DEVELOPING FUTURE GEAR BY OPTIMISED INTERNAL GEOMETRY

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Faculty of Mechanical and Manufacturing Engineering Technology

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**A thesis submitted
in fulfilment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Building Maintenance) with
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DECLARATION

I declare that this Choose an item. entitled “Developing Future Gear By Optimised Internal Geometry" is the result of my research except as cited in the references. Choose an item. has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature	:	
Name	:	Nur Balqish binti Muslim
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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering Technology (Building Maintenance) with Honours

Signature :

Supervisor Name : Dr. Muhammad Ilman Hakimi Chua Bin Abdullah

Date :

DEDICATION

This project is dedicated works to my beloved parents, family, and especially to my supervisor Dr. Muhammad Ilman Hakimi Chua Bin Abdullah, whose prayers, offered affection enabled love and support which always acted as a catalyst. Thank you so much for giving me strength to finish my Final Year Project. They have given me the motivation and discipline to take on any assignment with passion and commitment, no matter how difficult. Last but not least, thank you to all of my friends who have supported me throughout this process. It would not have been able to complete this task without their assistance.

ABSTRACT

The purpose of this research is to study the design of optimised gear based on the existing gear in the online market. There are many types of gear that exist, made from different materials. Each type of gear has unique properties such as bending stress, strength, wear, and so on.The material has been used in appropriate conditions as needed. For this research project, the simplest gear has been chosen, which is spur gear from the online store. One of the gear models has been chosen and drawn in CATIA V5R21, which is one of the CAD software. Next, the model of the gear has been analysed and drawn in CATIA V5R21, followed by the dimension that has been given in the catalogue for the customer. Then, in CATIA V5R21 too, simple simulations have been analysed in the software for analysing static analysis and dynamic analysis. From the drawing, the replica of the gear is produced the same as the real one in the online market using 3D printing, which is an SLS machine. The gear replica is made from PA12 NYLON material, while the original gear that has been purchased is made from brass material. Both of these pieces of equipment are used to investigate the wear of each piece of equipment.The study used the disc experiment method. The result of the experiment and the data recorded are presented in this thesis. The result of the experiment was to differentiate between the two types of gear.

ABSTRAK

Kertas kajian ini bertujuan untuk mengkaji tentang reka bentuk gear yang optimum berdasarkan gear yang telah berada dipasaran. Terdapat pelbagai jenis gear yang dibuat dengan pebagai jenis bahan. Setiap bahan yang digunakan mempunyai ciri-ciri yang berbeza seperti tekanan lenturan, kekuatan bahan, keausan dan sebagainya mengikut kesesuaian dan keadaan yang diperlukan. Gear juga mempunya pelbagai jenis bentuk dan ukuran. Untuk kertas kajian ini, gear tunjang iaitu gear yang paling ringkas telah dipilih daripada laman web yang berada ditalian. Model gear yang telah dipilih kemudian dilukis semula salah satu daripada software CAD iaitu CATIA V5R21. Reka bentuk tersebut telah dianalisis dan dilukis didalam CATIA V5R21 mengikut dimensi yang diberikan didalam katalog yang diberikan untuk para pelanggan. Seterusnya, simulasi ringkas telah dianalisis didalam software yang sama iaitu CATIA V5R21 untuk analisis statik dan analisis dinamik. Melalui lukisan semula reka bentuk tersebut, replika gear telah dihasilkan menggunakan 3-D print iaitu SLS. Replika gear yang diperbuat daripada bahan PA12 NYLON berserta gear original yang telah dipurchase yang diperbuat dari bahan BRASS digunakan untuk mengkaji keausan bahan. Kajian tersebut menggunakan kaedah eksperimen pin on disc. Keputusan eksperimen berserta data yang dihasilkan telah dibentangkan didalam kertas kajian ini. Keputusan kajian daripada eksperimen tersebut adalah berkaitan untuk membanding beza antara kedua gear tersebut.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

A gear is one of the machine components that is used to transmit mechanical power from one shaft to another shaft, whose teeth are cut into cylindrical or cone-shaped patterns with equal spacing. The gear is the most crucial part of the machine that affects the efficiency of the machine's work. A pair of gears is used to transmit rotation and force. The optimal design of the gear helps to improve work performance in the machine and makes sure it is well functioning.

