FACTFILE: GCE TECHNOLOGY & DESIGN

1.47 MECHANICAL COMPONENTS AND SYSTEMS

Rewarding Learning

Cams

Learning outcomes

Students should be able to accurately draw cam profiles and performance diagrams:

- to achieve dwell, uniform velocity, uniform acceleration and retardation and simple harmonic motion;
- if the line of stroke of the follower is offset or in-line with the centre of the cam;
- using a range of followers including knife edge, and roller; and
- to achieve a range of outcomes.

Course content

Students should have a knowledge and understanding of cams and their applications. A cam is a rotating or sliding component in a mechanical system that changes rotary motion into linear motion. Cams have many applications for example in internal combustion engines, where the camshaft, powered by the rotating engine, moves a push rod, in a linear way so as to open and close the inlet and exhaust valves of the engine. The Pushrod is connected to the 'Camfollower' which is driven by the camshaft. This changes the rotational motion to reciprocating.

There are a number of common shaped cams including:

- The Pear-shaped cam
- The Eccentric cam
- The Drop cam – snail drop cam
- Cylindrical cam

All have various roles, but all do the same task of changing rotary motion into reciprocating motion but in differing ways.

Dwell, uniform velocity, uniform acceleration and retardation and simple harmonic motion

The motion of the cam follower is dependent on the shape of the cam. It is the profile of the cam that determines the action of the follower. There are three types of motion that are applied to the lifting and falling of the follower. These types of motion can be graphically displayed on a cam performance graph. The types of motion are:

Uniform velocity
Displayed on a performance graph as a straight line.

Uniform acceleration and retardation
Displayed on a performance graph as a sine curve.

Harmonic motion
This curve is constructed using the top, bottom and mid-points of a circle thus creating a smooth path

for the follower to travel along.
There is also Dwell, or dwell angle where the cam remains either at the top or the bottom of a cycle for a given part of the rotation.

Followers

The follower is a slider or a roller that is in contact with the cam. The movement of the follower is dictated by the shape of the cam. There are a number of types of follower that are all used in specific situations. The most common are:

Knife-edge followers
In the knife-edge follower the end of the follower has a profile that looks like a sharp knife. In theory, the knife edge follower is the best type of follower because there is no side thrust; it merely moved up and down. However, knife edge followers are rarely used because when applied practically, because of friction, they wear out very quickly.

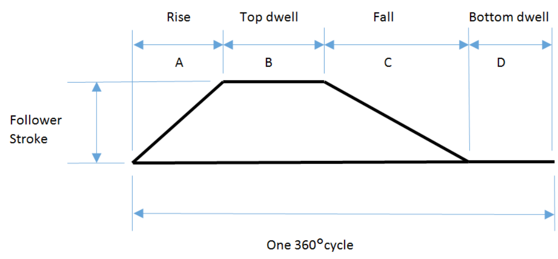
Roller followers
This is where the follower has a rotating roller or wheel at the point where the follower is in contact with the cam which follows the profile of the cam. The advantage of a roller follower is that because the roller is rotating, friction is reduced and consequently any wear is reduced. However, there is a disadvantage. The cam must be designed carefully so that the shape of the cam and the radius of the roller do not conflict.

There are also flat-faced followers, Oblique flat-faced followers and spherical-faced followers. All of which are used in specialist situations. Followers can be either in-line or off-set depending on their applications.

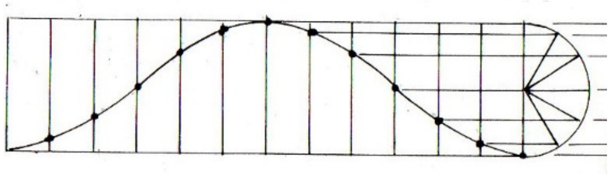
The main reason that a follower might be off-set is that side thrust that might be present thus making the cam and follower inefficient. By making the follower offset it reduces the side thrust on the roller in the follower.

Cam profiles and performance graphs
Cams can be characterised by their cam profile and performance graph. Students need to understand performance graphs and how they are constructed and how cam profiles are projected from performance graphs to produce representations of cams.

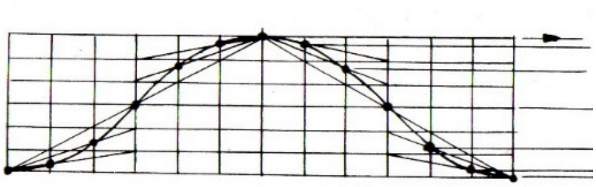
The following shows a performance graph:



In this performance graph, the follower stroke is indicated on the left hand side of the graph. The follower stroke is the vertical distance travelled by the follower for one revolution. A full revolution of 360° is the length of the graph. The graph illustrates the intervals of each section of a cycle. In this case, the distance A shows a rise represented by a straight line from the bottom to the top of the stroke. As it is a straight line, this represents a rise of uniform velocity. There then follows a period of dwell where the follower remains at the top of the stroke, B. It then falls, C, to the bottom of the stroke, again with a straight line and then a further dwell at the bottom of the stroke, D, ready to begin the cycle again.



Performance graph for uniform acceleration and retardation



Performance graph for harmonic motion

The cam profiles for different types of motion are achieved in different ways. The above shows the performance graphs for Simple Harmonic Motion and Uniform Acceleration and Retardation and how they are created. With Simple Harmonic Motion the profile is produced using a circle divided up into 30° elements and then projected back onto the graph. Uniform Acceleration and Retardation are created by dividing the stroke into equal sections and then projecting them back onto the graph.

Revision Questions

1 Using sketches, describe the shape that lines would trace on a cam performance graph for:

- Simple Harmonic Motion
- Uniform Acceleration and Retardation

2 Explain the role that CAM followers have in a car engine.
Use a sketch and notes to explain the function of cam followers in an internal combustion engine.

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3 Sketch the following cam profiles:

- The Pear-shaped cam
- The Eccentric cam
- The Drop cam
- Snail Drop cam
- The Drop cam