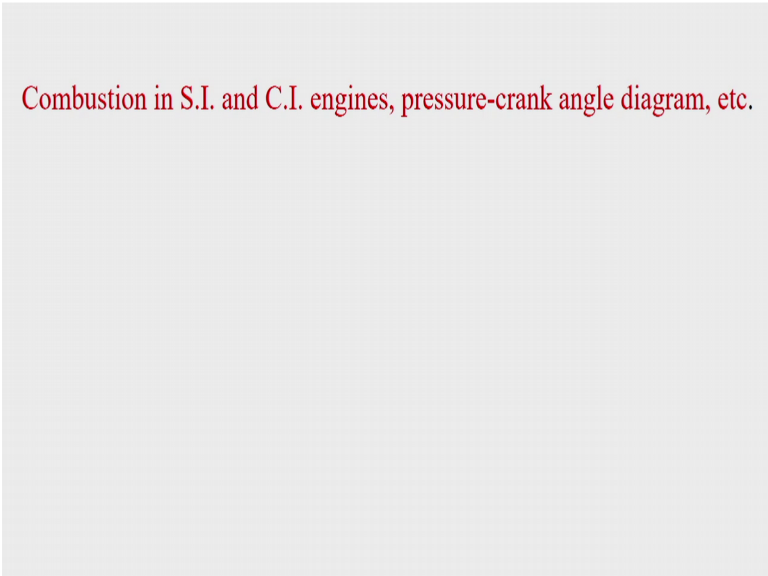
IC Engines and Gas Turbines
Dr. Pranab K. Mondal
Department of Mechanical Engineering
Indian Institute of Technology, Guwahati

Lecture – 23
Combustion in SI and CI Engines, Pressure Crank Angle Diagram (Contd.)

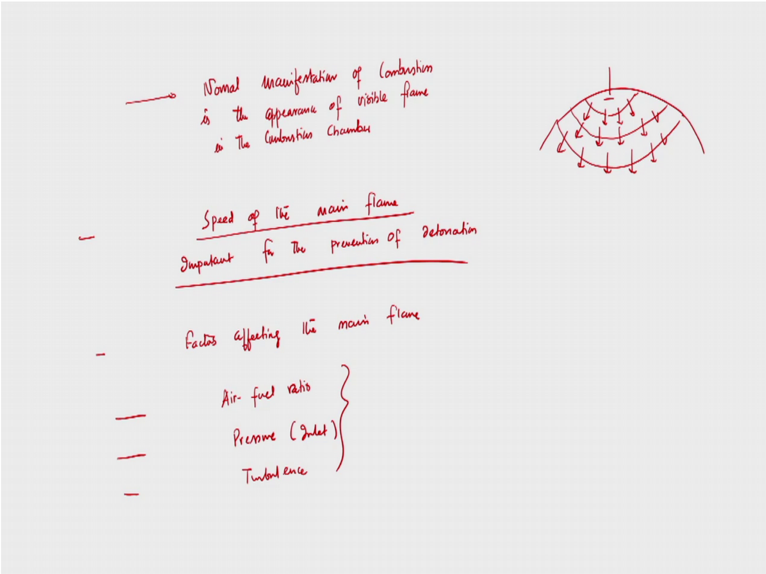
We will continue our discussion on IC Engine.

(Refer Slide Time: 00:32)



So, today we will discuss about combustion in CI engine. We have discussed of you know different aspects of the a spark ignition engine combustion, we have discussed about you know abnormal and normal combustion. Normal combustion is very hard to achieve, but we get always abnormal combustion and there are two different sub parts, we have discussed that preignition or surface ignition and also an important is that detonation and knocking that is also the part of the combustion process. So, we have understood that in a spark ignition engine combustion is initiated, you know I mean, the charge; compressed charged which is close to the spark plug from their combustion is initiated and there we can see a flame.

(Refer Slide Time: 01:22)



So, as I said you that the combustion whether it is in SI engine or CI engine. Combustion the normal manifestation of the combustion, you know is very important normal manifestation of combustion is essentially the appearance of visible flame in the visible flame either seen in the open eye, in the combustion chamber. So, so this is the important that when you can say that combustion is started; that means, it will manifest itself by the appearance of visible flame in the combustion chamber.