Gears are widely used in power and motion transfer work under differing loads and velocities. These gears are preferred and successfully used in machinery, the aerospace industry, textile machinery, and other industries. Gearing is an essential component of machinery, and gear collision is the primary cause of machinery failure. The spur gear is the simplest form of gear to make and is widely used to shift rotary motion between parallel shafts. Spur gears are exposed to a variety of stresses in operation, but two types of stresses, bending stress and contact stress, are critical from a design standpoint. In developing optimised gear, there are a few characteristics that need to be fulfilled, which are optimising the gear geometry, high-efficiency performance, and low noise when the machine is working. The geometry influences the gear's manufacturability and working parameters, which define the gear's potential use region.

All gears and most industrial rotating machinery require some gearing to allow the work to be done, and more work can be done in excess. The rapid transition of heavy industries such as automobile manufacturing and office automation tools will necessitate a refined application of gear technology. Furthermore, due to their high degree of reliability and compactness, gears may predominate as the most effective means of transmitting power in future machines. The growing demand for quiet power transmission in machines, vehicles, elevators, and generators has increased the demand for a more precise analysis of gear system characteristics. Higher reliability and lighter weight gears are required in the automobile industry, the largest manufacturer of gears, as lighter automobiles continue to be in demand.

Straight-cut gears are the simplest type of gearing. They have cylinders or discs as components parallel to the axis of rotation stresses are defined by the primary and secondary designations of the gears, and in complex gear trains, the parameters greatly influence the design. As a result, The American Gear Manufacturing Association, AGMA established the current standard for spur gear design. Two horizontal sprockets rotating at the same rate (and they are alike in all other respects) can be imagined to have a third at the interface provided the sole end of one gear can be seen when they roll slowly. The biggest problem with these rotating drums is the risk of slipping at the rotating joint, but this is mitigated by adding teeth to the rolling drums. Designed internal gear racks with heavy load ratios for the power transmission system are extremely heavy in use. Methods alike rely on analysis to convey strength and to offer data; in particular, they call for analysis to offer both "bending" and "stress" information and greater contact. The results of this variable are applied where the teeth meet the bushing, the interface of gears, which is observed during gear contact checking.

1.2 Problem Statement

Gears are used in situations where a constant velocity ratio is desired, and they have a low impact on the shafts on which they are mounted. For power transmission, a minimum of two gears are needed, one of which is smaller in diameter than the other device and is known as a pinion, and the other as a gear. As rotational speed is applied between these two touching gears, the axes of rotation of the two gears vary from one another. For this project, spur gear was chosen for fabrication using a 3D printer. Spur gears are used where all shafts on which the gears are placed must be parallel and the teeth of these gears are straight and parallel to the axis of the shafts. Because of their compact structure and nature, these gears are simple to make. By established spur gear using plastic, it gives an alternative to traditional metal gears for a wide range of industrial applications. Plastic gears have evolved from low weight, precise motion transmission to more advanced power transmission applications. This research project employs 3D printing technology to create spur gears with precise geometry. Custom designs may be produced in a short amount of time without using the traditional production process 3D printing technology can be used.

1.3 Objective

The objective of this project is stated as below;

1. To design and analyze future gear with optimizing geometry.
2. To fabricate the designed gear using 3D SLS machine.
3. To test gear compare to current gear by simulation.

1.4 Scope

The scope of this project is stated as below;

1. Investigating the optimum gear design that is commonly used in the industry by analyzing the geometry.
2. Fabricating the gear with analyzed the optimized geometry using Catia and 3D printing.
3. Testing the performance of the gear and analyzing the designed product in the spec of structure and performance compare to conventional gear by SIMSOLID simulation.

