Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Aircraft Maintenance (Engines)

Lecture – 04
Construction of Reciprocating Engine Contd…

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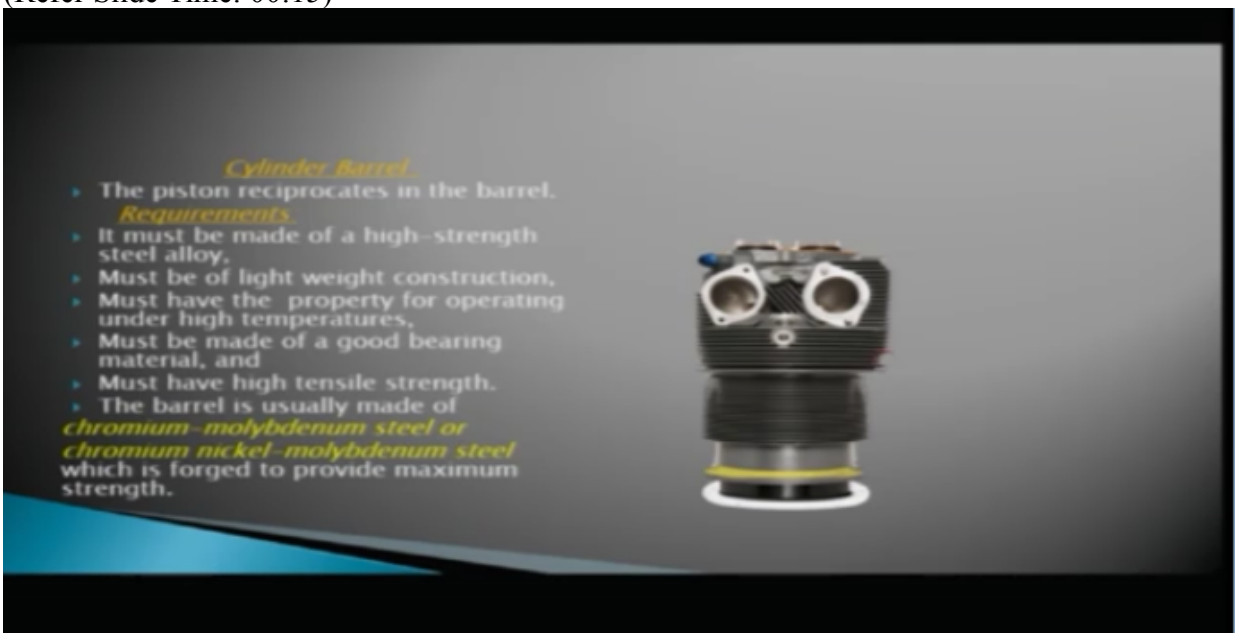

Now in the diagram you can see here this is a cylinder barrel, the piston reciprocates in the barrel, it must be made of high strength steel alloy, must be light weight construction, must have the property for operating under high temperatures, must be made of good bearing material, must have high tensile strength. And these are all the requirements which we had seen earlier also in the last slide, it must be made of very high strength alloy, steel alloy, it must be light in weight, it must have the property for operating under high temperatures, must have a good bearing material and must have high tensile strength.

The barrel, this is your barrel area, the barrel is usually made of chrome molybdenum steel or chrome nickel molybdenum steel which is forged to provide maximum strength. Again the cylinder barrel area is also forged to provide your, to provide maximum strength, generally made of chrome molybdenum steel or chrome nickel molybdenum steel.

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The cylinder barrel is machined with external cooling fins directly on the outside and a smooth cylindrical surface inside, so on the outside you can see you have the cooling fins outside, and you have a smooth cylindrical surface inside.

The cooling fins provide the best conduction of heat from the inside of the barrel to the cooling air, so the purpose of the cooling pins is to provide the conduction of heat from inside of the barrel to the outside cooling air, the inside of the cylinder barrel maybe surface-hardened by means of nitriding or it may be chromium plated to provide a long wearing surface, so the barrel from the inside may be surface hardened by nitriding or it may also be chrome plated to provide a long bearing surface,

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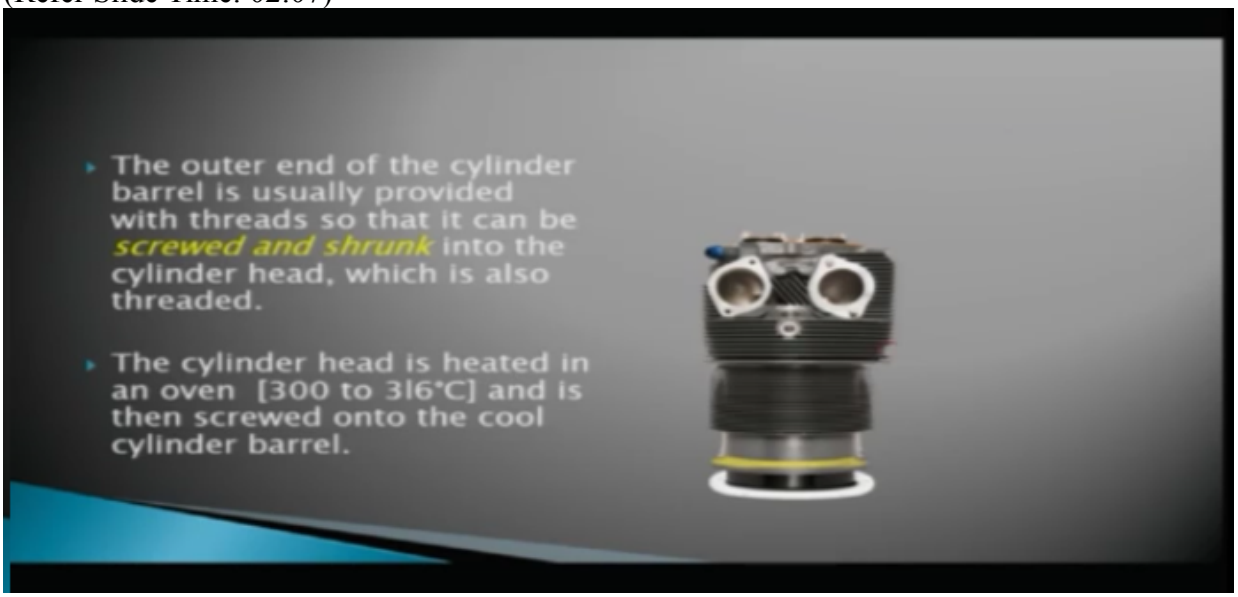

the outer and of the cylinder barrel is usually provided with threads, so that it can be screwed and shrunk into the cylinder head which is also threaded, so this is your cylinder barrel area,

this is your cylinder head area, the outer end of the cylinder barrel is generally provided with threads so that it can be screwed in the cylinder head and shrunk, the cylinder head is also a, has also a threaded and the cylinder barrel also has a threaded end, so the cylinder barrel is screwed in the cylinder head.

The cylinder head is heated in an oven for around 300 to 316 degree centigrade and is then screwed onto the cool cylinder barrel, so generally the cylinder barrel is in the cold condition, and the cylinder head is in a hot condition, we will see in the slide further how they are attached, the cylinder head and the cylinder barrel.