Now you know that; we have seen that in a spark ignition engine, spark plug is there, which ignites the fuel air mixture the charge which is close to that you know spark plug surface and then suppose if I have a spark plug here and from here the combustion will start from here; that means, we can see a visible flame over here when spark plug switch is on. Now we can say that combustion in SI engine is rather a you know almost uniform in a sense that, whenever flame is produced or flame is developed in the reason very close to the spark plug then we will have again a huge amount of heat generation and that heat will be utilized; that heat will try to utilized rather to increase the temperature of the compressed charge which is there nearer to that flame.

And in that way so, whenever this flame is developed here, because of this huge combustion essentially a chemical reaction, exothermic chemical reaction as so, we will have huge heat generation that heat will try to raise the temperature of the compressed charge which is there close to that flame and the nearby compressed charge again will ignite and again combustion will combustion will be there.

So, in that way the flame will proceeds in the you know combustion chamber and overall I mean the entire compressed charge in the combustion chamber will take part in the combustion and combustion will be completed. So, here the combustion is almost uniform, but we have seen that, not only uniform that if it is uniform rather when the flame moves in a fairly uniform manner, then we can say that it is abnormal; normal combustion, but it is not the case always we have seen that there might rather there are cases when we have preignition and also and of course, surface rather preignition leads to the phenomenon of detonation or knocking.

Now, we have identified that by somehow I mean, there are spots in the combustion chamber, where temperature is higher because of the continuous heat generation an and temperature will go high in such a way that, I mean that whenever compressed charge is coming in contact with those surfaces, I mean those surfaces will act like a artificial sparkplug and we may get a secondary flames from there.

Now, whenever secondary flames is then produced that flame again try to you know move and if the we have discussed that the preparation phase or the you know that, we have discussed today that whenever we are having critical pressure that the whenever that that main flame front is travelling it is acting like a piston and it is also creating pressure on the farthest charge. And whenever the pressure or the farthest charge will reach at the critical pressure and then we recall a finite time that is known as that is similar to the you know preparation phase.

So, then even the temperature, we have seen that temperature is, if the temperature becomes so high, then it will automatically try to ignite the surf charge which is there, otherwise even the temperature is not so high because of the you know pressure that is being produced because of the movement of the main flame, the farthest charge will overcome the preparation phase timing and it will ignite.

So, we have seen that if we somehow can restrict the movement of the flame front main flame front; so that, either not restrict. If we can restrict the movement of the secondary flames or we can increase the speed of the primary flame or main flame, then we can somehow avoid or prevent detonation or knocking.

So, I mean we can say that the time by which the main flame will be reaching at the farthest location and by that time, the you know although the temperature will be higher of the surface at some locations, but the charge which is there would not be able to I mean the preparation phase or the secondary flame although being developed, but it would not be able to proceed.

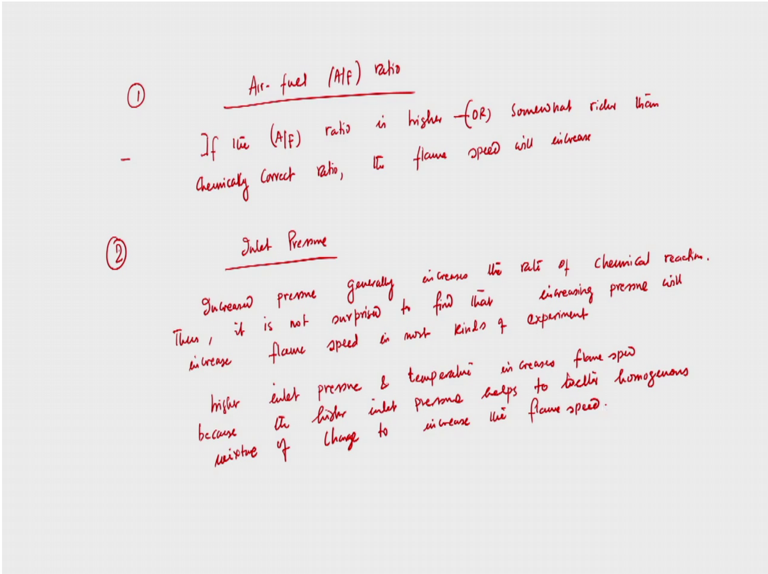
So, we need to ensure that the speed of the main flame will be will increase. So, that the secondary flame even though secondary flame only produced it is desirable but even though they are produced, they would not be able to proceed so that, direct collision which eventually leads to higher end vibration with audible noise that is known as detonation and knocking would not be there.

