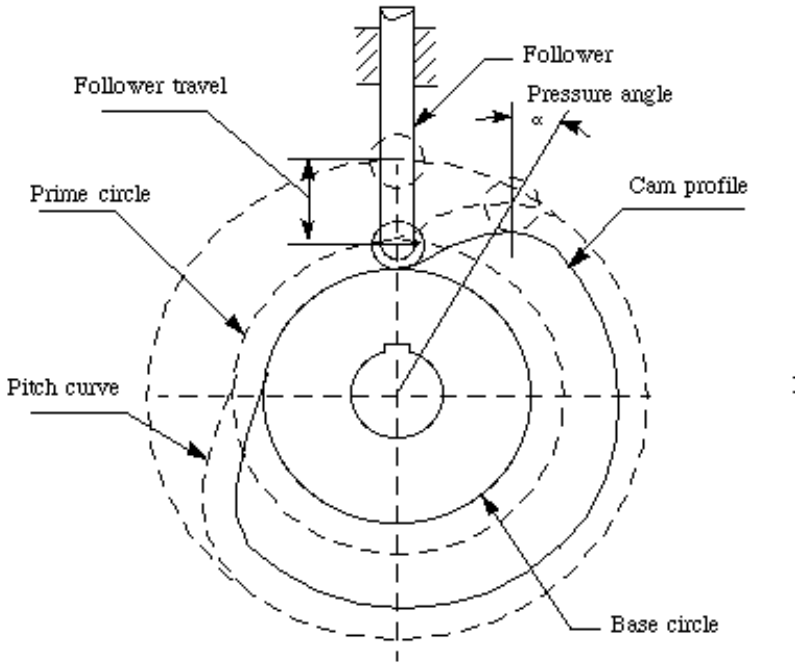
DESIGN & MANUFACTURING OF CAMSHAFT

INTRODUCTION

CAM: A projection on a rotating part in machinery, designed to make sliding contact with another part while rotating and to impart reciprocal or variable motion to it. Cams are used to convert rotary motion into reciprocating motion

CAMSHAFT: A shaft with one or more cams attached to it, e.g. working of valves in an internal combustion engine is controlled by camshaft. Cam shaft is called the "brain" of the engine.

CAM TERMINOLOGY



Base Circle: The smallest circle centered on the cam rotation axis, and tangent to the cam surface. The size of the base circle is dictated by spatial restrictions of the application.

Trace point: A theoretical point on the follower, corresponding to the point of a fictitious knife-edge follower. It is used to generate the pitch curve. In the case of a roller follower, the trace point is at the center of the roller.

Home Position: The orientation of the cam that corresponds to 0° on a displacement curve.

Reference Circle (or prime circle): A circle centered at the cam axis whose radius is equal to the distance to the trace point. It is the smallest circle from the cam center through the pitch curve

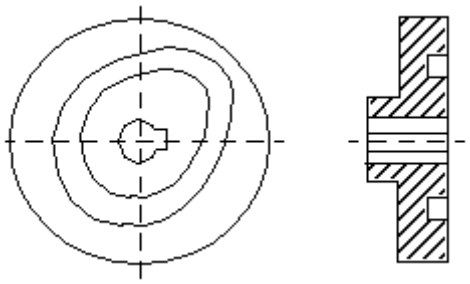
Pressure Angle: The angle between the direction of motion of the follower and the direction of the cam contact force is called pressure angle. Pressure angle should not exceed 30°.

Pitch curve: The path generated by the trace point at the follower is rotated about a stationary cam.

Working curve: The working surface of a cam in contact with the follower. For the knife-edge follower of the plate cam, the pitch curve and the working curves coincide. In a close or grooved cam there is an inner profile and an outer working curve.