CHAPTER 2

LITERATURE REVIEW

2.1 Gears

Gear is the component in the machine that has transmission power. The gears range from small-scale, which is from millimetre dimension installations, to large, powerful turbine gears of several metres in diameter. Gears can deliver very high angular or linear precision position transmissions, such as in-service mechanisms and military equipment. Gears can link power and movement between shafts that have parallel, twisted, or skewed axes. Gear designs are standardised according to size and shape for broad interchangeability. Gear has been used for more than 3000 years. It is very useful for every machine operation and has been used from generation to generation. Gears range in size from micrometres to 20m in diameter. From lightweight plastics to ultrahigh-strength heat-treated steel, materials are available (Davis & Associates, 2005). Each piece of gear has a unique characteristic that allows it to be used in the appropriate situation and according to the requirements. Rotation and power transmission between two parallel shafts If rotational transmission occurs at a constant ratio, which equals a constant RPM input, a constant output in RPM will be required (Stadtfeld, n.d.). The equation-based gearing law:

$$IN_1XR_1i.I = IN_2XR_2I = constant$$

N_1 normal vector flank point 1

R_1 radius vector tooth flank point 1

N_2 normal vector flank point 2

R_2 radius vector tooth flank point 2

i transmission ratio

2.1.1 Types of Gear

There are a lot of types of gear in this world. Every type of gear has its function. To achieve necessary force transmission in mechanical designs, it is necessary to accurately understand the differences between gear types. Even after deciding on a general type, dimensions and other factors must be considered. Gears of various shapes are available depending on the machine's requirements. Every piece of equipment has benefits and drawbacks that can be used in various conditions and situations.

Figure 2.1 Spur Gear (Petry-Johnson et al., 2008)

The spur gear is the simplest gear among the other types of gear. They are made up of a cylinder or disc with teeth that protrude radially. The edge of each tooth is straight and aligned parallel to the axis of rotation, despite the teeth not being straight-sided (but usually of a special form to achieve a constant drive ratio, primarily involute but less commonly cycloidal). Only when these gears are mounted on parallel shafts will they mesh properly. The tooth loads do not produce any axial thrust. Spur gears perform well at moderate speeds but are noisy at higher speeds.

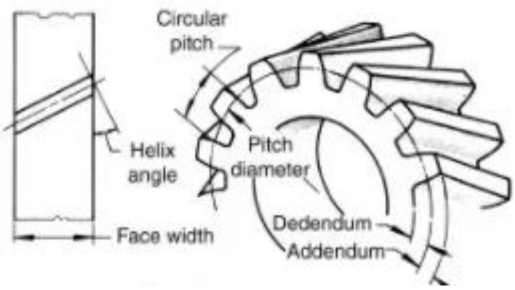

Figure 2.2 Helical Gear (Davis & Associates, 2005)

The shape of helical gear is almost the look like spur gear the cut of the teeth has an angle while the spur gear is straight to the center of the gear. Helical gears connecting parallel shafts will run more smoothly and quietly than spur gears, especially when the helix angle is large enough to ensure smooth operation that there is continuous contact from one tooth to the next (Niijjaawan & Niijjaawan, 2010).

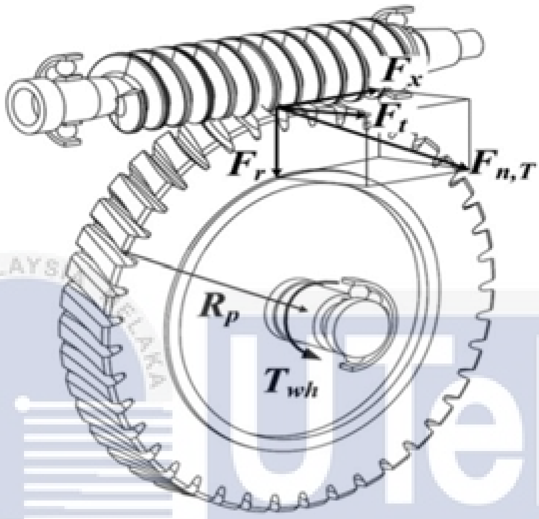

Figure 2.3 Worm gears (Hamid Seyed Sadeghi et al., 2017)

Worm gears are made up of a worm and a gear with shafts that are non-parallel and non-intersecting and are oriented at 90 degrees to each other. The worm resembles a screw with a V-type thread, while the gear resembles a spur gear. Typically, the worm is the driving component, with the worm's thread advancing the gear's teeth. Worm gears are made up of a worm and a gear with shafts that are non-parallel and non-intersecting and are oriented at 90 degrees to each other. The worm resembles a screw with a V-type thread, while the gear resembles a spur gear. Typically, the worm is the driving component, with the worm's thread advancing the gear's teeth (Niijjaawan & Niijjaawan, 2010).