Now coming to cylinder head, the cylinder head provides place for the combustion of fuel and air mixture,
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so cylinder head is the area where your combustion of fuel and air mixture is taking place, it contains the intake and exhaust valve, you can see the intake and exhaust area, the intake and exhaust valve area it houses the valve guides and the valve seats. It provide support for the rocker shafts you can see here this is the place where your rocker shaft will be there upon which the valve rocker arms are mounted, we will study about the valve rockers and the valve rocker shafts and the valve operating mechanism in further slides, so this is the place where your rocker arms are supported.
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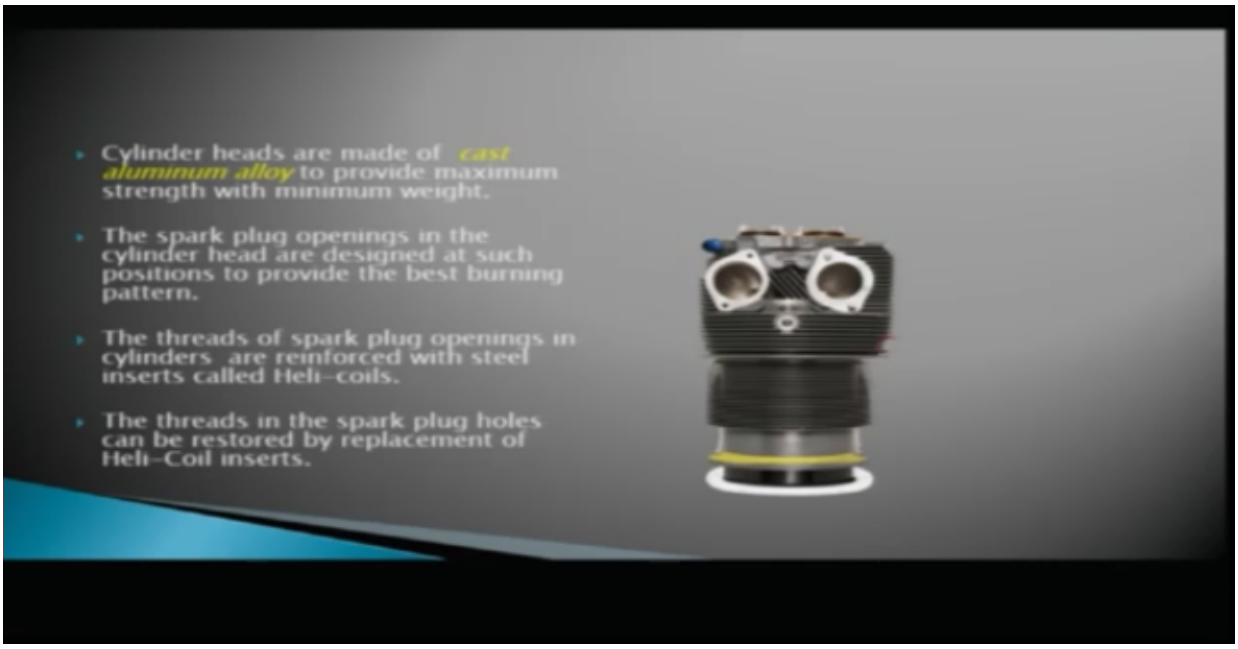

Cylinder heads are made of cast aluminum alloy to provide maximum strength with minimum weight, so cylinder heads they are cast, they are made of cast aluminum alloy so that your weight is kept to minimum and it also has maximum strength.

The spark plug openings in the cylinder head, this is your spark plug opening, spark plug openings in the cylinder head are designed at such positions to provide the best burning pattern, so the spark plug opening is designed in such a way, it is position in such a way that it provides the best burning pattern.

The threads of the spark plug openings in the cylinders are reinforced with steel inserts called Heli-coils, so the threads inside the spark plug openings they are reinforced by providing Heli-coil inserts. The threads in the spark plug holes can be restored by replacement of Heli-coil inserts.

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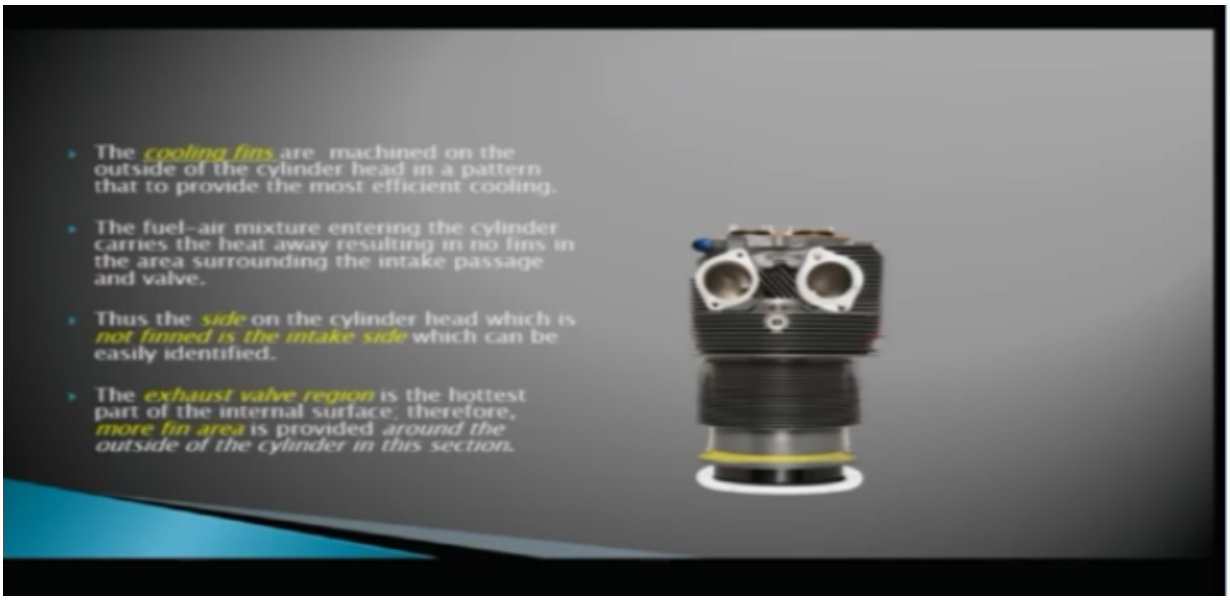

The cooling fins are machined on the outside of the cylinder head in a pattern to provide the most efficient cooling, so again the cylinder head also has cooling fins to provide the most efficient cooling.

Now the fuel air mixture which is entering inside the cylinder, it carries the heat away resulting in no fins in the area surrounding the intake passage and the valve, so generally the fuel and air mixture which is coming inside the cylinder is cold, so it carries away the heat with due to which no fins are required in the areas surrounding the intake passage and valve.

Thus the side of the cylinder head which is not finned is the intake side which can be easily identified, so on the cylinder the side where there are no fins is your intake area, and the side where you have the fins is the exhaust area.

The exhaust valve region is the hottest part of the internal surface, therefore more fin areas provided around the outside of the cylinder in this section, so on the exhaust side you have the hottest part of the internal surface, therefore more fins are required to provide cooling, so on the intake side there are no fins, on the exhaust side there you have more number of fins.

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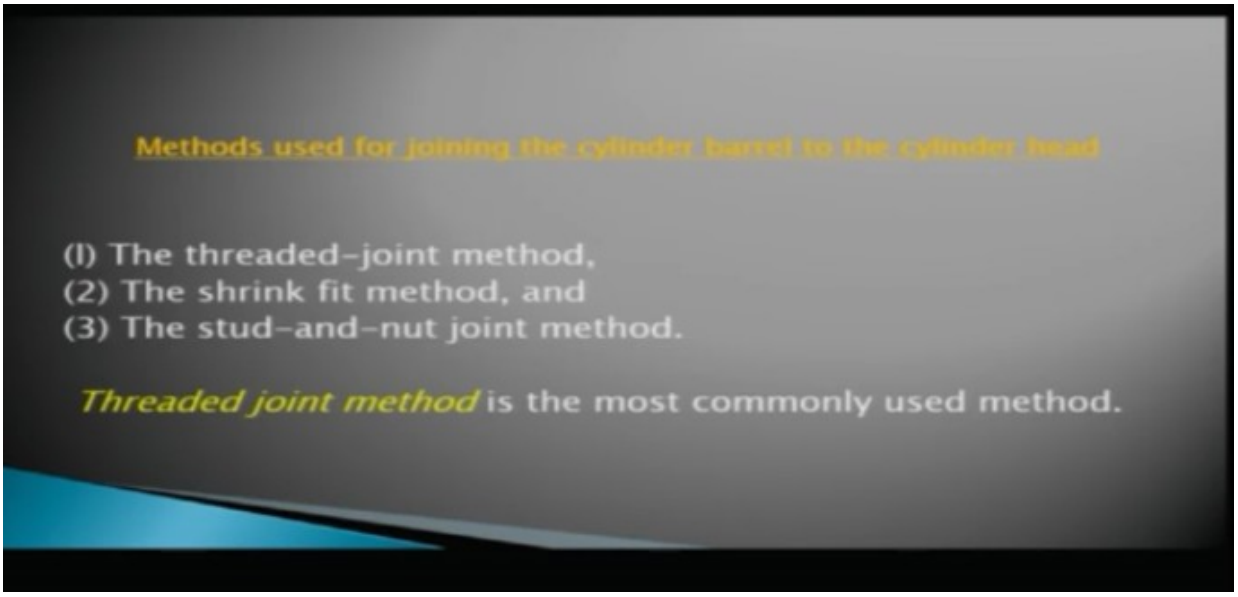

Now how do you attach the cylinder head and barrel together? There are various methods, the threaded joint method, the shrink fit method, and the stud and nut joint method, however the threaded joint method is the most commonly used method, in our earlier slide we had seen both the cylinder head and cylinder barrel they had the threads, so you can use threaded joint method to attach both of them.