So, we have seen that if I can increase the speed of the main flame front. So, speed of the main flame is very important for the very important I mean this is important for the prevention of detonation. And we have discussed a few things that how we can that there are many ways to control the detonation. So, speed is the oh speed is one of them otherwise we may have continuous supply of coolant, but we need to ensure that maybe we can supply coolant to reduce the temperature of those spots which are like a like artificial spark plug, but at the same time we need to ensure that the temperature would not go beyond a certain value otherwise again combustion efficiency will be reduced.

So, only one important aspect is if we can increase the speed of the main flame. So, that even the secondary flames are being produced they would not be able, they would not be able to collide with the main flame. So, now, what are the affectors or affecting the main speed? So, we have understood what up to till, now we have understood that the speed of the main flame is very important that is crucial for the prevention of the detonation. Now, we need to know what are the factors; so, factors affecting, the factors affecting the main flame, what are the factors? So, first one is of course, we have discussed that is known as air fuel ratio.

So, we will discuss in one by one air fuel ratio, second is of course is very important that known as pressure, inlet pressure; precisely inlet pressure and third is turbulence. So, we will discuss one by one. So, how these three factors; I mean influences how these three factors influence the flame speed in a combustion chamber so, that we can control or prevent the detonation.

(Refer Slide Time: 09:12.



So, we will discuss first that you know which is known a air fuel ratio. We have discussed one last that last class that air fuel ratio, that is air fuel ratio it influences the flame speed through the by how. So, we have seen that, the higher rather if the air fuel ratio if the air fuel ratio is higher because we cannot supply always higher air fuel ratio.

Because higher air fuel ratio will eventually we will not be economic always because we have discussed that always we need to supply asymmetric air fuel ratio that is chemically air fuel ratio. But fine that to prevent the detonation if you need to increase the main flame speed, we can reach the flame air fuel ratio, but it should be again you know, you know it should be economic again. So, we can say that if the higher the air fuel ratio is higher, I mean; I mean it is higher than chemically correct slightly somewhat richer are then chemically correct higher or I can say that or somewhat richer than chemically correct that is try symmetry chemically correct ratio the flame speed will increase flame speed will increase.

So, this is quite obvious because if it is richer; that means, we are having efficient combustion. So, we will have huge heat generation and high pressure so, that may increase the main flame speed. And we need to know that it should not be you know, you know very high than the chemi from the chemically correct ratio, but it will be somewhat richer than chemically correct ratio. So, that it will increase a you know air different speed.

Number 2, that is we have discussed about that is you know inlet pressure, inlet pressure. So, what if it does it have on the propagation of main flame rather how it controls the speed of the main flame. So, we have we can say that, generally increased pressure increases the rate of chemical reaction, we know that if we increase. So, increased pressure increased in increased pressure, generally increases the rate of chemical reaction. So, that is what I have discussed just now that, if you increase slight somewhat richer air fuel ratio; that means, we need to ensure that the chemical a combustion will be more efficient; that means, a rate of chemical reaction should be high and which in turn will try to increase the flame speed.

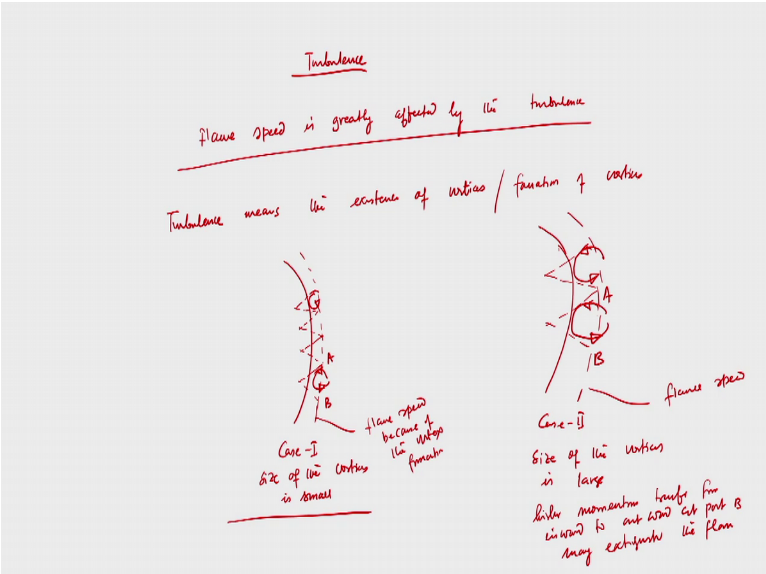
Similarly, if we increase the you know inlet pressure, that is increased pressure generally increases the rate of chemical reaction and thus it is not surprising to find the increased pressure increase the flame speed in most kind of experiment.

