Course Name: Engine System and Performance

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Week - 01

Lecture - 01

Lec 1: Introduction to Engine Systems and Its Types: A Focus on Ignition System

I welcome you all to the session on engine systems and performance. In today's lecture, we shall briefly discuss what an engine system is, and then we shall discuss the subsystems that work together to achieve some stated objectives of an engine. So, if we try to recall the definition of any mechanical system, by this time you have read a few subjects. What is a mechanical system? So, if we try to write the concept of a mechanical system, Like the definition of any system, we can also define a mechanical system wherein a few items work together to give some output, maybe at the cost of some energy exchange.

So, if we try to write the definition. What is the definition? A few items or components work together to deliver some output, depending on the requirement, at the cost of energy or motion exchange. So, this is the definition of a mechanical system.

So, now if we try to apply this concept to an engine system, what you can understand is that there will be a few components or subsystems. Those components or subsystems will work together to deliver some output, certainly at the cost of some energy. If we try to recall our understanding of thermodynamics, the energy would be, in terms of heat. Pertaining to the definition of an engine system, at the cost of some input energy in the form of heat, we are expecting or will expect to have some output energy in the form of work.

So, we can see from the schematic depiction that a few items or components are there and those components or items will work together to produce some output from this engine, certainly at the cost of some input energy. Now, let us get into those systems, or rather, subsystems. Let us look into these components or items. And you can see that this

schematic depiction is specific to a spark ignition engine because you can see the spark plug that is shown over here.

So, the spark plug is also an important or essential component for SI engines, and starting with the spark plug or this essential component, we can have several subsystems of an engine. So, if we try to define the engine system, then following the definition that we discussed a few minutes back, all these components together form an engine system. The sole purpose of this engine system is to produce some output at the cost of some input energy. Now, if we eliminate this component and if we can have one fuel injection system or fuel injector or fuel nozzle, then the schematic depiction will be used to define or signify a compression ignition engine.

So, whether the engine system will have a spark plug or it will have a fuel injection system, the engine nomenclature will be changed. So, this spark plug is responsible for the initiation of a spark, which in turn will be used to combust the fuel-air mixture or fuel. From there, we will get some energy in the form of heat, and that heat would be converted into useful work, and that is the purpose of having this system. So now, in this engine system, typically there are three subsystems. The first subsystem is, as, called the ignition system.

This ignition system is applicable for spark ignition engines, or equivalently, we can write fuel injection system for the CI engines. Since we have not classified engines until now. We are trying to have a generic expression or generic subsystems. So, this is the ignition system. The ignition system is for the SI engines.

Similarly, the fuel injection system will be there. The fuel injection subsystem will be there for the CI engines. The second is the lubrication system. And you can see that why the lubrication system is needed because you can understand from this schematic depiction that this engine is having one cylinder, that is, this also there is a piston.

And the piston will be having reciprocating movement between these two locations: one is the top dead center, and another one is the bottom dead center. So, the piston will be inside the engine cylinder, and the piston will be having continuous reciprocating motion between these two locations, and that reciprocating motion would be converted using

another mechanical subsystem, will be converted using another mechanical system into the rotary motion, and using that rotary motion, the wheel will rotate, and we can, traverse or travel a distance. So, this piston is inside the engine cylinder, so this piston will be having always in contact with the cylinder wall. So, these two, components, mating components, so out of these two mating components, there is a relative motion of the piston. So, to prevent several mechanical issues or minimize several losses, we need to supply lubrication, or we need to have a lubrication system. We need to supply lubricants, and that is why this lubrication system is important.

The last one, is the cooling system. What is a cooling system? You can still see, From the schematic depiction that, there is a cooling water jacket. That is also shown over here. What is the purpose of this particular item or component?

Because, whether the engine is an SI engine or a CI engine, we need to have some sort of combustion. Depending on the type of engine, combustion will be different. And it is because of this combustion, there will be a huge generation of heat, energy in the form of heat, because the reaction that occurs inside is an exothermic reaction. And, from an exothermic reaction, heat would be liberated, and that heat will essentially allow the reciprocating motion of the piston.

Now the question is, that heat, is it possible to utilize the whole heat that we'll produce because of this combustion into the equivalent amount of work? No, because that is what we have learned from our basic thermodynamics. So certainly, a certain amount of heat needs to be transferred from the combustion chamber into the ambience through the cylinder wall. So that means if we do not have enough provision for the transport of heat, which will be developed or generated inside the combustion chamber into the ambience, that heat will again lead to several other mechanical issues like the development of a crack, the engine cylinder might get break.