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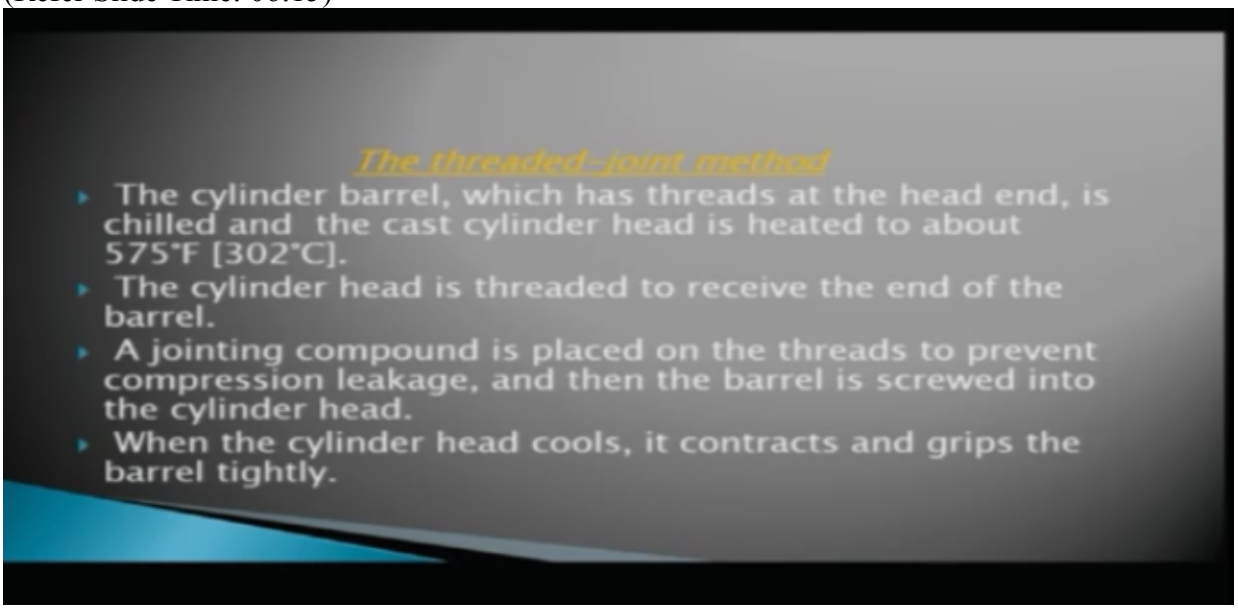

In the threaded joint method the cylinder barrel which has threads at the head and is chilled and the cast cylinder head is heated to about 302 degree centigrade, something around 300 degree centigrade, so your cylinder head is heated and your cylinder barrel is kept cold is chilled. The cylinder head is threaded to receive the end of barrel, cylinder head is also threaded so that your barrel can be screwed in the cylinder head.

A jointing compound is placed on the threads to prevent the compression leakage, and then the barrel is screwed into the cylinder head, so this jointing compound will prevent the compression leakage and the barrel is screwed into the cylinder head. So when the cylinder head cools, it contracts and grips the barrel tightly, so you have seen both the cylinder barrel and cylinder head have threads, jointing compound is also placed to prevent cylinder compression, the cylinder head is heated and the cylinder barrel is chilled, so when the cylinder head cools it contracts and grips the barrel tightly.

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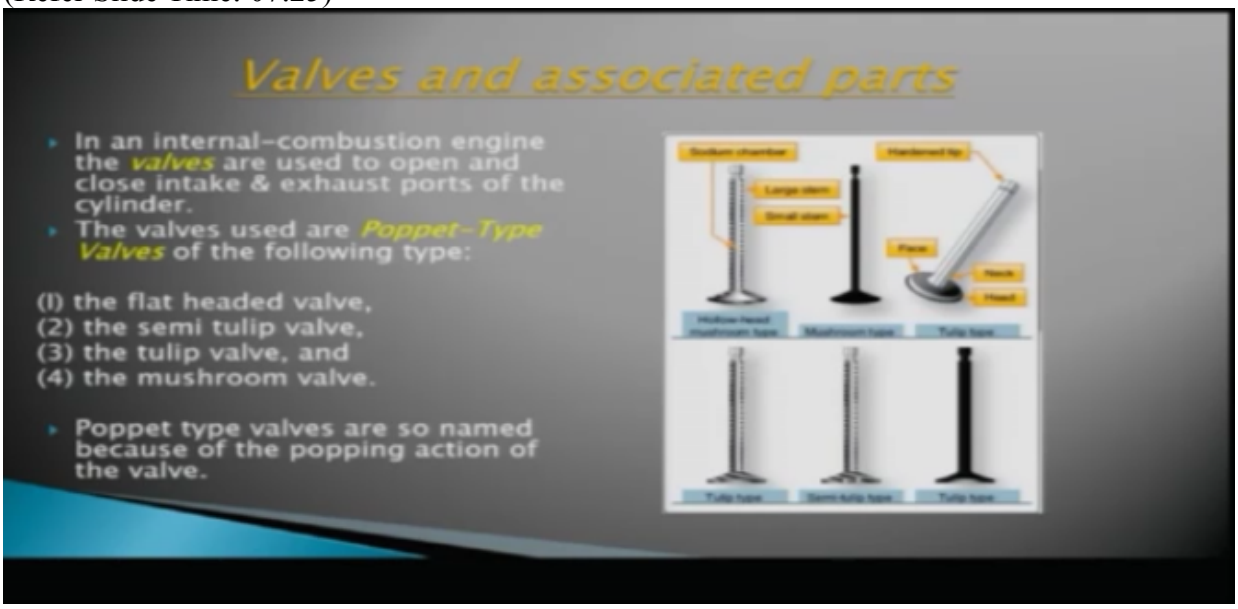

Now coming to valves and its associated parts, there is an intake area in the cylinder where you have the intake valve, the exhaust area where you have the exhaust valve, so we have two valves, intake valve and exhaust valve on the cylinder, so in any internal combustion engine the valves are used to open and closed the intake and exhaust ports of the cylinder.

So in order to open the intake port and the exhaust port, in order to open or close both the ports you need valves, the valves used are Poppet type valves or the following type, so generally that valves being used are the Poppet type, the name Poppet is given because of the popping action of the valve, so they are called Poppet type valves, they are of different types, the flat head valves, the semi tulip valves, the tulip valve and the mushroom valve, so here in the diagram you can see there are various types of valves shown here, the semi tulip valve here you can see this is your semi tulip valve, then you have this is your tulip type valve, here you have this is your tulip type valve, this is your semi tulip valve and this is your mushroom type valve, okay.

So different types of valves also the flat head type valves, it is not shown here in this diagram but you have the flat head valves, the semi tulip valves, the tulip valves and the mushroom valves.