So, therefore, or thus it is not surprised it is not surprised to find that, to find that the increased pressure that the increasing, that increasing pressure will increase the will increase flame speed flame speed in most kinds of experiments, in most kinds of experiment. Actually, the higher inlet pressure, the higher inlet pressure and temperature as well increases flame speed flame speed, because the higher inlet pressure, higher inlet pressure helps to better homogeneous mixture of helps to help to you know better homogeneous mixture homogeneous mixture of vapor and air I mean mixture of you know charge rather and increases the flame speed to increase to increase the flame speed.

So; that means, if we rim reduce the I mean, how I can increase the throttling that how they increase inlet pressure? That is by if we have throttling, then we can re throttling reduce rather reduces the in inlet pressure. So, you should have you know full throttling or nearly full throttling so, that we can increase the inlet pressure which will help to have a homogeneous mixture of the charge essentially to increase the flame speed through you know efficient or through the higher rate of chemical reaction. And next we will discuss is important again this turbulence. So, it is again we cannot expect that how turbulent will turbulence will help to have a better or higher flame speed so, the turbulence right.

So, what is turbulence? You know see that, you know if we increase the speed of the piston so; that means, speed of the piston if you increase. So, then we can increase the you know, you know flow of you know whenever you are compressing of course, we can increase the speed of the piston will increase the Reynolds number of the Reynolds number; that means, that compressed charge, the charge which is being compressed will have higher Reynolds number and then we may have you know better flame speed and by how that is what is will discuss now.

(Refer Slide Time: 16:10)



Now, question is the turbulence is essentially whenever we will we are telling that in fact, the flame speed is greatly affected by the turbulence, I can write that flame speed is greatly affected by the turbulence. So, now, by how we will write turbulence means I mean again I am telling that we can say turbulence; that means there are vortices. So, turbulence means formation of vortices which was I mean again I am telling means as I said you that this course required you know knowledge basic knowledge in fluid mechanics. So, I am telling turbulence, if we increase the speed of the piston perhaps that charge which is being compressed will have higher Reynolds number and because of higher speed and since density and viscosity are you know same.

So, turbulence means in a the existence of vortices; a kotic movement aortic movement rather existence of vortices. So, existence of existence rather vortices or formation of vortices I can say formation of vortices. So, now, if I draw suppose this is the main flame speed and if we have vortices. So, we will have if we have vortices very on the top surface, then what will happen? The flame which will come there will be change in momentum I can say and then we will have rather instead of uniform movement of the flame we will have a movement like this. So, these two are vortices, I have taken two example let us say this is surface A and this is surface B. So, I am taking example case I.

So, whenever turbulence is near; that means they are vortices. So, whenever vortices are there and whenever we are having vortices in front of the main flame, then there is suppose if I have taken two points A and B. Now question is if the size of the vot so, case I when size of the vortices is size of the vortices are small, is small and I can take another example this is case II size of the vortices is large so; that means, I can take big vortices, again I am taking two different points A and B. So, let me discuss.

So, these are vortex we have seen. So, whenever we have turbulence so, we are we assume that there are we are assuming, but it is true that there are vortices or vortex formation is there. So, vortex we will try to disturb the main flame by how that is what it is shown in the figure you know case I and case II through a you know zig zag line

So, whenever the vo vortex is having you know always either clockwise or counter clise counter clockwise movement. So, we can see at point A when flame is there because vortex are vortex will deform the inter flame speed by how at point A momentum will transform from outward, out side to inner side; that means, when vortex is formed the main flame which is being developed it will be disturbed because of the presence of vortex or vortices, at point A if you consider both the cases case I and case II, at point A a momentum will go because of this we have considered the counter clockwise rotation of the vortex. So, at point A the you know momentum will transform from outward to you know inward; that means, it the vortex will try to take the flame in the inner side

Similarly, at point B again momentum will transform for inner to, inner ward even inside to outside and then it will try to stress the flame, the vortex will try to stress the flame and as a result of which will get the zig zag motion.