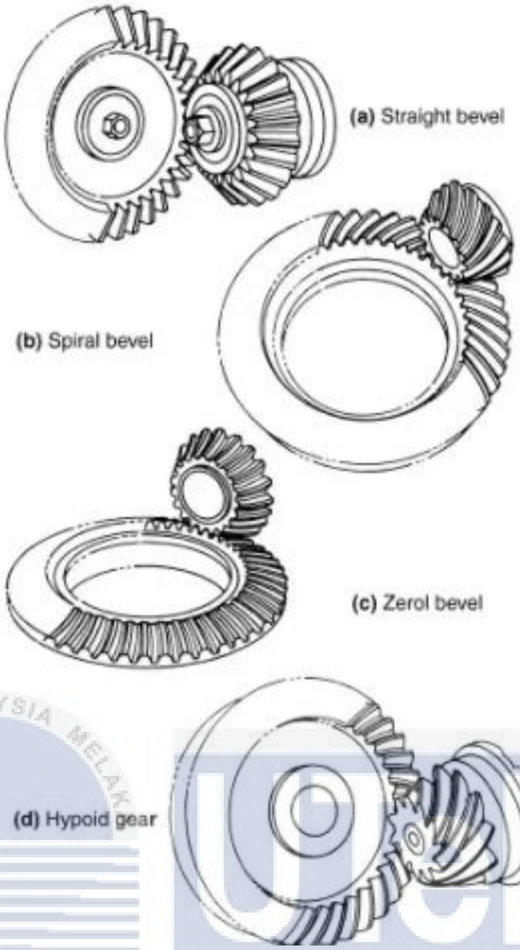

Figure 2.4 Bevel Gears (Davis & Associates, 2005)

Bevel gear is different from other types of gear that exist. Bevel gear The axes of the two shafts intersect in bevel gears, and the tooth-bearing faces of the gears themselves are conically shaped. Bevel gears are typically mounted on shafts that are 90 degrees apart, but they can also be designed to work at different angles. Bevel gears have a cone-shaped pitch surface. The axes of the two shafts intersect in bevel gears, and the tooth-bearing faces of the gears themselves are conically shaped. Bevel gears are typically mounted on shafts that are 90 degrees apart, but they can also be designed to work at different angles. Bevel gears have a cone-shaped pitch surface (Childs, 2019).

2.1.2 Material in gear

The material of gear is really important to choose depending on the needs. There are a lot of sorts of materials that have been used, such as steel, bronze, plastics, ductile iron, cast iron, brass, and metal. When creating the gear, strength, durability, and other material attributes must be taken into account. While the relevance of these elements varies depending on the project, the key to material selection is finding the perfect mix of physical attributes that meet the project's objectives at the lowest cost. Davis & Associates said among the through-hardening steels in wide use are 1040, 1060, 4140, and 4340. These steels can also be effectively case hardened by induction heating. Among the carburizing steels used in gears, see Table 2.1.

Table 2.1 Recommended steels for various applications and gear types (Davis & Associates, 2005)

Typical industrial application	Gear design type	Typical material choice
Differentials		
Automotive	Hypoid, spiral/straight bevel	4118, 4140, 4027, 4028, 4620, 8620,8625, 8822
Heavy truck	Hypoid, spiral/straight bevel	4817, 4820, 8625, 8822
Drives		
Industrial	Helical, spur rack and pinion, worm	1045, 1050, 4140, 4142, 4150, 4320, 4340, 4620
Tractor-accessory	Crossed-axis helical, helical	1045, 1144, 4118, 4140
Engine		
Heavy Truck	Crossed-axis helical, spur, worm	1020, 1117, 4140, 4145, 5140, 8620
Equipment		
Earth moving	Spiral/straight bevel, zerol	1045, 4140, 4150, 4340, 4620, 4820, 8620, 9310
Farming	Face, internal, spiral/straight bevel, spur	4118, 4320, 4817, 4820, 8620, 8822
Mining, Paper/steel Mill	Helical, herringbone, miter, spur, spur rack and pinion	1020, 1045, 4140, 4150, 4320, 4620
Starters		
Automotive	Spur	1045,1050
Transmission		
Automotive	Helical, spur	4027, 4028, 4118, 8620
Heavy Truck	Helical, spur	4027, 4028, 4620, 4817, 5120, 8620, 8622, 9310
Marine	Helical, helical conical, spiral bevel	8620, 8622