So, all these, detrimental issues, detrimental effects will be there. So, to prevent all these mechanical, abnormalities or mechanical issues, we need to supply coolant to minimize or to reduce the, or to enhance the heat transfer. So that is why this cooling system will be there. So, these three are the major, subsystems. What we can see from the schematic

depiction, there are many other components and sub-components, but these three systems are the main systems which are needed for an engine for its best performance or operation. Now, let us quickly revisit. What is the need of an ignition system, lubrication system, and cooling system?

The question is, as I told you, say for example, if we pick up this particular system or subsystem, what you can see, we have understood that we need to supply coolant, maybe water if it is a liquid coolant, or maybe air if it is an air-cooled engine. If it is a water-cooled engine, we need to supply water. If it is an air-cooled engine, we need to supply air. Whatever the case may be, we are supplying, say for example, water to reduce the temperature, to take a certain amount of heat away from the engine cylinder. Now, we really do not know what should be the amount of water circulated, so that information nowadays must come from, state-of-the-art sensors. So that part we will discuss, what is the amount of water that needs to be circulated through this cooling water jacket, what is the temperature that should be taken away from the engine cylinder, because there is again, an important aspect. If we supply more amount of water through the cooling water jacket or into the cooling water jacket, that water will, take away a substantial amount of heat from the engine cylinder. If it is the case, so that heat, instead of doing a certain amount of work will be lost. So that should not be the design criteria. So, all these aspects are taken into account nowadays using state-of-the-art sensors. That part we will discuss in our subsequent lectures.

So, if we now go into this ignition system, just for the sake of completeness, Ignition system. What is the requirement? The requirement is to supply minimum energy. Number two is to initiate combustion. And number three is to establish, to supply, to initiate, to establish, a flame under all operating conditions.

So, if we go back to the previous slide, as you can see, the spark plug is there; that element is responsible for initiating a spark, and that spark will essentially help to initiate combustion. And so, we should have a system, or subsystem, that would be responsible for initiating a spark at the proper time, that spark will initiate combustion at the perfect time, and that combustion. What is combustion? Combustion is basically, a very

complicated process. You need to understand so many, fundamental subjects like fluid mechanics, heat transfer, and thermodynamics.

So, cursorily, I can say that combustion is nothing but the appearance of a visible flame. So, when the flame is produced, we will understand that combustion has initiated, and the flame should traverse or travel across the engine cylinder. So that means the flame will be produced because of this combustion, and that flame will be there under all operating conditions. We can ensure all these three using the system that is the ignition system. So, these are the requirements for an ignition system.

Now then, what are the functions? So, if we write, the functions, right. So, the function is, as you have seen, the spark plug is there. So, in an ignition system or subsystem, the spark plug is an integral component. The spark plug will be there, and it will produce, a high-voltage spark. Across the spark plug. Then, number two is not only it will produce, so basically, we are talking about the spark plug now because the spark plug is an integral component of an ignition system. So then, to know about the functions of an ignition system, we must know about the function of a spark plug.

So, it will produce a high-voltage spark, but not only will it produce a high-voltage spark, but it will also distribute a high-voltage spark. To each spark plug because an engine might have multiple spark plugs. This is the thing, and then, so this is one, this is two, we can write three that it will ensure the spark to occur at, a proper time. What does it mean? That means exactly when, I hope you have read about internal combustion engines, so pertaining to spark ignition engines, actual combustion starts when the piston is reaching towards TDC from BDC, and when the piston is about to reach TDC, this spark will occur. So that is the concept, and the most important function is it will allow varying the spark timing.

With load because it is not, or it won't be the case always that the engine will operate at a design condition. The engine might have to bear additional load. In that case, the spark plug system should allow varying the spark timing depending on the load. Being expected from the engine, so these are the ignition system requirements, now having discussed all these, that is the requirement of an ignition system, which is essentially for

the spark plug, and then the functionalities of an ignition system, let us now briefly revisit what are the different types of ignition system. Different types of ignition system, though you have read all these in detail in your internal combustion engine course at the undergraduate level, but still, as I said, for the sake of completeness, I am trying to revisit all these, so different types are:

Battery coil type, magneto type. Number three is electronically controlled. Electronically controlled, still it can be subclassified into two different categories. The first one is transistorized coil ignition, and the second one is capacitor discharge ignition. So, these three are, the three different types of ignition system typically used in SI engines.

