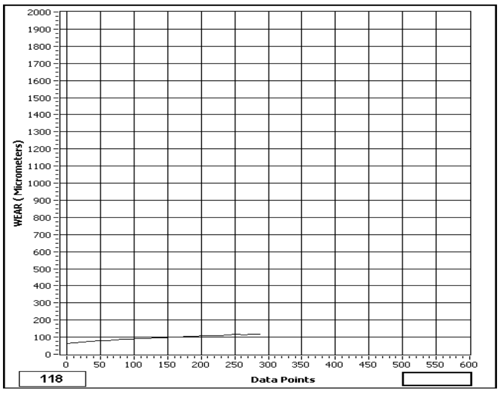

Fig.3. Exact Wear at 1 Kg

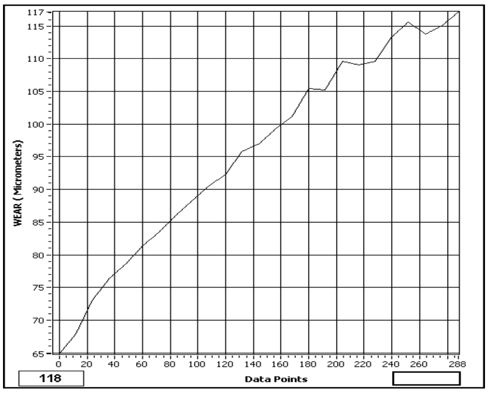

Fig.4. Magnified Wear at 1 Kg

Table.4. Wear test for Needle Bearing Material

Specimen Material	SAE 52100 Alloy Steel
Specimen Dimension	Diameter = 8 mm, Length = 35 mm
Disk Material	EN 31 Steel
Disk Size	60 mm

Table.5. Wear test for SAE 52100 alloy steel of 5 Minutes duration

Load (Kg)	Speed (rpm)	Frictional force (N)	Wear (Micron)
0.5	845	4.7	8
1	845	9.1	57

From table.5, we got the above results from the wear test. The following the graph shows the wear and frictional force of the needle bearing specimen.

