Experimental Investigation of Noise and Vibrations in Nylon66 Plastic Helical Gear used in Automobile Application

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Abstract

Polymer gears are used in power transmission due to its several merits. The noise and vibrations are key parameters in performance testing in any gear box which play vital role in automobile. The good damping and self lubrication property of Nylon 66 gear reduce noise and vibrations to great extent. An attempt has been made in this regard by experimentation to evaluate noise and vibrations occurred in gear box of moped by using Nylon 66 helical gear as replacement to metal gear.
This paper presents experimentally the noise and vibrations generated during power transmission both in metallic and non metallic gear in the gear box of moped, and compares between them. The results obtained by plotting characteristics for both noise and vibrations generated become benchmark and one step to find the feasibility of replacement of gear box in small and light vehicles.

Keywords—*Gear; Nylon66, noise, speed, vibrations.*

I. INTRODUCTION

Plastic gears find increasing application due to advantages of noiseless running, light weight, resistance to corrosion, lower coefficient of friction, the ability to run without external lubrication, superior properties. In competitive technological world people are demanding smooth, noiseless and vehicle having good performance. The parameter that is employed to measure smoothness is the Transmission Error [1]. Noise and vibrations are dominant parameters which influence the environment badly. Since vibrations produce noise, it may be reduced by decreasing vibrations related to them [2]. It is a need to understand the causes of vibrations and noise to develop methods to measure and prevent them [3]. Plastic gear continues to replace metal gears in automobiles, appliances and machinery due to its good properties, economical considerations and simple manufacturing. The trend is being aided by technological developments that are widening the performance envelope of polymers used in gears. Plastic gears meet desired performance challenges.

The selected Nylon66 material was tested in accredited material testing laboratory for mechanical properties and later helical gears were design [4].After selection of material and design, the gear are developed by Hobbing process with same accuracy and finish and keeping all other parameters same as existing metal gear parameters. Further they were tested for various speeds at constant torque. The testing is performed on moped 50 CC. Initially metal gear were tested for various speed at constant torque and reading was noted later metal gear replaced by Nylon66 gear and procedure was repeated for testing and reading was noted.

II. AIM OF INVESTIGATION

The aim of investigation is to find out data of noise and vibrations of metal and non metal helical gear by experimentation and to compare results obtained from them.
Polymer gear has several merits compared to metal gear which includes economical cheaper, less weight, good strength, less wear, low noise and vibrations, corrosion resistance, self lubrication etc. Development of polymer gear is convenient compared to metal gear [5]; it has wide choices of appearance, colors and transparencies better material, design optimization. Noise and vibrations are main reasons to influence environment badly and disturb working environment resulting into putting down working efficiency. Considering above fact the topic is undertaken for study.

III. TEST GEARS

The material selected for non metal gear is Nylon 66 [5] which having superior mechanical strength and other valuable properties. The gear having following specification and tolerances are design and manufactured on Hobbing machine which gives good surface quality, close tolerance and also economical cheaper compare to other. The metal gear (SCM420H) is also having same specification and tolerance. Design parameters of gear are Power = 2.69 KW, Speed = 6500rpm

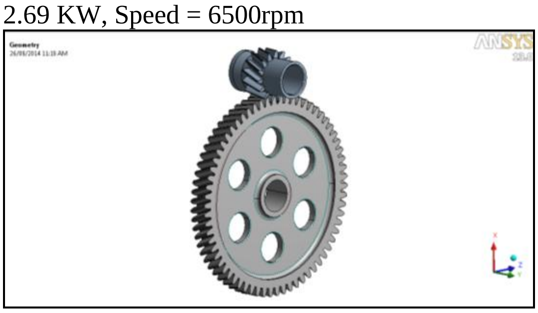

Fig.1.Specimen Helical Gear In Meshing.

Table I-Gear Data for the Test Gear

Sr No	Specification	Pinion Gear	Driver Gear
1	Tooth profile	Involute	Involute
2	Material	Nylon66	Nylon66
3	Normal Module	1.5	1.5
3	Normal Pressure angle	20^0	20^0
4	Helix angle	20^0	20^0
5	Direction of helix	LH	RH
5	Number of teeth	66	15
6	Pitch circle Diameter	105.35	23.94
7	Operating centre distance(mm)	65.5	65.5

IV. MEASUREMENT METHODOLOGY

A. Experimental Planning for Measurement of Noise and Vibrations

The selected helical gear pair having gear teeth 15:66 in the gear box of moped was run at various speeds and at constant torque. Initially metal gears were tested and later replaced Nylon 66 gears were tested as per test cycle. Measurement of noise and vibrations has been carried out as per international standards.