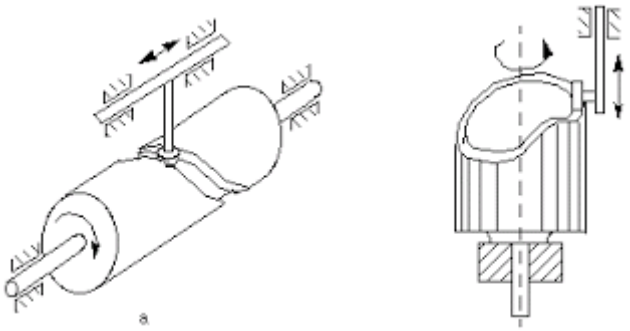
CAM SHAPE

1. **PLATE CAM** OR **DISC CAM**:
   The follower moves in a plane perpendicular to the axis of rotation of the camshaft. A translating or a swing arm follower must be constrained to maintain contact with the cam profile.
2. **GROOVED CAM** or **closed cam**:
   This is a plate cam with the follower riding in a groove in the face of the cam.



Grooved cam

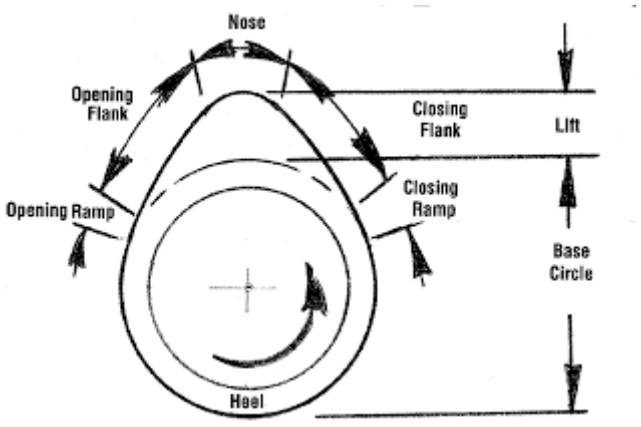
1. **CYLINDRICAL CAM OR BARREL CAM**
   The roller follower operates in a groove cut on the periphery of a cylinder. The follower may translate or oscillate. If the cylindrical surface is replaced by a conical one, a conical cam results
2. **END CAM**
   This cam has a rotating portion of a cylinder. 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.

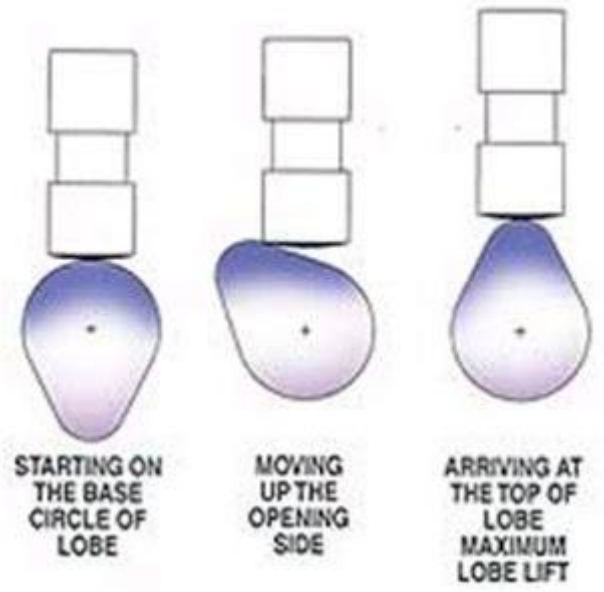


Cylindrical cam and End cam

MOTION OF THE CAM

When the cam turns through one motion cycle, the follower executes a series of events consisting of rises, dwells and returns. **Rise** is the motion of the follower away from the cam center, **dwell** is the motion during which the follower is at rest; and **return** is the motion of the follower toward the cam center.





Lift:

- Lobe lift is the distance the lifter moves in one direction
- Lobe lift is the difference in measurement between the nose of the lobe and the base circle of the lobe
- Valve lift is what most people are taking about when they refer to lift and is simply lobe lift multiplied by the rocker arm ratio

MATERIALS USED IN CAMSHAFT:

Camshaft material is the most important detail in stopping premature wear of performance camshafts.
There are various materials that camshafts are manufactured from:-

CAST IRONS

1. HARDENABLE IRON:

This is Grade 17 cast iron with an addition of 1% chrome to create 5 to 7% free carbide.
After casting, the material is flame/or induction hardened, to give a Rockwell hardness of 52 to 56 on the C Scale. It is not the most suitable material for performance camshafts in overhead cam (OHC) engines.