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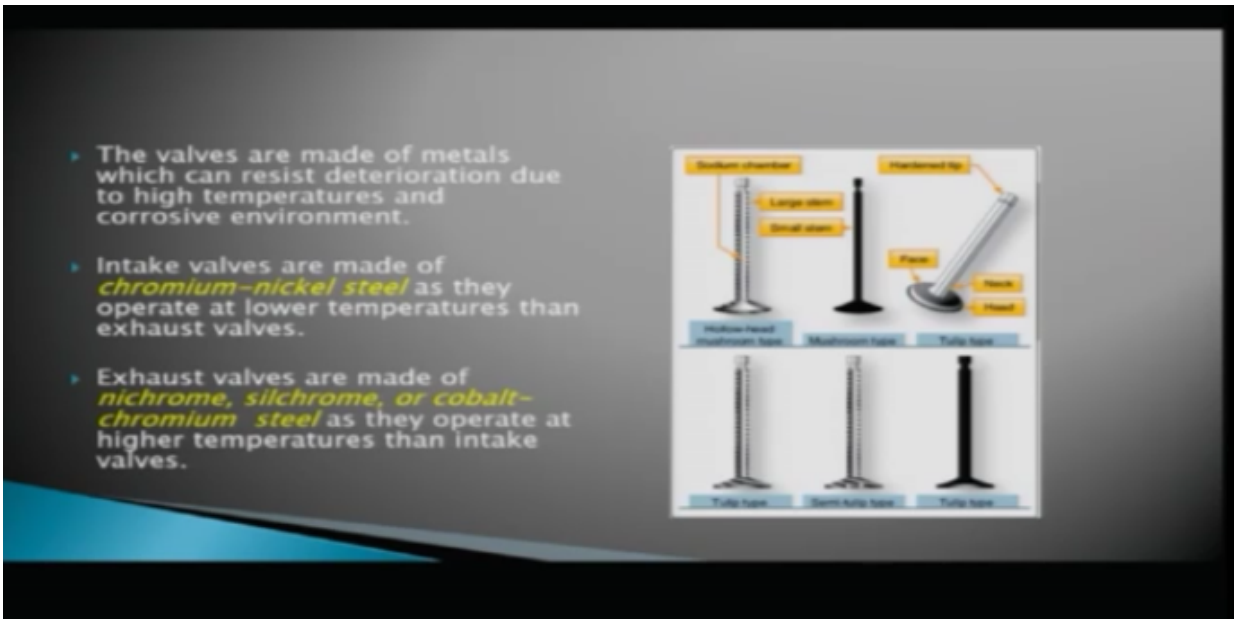

The valves are made of metals which can resist deterioration due to high temperature and corrosive environment, now the valves, these valves are also exposed to very high temperatures and corrosive environments, so they need to be made of metals which can resist deterioration due to this high temperature and corrosive environment.

Intake valves are made of chromium nickel steel as they operate at lower temperatures then exhaust valves, now the intake valves, since they are operating at lower temperature as compared to exhaust valves they are made of chromium nickel steel.

Exhaust valves since they are operating at very high temperatures as compared to intake valves, they are made of nichrome, silchrome or cobalt chromium steel.
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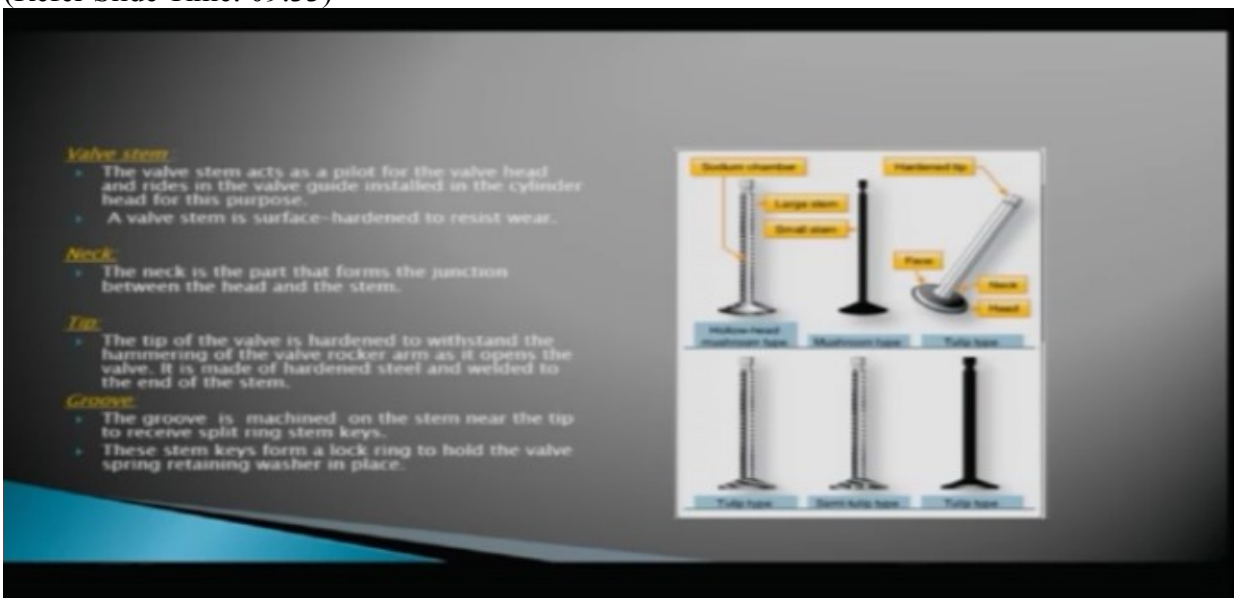

Now on the valve you have different parts, first is your valve stem, you see this portion, this is your valve stem, the valve stem acts as a pilot for the valve head, this is your valve stem, this is

your head, this is your valve head, this is your face of the valve, this is the neck portion, this is your stem, this is your tip, so the valve stem, this valve stem this acts as a pilot for the valve head, so this is your valve head, this acts as a pilot for the valve head and rides in the valve guides installed in the cylinder head for this purpose, so within the cylinder heads you have valve guides installed and inside those valve guides this valve stem rides. A valve stem is surface hardened to resist wear, so this valve stem is also surface hardened to resist wear.

Next is your neck, this is your neck area, this is your neck area, so the neck is the part that forms the junction between the head and the stem, so this is your head, this is your head, and this is your stem so the junction between the head and the stem is your neck area.

The tip, this is your tip area, the tip of the valve is hardened so this area is also hardened to withstand the hammering of the valve rocker arm, now the valve rocker arm we'll see in the further slides, this valve rocker arm hammers on the tip of the valve, so in order to withstand the hammering of the valve rocker arm, it is made of harden steel and welded to the end of the stem, so this is made of hardened steel and is welded to the end of the stem.

On the stem you also have the grooves, the groove is machined on the stem near the tip, the groove is machined on the stem near the tip to receive split ring stem keys, so in order to receive the split rings stem keys the valve stems are grooved, these stem keys form a lock ring to hole the valve spring retaining washer in place, so in order to hole the valve springs these grooves are provided to hole the valve spring retaining washers.

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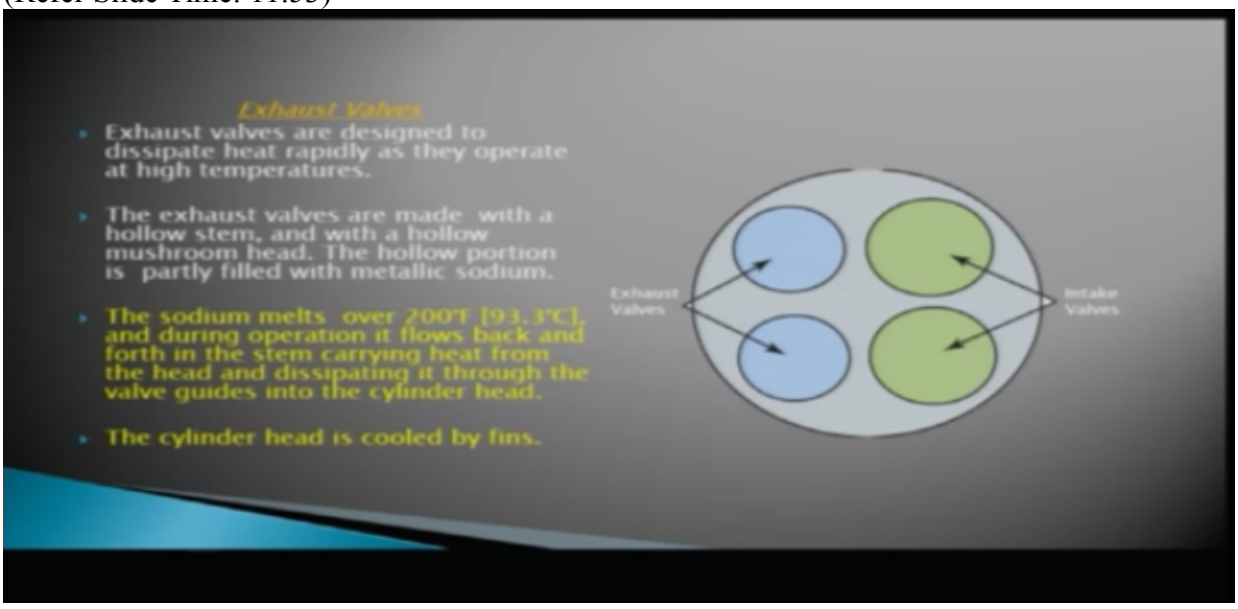