The noise for gear pair is measured by using Sound level meter and vibrations by using small piezoelectric accelerometer. Now by increasing speed, noise and vibrations is measured by same way. After completion of metal gear experimentation for noise and vibrations, the pair of metal gear is replaced by Nylon 66 material. In this way Nylon 66 gears are tested along with original cast iron gears and noise and vibrations has been recorded for various speeds at constant torque. The ambient temperature is measured at the time of experimentation is 26^0C.

1) Test Cycle

The test cycles [6] consist of 400, 600,800, 1000 and 1200 rpm at 4 N-m torque running each cycle for 1 hour at ambient temperature of 26^0C.

2) Instruments Used

a) Sound Level Meter

Digital sound level meters model (Sl-4005) having microphone of 10mm (0.5”) Electret condensor, measurement bandwidth of 300Hz to 8KHz,with accuracy/resolution of ± 2dB @1kHz (under reference conditions) / 0.1dB, and Response time Fast: 125 milliseconds / Slow: 1 second.
The microphone is the interface between the acoustic field and the measuring system. It responds to sound pressure and transforms it into an electric signal which can be interpreted by the measuring instrument (e.g. the sound level meter). The electrical signal from the transducer is fed to the pre-amplifier of the sound level meter and, if needed, a weighted filter over a specified range of frequencies. Further amplification prepares the signal for output as direct reading on the meter. The rectifier gives the RMS value of the signal. The RMS signal is then exponentially averaged using a time constant of 0.1 s ("FAST") or 1 s ("SLOW") and the result is displayed digitally on meter.

It measure sound pressure level and are commonly used in noise pollution studies for the quantification of almost any noise [7], but especially for-industrial, environmental and aircraft noise. However, the reading given by a sound level meter does not correlate well to human-perceived loudness; for this a loudness meter is needed. The current International standard for sound level meter performance is IEC 61672:2003 and this mandates the inclusion of an A-

Fig 1. Sound Level Meter

frequency -weighting filter and also describes other frequency weightings of C and Z (zero) frequency weightings. The older B and D frequency-weightings are now obsolete and are no longer described in the standard.

b) Vibrations Meter

Piezoelectric Accelerometer model (VB-8203) is used for vibrations measurement. The instrument having resolution of 0.1 m/s^2 and having range of 0.5 to199 m/s^2. Its measurements provide the following parameters: vibrations acceleration, vibrations velocity and vibrations displacement. The devices are usually portable and their readings can be saved partly and retrieved for later use. Vibrations meters are an irreplaceable tool for the professional on the job. Vibrations transducer is sensitive and gives accurate reading.

Fig 2. Vibrations Meter

In this way the vibrations is recorded with great precision.

c) C) Digital Tachometer

The Tachometer is an instrument that indicates the speed, usually in revolutions per minute, at which an engine shaft is rotating. Other types, often connected directly to the shaft whose speed they indicate, are small electric generators, the output voltage of which is proportional to speed. This voltage is applied to a voltmeter whose dial is calibrated in speed units.

Fig 3. Digital Tachometer

Some tachometers, especially those used in automobiles, are similar in construction and operation to automotive speedometers.

B. Measurement of Noise

The noise produced by gear pair was measured using digital sound level meter [9]. The calibration of sound level meter is done before experimentation is carried out. Digital sound level meters model (SL-4005) consist of microphone of 10mm (0.5”) Electret condensor, measurement bandwidth of 300Hz to 8KHz,with accuracy/resolution of ± 2dB @1kHz (under reference conditions) / 0.1dB, Response time Fast: 125 milliseconds / Slow: 1 second. The sound level meter kept 2m away from gear box while experimentation is carried out.

