

# Vibration Measurement and Noise Control in Planetary Gear Train

A.R.Mokate<sup>1</sup>, R.R.Navthar<sup>2</sup>P.G. Student, Department of Mechanical Engineering, PDVVP COE, A. Nagar, Maharashtra, India<sup>1</sup>Assistance Professor, Department of Mechanical Engineering, PDVVP COE, A. Nagar, Maharashtra, India<sup>2</sup>

**ABSTRACT:** In recent days reduction in noise and vibration are mainly focused by researchers. Vibration and noise generated in the gear train is mainly due to the meshing of gear pair and transmission errors. By minimizing the transmission errors the fluctuation is effective only for certain torque level. In this paper we are using the planetary gear train due to advantages over the parallel shaft gear system. We focused on different angular positions that mean phasing of gear pair by keeping the every individual set unchanged. The vibration and noise in this system are measured by FFT analyzer by phasing and without phasing arrangement. It was determined that amplitude of vibration were getting changed by phasing arrangement between two gear pair which will help for reduction of noise in planetary gear train.

**KEYWORDS:** Planetary gears train (PGT), Phasing, FFT analyzer, transmission errors.

## I. INTRODUCTION

Gears are essential parts of many precision power and torque transmitting machine such as an automobile. The major functions of a gearbox are to transform speed and torque in a given ratio and to change the axis of rotation. Planetary gears yield several advantages over conventional parallel shaft gear systems. They produce high speed reductions in compact spaces, greater load sharing, higher torque to weight ratio, diminished bearing loads, and reduced noise and vibration. They are used in automobiles, helicopters, aircraft engines, heavy machinery, and a variety of other applications. Despite their advantages, the noise induced by the vibration of planetary gear systems remains a key concern. Planetary gears have received considerably less research attention than single mesh gear pairs. There is a particular scarcity of analysis of two planetary gear systems and their dynamic response. This paper focus on the study of two PGTs with different phasing (angular positions) while keeping every individual set unchanged.

To control the vibrations in tooth gearings effectively, one should have an adequate knowledge of the physical nature of what causes vibrations in spur gear pair with imprecise and deformed teeth. Vibrations in gearing is caused by an internal excitations, as it occurs at the contact of two compressed elastic bodies (teeth) during their relative motion and acts on both bodies with the same intensity but in opposite directions. Because the variation of tooth mesh stiffness during meshing as a principal source of internal excitation force and vibration, modifications of the optimal tooth shape and contact ratio (CR) have been studied as ways of reducing the variation in mesh stiffness. Major variations in stiffness are caused by changes in meshing pair numbers, usually in the range 1.0-2.0 for normal spur gears. It is impossible to avoid this variation due to the integer numbers of gear teeth.

## II. RELATED WORK

In the present paper two different approaches for spur gear noise reduction using micro-geometrical modifications are compared. The two approaches are based respectively on the reduction of Static Transmission Error (STE) and Dynamic Transmission Error (DTE) fluctuations. The dynamic behaviour of the system is computed through a simple lumped parameter model. A genetic algorithm is proposed to find the best solutions inside the parameters space because the evaluation of the objective functions requires finite elements calculations and numerical ODE integrations. A reliability analysis is afterwards performed to evaluate the effect of manufacturing errors on the dynamic performance of the achieved optimum.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Most this work develops an analytical model of planetary gears and uses it to investigate their natural frequencies and vibration modes. The model admits three planar degrees of freedom for each of the sun, ring, carrier and planets. For the linear, time-invariant case, examination of the associated eigen value problem reveals the well-defined structure of the vibration modes, where the special structure results from the cyclic symmetry of planetary gears. Vibration modes are classified into rotational, translational and planet modes. The natural frequency sensitivities to system parameters are investigated for tuned (cyclically symmetric) planetary gears. Parameters under consideration include support and mesh stiffnesses, component masses, and moments of inertia. Using the well-defined vibration mode properties of tuned planetary gears, the eigen sensitivities are calculated and expressed in simple, exact formulae. These formulae connect natural frequency sensitivity with the modal strain or kinetic energy and provide efficient means to determine the sensitivity to all stiffness and inertia parameters by inspection of the modal energy distribution.

### III. PROBLEM FORMULATION

Meshing of the gears in the planetary gear set that forms the ratio-changing mechanism of an automatic transmission produces gear noise over a wide range of driving conditions from low to high vehicle speed. As per the literature survey and industrial survey it is observed that the internal excitation caused by the variation in tooth mesh stiffness is a key factor in causing vibrations. To reduce gear vibrations, numbers of passive and active methods are reported. Many studies have been concentrated on the modification of gear teeth, but these methods have limitations on modifications. Passive methods like the use of periodic struts for gearbox support systems and periodic drive shafts are also reported to reduce gear vibrations. But these methods require additional actuators, external power, and many signal processing techniques. Hence in order to investigate noise and vibration reductions in planetary gear train by phasing.

