Course Name: Engine System and Performance
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Lec 7: Shape and Material of Engine Components

I welcome you all to the session on engine systems and performance, and in continuation of our last lecture on the design, constructional features, safety, and materials of several components of the engine. Today, we shall discuss this part, which is the last part: materials of several components. In the last two lectures, we have discussed engine components. We have identified several components, though we could not discuss all of them. We have tried to discuss or identify several major components or major parts, and then we have discussed the constructional features and also, to some extent, the safety of two major parts: the arrangement of engine cylinders and also the valve or valving arrangements.

Based on the design and constructional features of valves and valving arrangements, we could classify engines into several categories. And also, based on the cylinder arrangements and the constructional features of cylinders, we could classify engines into different categories. So, today we shall discuss an important part or aspect of engine design: the selection of materials, which is very important. So, let us now discuss the components that we have discussed in one of the previous classes, and then we will discuss the shape and materials of those components in today's class.

We shall be discussing the shape and materials of the engine components. So, this is the topic of our discussion today. So, again, I have attached the schematic in the slide just to recap the components that we have identified and discussed as well.

So, to start with, let us discuss the block, which is a very important component. So, if we write here 'block' again. So, what is this shape? First of all, we shall discuss the shape. In the previous class, we talked about the arrangement of cylinders, and then, based on the cylinder arrangements, we could classify engines into several categories.

So, the shape of the block can be like what we discussed in the previous class, that is, cylinder arrangement: single, then inline engine block, we can have V engine block, we

can have W-shaped engine block. That means, try to recall what we discussed in the previous class. Cylinders are, placed inside the block.

So, cylinders can be placed in an inline arrangement, that is, one behind or one after another, along the line of the crankshaft, inline arrangement. We can have two banks of cylinders placed in such a way that it will take a shape like the letter V, and it can also have a shape like this, W-shaped engine block. Now, these are the several shapes, several shapes rather. So, now the question is, what would be the material of this block? So, material.

Material is, typically cast iron or even an aluminum block. So, these are typically the materials used for fabricating the engine block. So now let us move.

To the next component, which is the camshaft. So, this is the camshaft. Again, we are writing the component as camshaft. It has, we shall be discussing its shape as well as material. What would be the shape of the camshaft? So, this is not the camshaft; rather, this is the crankshaft. Let me erase this part, and the camshaft is here. So, what would be the shape?

Let me write it down here. Shape is egg-shaped, and material is forged steel or cast iron. I am writing CI for cast iron, so this is for cast iron, CI. So, this is the shape is egg-shaped, and the material we can use is forged steel or cast iron as the material for the camshaft. The next is the combustion chamber.

So, let me mark here. So, this is the combustion chamber, which is a very important part of the engine block, or rather, I should say. Because we know that this is the chamber wherein combustion will occur, and since combustion is an exothermic process—I mean, combustion is a very complicated process—but what we know is that in this process, we need to have or we need to generate extensive heat. So, there will be an extensive rise in temperature as well as an increase in pressure.

So, since this chamber is needs to withstand high temperature as well as high pressure, the material should be selected accordingly. So, if we write here, combustion chamber, again, the shape is that we have discussed in the last class, basically, the combustion chamber phase is variable. So, when the piston is at the bottom dead center, we will have a larger space in the combustion chamber, to be precise, but when the piston arrives at the top dead center, the combustion chamber space will be reduced. So, the shape is basically cylindrical, a cylindrical shape.

It can have an open chamber or it can have a closed chamber. An open chamber means it can have one chamber for each cylinder. So, this is what an open chamber is, but it still can have, a dual chamber on each cylinder connected by an orifice passage, or it can have a divided chamber, that is, dual chambers on each cylinder. Connected by an orifice passage. So, this is basically, an open chamber.