Fig 4. Testing of Gear

The microphone is the interface between the acoustic field and the measuring system [8]. It responds to sound pressure and transforms it into an electric signal which can be interpreted by the measuring instrument (e.g. the sound level meter). The electrical signal from the transducer is fed to the pre-amplifier of the sound level meter and, if needed, a weighted filter over a specified range of frequencies. Further amplification prepares the signal for output as direct reading on the meter. The rectifier gives the RMS value of the signal. The RMS signal is then exponentially averaged using a time constant of 0.1 s ("FAST") or 1 s ("SLOW") and the result is displayed digitally on meter. After running for each test cycle, the reading get stabilize and RMS value in dB is recorded for each gear materials of the gear drive. The graphs of the noise are plotted against speed at constant torque for each gear material is shown here under.

C. Measurement of Vibrations

Vibrations of gear pair is measured with small piezoelectric accelerometer. The vibrations produced was measured using Piezoelectric Accelerometer model (VB-8203).The calibration of vibrations meter is done before experimentation is carried out. The instrument having resolution of 0.1 m/s^2 and having range of 0.5 to 199 m/s^2. The magnetic probe of Accelerometer was mounted on gear box casing. When the accelerometer is subjected to vibrations, a force is generated which acts on the piezoelectric element. By Newton’s Law this force is equal to the product of the acceleration and the seismic mass [9]. According to the piezoelectric effect a charge output proportional to the applied force is generated. Since the seismic mass is constant the charge output signal is proportional to the acceleration of the mass. After running for each test cycle, the reading get stabilize and RMS value is recorded for each gear materials of the gear drive [10]. The graphs of the vibrations are plotted against speed at constant torque for each gear material is shown here under.

V. EXPERIMENTAL RESULTS

The experimental investigation shows the following results which are noted during the performance. As speed increases the vibrations increases resulting in noise level increment. Here both metal and Nylon 66 gear results were noted.

Table II.-Results of Nylon 66 Gears

RPM	NOISE(dB)	Vibrations(m/s^2)
400	0.99	1.2
600	100.7	1.5
800	101.06	1.7
1000	102.04	2.0
1200	105.0	2.5

Table II- Results of Metal Gear

RPM	NOISE(dB)	Vibrations(m/s^2)
400	103.000	2.500
600	104.000	3.200
800	107.080	4.100
1000	110.020	4.800
1200	115.020	5.600

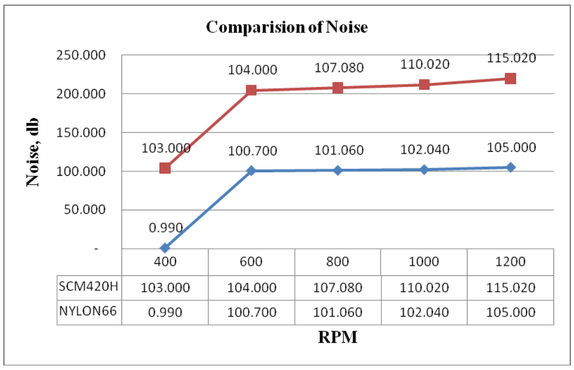

Fig 5. Comparison of Noise

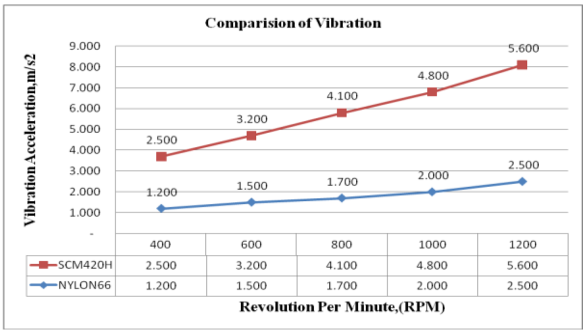

Fig 6. Comparison of Vibrations

Fig 7. Nylon 66 Gear

Fig 8. Metal Gear

VI. CONCLUSION

The experimental investigation carried out shows remarkable reduction in Noise and Vibrations of Nylon 66 gears and also shows better performance comparative to Metal gear. The Nylon 66 material help to reduce the Noise and Vibrations of gear box in addition it help to reduce weight of gear box resulting improvement in performance of gearbox. It is economical and easy to manufacture and may be used for other gear box also.

It is found that at lower speed the noise obtained in Nylon 66 gears is very less compared to metallic gears. The trend is similar in higher speed and noise generated in all speed is less in Nylon 66 gears. Similarly it is noted that vibrations obtained at lower speed in Nylon 66 gears is very less compared to metallic gears. The trend is similar in higher speed and vibrations generated in all speed are less in Nylon 66 gears.

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