The exhaust valves, the exhaust valves are designed to dissipate heat rapidly as they operate at high temperatures, since the exhaust valves are operating at very high temperatures they are designed so that they are able to dissipate heat rapidly.

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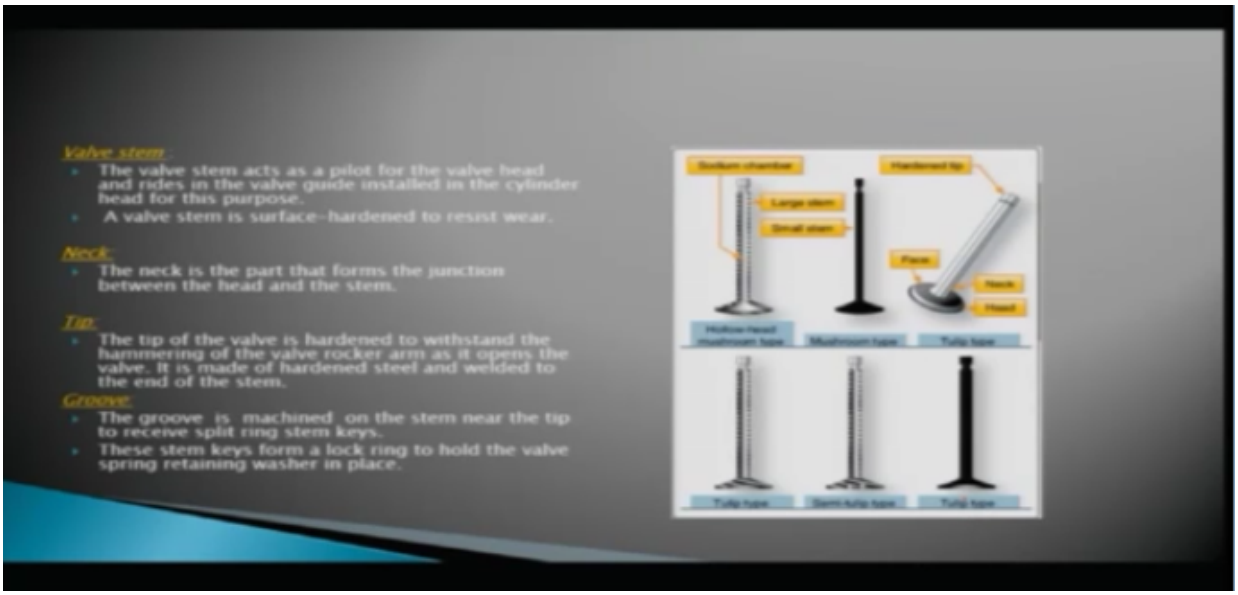

The exhaust valves are made with the hollow stem and with the hollow mushroom head, so generally the exhaust valves are made with the hollow stem and to the hollow mushroom head, you've seen here in the earlier diagram, you see here this is your mushroom type, in the exhaust valve you have, this is your exhaust valve, you have the hollow head, the head is hollow and the stem is hollow.

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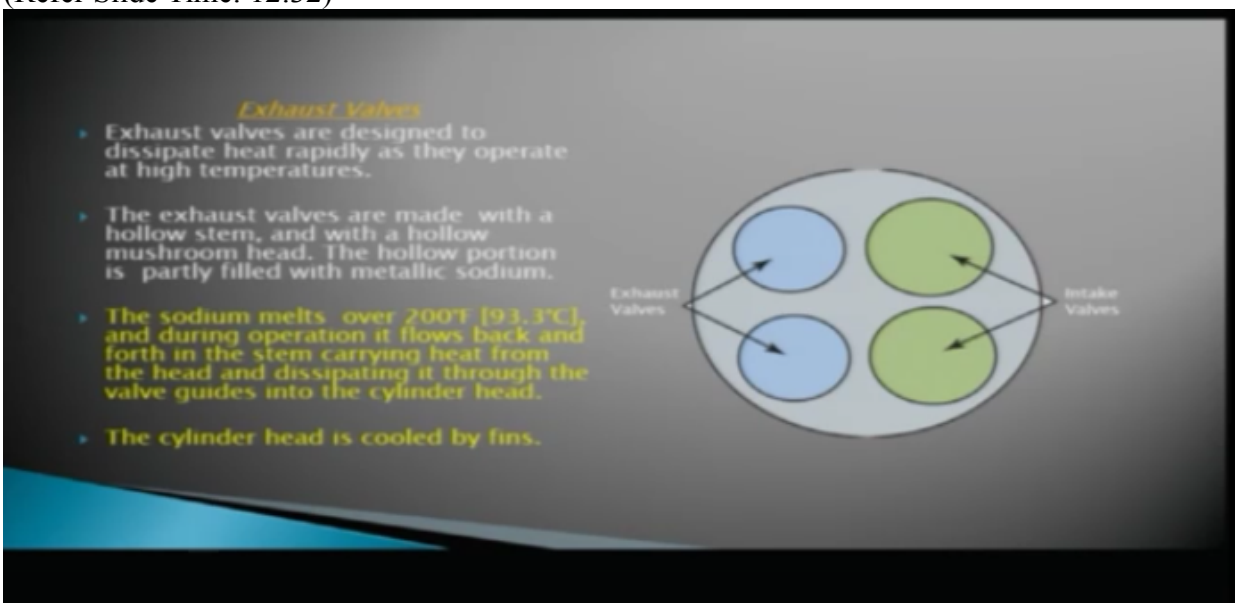

The hollow portion is partially build with metallic sodium, so here you see this hollow portion is partially filled with metallic sodium, the sodium melts over 200 degrees Fahrenheit, so over 200 degree Fahrenheit or 93 degree centigrade the sodium melts and during operation it flows backend forth in the stem carrying heat from the head and dissipating through the valve guides into the cylinder head, so this metallic sodium above 93 degree centigrade this metallic sodium this turns into liquid and it moves backend forth between the head and the stem and dissipates heat, transfers it to the valve guide and finally to the cylinder head.