2. **SPHEROIDAL GRAPHITE CAST IRON KNOWN AS SG IRON:**

A material giving similar characteristics to hardenable. Its failing as a camshaft material is hardness in its cast form, which tends to scuff bearings in adverse conditions. The material will heat treat to 52 to 58 RockwellC. This material was used by Fiat in the 1980's

3. **CHILLED CHROME CAST IRON:**

Chilled iron is Grade 17 cast iron with 1% chrome. When the camshaft is cast in the foundry, machined steel moulds the shape of the cam lobe are incorporated in the mould. When the iron is poured, it hardens off very quickly (known as chilling), causing the cam lobe material to form a matrix of carbide (this material will cut glass) on the cam lobe. This material is exceedingly scuff-resistant and is the only material for producing quantity OHC performance camshafts.

CONCLUSION OF CAST CAMSHAFTS:

When purchasing a camshaft, enquire which material the camshafts are produced from. A chilled iron camshaft may be more expensive, but its resistance to wear in all conditions, far exceeds any other type of cast iron.

STEEL CAMSHAFTS

1. CARBON STEEL – EN8 (BS970 080M40) /EN99(BS970 070M55):

Used mainly in the 1930 to 1945 period and is currently used for induction hardened camshafts in conjunction with roller cam followers, due to the through-hardening characteristics of the material.

2. ALLOYED STEELS – EN351 AISI 8620 and EN34:

Used by British Leyland in the A Series and B Series engine and best when run against a chilled cam follower.

3. NITRIDING STEEL – EN40B:

The best steel for camshafts. When nitrided it gives a surface hardness and finish similar to chilled iron.We used this when replacing chilled iron camshafts in competition engines. This material is used on several of the current F1 engines.

CONCLUSION

In general, steel is a good camshaft material. However, the type of steel has to be matched with the cam follower it runs against, as different grades of steel have different scuff characteristics.

METHODS OF MANUFACTURING:

1. CASTING:

Chilled cast iron is primarily used for production of cam shaft. The development of automobile industry and engine power brings up more advance requirement for properties of camshaft. In casting process, there are more chances of casting defects such as shrinkage defect, porosity, crack, insufficient pouring. However for higher loads in roller contact, cast camshafts with induction hardened cam lobes can be used.

2. **FORGING:**
Forged or manufactured from a steel bar camshafts are also used for certain high loaded diesel engines. These are produced on computer-controlled forging systems with integrated heat treatment or machined from steel bar.