Now, question is eventually if I now plot so, actual mean speed was like this, but now eventually as if the we will get the flame speed like this. So, this is now the you know flame speed because of the vortex formation. That means, flame sp flame will be stretched or apparently we will have a higher velocity because of the vortex formation. Now, we need to be, we need to ensure that whenever vortex size base vortex size is small there is no problem, we can get even flame which is a continuous flame and but the apparent, you know location or the speed of the flame will in will be increased.

Note that, when we will have relatively larger vortex then of course, the same phenomenon will be there; that means, momentum will transform from outward to inner inward at point A, and again it will be from inward to outer ward at point B and since the vortex size is large. So, higher momentum will be transformed from inward to outward and again outward to inward and again from inward to outward and there might be a situation when and it is too large that the momentum transfer is too high because of the higher size of the vortex.

So, vortex formation I can say in the, in this context whenever vertex or a vertices are formed, they are taking energy or they extracting energy from the mean flow. And higher vertex are having higher energy so; that means, when that moment when momentum is getting transformed transferred at point A from outward to inward, because of the relatively larger size of the vortex there will be a larger momentum and larger momentum will be transformed transferred from outward to inward at point A and similarly from again inward to outward at point B. Momentum will be too large, that this large vertex sometimes may leads to the you know rather it would not allow to have a continuous flame rather it will try to extinguish the flame.

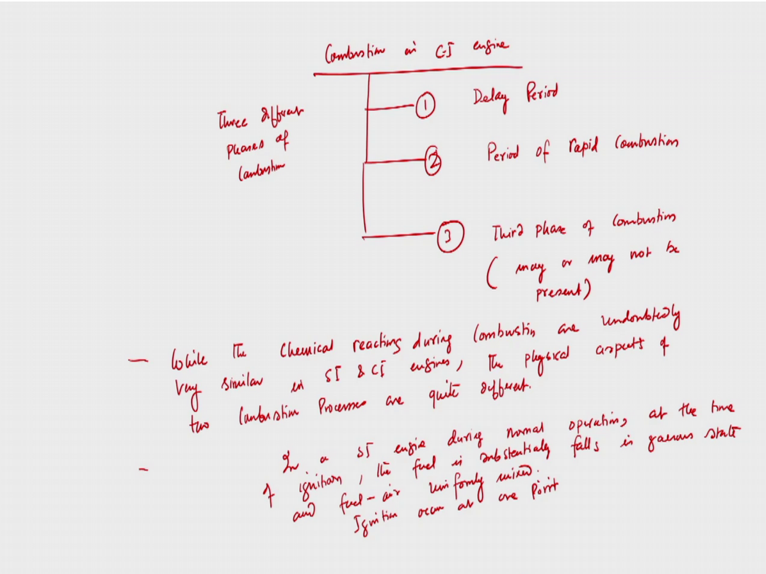
So, because of the stretching so, here we may get of course, we may get relatively higher velocity again. So, we may get here. So, this is the flame speed apparent flame speed so this is the flame speed. So, if we have a larger flame larger vertex size, then we may get even larger velocity flame speed, but we need to keep in mind that sometimes because of the larger transfer of momentum, the higher larger vertex may leads to rather may extinguish the flame.

So, this larger or higher momentum transfer higher momentum transfer from inward to outward at point B may extinguish the flame. So, our objective was to have a higher flame velocity or instead of getting, we are getting we may get higher flame velocity of that is true, but we may get always, we the chances are there that that the flame might extinguish. So, flame might extinguish so I mean, it is not it is now our objective at all.

So, we have discussed about the you know, combustion different aspects of combustion in SI engine and we have discussed that, if we can control the ab normal combustion is there, but normal combustion is very hard to achieve. So, we always there abnormal combustion that is surface ignition and detonation, but detonation is not at not a desirable phenomenon at all. So, we need to ensure that we can we always prevent detonation.

So, by how we can control the detonation that by prevent detonation by controlling the speed of the flame main flame, and we have discussed about the three important factors that is you know inlet pressure air fuel ratio and the after turbulence and we have discussed their effect separately.

