Noise and Vibrations reduction in Planetary gear box

Minimizing Noise and Vibrations: Strategies for Enhancing Planetary Gearbox Performance

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***Abstract*- This paper presents the techniques to decrease noise and vibrations in planetary gear box. Planetary gears are used in many industries such as automobile, heavy machinery, aviation industry and many more. Due to their benefits, such as large-power density, compactness, big compact gear ratios, and load sharing among planets, planetary gears are very prevalent. Though there are several benefits of planetary gears, there is one underlying issue in planetary gears i.e., noise and vibrations. So, in recent years, several research have proposed different techniques to decrease the noise and vibrations in planetary gear box. In this paper two experimental methods have been adopted to minimal the noise and vibrations i.e., planet phasing and blu matching method. An experimental setup is prepared, and trails were performed to see extent of reduction of noise and vibrations. It was seen that noise and vibrations were decreased by 10-15% by using phasing arrangement in planetary gears.**

***Index Terms*: Planetary gears, Heavy machinery, and Power transmission system**

I. INTRODUCTION

Planetary gears have played an important role in power transmission systems for a long time and many researchers have proposed various techniques to improve the power transmission capability of gear box. There are four major components of planetary gear box. They are planet, sun, ring gear and carrier. Figure 1 shows the basic layout of the planetary gear box, and it is more preferred for reduction of speeds over the shaft gear systems. The major advantages of planetary gear box are large power density, compactness, large compact gear ratios, and load sharing among planets are all advantages. The load ability and torque density can be increased by using a greater number of planet gears.

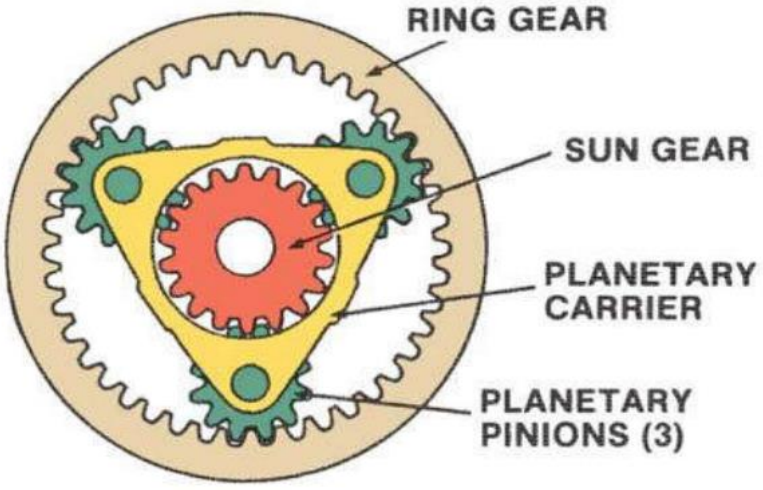


Figure 1: Planetary gear box layout (S.H. Gawande, 2014)

In recent years as specially in automobile industry, the demand of cars having more aesthetic looks and quiet interior have increased rapidly. Planetary gears play a huge role in automatic transmission because of their compact design and high-speed reduction ratios. There is one major disadvantage of the planetary gears is noise and vibration problem. Methods such as phasing of gears and blu matching technique can be used to solve these problems.

II. OBJECTIVE

The main objective of this report is to reduce the occurrence of noise and vibrations by applying various methods. At first when the noise and vibrations arise in the gear box, traditional methods were used i.e., trial and error methods. But with the advancement in technology there are different methods available to reduce the noise and vibrations in planetary gears. Methods includes

modification of gear teeth, providing periodic drive shafts and periodic struts to gear box. All these methods have their own limitations. Methods such as phasing of gears and blu matching can be used to decrease planetary gear set noise and vibrations.

III. APPROACH

Noise and vibrations are one of the prominent problems in planetary gear box. Industries manufacturing planetary gear box have been facing this problem for a long time. In industries when the noise and vibrations arise in the planetary gear box, identification of part takes place i.e., from which part the noise and vibrations are arising.

After the part is identified, blue matching and mesh phasing methods are applied to eliminate the problem. As we have seen in the adjacent table that the 90% of the noise and vibration problem arises due to imperfection in matching of profile of ring, sun, planet gear.

In blue matching method, solution is applied on any one of ring, sun, planet gear. Then that gear is rotated with the other two gears individually. For e.g., Suppose we apply the solution on the sun gear, then the sun gear is rotated with ring gear and planet gear.

