PC CAM (PLATE + CYLINDRICAL CAM) DESIGN

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INTRODUCTION

1.1 Introduction

This paper is to study and explore information’s in order to understand clearly about cam mechanism to design the new innovation of cam. A cam may be defined as a machine element having a curved outline or a curved groove, which, by its oscillation or rotation motion, gives a predetermined specified motion to another element called the follower.

Abstract: The cam has a very important function in the operation of many classes of machines, especially those of the automatic type, such as printing presses, shoe machinery, textile machinery, gear-cutting machines, and screw machines. In any class of machinery in which automatic control and accurate timing are paramount, the cam is an indispensable part of mechanism. The possible applications of cams are unlimited, and their shapes occur in great variety. Some of the most common forms will be considered in this paper.
This thesis is a analyzing of combination of plate and cylindrical cam motion follower shape in horizontal and vertical position using knife follower. The objective of this thesis is to identify the different types and mechanism of cams and cam follower. This thesis also to design PC Cam (Plate + Cylindrical cam) by engineering software. The performance of the disk cam mechanism system is based upon the shape of the cam, type of the follower that will be used, and what the application that the cam is used it, wherever high speed application or low speed application. The method that will be used in analyzing the disk cam mechanism in this thesis is two, using the theoretical manner that is graphical method and the experimental method using the Solid Work 2013 and AutoCad Inventor 2010 software. From this thesis, show that this type of cam only suitable for low speed application because it will endure the high vibration while operating in high speed application.
1.2 PROBLEM STATEMENT

In this paper, cams are fully mechanical operated, compare to current electrical system of cam mechanism. Performance of cam mechanism system is based upon cam shape, type of follower Used, and what it will use for. These performances depend on the high speed or low speed application. Theoretically, if cam is used in high speed application, it will undergo the high vibration and affect the performance of the cam.

Using temperature and high pressure is not suitable for this fully mechanical cam compare to electrical system of cam. Combination of mechanical and electrical system for cam is difficult to determine the most suitable cam. Therefore this study will develop the for cam selection focus on kinematic variables.

The most problem is one cam for one application. Plate cam used for vertical (up and down) motion and cylindrical used for horizontal (left and right) motion. Therefore, this research is to design the cam that can use more than one application for each cam.

1.3 Objectives

For this research, the objectives that are tried to achieve by the researcher are:

1. Identify the different types and mechanism of cams and cam follower

2. Design PC Cam – Plate & Cylindrical cam by engineering software

3. Use equations to construct cam follower displacement diagrams.
1.4 Scope of Study

The scopes of this project are:

1. Identify the different types and mechanism of cams and cam follower

2. Design PC Cam – Plate & Cylindrical cam by engineering software

3. Use equations to construct cam follower displacement diagrams.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

An early cam was built into Hellenistic water-driven automata from the 3rd century BC. The use of cams was later employed by Al-Jazari who employed them in his own automata. The cam and camshaft appeared in European mechanisms from the 14th century.

Cams are commonly used in opening and closing of valves in internal combustion engines. Both the inlet and outlet valves are regulated using cam and follower. The study of cam and follower mechanism becomes important for desired and required performance of the engines. In this paper, complete kinematic and dynamic analysis of cam and follower mechanism is carried out using analytical method. The equations for governing motion of the follower have been taken from the literature. The kinematic analysis of mechanism helps in answering many questions related to motion of the follower. In this present work displacement,
velocity and acceleration values are calculated at each 100 rotation of cam using analytical relations. Fig.1 shows cam follower assembly.

![Diagram of Cam Follower Assembly](image)

Figure 2.2: Cam Follower Assembly

The dynamic analysis includes the static and inertia force analysis of the follower. For normal working of mechanism, the resultant vertical force has to be in downward direction. If the instant force changes its direction, lifting of follower will take place and design will fail. In this paper kinematic parameters and forces are calculated analytically and critical angular speed of rotation is found for the design specification. The equations have been programmed for the computer solution for rotation of cam by an interval of 100.

There are compare competitive products from global Cam Follower manufacturers and suppliers sell Cam Follower to global importers or seek cooperate opportunities of Cam Follower. Trade offers of Cam Follower related offers such as Pc Cam, Follow Spot, Water Follow and Follow Light.
2.2 Cam

A cam is a rotating or sliding piece in a mechanical linkage used especially in transforming rotary motion into linear motion or vice-versa. It is often a part of a rotating wheel (e.g. an eccentric wheel) or shaft (e.g. a cylinder with an irregular shape) that strikes a lever at one or more points on its circular path.