Please don't be confused with the word 'open.' It doesn't mean that the chamber is open to the ambiance. So, this is an open chamber just to and this is a divided chamber just to distinguish this one chamber for each cylinder from the dual chamber. I mean, in each cylinder, there are two, dual chambers, and the chambers are connected by an orifice passage just to distinguish. This particular case from this, divided chamber, we are giving a name 'open chamber,' that is, there is no, divider.

And then, what is the, what should be the material we need to write? The material is, the combustion chamber needs to withstand high temperature as well as high pressure. So, the material should be selected accordingly, and the material is cast iron, or we can write steel alloys, and steel. We can use nickel-based super alloys. So, these two are the materials used to fabricate the combustion chamber. So, we can now move to discuss the next component, which is the connecting rod.

So, this is the connecting rod. So, if we write here, 'connecting rod.' The shape is I-shaped or H-shaped. So, this is either an I or H-shaped rod, and the material that the connecting rod is also.

The connecting rod will travel because it is integrated with the piston, so this part is also exposed to a high-temperature environment. Therefore, the material should be selected based on that particular consideration. Typically, steel is used, or we can use an alloy as the material, or we can still use aluminum. So, these are the materials used to fabricate or construct the connecting rod. The next component is the crankcase. So, shape and material. The shape would be rectangular or a box-like structure.

Rectangular or a box-like structure rather, and the material we can use is aluminum alloys, cast iron (CI), or aluminum. So, this is the material, or these are the materials used to fabricate the crankcase. So, if we move to the next slide, the next component is the crankshaft. So, the shape and material that we have discussed are for the crankcase.

The crankcase that we have discussed, but now we will discuss the crankshaft, here the crankshaft. So, if we now discuss the crankshaft, then again, we shall look at or look into

the shape of this particular component, the crankshaft. The crankshaft is again cylindrical. And the material is cast iron. So, these are the shape and material used to construct or fabricate the crankshaft. So, we have also discussed the crankcase in the previous slide.

Next is the cylinder. So, if we now mark this component is the cylinder, which is again very important. So, the cylinder again, we have to discuss its shape. The cylinder shape is circular and the material is cast iron, or you can use aluminum alloys. So again, these are the shape and materials rather used to fabricate the cylinder of the engine. Okay, so if we go to the next slide, then we have the exhaust manifold, which is this one. So, this is the exhaust manifold. This is again a very important component because this exhaust manifold, which we have discussed, has some piping arrangements through which combustion gases will go out from the engine cylinder or combustion chamber into the ambiance.

So, if we write now, this is the exhaust manifold. The shape is, a cylindrical pipe, which we have discussed. So, the shape is a cylindrical pipe, a cylindrical tube rather, or pipe. So, and the material, again, this pipe or tube should always be in contact with high-temperature combustion gases. So, the material should be selected based on this consideration so that because of temperature or high temperature, no thermal crack will develop. So, the material is stainless steel sometimes cast iron, or mostly Inconel.

That is nickel-chromium alloys. Nickel-chromium alloys, that is Inconel, are also used. Now let me talk about this particular part again. The exhaust manifold, is not only a cylindrical piping arrangement because this part is connected to two other important components. So, in this context, let me discuss two other important components, which are the catalytic converter, used to reduce NOx emissions.

And then it is also connected to a muffler just to reduce the noise. Otherwise, if that muffler is not provided, then from the exhaust manifold when combustion gases come out, it will create some noise. And so, the exhaust manifold is connected to a catalytic converter to reduce emissions or NOx emissions to reduce environmental pollution, and to reduce noise, a muffler is also connected. So, this part is connected to the thermal or catalytic converter purpose is to reduce, emissions, NOx, and muffler.

To reduce noise, engine noise rather, the noise of the engine. So, this is what we have discussed about the exhaust manifold. Now, if we move to the next one, that is the head.

So, if we just mark this component that is the head, briefly discuss this. So, the head, again we need to know about the shape.

What is the shape of this component? That also we have discussed, that is, again based on the valve arrangement. It can have an L head, H head, T head, all these things. So, the shape is a flat head or L head. It can be overhead or, I head, it can also be a pent roof head, etc., and it can also be a cross-flow head.