By doing this, impressions of the solution will be formed on the adjacent gear on which it is rotated. If impressions are formed perfectly than we can say that the gear on which the solution is applied has perfect profile. Same method is repeated for the other two gears also.

Process	**Causes**	**Potential Failure**	**Severity Low – 1 high- 10**	**Occurrence low-1 high-10**	**Detection low – 1 high - 10**
Noise and vibration in planetary gear box	Imperfection in matching pf profile of ring, sun, planet gear	Teeth of sun, planet, ring gears gets worm out	**8**	**7**	**5**
	Fault in assembly of bearings	Damage or break the bearings	**5**	**3**	**1**
	Dent and high point in gear	Damage the teeth of other parts	**3**	**2**	**1**

Table 1

IV. LITERATURE REVIEW EXPERIMENTAL PROCEDURE

Noise and vibrations have been a major concern of planetary gear box in various practical applications such as aviation industry, automobiles, heavy machineries etc. Many researchers have provided techniques by which this problem can be minimized. (Chen, 2003) Investigated the relationship between planet gear torsional vibration and the meshing phase difference. The new approach of planetary gearset vibration reduction was rolled by (Schlege, 1967).

(Richards, 2003) from analytical and experimental findings came to the conclusion that transfer of vibrations produce by spur gear pair can be reduced by installation of periodic shaft. (Jeong, 2000) used an indirect analysis to identify the fruitfulness of using one way clutch in spur gear pair in order to reduce the vibrations. using non. The reduction of gear noise and vibration has also been suggested in several studies using gear dynamics.

(Hidaka, 1979) and his colleagues conducted a number of experimental studies on the dynamic behaviour of planetary gears in 1979.The connection between intelligent character recognition and (Kahraman, 1999) investigated the dynamic performance of a pair of spur gears. The effect of intricate contact ratio on the torsional vibration behaviour of 8 gear pairs with various contact ratios was investigated experimentally. (Kaharamam, 1994) used phasing method in helical planetary gear sets.

V. EXPERIMENTAL PROCEDURE

Many techniques have been proposed by researchers to decease noise and vibrations in planetary gear boxes. In some studies, the researchers have suggested the modification of teeth of gears, but this method has its own constraints. In other studies, many different methods have been suggested but these methods include installation of external parts which is not feasible to install in practical situations.

So, there was requirement to evolve a new method which doesn't need any modifications in gear teeth and no additional components needs to be added. So, in "**PHASING METHOD**" no external components or any modifications are needed. In order to understand how this method helps to reduce the noise and vibration, a set up was created which is shown in figure 2.

The components used in the set up shown in figure 2 are motor, couplings, planetary gear sets, speed controllers. Number of trials was for both phasing and without phasing. The results obtained from these trials were plotted on the graph. In these trials two sets of planetary gear pairs were taken. One set of gear pair was in phasing condition and other was in non-phasing condition. Also,

SLM (sound level meter) was also install in order to record the noise produce in planetary gears. The loads taken during these trails vary from 1kg to 6kg.

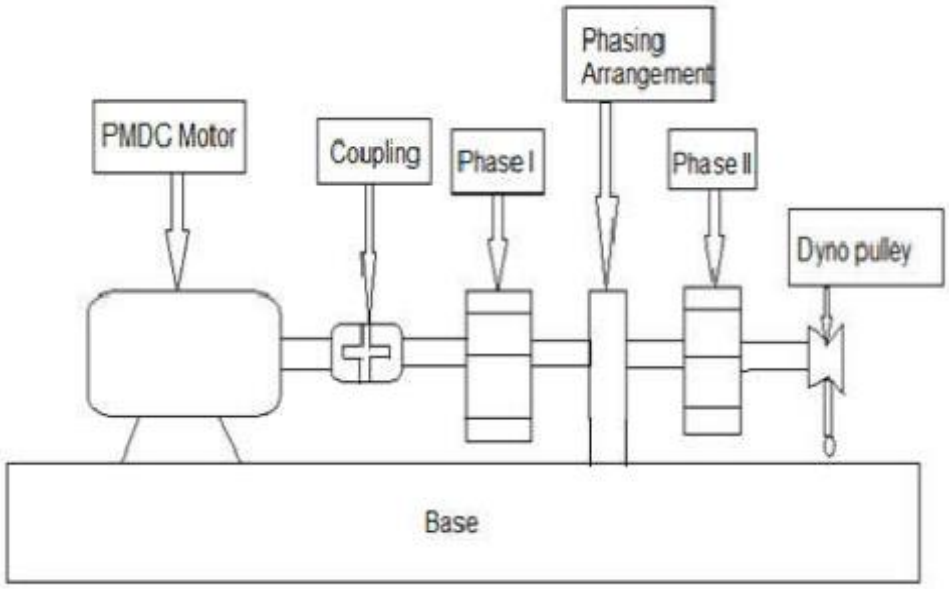


Figure 2 experimental setup layouts (S.H. Gawande, 2014)