(Refer Slide Time: 24:45)



So, now I will discuss about the combustion in SI engine. So, we have seen that you know combustion in SI engine very important, that combustion in SI engine; combustion in SI engine is not combustion in CI engine. Combustion in CI engine is not similar there are you know you know I mean to be a there are differences I mean if we compare combustion of CI and SI engine. So, if we can recall rather if you try to recall that, in a CI engine we do not have spark plug.

So, what is done basically the intake air during intake stroke is getting compressed during compression stroke and towards the end of the compression stroke temperature and pressure of the air is becomes higher of course, because CI engines are having preferably higher compression ratio always had CI engines are having always higher compression ratio. So, that means pressure and temperature will be higher at the end of the compression and pressure and temperature is higher in. So, that the whenever we start injecting fuel from fuel injector or nozzle, then it will try to automatic it whether higher pressure and temperature of the air allow to ignite fuel automatically without help of any external agent like spark plug.

Now, this is true that. So, this combustion in CI engine is not the fact that we have spark plug. So, we can have a visible flame from the region very close to the spark plug and that then that flame front will proceed towards the next you know regime of the compressed charge and there again combustion will take part and again there will be re release of heat that it will try to you know rise the temperature of the surrounding layer and in that way entire combustion will be completed.

So, the rather this the combustion in a c SI engine relatively you know in a is happening in a rather controlled manner, but in case of a CI engine it is not happening in a control manner rather, we have higher pressure high temperature of the air and we are in injecting fuel. So, depending upon the spray pattern of the fuel and depending upon the finer size of the fuel droplet, overall combustion will be dictated rather I can say that overall combustion will be completed.

So, now there are three different phases of combustion. So, three different phases of combustion in CI engine, three different phases of combustion, number 1 is number 2 and number 3. Number 1 is essentially number 2 and number 3; number 1 is delay period that we will discuss delay period, number 2 is a period of rapid combustion, period of rapid combustion and number 3 is third phase of combustion which may or may not be present third phase of combustion.

So, this phase may or may not be present, may or may not be present. So, we will discuss again what is delay period or rapid combustion third phase of combustion, but let me tell you the chemical reaction during combustion ah so, I am writing while a chemical reaction during combustion. Because we are using fuel is family of hydrocarbon it depends and we have discussed that which fuel is used for which engines I mean essentially the high it is a hydrocarbon. So, while a chemical reaction during combustion are chemical while chemical reaction during, while the che, while the chemical reactions while the chemical reactions during combustions are undoubtedly similar very similar, very similar in SI and CI engines, the physical aspect physical aspects of two combustion processes are quite different.

So, this is important that chemical reactions are undoubtedly similar because we need to supply air there will be hydrocarbon fuel is hydrocarbon. So, in presence of air it will ignite and it will give rise to vapor and carbon di oxide and it will release heat.

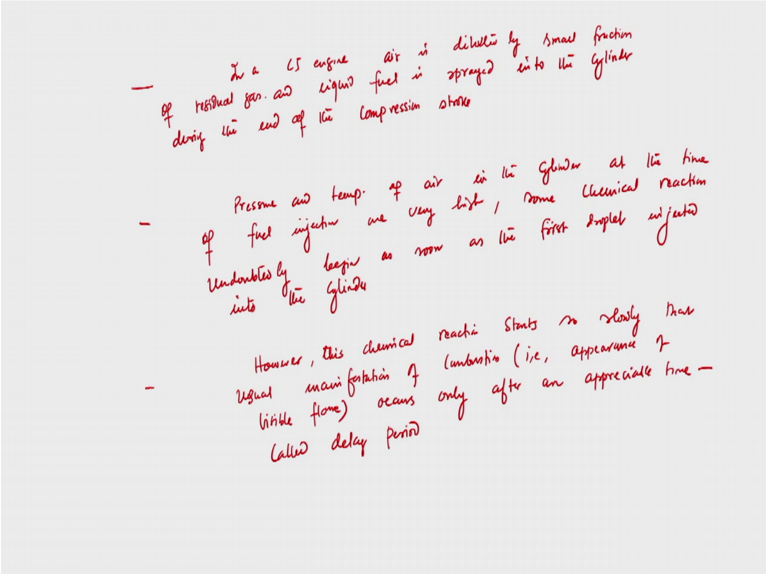
So, they are similar, but the physical aspects of two combustions are different what are the difference? So, we have understood rather we have learnt you know the we have the process of combustion in a SI engine why. So, what are the processes in SI engine in a SI engine, during combustion during combustion rather during normal operation I can say, during normal operation, during normal operation, at the time of ignition at the time of ignition of the fuel is substantially fall, the fuel is substantially falls in gaseous state gaseous state and fuel air fuel air fuel air are rather fuel air or residue are you know uniformly mixed uniformly mixed.