We all know about all these: battery coil type, magneto type, electronically controlled type, which can again be subclassified into two different categories. So, let us now briefly discuss the common types. The most common type used in internal combustion engines is the battery coil. So, this is the most common type.

So, let us now discuss this particular type, the kind of advantages and disadvantages. So, if we write Battery coil type, I will draw the schematic depiction of this coil type. Let us first discuss what the components are. Certainly, you can understand the battery will be there. The ignition switch will be there, then the ignition coil will be there. Then, the switching device, the spark plug, and then the ignition system wiring.

So, all these, components are there for a battery coil type. Let us briefly, kind of draw the schematic depiction of this particular type. So, let us draw the schematic depiction of this particular type. Schematically, I am trying to, illustrate or demonstrate several components. So, this is the battery.

Then from the battery, we will be having one ignition switch. Then we have one ignition coil. So, this is the ignition coil, then from this ignition coil, this spark will develop, and that spark will go to the spark plug, and so from there, we will be getting an electronic arc. So, this is the electronic arc.

And this switching device will be there. So, this is a switching device. This is the spark plug. And this is the spark plug wire. Now, this is basically, the ignition switch. So, this is the ignition switch. So, this is the schematic depiction of a battery coil type.

You can understand exactly what the components I have written over here are in this schematic depiction. So, I am not going to discuss in detail the functionalities of this because you have read the basic principle of this particular circuit. So, the idea is that the entire purpose is to produce an electric arc, and that spark will initiate combustion. So, if we go back to the previous slide, there are several other types also. So, certainly, though the battery coil type is the most common type, still, since there are several other types, certainly this type also has certain disadvantages.
So, we should know all these. So, what are the advantages of the battery coil type? Advantages are:

1) It is cheap compared to the other types. We have discussed today.
2) It provides a spark at both high and low speeds.
3) Maintenance is negligible except for the battery.

And that is why it can be used in cars or buses. But, despite all these advantages, there are certain disadvantages as well. And it is because of these disadvantages that several other types emerged. So, the disadvantages are:

1) It is heavy and bulky. So, it takes more space. So, it occupies more space.
2) When the engine speed increases, the spark strength drops.
3) If the battery is discharged completely, not completely, but even if the battery is discharged, the engine cannot be started. It is not necessary that the battery has to be discharged completely, but even when the battery is partially discharged, it is very difficult to start the engine.

So, despite all these, favorable aspects, we still have a few drawbacks, and it is because of this reason that two other types, that is the magneto type and the electronically controlled type, are in place, which are also used for the engine. I am not going to discuss again the advantages and disadvantages of the magneto type, but certainly, you can understand that since we could identify all these drawbacks associated with a battery coil

type ignition system, the idea should be to eliminate all these issues using another system, that is the magneto type or another type. So, the magneto type will not have all these issues. So, if I just write it very quickly, the magneto type, and let me write the advantages. Number one is less maintenance. Number two is light in weight, that is not heavy or bulky, so it occupies less space. As I told you, we had seen that it is heavy and bulky, so it occupies more space. So, certainly, we should design another type, and in that particular type, we can eliminate this particular problem or issue. So, that is this. And number 3 is, it provides a high-intensity spark at high speed. And number 4 is used in two-wheelers, right and airplanes. So, these are, the kind of favorable parts of this particular type. But since this is again a mechanical subsystem, it will have a few other drawbacks. So, what are the drawbacks or disadvantages? I didn't draw the schematic depiction, but the magneto type is, so we need to have some permanent magnets and some magnetic current will be produced. So, when the current flows, the wiring carries high voltage current, there is a possibility of leakage, thus causing misfiring.

So, this is number one, and number two is, since there is a possibility of having leakage of current causing misfiring, the shielding would be there, and that shielding is expensive. So, I am writing here: expensive shielding is needed to prevent leakage current, right. So, if we summarize today's discussion, we can see that we have discussed the engine system, starting from the definition of a mechanical system. We also could define the engine system. In the engine system, there are several subsystems. We have identified three major subsystems.

We have discussed an important subsystem today and several types, their advantages, and also disadvantages. In the next class, we shall discuss the remaining two subsystems, that is, the cooling system and the lubrication system. We shall discuss the need for having these two systems together with different types, and then we shall discuss that to operate all these subsystems, as I have briefly mentioned today at the beginning of today's lecture, that we need to resort to several state-of-the-art electronic circuits or sensors, so that all these systems or subsystems can perform efficiently to enable the engine system to run smoothly.

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

Thank you.