As stated in table 1, 90% of noise and vibrations in planetary gear box arises due to imperfection in matching of profile of ring, sun and planet gears. There are many factors due to which profile of sun, planet and ring gear doesn't match. Some of them are

- Dent or high point on surface of gears
- Faulty module cutters used to shape the gears
- Fault in the machines used to shape the gears

To overcome this problem "blue matching" method can be used to detect the faulty gears that are manufactured. Once the identification of faulty gears is made then there will be no problem of imperfection in matching of profile of ring, sun and planet gears ultimately resulting in noise and vibration free planetary gear box.

In blue matching method, solution is applied on any one of ring, sun, planet gear. Then that gear is rotated with the other two gears individually. For e.g., suppose we apply the solution on the sun gear, then it is rotated with ring gear and planet gear. By doing this, impressions of the solution will be formed on the adjacent gear on which it is rotated. The impressions formed on the ring gear are noted. Then the sun gear after applying solution is rotated against the planet gear and the impression formed is noted. Both the impressions i.e., one on the ring gear and another on the planet gear are compared. The gear on which 80% of impressions are formed is considered to be perfect. Three situations arise:

Situation 1: If the impressions on the ring gear formed are not 80% then the sun gear is rotated along with planet gear. If 80% of impressions are obtained on planet gear than we can say that there is fault in ring gear.

Situation 2: If we have got 80% impression on ring gear than the sun gear is rotated along with planet gear. If we didn't get the 80% impression on the planet gear than we can say that there is a fault in planet gear.

Situation 3: if we have got 80% impression on both ring and sun gear than we can say that al the three gears are faultless. Thus, blue matching method is an indirect technique of identification and reduction of noise and vibrations in planetary gear box.

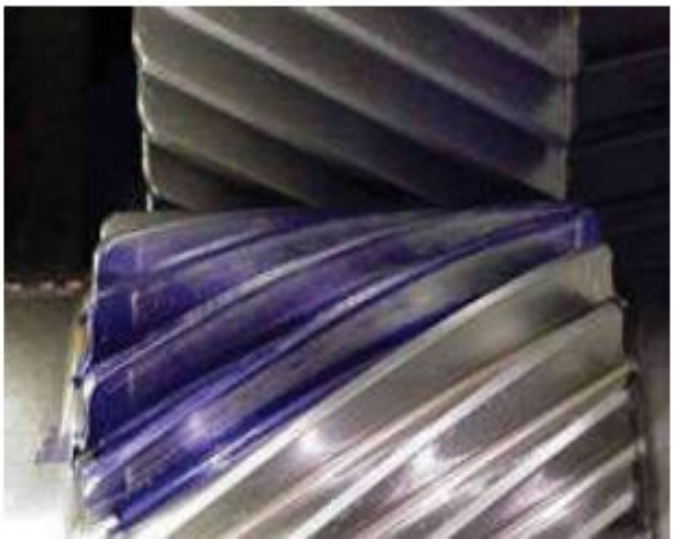


Figure 3 80% impressions formed on the adjacent gears

Figure 4 30% impressions formed on the adjacent gears

VI. Result and Discussion

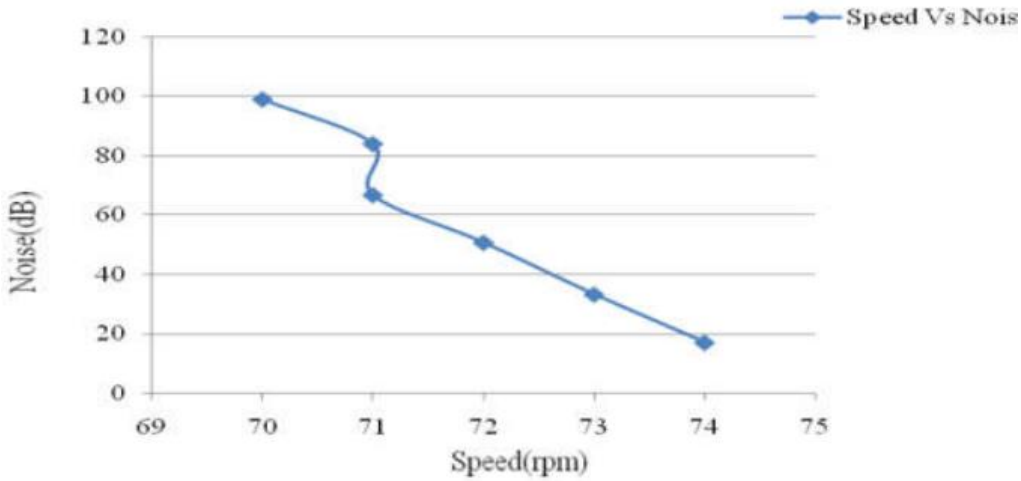
The data of trials was performed by changing the load from one kg to six kg in order to study the effect of the phasing method. Following tables shows the outcomes of trials performed with phasing arrangement and without phasing arrangement. Noise, efficiency, speed, and power were noted for the both the cases.

