ANALYSIS OF DISK CAM MOTION FOR FOLLOWER SHAPE IN VERTICAL POSITION

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Report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Mechanical Engineering

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SUPERVISOR’S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree Bachelor of Mechanical Engineering.

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STUDENT’S DECLARATION

I declared that this dissertation entitled “ANALYSIS OF DISK CAM MOTION FOR FOLLOWER SHAPE IN VERTICAL POSITION” is the result of my own research except as cited in the references. The dissertation has not been accepted for any degree and is not currently submitted in candidature of any other degree.

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To my beloved mother and father,

Mrs. Rohani binti Mamat
Mr. Abd Rahman bin Abdullah
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ABSTRACT

Cam is a mechanical component that translates movement from circular to reciprocating by using mating component, called the follower. The cam performance can be analyzed in vertical position to find time of one cycle, $T$, and the displacement of cam follower $\Delta R$ at the rotational angle, $\Phi$. Every cam profile have its own performance and different from each other. This thesis is carried out to analyze the disk cam profile for the heart shape cam and tested in vertical position to find out its kinematics motion. In order to do the analysis, graphical method and experimental data are used to compare the error from the actual cam. The results from the analysis show that this cam is most suitable for low speed application because it shows small error at low speed input.
ABSTRAK

Sesondal merupakan komponen mekanikal yang menukarkan pergerakan daripada pusingan kepada pergerakan timbal balik dengan menggunakan pasangan komponen yang dikenali sebagai penurut. Prestasi sesondol boleh dianalisis dalam kedudukan tegak untuk mencari satu selang masa, $T$, dan jarak pergerakan penurut sesondol $\Delta R$ pada setiap darjah pusingan, $\Phi$. Setiap tampang muka sesondol mempunyai prestasi tersendiri dan adalah berbeza untuk setiap sesondol. Tesis ini dibuat adalah untuk menganalisis tampang muka sesondol yang berbentuk jantung dan diuji pada kedudukan menegak untuk mencari pergerakan kinematik. Untuk membuat analisis ini, kaedah grafikal dan data yang diperoleh dari experiment telah digunakan untuk membuat perbandingan kesalahan yang berlaku dengan sesondol yang sebenar. Hasil analisis menunjukkan bahawa sesondol ini lebih sesuai digunakan pada kelajuan yang rendah kerana ia menunjukkan kesalahan yang paling kecil ketika beroperasi pada kelajuan rendah.
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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Cam is a mechanical component that translates movement from circular to reciprocating by using mating component, called the follower. A cam can be defined as a device that having a curved outline or a curved groove that usually called as cam profile. Cams can be conveniently classified into two main groups,

1. Cams that impart motion to the follower in a plane in line with the axis of rotation of the cam (as does a cylindrical cam).
2. Cams that impart motion to the follower in a plane at 90 degrees to the axis of rotation, as with face or edge cams and most cams fall into this category. (Kenneth Nolan, 1998)

There are three types of cam followers, and each the type of follower influences the profile of the cam. The three types are the knife-edge, the roller follower and the flat-face follower.

The cam mechanism is the most versatile one which is suitable for various applications. It can be designed to produce almost unlimited types of motion in the follower. It is used to transform a rotary motion into a translating or oscillating motion.
Cam is widely used in variety of automatic machines and instruments. Typical examples of their usage include textile machineries, printing presses, food processing machines, internal combustion engines and other automatic machines, control system and devices.

For instance, in internal combustion (IC) engine, the valvetrain mechanism takes place as operated device to control the exchange of inlet and exhaust gases in the internal-combustion engine. The valvetrain assembly includes the poppet type valve (inlet or exhaust), the spring which closes it, the force transmission components (cam follower, pushrod, rocker arm) and the cam driving assembly, which transmits the operating force from the engine power output shaft to the camshaft in which the cam is mounted.

In real world application, cam is offering a high repeatability, low cost and minimal maintenance for long term maintenance. The mechanism is also a simple rotary motion that can be utilized to produce linear motion.

Today, common cam manufacturing method can be categorized such as, manual or numerical control (NC), analog duplication of hand dressed master cam, computer numerical control (CNC) with linear, circular, spherical or Bezier curve interpolation, electrodischarge machining (EDM) and others method such as flame cutting, die casting, die forging, stamping and powder metallurgy.
1.2 PROBLEM STATEMENT

When cam rotates, it shows a series of motion such as rises, dwell and fall. Rises is the follower motion away from cam center while dwell is the follower at rest and fall is follower motion toward the cam center. The cam performance can be analyzed in vertical position to find time of one cycle, \( T \), and the displacement of cam follower \( \Delta R \) at the rotational angle, \( \Phi \). Every cam profile have it own performance and different from each other.

1.3 PROJECT OBJECTIVES

The objective of this project is;

1. To analyze disk cam profile
2. To analyze the disk cam motion in vertical position.

1.4 PROJECT SCOPE

This research is carried out to verify the disk cam motion by following the according scopes:

1. To find the disk cam profile and its performance.
2. To run the experiment for the disk cam in vertical position.
3. To analyze the data and find it’s the kinematics motion.
CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Cams are widely used in many types of machines because they make it possible to obtain an unlimited variety of motions. Many different types of cam profiles are designed and manufactured depending on a machine’s requirements (P.W. Jensen, 1987). Cam is a part of a rotating wheel or shaft that strikes a lever at one or more points on its circular path. The cam is in most cases merely a flat piece of metal that has had an unusual shape or profile machined onto it.