So, these are the shapes, and certainly, we need to know about the materials or material used to fabricate this component, which is either cast iron or aluminum. So, this is for the head, and then we can have Another component, we can have a discussion on another component, which is the intake manifold. This manifold is again some piping arrangement, but mostly, the coolest part of the engine, wherein the temperature is not that high. And mostly, intake manifolds are used to supply air in CI engines and also in modern SI engines. But in earlier SI engines also, this intake manifold is used to supply the fuel-air mixture, that is the charge, when the carburetor will be there.

But nowadays, in modern engines, the carburetor is not used. That part is almost obsolete. So, that is intake manifolds. Shape is again, cylindrical pipe, and material, since the temperature of this part is relatively less as compared to other parts of the engine, we can use plastic. And also, we can use composite material.

Composite or cast material. So now, we should move to discuss another component, which is the oil pan. Again, let me mark this particular component. And very quickly, we have to complete the oil pan.

This oil pan shape is, part of the crankcase. So, we have already discussed the shape of the crankcase. Accordingly, the shape of the oil pan would be determined, along with the material. The material is mild steel, but we can also use aluminum alloys. Next is the piston, which is a very important part of the engine. Let me write here: piston. What should be the shape? You can understand that the piston shape should be cylindrical. And again, the material of this particular component should be such that it can withstand high temperature and high pressure.

So, the material is, steel, or we can use aluminum and composite material. If we use steel, it has lower thermal expansion, which is very important. It provides higher tolerance. If we use aluminum, it has low mass inertia. Sometimes, we can also use composite material. So, if we use steel, it has, relatively lower thermal expansion.

So, the tolerance would be better. Because we always need to maintain the gap between the cylinder inner wall and the piston outer wall. If the gap is too much, it will be very difficult. So, we need to maintain, the tolerance up to the mark. So, in that case, steel is good enough because, even when experiencing high temperature, the tolerance level can have some deterioration or some sort of deviation.

So, that is these are the materials used to fabricate, design, or construct a piston. Next, we can move on to the piston ring. So, let me mark these piston rings here. So again, if I write the piston rings' shape, hollow cylindrical rings and material, because these rings are, provided at the outer periphery of the cylinder just to, prevent the leakage of high-pressure gases, through the gap between the cylinder's inner wall and the piston's outer wall, and also, one ring provides lubrication to the cylinder's inner wall, and rings are also provided to increase the life of the piston, as we have discussed.

So, rings are also exposed to high temperatures, and those two rings will be in contact with the cylinder's inner wall, so frictional effects will be there. The rise in temperature is due to the combustion process and also due to continuous friction. So, the material of the cylinder piston rings should be metal rings.

And then we have the push rod. Let me mark this. The push rod is here. So again, if we write the push rod's shape and material, the push rod's shape is cylindrical, and the material is high-strength steel or aluminum.

Then another two components: one is the valve. If we write the material and shape for the valves, shape and also the material. So, the valve is, sort of rotary type, poppet valve, spring-loaded. So, basically, rotary or poppet valve, and the material is hardened steel or ceramic. Sometimes ceramics also.

And the last component that we should know for this class is the water jacket. So again, if I mark that particular component, that is the water jacket. So, water jacket. Shape is, circular or oval passage. And material by this time. The cooling water jacket is provided. Just to reduce temperature. It is either cast iron. Or Aluminum alloys or we can use copper.

So, these are typically used to fabricate cooling water jackets. So, to summarize today's discussion, we have again identified all the components, other major components. In addition to the major components, we have also introduced two other components, which are the catalytic converter and the muffler. These are connected to the exhaust manifold

to reduce emissions and engine noise, respectively. And then we have discussed the material and shape of all these components, and we have also tried to discuss the need for a particular material for the construction of a particular component.

So, with this, I stop here today, and we shall continue our discussion in the next class. Thank you.