Weight (Kg)	Speed (rpm)	Power(W)	Efficiency (%)	Noise (dB)
1	75.8	13	18	79
2	74	24.5	31.25	81
3	73	36.54	55.74	82
4	72	47.81	67.23	84
5	71	59.28	89.23	88
6	70	68.23	98.25	92

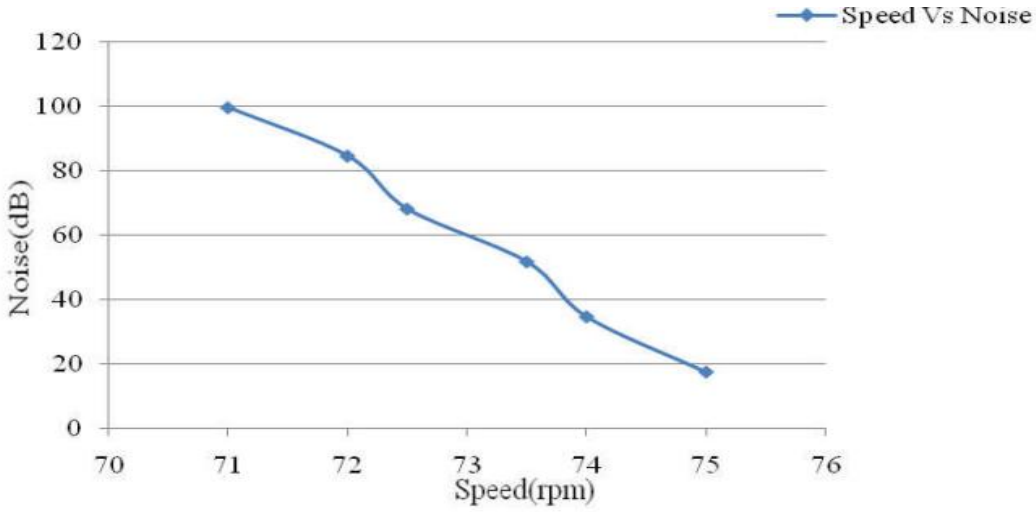
Table 2 outcomes obtained from gear sets which are not in phase

Weight (Kg)	Speed (rpm)	Power(W)	Efficiency (%)	Noise (dB)
1	76	13.35	19.25	73.5
2	75	26.5	33.45	74
3	74.28	39.2	57.89	75.5
4	73.6	48.33	69.24	78
5	72.33	60.2	92.22	82
6	71	70	99.2	84