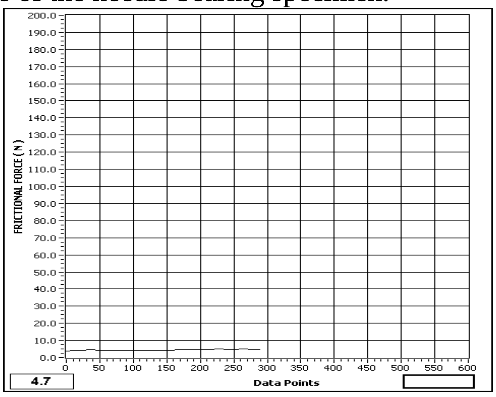

Fig.5. Magnified frictional force at 0.5 Kg

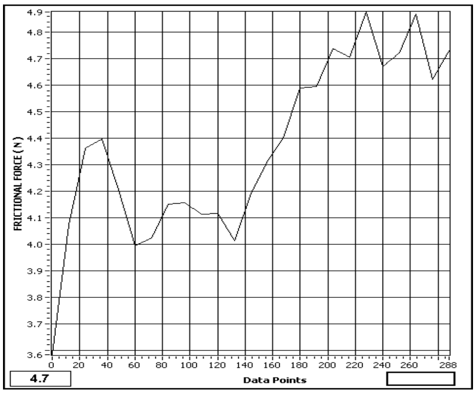

Fig.6. Magnified frictional force at 0.5 Kg

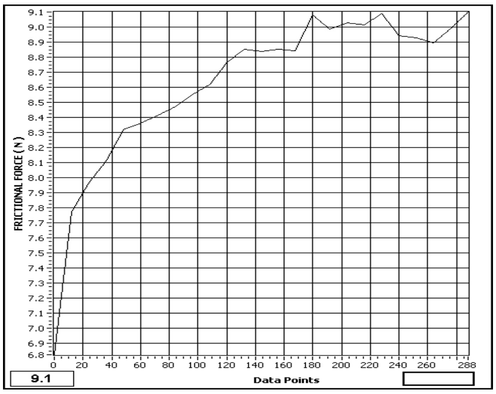

Fig.7. Magnified frictional force at 1 Kg

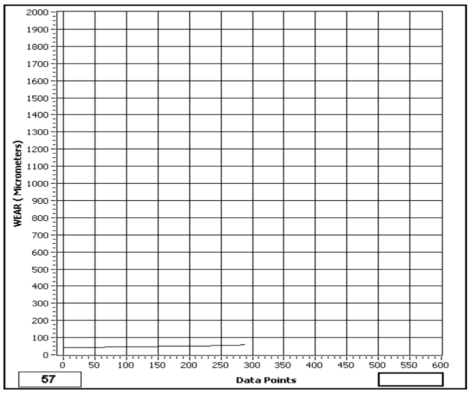

Fig.8. Exact Wear at 1 Kg

DISCUSSION

From the above experiments we found that the wear of the material SAE 52100 alloy steel is lesser than that of the Gun Metal. Hence the bearing material is SAE 52100 is selected as the bearing material. The bearing that has SAE 21500 alloy steel is needle roller bearing. Hence we use this bearing for replacing journal bearing in the engine crankshaft.

Table.6. Life Calculation for Bearing Engine

Type	Water cooled SOHC petrol	
Displacement	796cc	
Cylinders	3	
Valve train	2valves per cylinders	
Bore & stroke	68.5×72.0mm	
Max power	37BHP @5000rpm	
Max torque	59Nm@2500rpm	
Power/weight ratio	56.92 BHP/ton	55.63 BHP/ton
Torque/weight ratio	90.76 Nm/ton	88.72Nm/ton
Drive train	FWD	
BHP/liter	46.25	
Transmission	4-speed manual	

For Big Journal: T = 59 Nm @ 2500 rpm (in the engine specification)

Force (F) = $\frac{T}{r}$

r = Radius of big journal

Where, D= 50 mm, r = 50 / 2 = 25 mm = 25×10^{-3} m, F = T / r = 59 / 25×10^{-3}, F = 2360 N → Radial load,
Axial load (AL) = 0.5RL= 0.5 × 2360, AL = 1180 N

Total load (P) = RL + AL

= 2360 + 1180

P = 3540N

From Needle bearing load rating data size of diameter 50mm has c = 45000 and þ = 3.33

C → basic dynamic rated load.

Þ → constant roller bearing.

P → Bearing load.

$L_{10} = \{C / P\}^{þ}$

$= \{45000 / 3540\}^{3.33}\times10^6$

$L_{10} = 4753.5\times10^6$ rev

For $L_{10} = 4753.5\times10^6$ rev

n= 2500 rpm

$L_{10} = 60\times n\times L_h / 10^6$

$L_h = 4753.5\times10^6 / 60 \times 2500$

L_h =31686.667 hours

Life of needle bearing (L_h)=3.61years

Life of plain bearing (L_h)=2.92years

For Small Journal: T = 59 Nm @ 2500rpm (in the engine specification)

Force (F) = T / r

r = Radius of small journal

Where, D = 38 mm, r = 38 / 2 = 19 mm = 19×10^{-3} m, F = T / r = 59 / 19×10^{-3}, F = 3106 N → Radial load

Axial load (AL) = 0.5RL= 0.5 × 3106

AL = 1552 N

Total load (P) = RL + AL= 3106 + 1552

P = 4658N

From Needle bearing load rating data size of diameter 38mm has C = 60000 and þ = 3.33

C → basic dynamic rated load.

Þ → constant roller bearing.

P → Bearing load.