### IV. EXPERIMENTAL SETUP

In the experimental setup we are using the PMDC Motor which is connected to the gear pair 1 with the help of love-joy coupling. The phasing arrangement is placed between the two gear pair which is used to provide a phase angle between the two gear pair. The phase is angle is depends on the number of teeth due to variation of pitch by changing the number of teeth of gear.

The vibration and noise measured in the planetary gear train by using the Nylon-6 gear box. The rectangular plate is placed between the two gear pair which provides the phasing angle between the two gears set I and II. The configuration for each component is as follows-

TABLE NO. - I  
SELECTION OF MOTOR

RPM	0-1500 rpm
Power	180 watts ,180 vdc
Current	1.1 amp

TABLE NO. -II  
SPECIFICATION OF RING GEAR

No. of teeth	46
Module	1.5
PCD	66

**International Journal of Innovative Research in Science,  
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

**Vol. 4, Issue 8, August 2015**

TABLE NO. –III  
SPECIFICATION OF PLANET & SUN GEAR

No. of teeth	16
Module	1.5
PCD	22

TABLE NO. – IV  
SPECIFICATION OF FFT ANALYSER

Model	COCO-80(gram M/s Crystal Instrument , USA)
Accelerometer	3 Nos. ABRO inc USA make accelerometer sensor type
Input Channel	4 Channel input
Dynamic Range	130 dB
A/D Resolution	24 bits
Sampling rate	0.48 Hz to 102.4 kHz

TABLE NO.-V  
SPECIFICATION OF NOISE MEASURING INSTRUMENT

Frequency Range	31.5 Hz to 8 kHz
Resolution	0.1 dB
Power	9 Volt battery
Measuring rate	Every 0.5 sec.
Automatic Range	30-130

**V. RESULTS AND DISCUSSION**

The noise and vibration measured at various speed of motor i.e. Up to 0 to 1440 rpm. The Noise and vibrations were measured by phasing and without phasing arrangement.

TABLE NO.-VI  
NOISE MEASUREMENT WITHOUT PHASING ARRANGEMENT

Sr. No.	Speed (rpm)	Noise (dB)
1	100	83
2	200	74
3	250	80
4	300	82
5	350	79

**International Journal of Innovative Research in Science,  
Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

**Vol. 4, Issue 8, August 2015**

TABLE NO. -7  
NOISE MEASUREMENT WITH PHASING ARRANGEMENT

Sr. No.	Speed	Noise (dB)
1	100	72
2	200	67
3	250	72
4	300	73
5	350	71

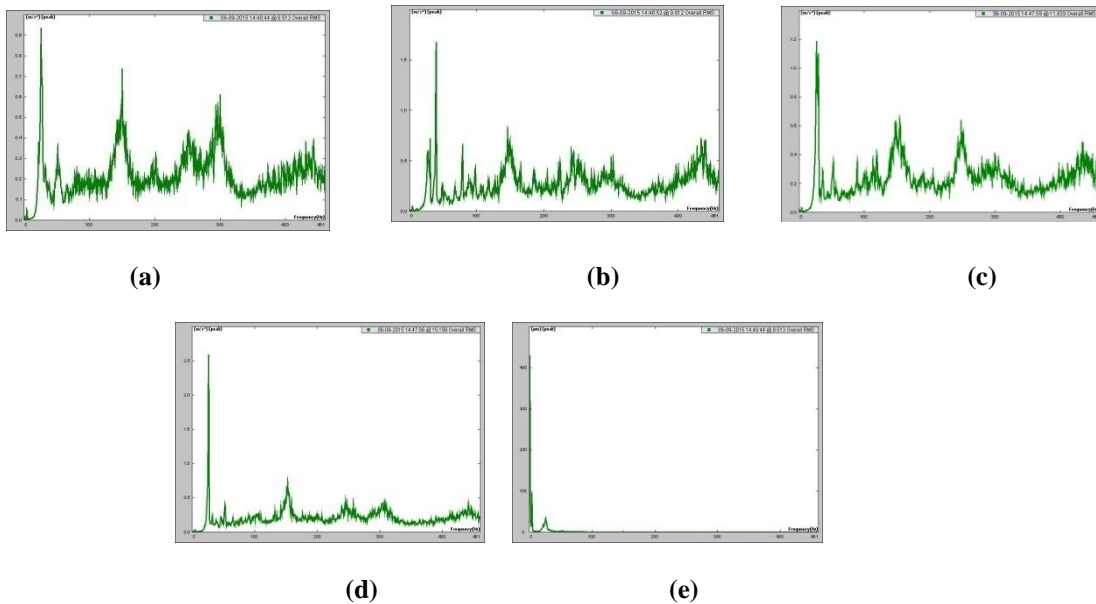
TABLE NO.-8  
ACCELERATION, VELOCITY & DISPLACEMENT MEASUREMENT AT WITHOUT PHASING ARRANGEMENT

