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Development of Pressure Loaded Gear Test Rig

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Abstract—*In this paper, The developed pressure loaded gear test rig which offers the possibility of field testing before applying it in real working condition has been discussed 50 HP motor was used to drive the transmission system. Sensors were used to measure oil temperature, the temperature in the gear tooth contact surface, vibration, noise, and speed of output shaft. Trial measurements were taken at 500 rpm with a pressure range of 0 to 50kg/cm^2. Loading of gears inside gear box is achieved by a hydraulic gear pump with assist of pressure relief valve. By means of this test rig, new materials for gears and design modification for gears can also be evaluated.*

Keywords: *Gear, Temperature, Noise, Vibration, Test rig.*

1. INTRODUCTION

The working of gear box relies on its, design, manufacturing, material and so forth, to foreshadow the life of power train and Gears, this type of R & D test rigs becomes mandatory [1] - [9]. To confirm the quality of oils newly developed for gears and to verify the new design of gears, test rig can be used. The FZG test rig developed in gear research center at the technological university of Munich is most often utilized for these types of test [3]. Close to FZG test rig some other scientific centers also developed their own test rig because of some limitations with the FZG test rig [4]. The interference of the gearbox doesn't only depend on gear accuracy besides that, it also depends on shafts, bearings and gearbox housing [9], [10] so it's necessary to run the gearbox in a real field like environment considering all the factors.

2. EXPERIMENTAL ARRANGEMENT

Cement concrete stage was formed for constructing the test rig system. Floor bed bolts were set along the stage and dried out for 24 hours. Afterwards that, motor and L bracket (for mounting, transmission system, Gear box, Pump) were bolted to the test rig. In the Developed test rig Gear box is directly connected to the motor output shaft were, this case of arrangement is applied to examine the performance of gear and pinion inside the Gear box as indicated in Fig. 1.

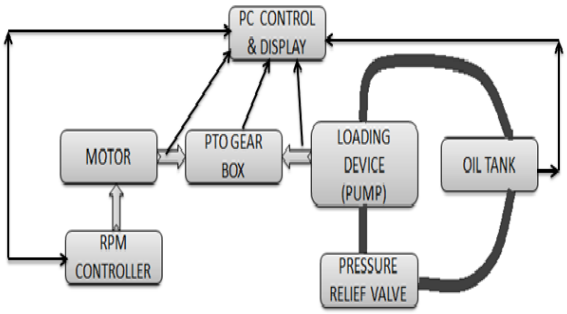

Fig. 1: Gear box directly connected to the motor

Fig. 2: Gear Test Rig

2.1. Gear Box

Gear box consists of two shafts, one is input shaft and another one is the output shaft. The input shaft is connected to the output shaft of the motor with the help of flange coupling and output shaft connects with the pump via propeller shaft and flange coupling The aim is simply to test the gears, Fig. 3 and 4 shows the exploded view of the Gear box and fabricated Gear box which shows the input and output shaft of the Gear box. Specification of the gear and the pinion is shown in Table 1.

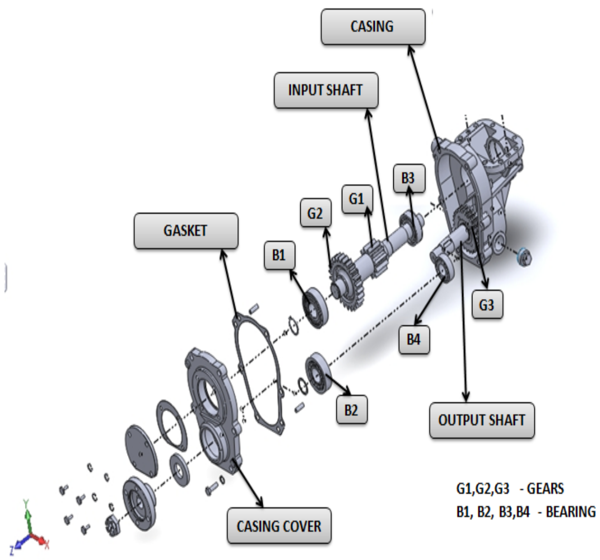

Fig. 3: Exploded View of Gear box

Fig. 4: Fabricated Gear box

Gear box used in this test rig is designed for S.A.E standard pertaining to transmission mounted. Gear box horsepower (HP) can be calculated by

HP= Pitch line velocity*engine RPM*K / 100.

Where, **K** is the factor which represents a horse power / foot of pitch line velocity that transmission can give.

