International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 11, November 2015
Available at http://internationaljournalofresearch.org

Designing, Dynamic and Meshing Analysis of Planetary Gears Assembly

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ABSTRACT:

A Machine consists of a power source and a power transmission system, which provides control application of the power. Often transmission refers simply to the gear box that uses gears and gears trains to provide speed and torque conversions from a rotating power source to another device The main aim of our project is to focus on the mechanical design and analysis on assembly of gears in Planetarium gear box. Analysis is also conducted by varying the materials for gears, i.e., Titanium Alloy and cast iron. Presently used materials for gears and gear shafts are Cast Iron. In this project to replace the materials with Titanium Alloy for reducing weight of the product decrease deformation and stress factor. Total Model and Static analysis is completely analyzed by considering weight reduction in the gear box. The design is done by using CATIA software. Modeling and assembly is done in CATIA. And following gear design is imported in ANSYS and under static structure analysis, behavior of gears is studied.

INTRODUCTION

Planetary gear trains are one of the main subdivisions of the simple epicyclic gear train family. The epicyclical gear train family in general has a central “sun” gear which meshes with and is surrounded by planet gears. The outermost gear, the ring gear, meshes with each of the planet gears. The planet gears are held to a cage or carrier that fixes the planets in orbit relative to each other. Planetary gear is a widely used industrial product in mid-level precision industry, such as printing lathe, automation assembly, semiconductor equipment and automation system. Planetary gearing could increase torque and reduce load inertia while slowdown the speed. To compare with traditional gearbox, planetary gear has several advantages. One advantage is its unique combination of both compactness and outstanding power transmission efficiencies. A typical efficiency loss in a planetary gearbox arrangement is only 3% per stage. This type of efficiency ensures that a high proportion of the energy being input is transmitted through the gearbox, rather than being wasted on mechanical losses inside the gearbox. 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. Greater load ability, as well as higher torque density is obtained with more planets in the system. The planetary gearbox arrangement also creates greater stability due to the even distribution of mass and increased rotational stiffness. Based on so many advantages of planetary gear above, we did our 3D model of multiple layers of planetary gear to get the speed reduction. And by using COS- MOS Motion, we achieve the visual movement simulation of it. Also we build the solid model using FDM machine.

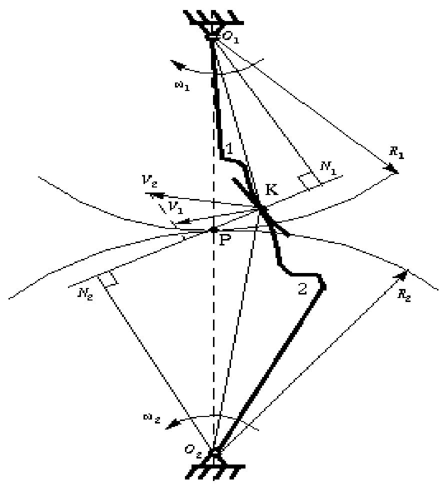
Finally, we hope our product can be used in industry in the future.

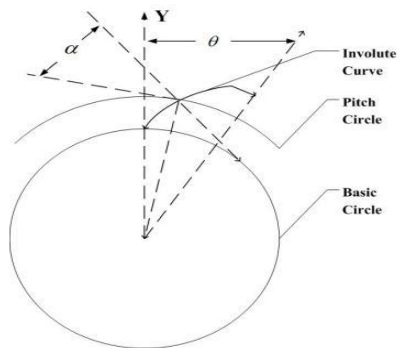
2.Planetary gear generation

By using SolidWorks software to build the 3D model of planetary gear, there are some things to do first, such as keeping a constant velocity ratio between two adjacent gear teeth, generating involute curve and set parameters of spur gear.

2.1 Constant Velocity Ratio

To get a constant velocity ratio, the common normal to the tooth profiles at the point of contact must always pass through a fixed point (the pitch point) on the line of centers. In figure 1, although the two profiles have different velocities at the contact point K, their velocities along N1N2 that is passing through the pitch point P are equal in both magnitude and direction. Otherwise the two tooth profiles would separate from each other. Therefore, we get the velocity ratio, which is equal to the inverse ratio of the diameters of these two tooth profiles. This is called fundamental law of gear-tooth action. For each two mating gearing tooth profiles, they should satisfy the fundamental law to get a constant velocity ratio.





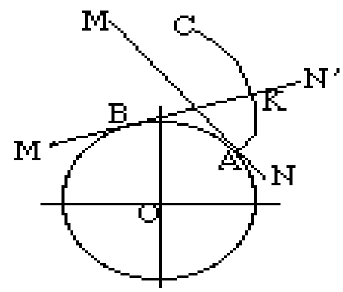


Figure 1. Constant velocity ratio

2.2 Generation of Involute Curve

The first step of generation a single tooth of the gear is to generating the involute curve. This involute curve is the path traced by a point on a line as the line rolls without slipping on the circumference of a circle. In Figure 2, let line MN roll in the counterclockwise direction on the circumference of a circle without slipping. When the line has reached the position M'N', its original point of tangent A has reached the position K, having traced the involute curve AK during the motion. As the motion continues, the point A will trace the involute curve AKC.