$L_{10} = \{C / P\}^{þ}$

$= \{60000 / 4658\}^{3.33}\times10^6$

$L_{10} = 4967.9\times10^6$ rev

For $L_{10} = 4957.9\times10^6$ rev

n= 2500 rpm

$L_{10} = 60\times n\times L_h / 10^6$

$L_h = 4957.9\times10^6 / 60 \times 2500$

L_h =33052.667 hours

Life of needle bearing (L_h)=3.77years

Life of plain bearing (L_h)=2.96years

Life of the bearing:

$$L = \left[\frac{1}{\left(\frac{1}{L_1^e}\right)+\left(\frac{1}{L_2^e}\right)+\left(\frac{1}{L_3^e}\right)+\left(\frac{1}{L_4^e}\right)+\left(\frac{1}{L_5^e}\right)+\left(\frac{1}{L_6^e}\right)+\left(\frac{1}{L_7^e}\right)}\right]^{1/e}$$

Where, e = 9 / 8 =1.125, L_1, L_3, L_5, L_7→ for big journals, L_2, L_4, L_6 → for small journals, L = 6.412×10^8 revolutions.

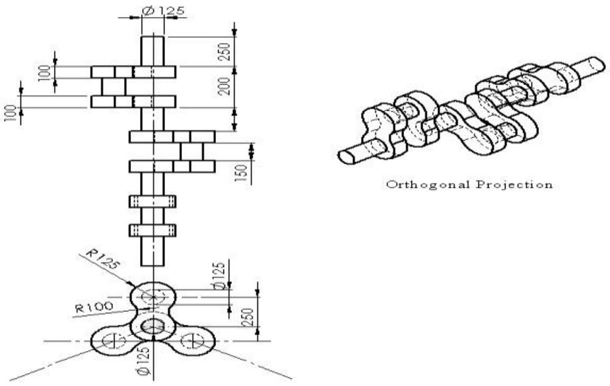

Fig.9. Isometric Projection of Crankshaft

Performance Test Formula:

Brake Power (Bp) = BP = $\frac{2\pi NT}{60 \text{ x } 1000}$Kw

Where, T = (W-S) x π x 9.81, W = Weight added in Kg, S = spring balance Weight in Kg

Total Fuel Consumed (TFC) = TFC = $\frac{q}{t}$ x $\frac{\rho}{1000}$Kg/Kw.hr

Where, q = fuel consumption (10cc), t = time take for 10cc of fuel consumption (sec), ρ = density of fuel used = 0.749 (gm/cc) for Petrol

Friction Power (FP) (from William's line graph):

Indicated Power (Ip) = Ip = Bp + Fp (Kw)

Mechanical Efficiency (η_{mech}) = η_{mech}= $\frac{Bp}{Ip}$x 100

Table.7. Performance test of 4 Stroke Petrol Engine with Plain Bearing

Speed N (rpm)	Time T (Sec)	Load			TFC (Kg/Kw.hr)	Fp (Kw)	Torque (Nm)	Bp (Kw)	Ip (Kw)	η_{mech} (%)
		W	S	W-S						
1500	105	5	1.2	3.8	0.26	2.094	117.11	18.39	90.39	20.34
1487	87	10	1.8	8.2	0.31	2.497	252.71	39.35	111.35	35.34
1463	73	15	2.3	12.7	0.37	2.981	372.91	59.96	131.96	45.44
1442	69	20	4.5	15.5	0.39	1.162	486.94	72.13	144.13	50.04

Brake Power (Bp) = BP = $\frac{2\pi \text{ x } 1500 \text{ x } 117.11}{60 \text{ x } 1000}$= 18.39 Kw

Where, T = (5 – 1.2) x π x 9.81 = 117.11, W = Weight added in Kg, S = spring balance Weight in Kg

Total Fuel Consumed (TFC) = TFC = $\frac{10}{105}$ x $\frac{0.749}{1000}$= 0.26Kg/Kw.hr

Where, q = fuel consumption (10cc), t = time take for 10cc of fuel consumption (sec), ρ = density of fuel used = 0.749 (gm/cc) for Petrol