TABLE 1: Specification of input shaft gear and output shaft pinion

DESCRIPTION	GEAR	PINION
Number of tooth	20	25
Face width	20 mm	20 mm
Module	4	4
Pitch circle diameter	77.9 mm	97.45 mm
Outer diameter	87.8 mm	107.3 mm
Base diameter	73.2 mm	91.5 mm
Root diameter	69.8 mm	89.3 mm
Pressure angle	20	20
Centre distance	90 mm	

2.2. Drive unit

3Φ 50 HP AC induction motor is used to give input power to the gearbox. The speed of the motor can be mastered using an RPM controller (inverter). Speed range of 0 to 3000 RPM can be attained using this RPM Controller. Motor and RPM controller arrangement is shown in Fig. 5. 1.25 times increase in speed is achieved by the gear ratio between G2 and G3 (Fig. 3). It is also possible to analyze the performance of spur gear and pinions for various combinations. Lubricating oil performance can also be examined utilizing the same test Gear box.

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Fig. 5: Arrangement of Motor and RPM controller

2.3. Loading Unit

Loading of gearbox is made out by a hydraulic gear pump. A pressure relief valve is mounted in the hydraulic line between the pump production and oil reservoir. By setting the pressure relief valve, load can be increased or decreased even in dynamic condition (Fig. 6). Hydraulic oil used here is ISO VG68 which have the best anti wear capability, this high quality oil is used in a variety of mobile and industrial applications [13]. Performance curve for ISO VG 68 is shown Fig. 7. [14]

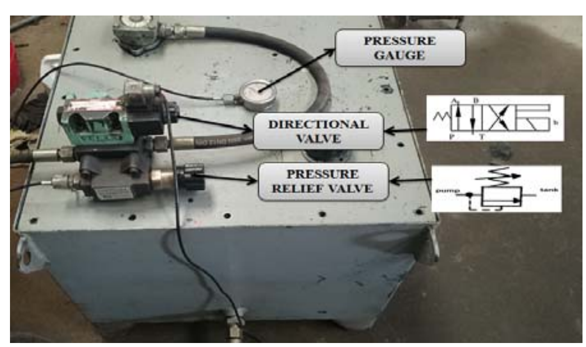

Fig. 6: Hydraulic control system

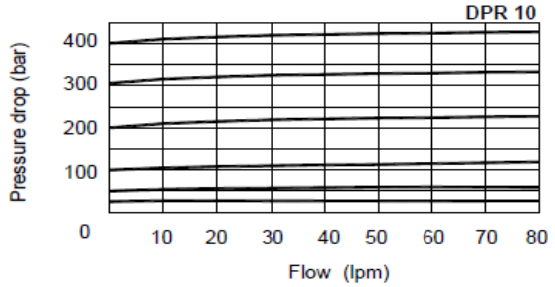

Fig. 7: Performance curve of ISO VG 68

AC Solenoid Operated Directional Valves which have a maximum operating pressure of 315 Kgf/cm2 and flow rate of120 L/min is used to guide the current straight off to the tank or through the pressure relief valve. When the flow is through the pressure relief valve, loading of the gear takes place. 0 to 700 bar pressure can be utilized through the pressure relief valve. Terminal Box Type Electrical Conduit Connection with relay is provided for solenoid operation where, we can set cycle time for the solenoid on/off. This solenoid control function makes the system more realistic similar to field testing.

Axial movement of Pinion permitted by roller bearing B2, B4 (Fig. 3) is taken care by universal coupling mounted between Gear box output and pump as shown in Fig. 6.