The cam can be a simple tooth, as is used to deliver pulses of power to a steam hammer, for example, or an eccentric disc or other shape that produces a smooth reciprocating (back and forth) motion in the follower, which is a lever making contact with the cam. Cam use as mechanical component of a machine to transmit motion to another component, called the follower, through a prescribed motion program by direct contact.

Example of Application of Cam

![Cam Operated Valve](image)

Figure 2.3: Cam Operated Valve
Figure 2.4: Application of Cams

Figure above shows some example of application of cams:

a. A cam and follower system at an internal combustion engine

b. A camshaft in a pump

c. A camshaft

d. A rocker camshaft

Cam and follower are widely used in regulating, opening and closing of valves (inlet and exhaust) in the internal combustion engines. Proper design of cam and follower is required for perfect tuning between opening and closing of valves with cam shaft speed.
A cam mechanism consists of three elements: the cam, the follower (or follower system), and the frame. The follower is in direct contact with the cam. The cam may be of various shapes. The follower system includes all of the elements to which motion is imparted by the cam. This may be connected directly to the follower, or connected through linkages and gearing. The frame of the machine supports the bearing surfaces for the cam and for the follower.

**Type of cams**

The most commonly used cam is the plate cam which is cut out of a piece of flat metal or plate. Here, the follower moves in a plane perpendicular to the axis of rotation of the camshaft. Several key terms are relevant in such a construction of plate cams: base circle, prime circle (with radius equal to the sum of the follower radius and the base circle radius), pitch curve which is the radial curve traced out by applying the radial displacements away from the prime circle across all angles, and the lobe separation angle (LSA - the angle between two adjacent intake and exhaust cam lobes).

1. **Plate Cam or disk cams** are the simplest and most common type of cam. The radial distance from the center of the disk is varied throughout the circumference of the cam. Allowing a radial motion.

![Figure 2.5: Plate Cam](image-url)
2. **Cylindrical Cam or drum cam** is formed on a cylinder. A groove is cut into the cylinder, with a varying location along the axis of rotation. Attaching a follower that rides in the groove gives the follower motion along the axis of rotation.

![Cylindrical Cam](image)

Figure 2.6: Cylindrical Cam

3. **Linear Cam** this type of cam is formed on a translated block. A groove is cut into the block with a distance that varies from the plane of translation. Attaching a follower that rides in the groove gives the follower motions perpendicular to the planes of translation.

![Linear Cam](image)

Figure 2.7: Linear Cam
4. **End cam** has a rotating portion of a cylinder. The follower translates or oscillates, whereas the cam usually rotates. The end cam is rarely used because of the cost and the difficulty in cutting its contour.

![Figure 2.8: End Cam](image)

5. **Grooved cam or closed cam** is a plate cam with the follower riding in a groove in the face of the cam.

![Figure 2.9: Grooved cam or closed cam](image)

**Uses for cams**

The cam mechanism is a versatile one. It can be designed to produce almost unlimited types of motioning the follower. It is used to transform a rotary motion into a translating or oscillating motion. On certain occasions, it is also used to transform one translating or oscillating motion into a different translating or oscillating motion.
Cams are used in a wide variety of automatic machines and instruments. Typical examples of their usage include textile machineries, computers, printing presses, food processing machines, internal combustion engines, and countless other automatic machines, control systems and devices. The cam mechanism is indeed a very important component in modern mechanization.

Types of followers

Followers are classified by their motion, shape and position. Followers motion can be separated into the following two categories;

1. **Translating followers** are constrained to motion in a straight line.

![Translating Follower](image)

Figure 2.10: Translating Follower

2. **Swinging arm or pivoted followers** are constrained to rotation motion.

![Swinging Arm or Pivoted Follower](image)

Figure 2.11: Swinging Arm or Pivoted Follower
**Follower position:**

The follower position, relative to the center of rotation of the cam, is typically influenced by any spacing requirements of the machine. The position of translating followers can be separated into two categories.

1. **An in line follower exhibits straight line motion**, such that that the line of translation extends through the center of rotation of the cam.

2. **An offset follower exhibits straight-line motion**, such that the line of the motion is offset from the center of rotation of the cam.

In the case of pivoted followers, there is no need to distinguish between in line and offset followers because they exhibit identical kinematics.

**The cam operated valve system:**

The most well-known use of cams is in car engines. The Cam operated valve system can be found in modern car engines and incorporates a number of cams; the valves are opened by cams, four- and six-lobed cams govern the spark distribution and many car petrol oil pumps are cam driven.
The follower shape can be separated into the following 4 categories:

1. A knife-edge follower consists of a follower that is formed to a point and drags on the edge of the cam. It is the simplest form, but the sharp edge produces high contact stresses and wears rapidly. Consequently, this type of follower is rarely used.