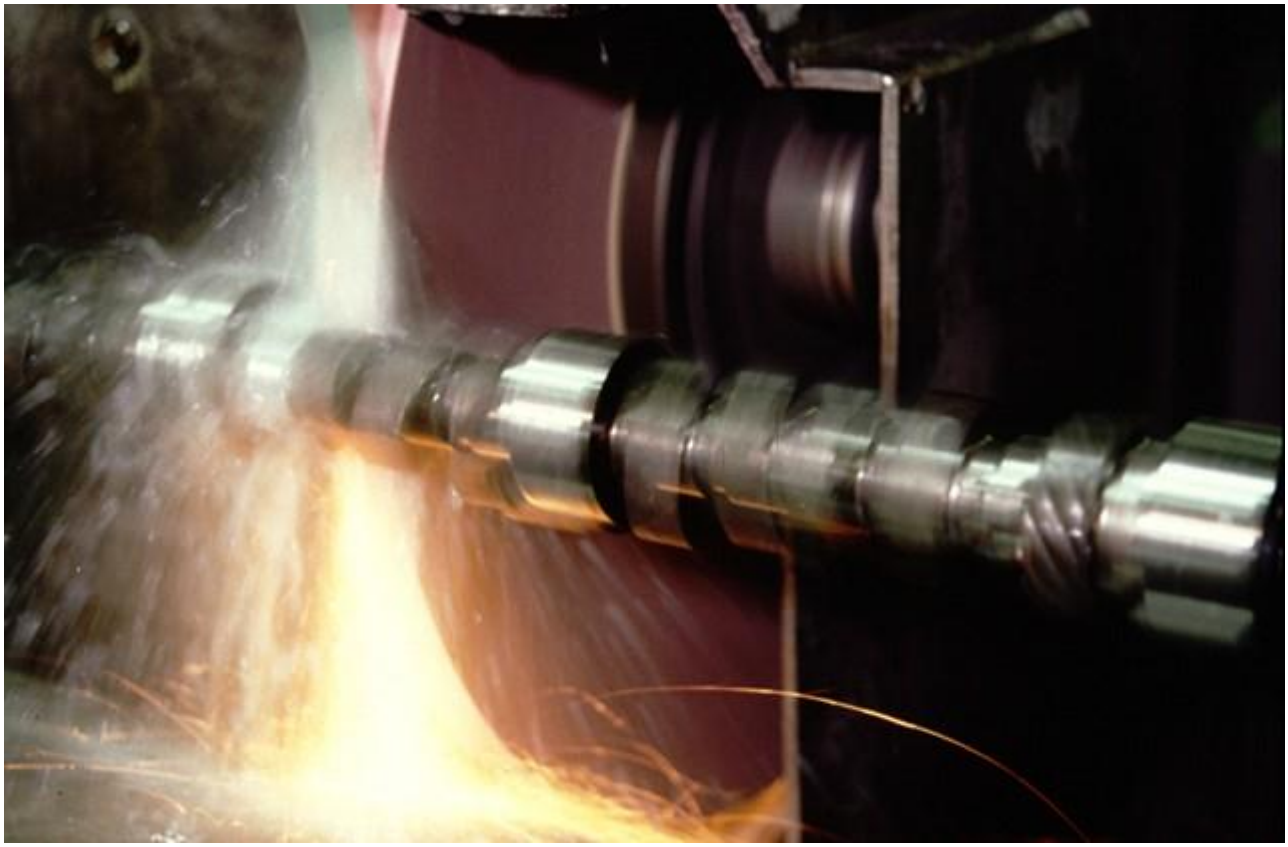
3. MACHINING: Machining is necessary for giving final dimension to the cam.

A. While using Casted or Forged CAM only Final Machining is require to achieve final size within the required tolerances. In this process casted or forged CAM are in the required shape but their size is maintained by machining and finishing operation.

B. While Using Metal Billet (metal rod), the profile of cam is obtained by removing excess material which from metal billet. In this process only machining is required to manufacture CAM.

A detailed description of the processes for mass manufacturing is as follows:

1.**TURNING & DRILLING**: The raw forging is put in this machine and center drilling and turning on one side is done here.



2. **TURNING:** Here the turning of the 6 journals takes place. There are 4 tools used for this turning – Rough, Neutral, Left and Right tool. Also, Grooving and Parting operation is performed on the left side of the shaft.

3. **DRILLING:** This machine drills the diameter 4.5 dowel hole which is used as reference for further operations.

4. **GRINDING JOURNALS:** Here grinding and finish grinding of the 6 journals takes place. Carborundum wheels are used for grinding.

5. **GRINDING ON FACE:** An angular grinding wheel is used for the face grinding operation. At this stage, inspection is done after every 10 components using gauges.

6. **DRILL DOVEL HOLE:** Grinding of the Cam is done here. The dowel hole is taken as the reference.

7. **LAPPING:** To give superfinish in microns, lapping is done using lapping paper on the Cams and the Oil seal area

8. **SLITTING:** This machine makes a slit in the right side of the shaft to fit in the engine. The cutter used is a Saw cutter and pneumatic deburring is done here.

9. **AIR & WATER CLEANING*:*** This is the Washing Machine where water and air jets are used to clean the component of dust, oil, chips etc.

10. **INSPECTION:** This is a Measuring Machine used to check for tolerances - Runouts and Diameters of journals (all 6 and center 4). The machine then declares the component as OK, NG, or BAD.