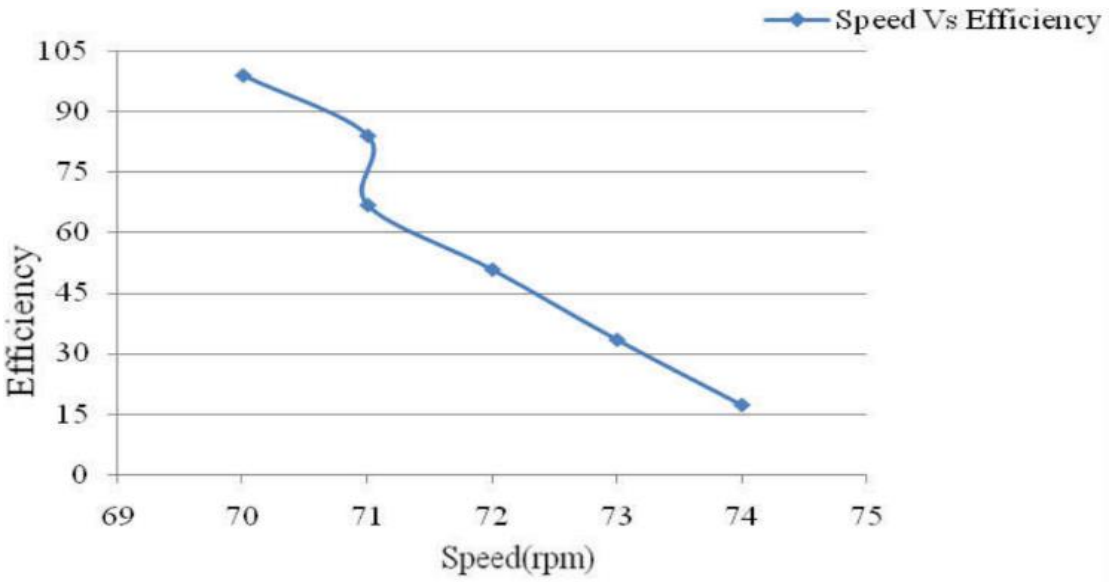
Table 3 outcomes obtained from gear sets which are in phase



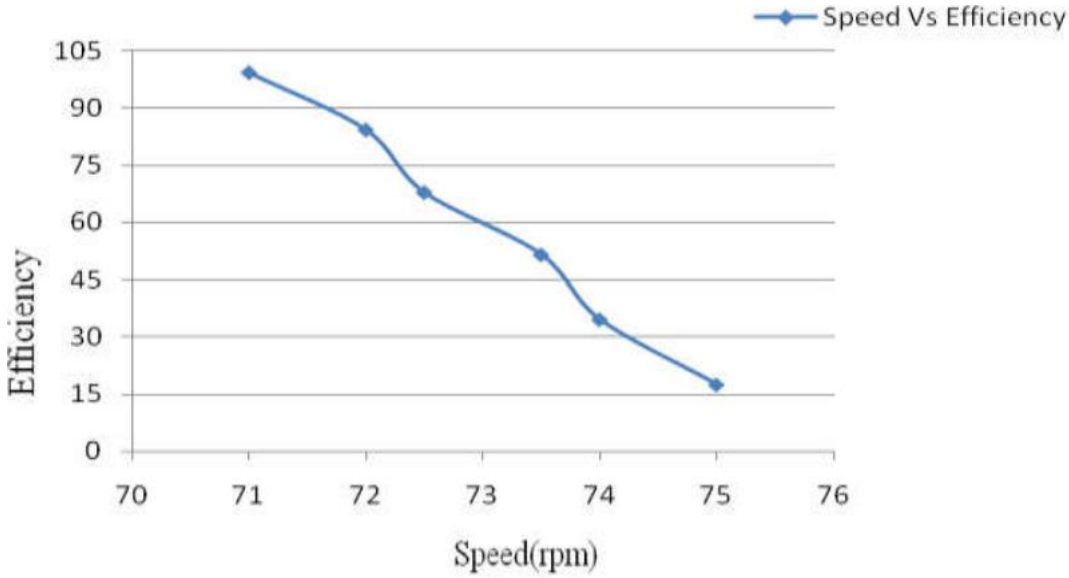
Graph 1 Graph of speed vs noise of gear sets which are not in phase



Graph 2 Graph of speed vs power of gear sets which are in phase



Graph 3 Graph of speed vs efficiency of gear sets which are not in phase



Graph 4 Graph of speed vs efficiency of gear sets which are in phase

From table 4.1 and table 4.2 it is seen that as we increase the load, the speed decreases. As the speed increases the noise level decreases as with increases in load speed decreases. Noise level in without phasing is high compared to that of with phasing arrangement. As we increase the load, the power in both the cases i.e., in with phasing arrangement and without phasing arrangement increases. Same is with the efficiency as we increase the load the efficiency in both the cases increases.

But when we compare both the arrangements, we can see that the efficiency and power ratings of phasing arrangement is higher in comparison to that of in without phasing arrangement. The increase in efficiency can be considered as a positive point. But the increase in power rating can be considered as one of the disadvantages of phasing method.

VII. Conclusion

The main purpose of this project was reduction of noise and vibrations in planetary gear box. We have seen that by applying phasing method there is reduction in noise and vibrations by 8dB to 10dB. By using blue matching method one can easily identify the faulty gears and necessary steps could be taken to resolve the problem. So, we can conclude that by application of phasing method and blue matching method one can decease the noise and vibrations in planetary gear box.

VIII. Acknowledgment

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