2. A roller follower consists of a follower that has a separate part, the roller that is pinned to the follower stem. As the cam rotates, the follower maintains contact with the cam and rolls on the cam surface. This is the most commonly used follower, as the friction and contact stresses are lower than those for the knife-edge follower. However, a roller follower can possibly jam during step cam displacements.
3. A flat-faced follower consists of a follower that is formed with a large, flat surface available to contact the cam. This type of follower can be used with a steep cam motion and does not jam. Consequently, this type of follower is used when quick motions are required. However, any follower deflection or misalignment causes high surface stresses. In addition, the frictional forces are greater than those of the roller follower because of the intense sliding contact between the cam and the follower.

4. A spherical-faced follower consists of a follower formed with a radius face that contacts the cam. As with the flat-faced follower, the spherical face can be used with a steep cam motion without jamming. The radius face compensates for deflection or misalignment. Yet, like the flat-faced follower, the frictional forces are greater than those of the roller follower.
Profile shapes of some cams design

The most common kind of cam is the plate cam. It consists of a narrow plate or disc, which is fixed to a rotating shaft. The plate is shaped so that the follower will produce a pre-determined form of motion. Most cams are designed to have a smooth curved shape so that the motion transmitted to the follower is smooth and without sudden jerks.

1. Pear-shaped cams design:

These type 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. 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.

Figure 2.13: Pear-Shaped Cams Design

2. Circular cams design:

These cams are sometimes called eccentric cams. The cam profile is a circle. 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. Circular cams are often used to operate steam engine valves. As the cam is symmetrical, the rise and fall motions are the same.
3. Heart shaped cams design:

This cam causes the follower to move with a uniform velocity. Heart-shaped cams are essential when the follower motion needs to be uniform or steady as, for example, in the mechanism that winds thread evenly on the bobbin of a sewing machine. A heart-shaped cam can be used for winding wire evenly on the former of a solenoid.

4. Uniform Acceleration And Retardation Cams:

A cam shaped as shown controls the motion of the follower so that it moves with uniform acceleration and retardation. The follower gains and looses velocity at a constant rate. Uniform acceleration and retardation cams are used to controls the motion of linkages in complex machinery.
Considerations to be taken in cam design:

If the cam follower and its mechanism are made too heavy, then during the early part of the cam rise (that is, the acceleration portion) the force imparted to the follower by the cam will be large. This gives a high torque requirement at this part of the camshaft revolution. Furthermore, once the heavy follower and its mechanism are moving, the momentum will tend to keep it moving at that speed. This means that the cam may not be in control, during the second part of the rise, and the heavy spring loading will be necessary to maintain contact between the cam and the follower at the end of the rise.

From these considerations, it can be seen that among the main aims to be borne in mind during cam design are:

1. High accelerations and declarations are to be avoided to minimize force requirements.
2. Maximum accelerations should occur during the middle of the stroke.
3. The mass of the mechanism to be moved by the cam should be as small as is practicable.
Classification of Cam Mechanisms

Classify of cam mechanisms by the modes of input/output motion, the configuration and arrangement of the follower, and the shape of the cam. We can also classify cams by the different types of motion events of the follower and by means of a great variety of the motion characteristics of the cam profile.

![Figure 2.17: Classification of cam mechanisms](image)

Modes of Input/Output Motion

1. Rotating cam-translating follower. (Figure 1.14 a,b,c,d,e)

2. Rotating follower (Figure 1.14 f):

   The follower arm swings or oscillates in a circular arc with respect to the follower pivot.

3. Translating cam-translating follower.

4. Stationary cam-rotating follower:

   The follower system revolves with respect to the center line of the vertical shaft.
Design Concentration: Cylindrical / Drum Cam with Follower

Cylindrical Cam and Roller Follower

This cam and follower system is slightly different to the plate cams. This type of cam is cylindrical in shape with a profile machined onto it.

![Cylindrical Cam and Roller Follower](image)

Figure 2.18: Cylindrical Cam and Roller Follower

Design Concentration: Plate / Disk Cam with Follower

Plate Cam and Flat Follower

The diagram above shows an animation of a rotating cam and flat follower. As the cam rotates the follower is pushed up and down. There is some external force pushing the cam back down, so that it remains in contact with the cam profile. The cam shown above is also known as a plate cam. This type of follower can be found in the cam and follower system used to open and close inlet and exhaust valves in an engine.

![Plate Cam and Flat Follower](image)

Figure 2.19: Cylindrical Cam and Roller Follower
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