- **Generation of Spur Gear**

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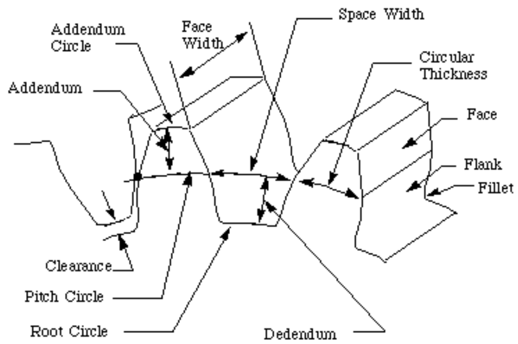


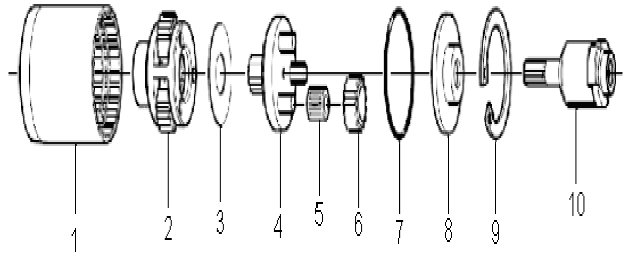
Usually we use the involute curve to generate a spur gear . The involute has important advantages -- it is easy to manufacture and the center distance between a pair of involute gears can be varied without changing the velocity ratio. Thus, we generate the involute curve to generate a spur gear

To generate a spur gear, some terminologies of the gear should be taken into consideration. The most important parameters in modeling we need to set the planetary gear are numbers of tooth, module, pitch circle diameter, pressure angle, basis circle diameter, addendum and dedendum. Figure 3 shows these terms. And Table 1 lists the standard tooth system for spur gears. circle and the dedendum circle to cut the two involute curves, and add the curve between them, extrude them to the certain width, then we have one tooth. Use the symmetry to arrange the tooth to the entire circle, and we have done with the gear model. The process of generating gears can be shown in Figure 4. Generating gears

2.5 Gears Generated

Based on the above method and parameter, we generated our planetary gear system, which contains one ring gear, two sun gears and four planet gears

3.The Gearbox design



The gearbox focused on, and used for model validation in this report is a 2 stage planetary gearbox made by Atlas Copco. The exploded view shows the components of the gearbox that will be explained in this chapter.

1. gear rim that functions as ring wheel

2. the planetary holder stage 2 complete assembly with planetary wheels

3. thin distance washer between stage 1 and 2

4. planetary holder stage 1 also acting sun wheel stage 2

5. needle bearing

6. planetary wheel stage 1

7. o-ring

8. thick washer or endplate stage 1

9. circlip to keep the thick washer in place

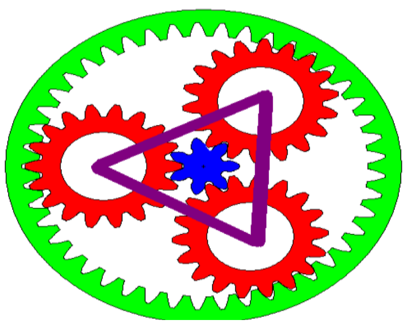
10. ingoing shaft from electric motor with sun wheel

The gearbox is made from hardened steel and has a gear ratio of 35 times in order to convert a high rotational speed into a large torque.

The power comes in from the electric motor to shaft (10) which is the sun wheel of the first stage. The sun wheel drives the planetary wheels (6) witch rotates in the gear rim causing a lower speed on the planetary holder (4) stage 1. The power is transferred to the planetary wheels stage 2 (2) through the sun wheel stage 2 (4) that has the same rotational speed as the planetary holder stage 1. The outgoing shaft is the planetary holder (2) stage 2 which has 35 times lower rotational speed than the electric motor.

The thin washer (3) is used as a distance between the planetary holders stage 1 and 2. It has a smooth surface since the planetary holders has different speeds.

Theory of the gearbox and power losses



Epicyclic gear or more commonly named planetary gear is a form of gear setup typically used in applications where high gear ratio and/or small dimensions are sought after. There are several different kinds of epicyclical gears available, the most common being the three and four wheel types. The gearbox in this thesis uses a three wheel design implementing three planetary gears in two stages. A three wheel design must however not use three planetary gears as three refer to the number of different sized wheels not the number of planetary wheels. A single stage can achieve a ratio of approximately ten, although sometimes an even higher ratio is required. In order to achieve this higher ratio two or more stages can be paired in an enclosure creating a gearbox with variable gear ratio and axis rotational direction.

The three wheel planetary gear stage consists of four parts.

1. Sun gear (center) S

2. Planetary gears (the three gears rotating around the Sun gear)

3. Planetary carrier (holds the planetary gears in place so the gear doesn’t jam) C

4. Ring wheel (the outer gear rim)

CONCLUSION

Designing Planet gear box is one of the difficult task, major part of our project is done in CATIA v5, which includes designing spur gears with involute teeth with required dimensions and assembly of messing gears Dynamic analysis is done by using ANSYS on planet and sun gear using different material, static analysis is done on meshing assembly of sun and planet gears using different material Now a days cast iron is widely used for gears, we analyzed on titanium alloy, the reason to chose these materials are high tensile strength, low density and high frequency handling properties we conclude that titanium alloy have good properties when compared to present using material (cast iron) Comparing to both material, titanium alloy has both good static and dynamic analysis features

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