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# VIBRATION AND NOISE REDUCTION IN PLANETARY GEAR TRAIN BY PHASING

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# TABLE OF CONTENTS

# CHAPTER 1

## INTRODUCTION

Gears are essential parts of many precision power 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. (01)

Planetary gear systems are used to perform speed reduction due to several advantages over conventional parallel shaft gear systems. Planetary gears are also used to obtain high power density, large reduction in small volume, pure torsion reactions, and multiple shafting. Another advantage of the planetary gearbox arrangement is load distribution. Because the load being transmitted is shared between multiple planets, torque capability is greatly increased. If the number of planets in the system are more the ability of load shearing is greater and the higher the torque density. The planetary gearbox arrangement also creates greater stability due to the even distribution of mass and increased rotational stiffness. Despite their advantages the noise induced by vibrations of planetary is concern, particularly in automotive industry where the vehicle interior noise is a key quality metric.

Noise and vibration generated in gears is mainly due to the transmission error, this is the difference between the position of the driven gear without torque and manufacturing errors, and the actual position including all those effects. Reducing the amplitude of the

transmission error is possible by selecting suitable profile modifications. Extensive research work has been carried out by many researchers on the analysis of errors, dynamic response, and noise and vibration reduction in single planetary gears. They are using the various methods of reducing the vibration and noise in planetary gear by changing the number of teeth and by using the analytical as well as FEM for reducing the vibration and noise.

Planetary gears are very popular due to their advantages such as high power density, compactness, and multiple and large compact gear ratios and load sharing among planets. Gearing arrangement is comprised of four different elements that produce a wide range of speed ratios in compact layout. These elements are, (1) Sun gear, an externally toothed ring gear co-axial with the gear train (2) Annulus, an internally toothed ring gear coaxial with the gear train (3) Planets, externally toothed gears which mesh with the sun and annulus, and (4) Planet Carrier, a support structure for planets, co-axial with the train. Planetary gear system as shown in Figure 1 is typically used to perform speed reduction due to several advantages over conventional parallel shaft gear systems. Planetary gears are also used to obtain high power density, large reduction in small volume, pure torsional reactions and multiple shafting. Another advantage of the planetary gearbox arrangement is load distribution. If the number of planets in the system are more the ability of load shearing is greater and the higher the torque density. The planetary gearbox arrangement also creates greater stability due to the even distribution of mass and increased rotational stiffness.

In recent years, enhancement of interior quietness in passenger cars, Automobiles is an important factor for influencing occupant comfort. Planetary gear sets are essential components of automatic transmissions because of their compact size and wide gear ratio range. They produce high speed reductions in compact spaces, greater load sharing, higher torque to weight ratio, diminished bearing loads and reduced noise and vibration. A Despite their advantage, 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. This paper focus on the study of two PGTs with different phasing (angular positions) while keeping every individual set unchanged.