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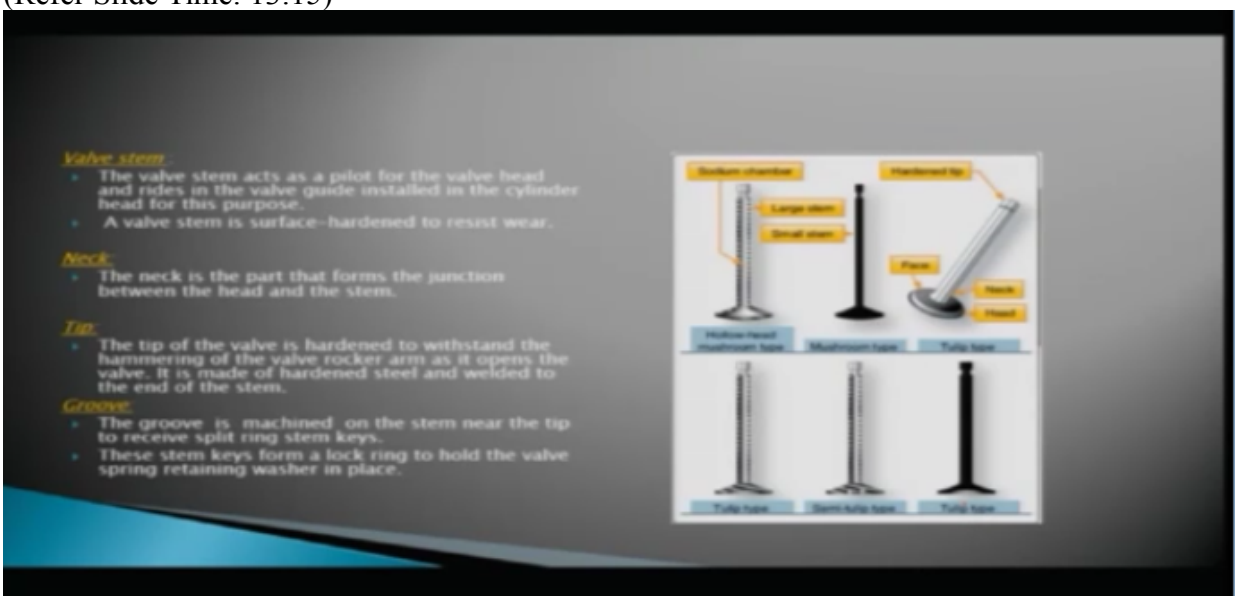

The cylinder head is also cooled by fins, as we have seen earlier the cylinder heads are also provided with cooling fins, so the heat being dissipated to the cylinder head is further dissipated to the outer air and the cylinder head is also cooled.

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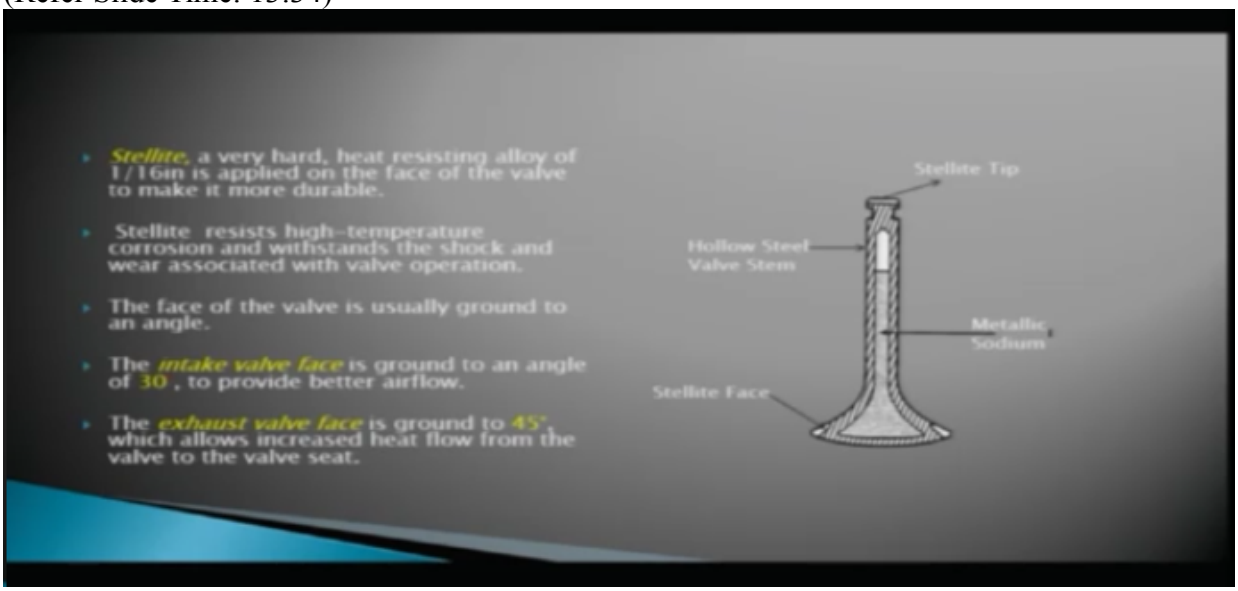

Here in this diagram you can see a hollow stem and a hollow face Stellite a very hard heat resisting alloy or 1/16 inches is applied on the face of the valve to make it more durable, so the face of the valve you can see here this is your face of the valve, this is your tip, the face and the tip they are provided with the Stellite material which is very hard, and it is heat resisting alloy, so around 1/16 inches of Stellite material is applied on the face and the tip.

Stellite resist high temperature corrosion and withstands the shock and wear associated with valve operation, now since the valve is exposed to very high temperature, corrosive

environment and also withstands the shock from the rocker arm, so in order to withstand all this high temperature, corrosive environment and hammering of the rocker arms, Stellite is provided, Stellite has the characteristic to resist high temperature corrosion and shock and wear associated with valve operation.

Now this face of the valve it is grounded to an angle, the intake valve face is grounded to an angle of 30 degrees to provide better air flow, and the exhaust valve face is ground to 45 degrees which allows increase heat flow from the valves to the valve seat.

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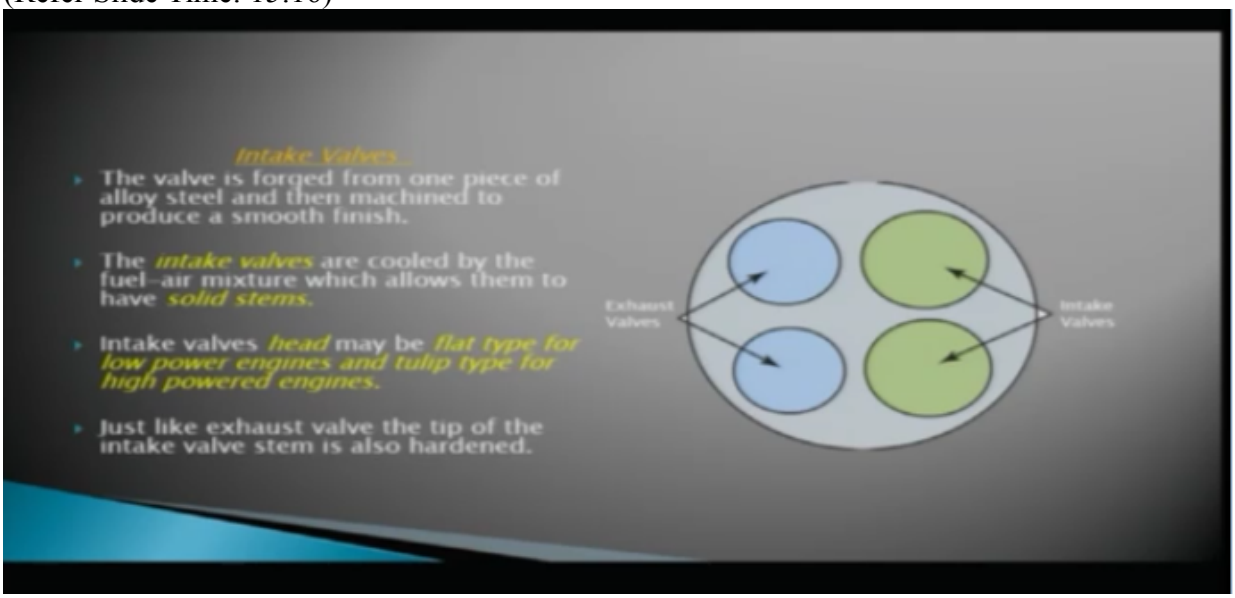

Now the intake valve is ground to 30 degrees angle and the exhaust valve face is ground to 45 degrees to allow increase heat flow from the exhaust valve to the valve seat.

Intake valves, the intake valve exposed from one piece of alloy steel and is then machined to produce a smooth finish, so since the intake valves are operating at a lower temperature as compared to exhaust valves, the intake valves are forged from one piece of alloy steel and are machine to provide a smooth finish, the intake valves are cooled by fuel air mixture which allows them to have solid stems.