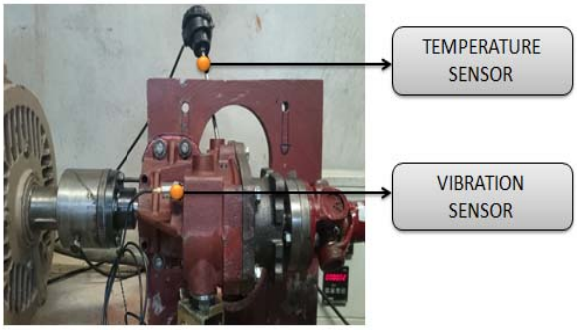

Fig. 8: Sensor mounted over Gear Box

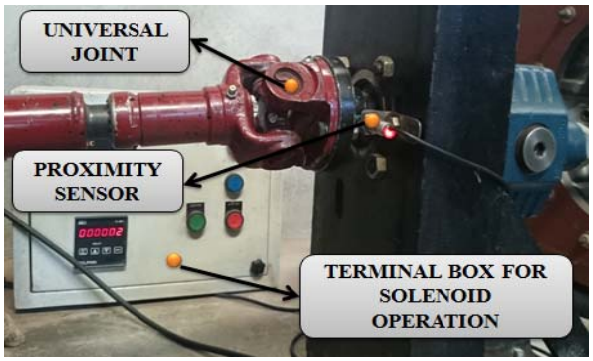

Fig. 9: Pump connected to propeller shaft

2.4. Instrumentation Unit

The instrumentation unit used in this test rig consists of vibration meter (Lutron made model: VB-8201HA, Frequency range is 10 Hz - 1 kHz, sensitivity meets ISO 2954.) which measures RMS and Peak value of acceleration and speed. Vibration sensors are mounted near the bearing area of the pinion shaft as shown in Figure81. Sound level meter (Lutron made Model : SL-4001) with a range of 30 to 130 dB is used to monitor the sound level of the gearbox which kept near the gear mesh zone. Data from sound and vibration can be used for FFT analysis. Infrared thermometer (Lutron made Model No : TM-956) having a range of -30 0C to 305 0 C is used to monitor the temperature rise in the gear tooth contact area through an opening provided in the gear box. J type thermocouple having range of −40 °C to +750 °C is used to measure temperature of gearbox oil. Data acquisition software has been developed in-house which have provision for monitoring gearbox oil temperature, speed of the motor and output speed of the gearbox, load given to the pump, hydraulic temperature in pump system. The speed of the motor can also be controlled by software using RPM controller.

3. PRACTICAL IMPLICATION

This test rig offers a convenient way of providing authentic working stipulation. New materials for gears, new design for gears can be studied using this test rig. Performance of gears, lubricating oil, and all other pieces of gear box can be monitored incessantly and data acquired can be stored for analyzing. Some of the trial test result absorbed from test rig are shown below.

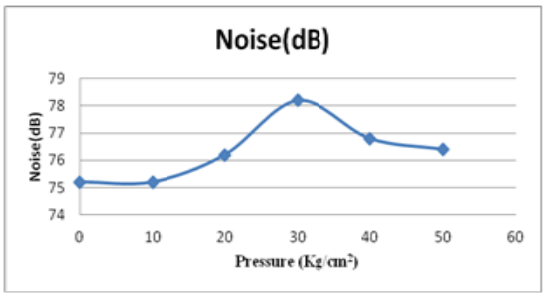

Fig. 10: Noise developed by the test rig

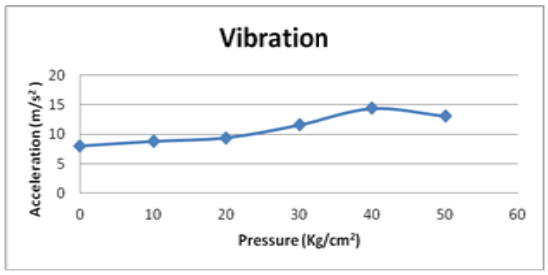

Fig. 11: Acceleration observed from the test rig

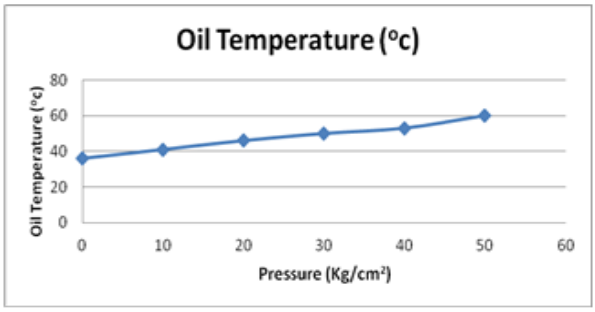

Fig. 12: Lubricating oil temperature with respect to pressure

Gear material used during this test is 20MnCr5 and its specification is shown in table 1. Fig. 10 shows the noise developed by the test rig, Fig. 11 shows the vibration level in terms of acceleration (m/s^2) and Fig. 12 shows the temperature level of lubricating oil in the gear box these readings are taken for the pressure range of 0 to 50 Kg/cm^2. Readings were taken after 5 minutes of running with one setting of pressure. After that lubricating oil was allowed to reach initial temperature again readings were taken for the new pressure setting with same time interval.

4. CONCLUSION

The developed test rig for Gear Box application performs like field testing. Data acquired from the test rig will be more useful for the development of products in this kind. This type of test rig will be more useful in research and development area to find alternate design and materials for gears. Verification of testing was done for 500rpm where the maximum noise 78.2dB, Acceleration 14.2 m/s^2 and Oil Temperature rises up to 60^o.

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