This cam is attached to a shaft which enables it to be turned by applying a turning action to the shaft. As the cam rotates, the profile or shape of the cam will cause the follower to move in a particular way. The movement of the follower in vertical or in horizontal position is then transmitted to another mechanism or another part of the mechanism.
2.2 TYPES OF DISK CAM

2.2.1 Pear Shaped Cam

Figure 2.1: Pear shaped cam

The pear shaped cams are often used for controlling valves. For example, they are used on motor car camshafts to operate the engine valves. A follower controlled by a pear-shaped cam remains motionless for about half a revolution of the cam (V. Ryan, 2006). During the time that the follower is stationary, the cam is in a dwell period. During the other half revolution of the cam, the follower rises and then falls. As the pear-shaped cam is symmetrical, the rise motion is the same as the fall motion.
2.2.2 Heart Shaped Cam

Figure 2.2: Heart-shaped cam

Figure 2.2 shows the heart shape cam. This cam causes the follower to move with a uniform velocity. The follower moves up and down in a vertical direction. Its movement is very smooth. Heart-shaped cams are essential when the follower motion needs to be uniform or steady. For example, in the mechanism that winds thread evenly on the bobbin of a sewing machine and in winding wire evenly on the former of a solenoid.

2.2.3 Circular Shaped Cam

Figure 2.3: Circular-shaped cam

Figure 2.3 sometimes called eccentric cams. The cam profile is a circle and the center of rotation of the cam is often from the geometric center of the circle. The circular cam produces a smooth form of motion called a simple harmonic motion. These cams are often used to produce motion in pumps and also used to operate steam engine valves (V.Ryan, 2006). As the cam is symmetrical, the rise and fall motions are the same.
2.3 Follower Shape

The follower shape can be categorized in four categories, which is;

2.3.1 The knife edge follower.

A knife edge follower in Figure 2.4 is formed to a point and drags the edges of cam. This is the simplest type, is not often used due to the rapid rate of wear.

![Figure 2.4: Knife Edge Follower.](image)

2.3.2 The Roller Follower.

A roller follower consists of follower that has a separate part, a roller that is pinned to the follower stem as shown in Figure 2.5. This is most commonly used follower because the friction and contact stress are lower than knife edge follower. However, it can possibly jam during steep cam displacement.

![Figure 2.5: Roller Follower](image)
2.3.3 The Flat-faced Follower

Figure 2.6 show a flat-faced follower that consists of a follower that is formed with large, flat surface to contact the cam. This type of follower can be used with steep cam motion and do not jam. Usually, this cam is used when quick motions are required.

![Flat-Faced Follower](image)

Figure 2.6: Flat-Faced Follower

2.3.4 Spherical faced follower

A spherical faced follower consist of a follower formed with a radius face that contact the cam and this follower can be used with steep cam motion without jamming. However, the frictional force of this follower greater than roller follower.

![Spherical Faced Follower](image)

Figure 2.7: Spherical Faced Follower
2.4 CAM MATERIAL

Cam are usually made from a strong and hard materials because to avoid wear. Basically, the four kinds of wear in cam follower mechanism are: adhesive wear, abrasive wear, corrosive wear, and surface fatigue wear (Harold A. Rothbart, 2005). The most commonly used cam material are cast iron and steel. (Robert L. Norton, 2002)

2.4.1 Cast iron

Cast iron constituted a whole family of material. Their main advantages are relatively low cost and ease of fabrication. Some are weak in tension compared to steel but like most cast material, have good compressive strength. Their densities are slightly lower than steel at about 6920kg/m3. Most cast iron are not exhibit a linear stress-strain below the elastic limit and do not obey Hooke’s Law.

2.4.2 Gray cast iron

This iron is most commonly used to form of cast design. Its graphite flakes gives its gray appearance and name. The ASTM grades gray cast iron into seven classes based on the minimum tensile strength in kpsi. Class 20 has a minimum tensile strength of 20 kpsi(138MPa). The class number 20, 25, 30, 35, 40, 50 and 60 then represent the tensile strengths in kpsi. This alloy is easy to pour, easy to machine and offer good acoustical damping.
2.4.3 Hot Rolled Steel

This hot rolled steel is produced by forcing hot billets of steel through set of roller or dies that progressively changes their shape into I-beam, channel section, angle iron, etc. The surface finish of this material is rough due to oxidation at the elevated temperatures. The mechanical properties are also relatively low because the material ends up in annealed or normalized state, unless deliberately heat-treated later.

2.4.4 Cold-rolled Steel

This steel is produce from a billet, the shape of cold rolled steel are brought to final form and size by rolling between hardened steel roller or drawing through dies at room temperatures. The result is a material with good surface finish and accurate dimension compared to hot rolled material. Its strength and hardness are increase at the expense of significant built in strain which can later be release during machining, welding or heat treatment.

2.4.5 Forged Steel

Large cams or complex shapes such as IC engine camshaft are often form by hot forging a steel billet to an approximate shape for later machining. If sufficient quantity is required to offset the cost of forging dies significant saving of machining time can be realized over starting each cam with billet. Also, the strength of forged part especially against fatigue loading can be superior to that of cam made from billet.