Now since the intake valves are cooled by the fuel air mixture and are being operated at lower temperatures as compared to exhaust valves, they can have solid stems. Intake valves head may be flat type for low power engines, and tulip type for high powered engines, so intake valves heads may be either flat type or tulip type, just like exhaust valves the tip of the intake valve stem is also hardened, so the intake valve stem tip is also hardened as it is done in the case of exhaust valve.

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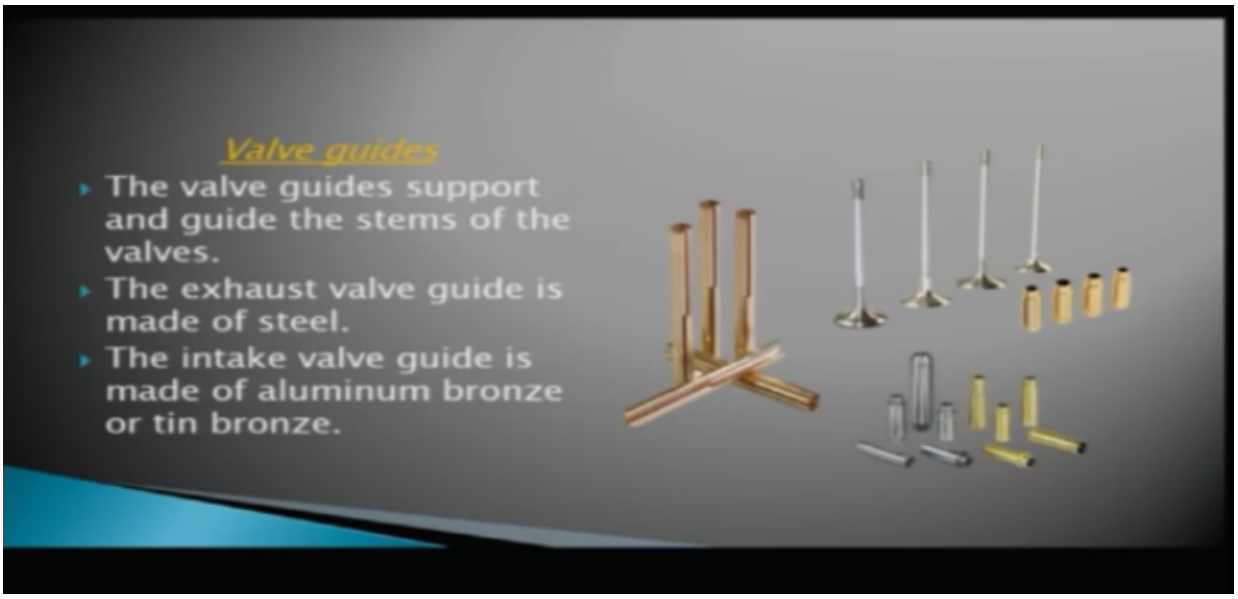

Next is valve guides, the valve guides support and guide the stems of the valves, so these valve guides they are provided to support and guide the stem of the valves, so these valve stems they ride inside this valve guides, this is your valves, the valve stem, these rides inside the valve guide, the exhaust valve guide is made of steel and the intake valve guide is made of aluminum bronze or tin bronze, so since the intake valve is operating at lower temperatures, the intake valve guide is made of aluminum bronze or tin bronze and the exhaust valve guide is made of steel.

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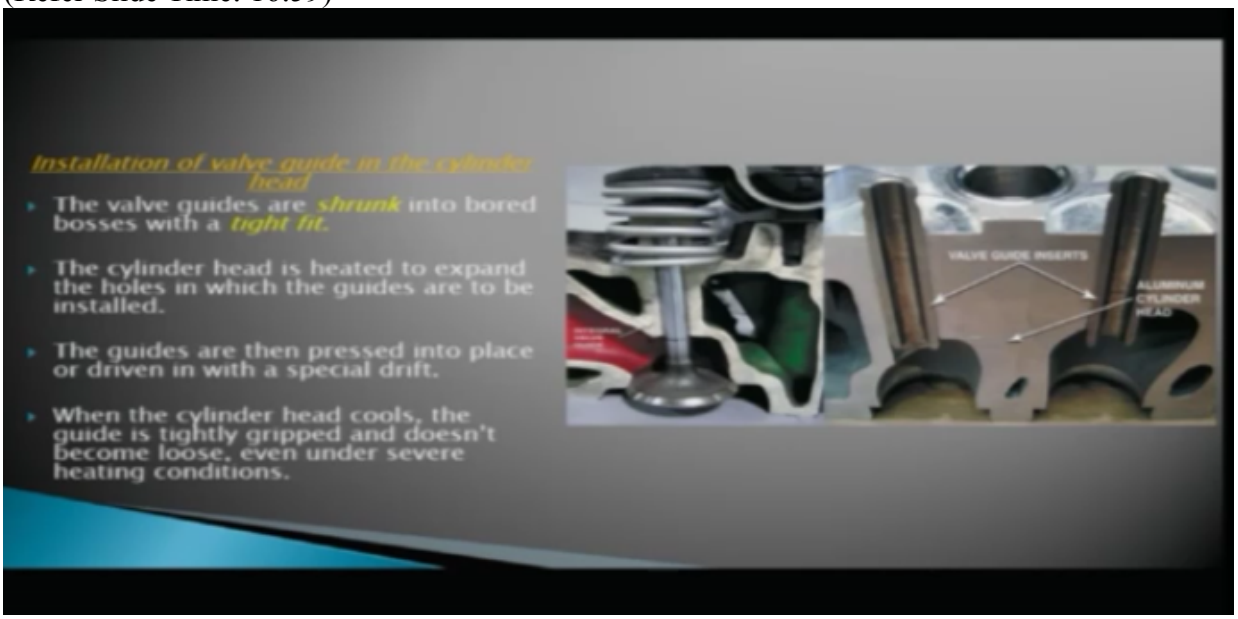

Here in the diagram you can see you have the valve guide inserts, this is your cylinder head area where the valve guides are provided and inside these valve guides the valve stem moves, you can see here this is your valve, this is your valve, this is your valve stem, you have the integral valve guide here in the cylinder head and within this cylinder head, this valve guide your valve stem will move.

The valve guides are shrunk into bored bosses with a tight fit, these valve guides they are also shrunk, you have the bored bosses inside the cylinder head and in these bored bosses the valve guides are shrunk fit, the cylinder head is heated to expand the holes in which the guides are to be installed, so cylinder head is heated to expand the guide holes, the guides are then pressed into place or driven with a specific drift, so these guides they are pressed into place when the cylinder head is heated, these holes expand and the guides are pressed into place.

When the cylinder head cools the guide is tightly gripped and doesn't become lose even under severe heating conditions, so they are placed in the cylinder head.

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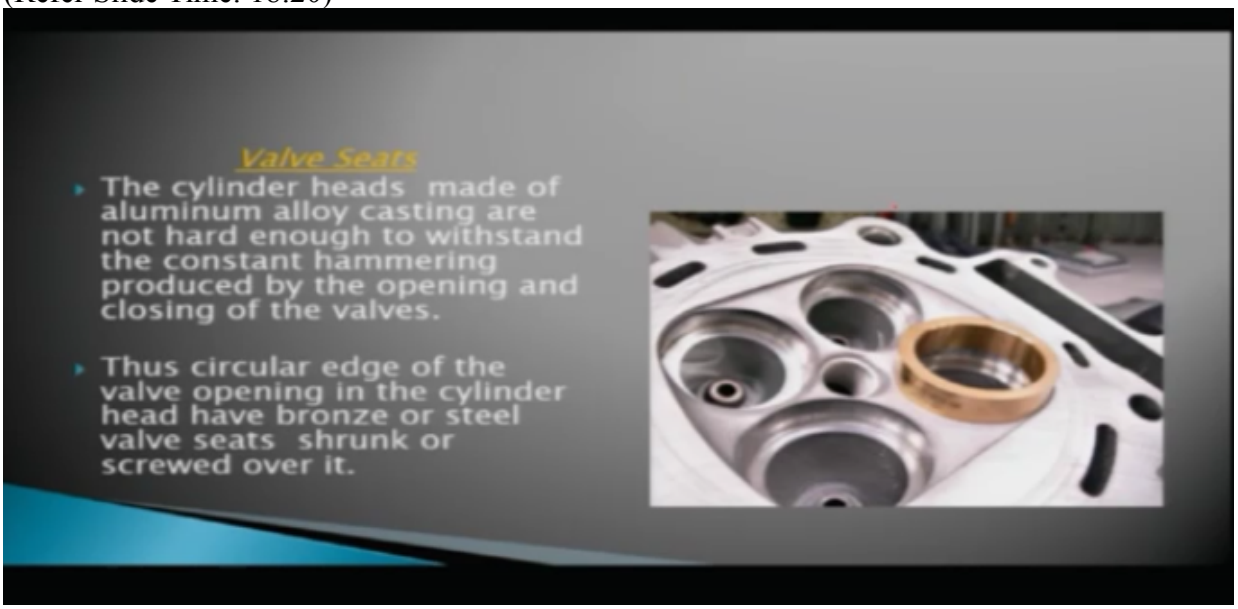