Rpm	Acceleratio m/(s*s) (overall rms)	Velocity mm/s (peak)	Displacement um (pk-pk)
100	12.4203	25.5349	297.9504
300	15.2623	47.6635	413.3204
500	16.9701	32.6739	330.2616
700	17.6031	26.0352	222.9477
900	18.1271	26.8332	160.5819

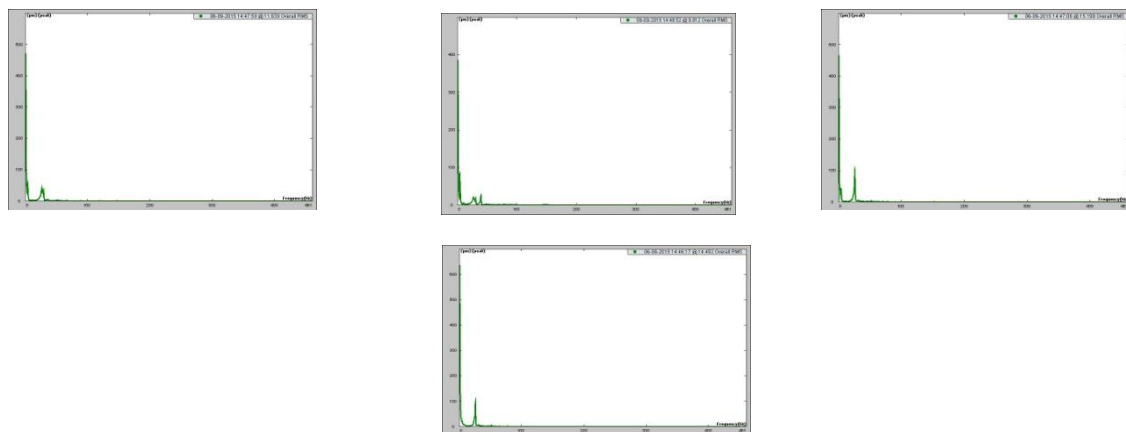
TABLE NO.-9  
ACCELERATION, VELOCITY & DISPLACEMENT MEASUREMENT AT WITH PHASING ARRANGEMENT

Rpm	Acceleration m/(s*s) (overall rms)	Velocity mm/s (peak)	Displacement um (pk-pk)
100	9.6203	32.0379	235.5620
300	10.1550	32.1732	345.8054
500	11.7532	15.2034	265.3466
700	14.2972	17.6303	169.0902
900	16.2631	19.3567	148.7726

The spectrums getting from FFT analyser for various speeds are as follows-



**Fig.:- Acceleration Spectrum from FFT analyser for various RPM's**



**Fig.:- Displacement Spectrum from FFT analyser for various RPM's**

The RPM's are vary between 100 RPM to 900 RPM and the graphs were plotted for that respective RPM and the vibration were calculated with the displacement value.

### VI.CONCLUSION

By comparing the results getting from phasing arrangement the noise and vibrations were reduced up to 10%. That concludes that noise and vibrations were reduced by phasing arrangement. This will improve the effectiveness of gear train due to reduction in vibration and noise which will affect the quality of automobile sector and gives the better performance.



ISSN(Online) : 2319-8753  
ISSN (Print) : 2347-6710

# International Journal of Innovative Research in Science, Engineering and Technology

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 4, Issue 8, August 2015**

## REFERENCES

1. S. H. Gawande, S. N. Shaikh, R. N. Yerrawar, and K. A. Mahajan, "Noise level reduction in planetary gear set," *Journal of Mechanical Design & Vibration*, vol. 2, no. 3, pp. 60–62, 2014.
2. M. G. Donley, T. C. Lim, and G. C. Steyer, "Dynamic analysis of automotive gearing systems," SAE Technical Paper 920762, 1992.
3. R.G. Parker, "Physical explanation for the effectiveness of planet phasing to suppress planetary gear vibration," *Journal of Sound and Vibration*, vol. 236, no. 4, pp. 561–573, 2000.
4. R. G. Schlegel and K. C. Mard, "Transmission noise control approaches in helicopter design," in *Proceedings of the ASME Design Engineering Conference*, ASME paper 67-DE-58, New York, NY, USA, 1967