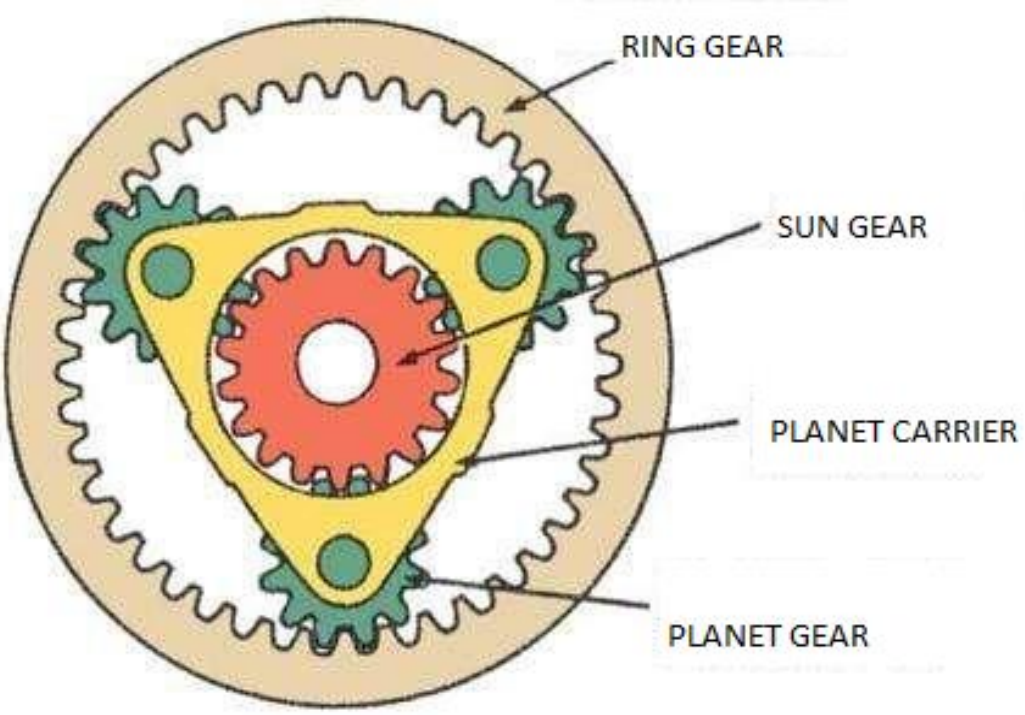


**Figure 1: Basic layout of planetary gear box**

This figure shows that the basic layout planetary gear train in which there is one Sun gear, Three Planet gear and one ring gear. They can produce the high speed reduction in compact space and having greater load shearing capacity & high torque to weight ratio.

## 1.1 Problem Statement

The vibration occurs due to the improper meshing between the gear and continuous wear of gear that occurs because of continuous machining operation & Defects in manufacturing. Due to the vibrations in the system noise is generated and also it impacts on the system performance.

## 1.2 Objectives

The main objective of project is to reduce the vibration and noise in the planetary gear train.

The objectives are as follows –

1. Development of experimental setup for reduce the Vibration and Noise in planetary gear train.
2. Measure the vibration with single PGT arrangement.
3. Measure the vibration & Noise in PGT with phasing arrangement.
4. Measure the vibration & Noise in PGT without phasing arrangement.
5. Comparison of results between phasing and without phasing arrangement.

## 1.3 Scope

Vibration and noise generated in the planetary gear train is reduced by phasing arrangement between two planetary gear sets. The phasing angle which is obtained from the number of teeth is provided between two gear sets for measuring the vibration and noise in gear train. The phasing angle to be used in planetary gear train should be as per calculated from number of teeth.

## 1.4 Methodology

After developing the experimental setup the vibrations and noise are measured by using FFT analyzer and sound measuring instrument. In the first part the vibration and noise are measured by without phasing arrangement of planetary gears after that the vibration and noise are measured by phasing arrangement between the planetary gear pair. After taking the results of both compare the results of noise and vibration with and without phasing arrangement.

### 1.4.1 Method of Phasing Gears

To control the vibrations in tooth gearings effectively, one should have an adequate knowledge of the physical nature of what causes vibrations in planetary 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.

If another meshed and phased gear pair is added to reverse the stiffness functions of the two pairs, these phasing gears will complement the primary gears and reduce the mesh stiffness variation. The phasing gear pair is made up of two gears half the width and half the pitch phasing of the primary gears. The conceptual model of phasing gears is shown in Figure 2.

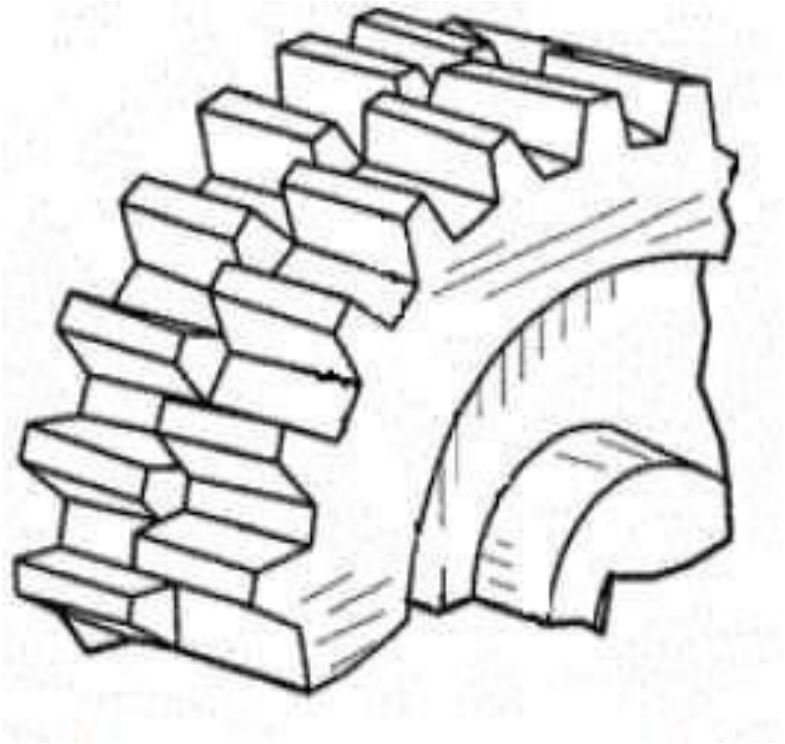

**Figure 2: Conceptual model of phasing of gear pair**

In this gear pair the angle is provided between the two teeth is depend on the number of teeth, is the number of teeth varies the angle between the two gears will be change. This figure shows the inclination of one gear pair by keeping another gear fixed.