Next is valve seats, the cylinder heads made of aluminum alloy casting are not hard enough to withstand the constant hammering produced by the opening and closing of the valves, so when the valves are continuously opening and closing they're providing the hammering on the cylinder head and cylinder head being made of cast aluminum alloy, they are not very strong, they are not very hard enough to withstand this hammering, so in order to avoid that valve seats are provided on the valve openings.

Thus circular edge of the valve opening in the cylinder head have bronze or steel valve seats shrunk or screwed over it, so you have the valve seats, this is your valve seat you can see here this is your valve seat it can be made of bronze or steel they are circular and they're provided in the cylinder head and placed either by shrunk fit or screwed.

Now here in the diagram you can see the intake valve openings they have aluminum bronze seats,
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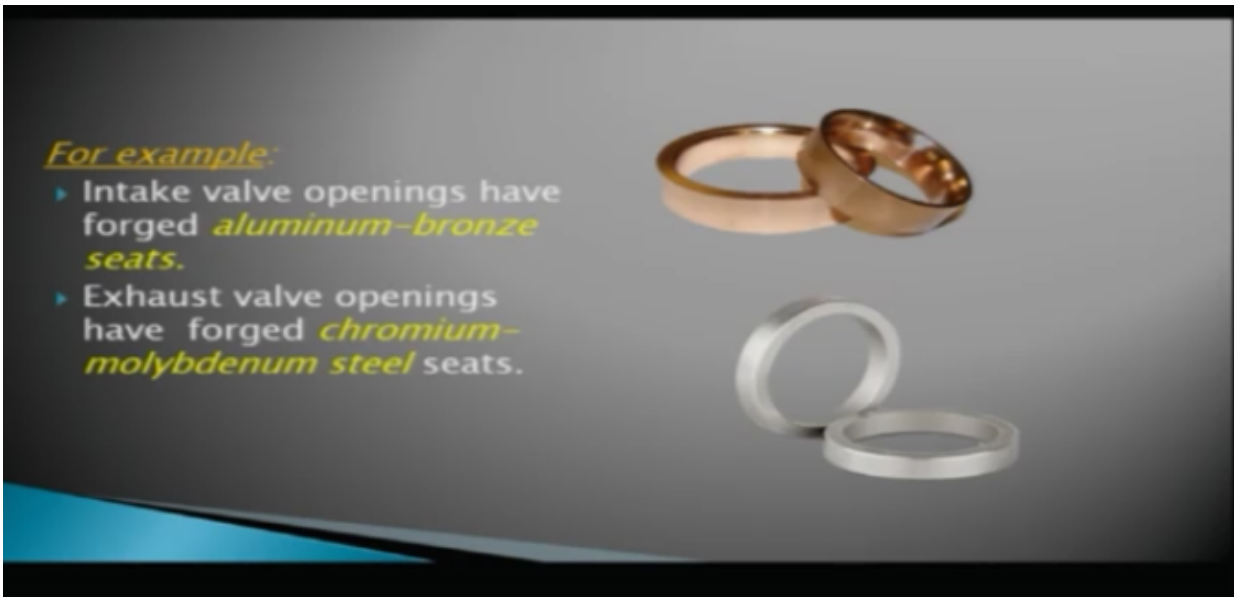

you can see here these are aluminum bronze seats meant for intake valve openings and for exhaust valve openings you have chromium molybdenum steel seats.

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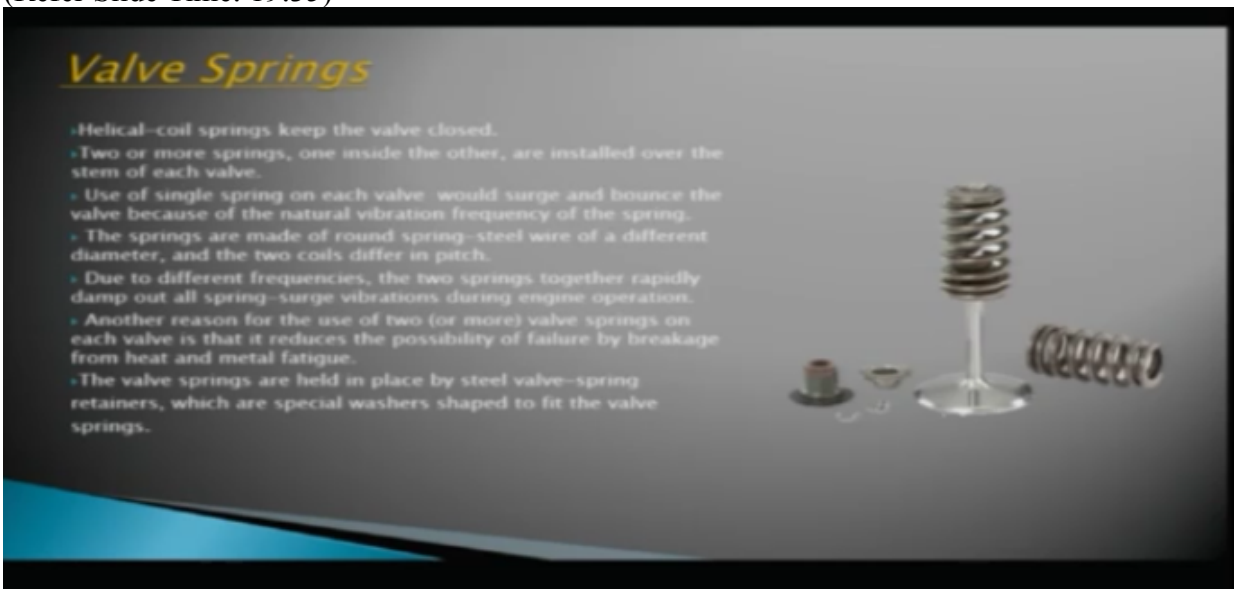

Next is valve springs, so on the, you've seen this is your valve, this is your valve head, this is your valve stem, and over the valve stem you can see here these are the springs, they are Heli-coil springs which will keep the valve closed.

Now two or more springs, one inside the other are installed over the stem of each valve, so over the stem of each valve two or more Heli-coil springs, one inside the other are provided.

Now use of single spring on each valve would surge and bounce the valve because of the natural vibration frequency of the spring, so because of the natural vibration of frequency of the spring the valve will surge and bounce, so that is why two or more springs are provided one inside the other.

The springs are made of round springs steel wire of different dia, these springs are made of round spring steel wire of different dia, since two or more coils are inserted one inside the other they also differ in pitch. Due to different frequencies, the two springs together rapidly damp out all springs surge vibrations during engine operation, because of the different frequencies the two springs together damp out all the springs surge vibrations during engine operation.

Another reason for the use of two or more valve springs on each valve is that it reduces the possibility of failure by breakage from heat and metal fatigue, so because you have two or more springs so the possibility of failure by breakage from heat or fatigue is also minimized, the valve springs are head in place by steel valve spring retainers which are special washers shaped to fit the valve springs, so here you can see there are special washers which keep the valve springs in place.

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