Frictional Power (FP): Frictional power for Plain Bearing = 72 Kw

Frictional power for Needle Bearing = 50 Kw (from fig 13.2)

Indicated Power (Ip) = Ip = 18.39 + 72= 90.39 Kw

Mechanical Efficiency (η_{mech}) = η_{mech}= $\frac{18.39}{90.39}$x 100 = 20.34

Table.8. Performance test of 4 Stroke Petrol Engine with Needle Bearing

Speed N (rpm)	Time T (Sec)	Load			TFC (Kg/Kw.hr)	Fp (Kw)	Torque (Nm)	Bp (Kw)	Ip (Kw)	η_{mech} (%)
		W	S	W-S						
1500	102	5	1.2	3.8	0.26	2.094	117.11	18.40	68.4	26.9
1483	81	10	1.8	8.2	0.339	2.731	252.71	39.25	89.25	43.49
1432	64	15	2.9	12.1	0.42	3.383	372.91	55.92	105.92	52.3
1397	58	20	4.2	15.8	0.46	3.701	486.94	71.24	121.24	58.27

2. CONCLUSION

The replacement of bearing in perspective with the load rating, life and running hours is based upon the fact of oil seals, blow of gas pressure, environmental conditions in which the engine prevails to work. This method of confining the bearing analysis gets into wide parametrical features. The journals which are fixed in the crank holds the running life much better so far than the other bearings right from the initial stage of crank installation.

Needle roller bearing is one of the widely used machine component nowadays for high load ratings too. The same also could be used in the crankshafts and loading is tested with the life, load rating. The engine is tested for various speeds and friction loads. The comparative statement for various plots is seen and that the results are positive towards the needle bearing. Thus this project shows out the results for replacement for journal bearing with needle bearing.

It provides better results than the journals in main and sub areas, which has better running hours and smooth working. Also the cost for replacement is not much high which results high in parameters of friction, load and running without jerks.

REFERENCES

Boopalan N, Marlon Jones Louis, Nachimuthu A.K, Design and Fabrication of Hybrid Two Wheeler, International Journal of Research and Innovation in Engineering Technology, 01, 2016, 8-12.

Dumitru N. Olaru, Mihaela Rodica D. Balan, Ana Tufescu, Vlad Carlescu, Gheorghe Prisacar, Influence of the cage on the friction torque in low loaded thrust ball bearings operating in lubricated conditions, Tribiology International, 107, 2017, 306-319.

Jamadar I.M, Vakharia D.P, A Novel Approach Integrating Dimensional Analysis and Neural Networks for the Detection of Localized Faults in Roller Bearings, Measurement, 94, 2016, 177-185.

Jorge G. Salazar, Ilmar F. Santos, Active Tilting-Pad Journal Bearings Supporting Flexible Rotors: Part I – The Hybrid Lubrication, Tribiology International, 107, 2017, 94-105.

Nachimuthu A.K, Marlon Jones Louis, Vembaiyan C, Analysis and Optimizing Connecting Rod for Weight and Cost Reduction, International Journal of Research and Innovation in Engineering Technology, 01, 2014, 1-7.

Nachimuthu A.K, Minimization of Surface Roughness in CNC Turning Using Taguchi Method, International Organization for Scientific Research, 8, 2014, 47-49.

Ricardo U. Mendes, Tiago H. Machado, Experimental wear parameters identification in hydrodynamic bearings via model based methodology, International journal of the science and technology of friction lubrication and wear, 372–373, 2017, 116–129.

Tao Wang, Jun-Ying Sun, Xi-Jiang Zhao, Yong Liu, Hai-bo Yin, Ceramic-on-ceramic bearings total hip arthroplasty in young patients, Arthroplasty Today, 2, 2016, 205-209.

Vineeth Kumar P, Ragunath S, Nachimuthu A.K, Numerical Study on Fatigue Life of Spot Welding using FEA, International Journal of Chem Tech Research, 09, 2016, 158-169.