That is true because the fuel which is used in a SI engines are almost in a I mean fall in the during at the time of ignition gaseous state and if we use carburetor of course, the function of carburetor that I have discussed that it allow to have a homogeneous mixture of air fuel ratio; that means, fuel and air are uniformly mixed.

And ignition occur at one point and at a ignition occurred that is very important, ignition occur at one point. That is we are having external spark plug and there ignition start right and this is very important, but in case of a CI engine and we have discussed that fuel ignition occurs at a given point flame combustion initiated; that means, we can have a visible flame and when that flame is produced that flame and the reaction is basically exothermic we get use in a heat, that heat is try a heat is used to raise rather the heat raises the temperature of the surrounding charge and there again charge will ignite and again we can see visible flame and in that way overall the com combustion is completed.

That are that is, it is almost occurring in a uniform manner of course, we have discussed that this is always possible to have uniform or a rather a normal combustion because of the hot spots. So, but it is a probability is there that there might if we have a better control that if you can control the temperature of the hot spot, we can have a better rather uniform combustion.

(Refer Slide Time: 32:39)



But in a CI engine, but in case of a, but in a CI engine in a CI engine in a CI engine air is diluted to small fraction of a residual gas. So, we have we take air. So, air is diluted air is you know diluted by small fraction of residual gas; that means, in a CI engine now we take air during intake stroke the compressed air then we you know spray fuel. So, the air although air fuel mixture is again diluted in SI engine as well, but in a CI engine air is diluted by small fraction of residual gas and liquid fuel, liquid fuel is sprayed liquid fuel is sprayed into the cylinder near the into the cylinder during the end of the compression stroke. So, this is the case that is what we have discussed many a times.

Now, question is pressure and temperature of the air or rather pressure and temperature of the air in the cylinder contains that at that are both be high. So, we are utilizing that condition. So, pressure and temperature of air in the cylinder at the time of, at the time of you know at the time of fuel injection at the time of fuel injection are very high very high very high some chemical reaction undoubtedly begin high, some chemical reaction undoubtedly began you know begin as soon as the first droplets is injected into the cylinder as soon as the first droplet injected into the cylinder.

So, what is that yes. So, since the pressure that we are utilizing the high pressure and temperature by air itself to self ignite the fuel. So, since the since the pressure and temperature of the air is so, high, the moment at which the first droplet enters into the cylinder that will take part in the combustion. So, I mean chemical reaction. This chemical reaction start so, slowly that I usual men again writing; however, this chemical reaction start so slowly that the usual manifestation of the that the usual of combustion that is appearance of visible flame appearance of visible flame occur only after appreciable time occurs only after an appreciable time which is called delay period called delay period.

So, although the moment when first droplet is sprayed into the cylinder combustion will start because the temperature pressure is very high, but the rate of chemical reaction is so slow, that the total usual manifestation of the combustion that is appearance of the visible flame occurs after a finite time interval. There are many reasons I will discuss because I have dis already discussed that what do you have a physical delay that is total delay period chemical delay and physical delay and we require a finite time interval to have this physical appearance of the flame.

So; that means, this delay period constitute two different times one is known as physical delay other is chemical delay. Chemical delay is directly associated with the chemical compression of the fuel and physical delay the time required for the you know droplet evaporation and we have discussed that we are relying on the mechanical component like nozzle and all those things. So, after keep on functioning they will after keep on using they will start malfunctioning. So, which is not expected that nozzle will perform any in a similar way, when it was during these, during the initial stage.

So, all these factors we need to we need into take we need into take into account, we need we need into we need to consider rather because if we do not consider those factors then we cannot the entire combustion cannot be described. So, these two you know de delays, I mean chemical delay and physical delay constitute or the physical total delay period and this is the delay period.

Another aspect I am telling so, this is the delay period and so and so in the first phase of the combustion is the basically the first phase of the combustion is basically the delay period that is what I am telling. So, it requires finite time interval. And again I have discussed that you know in a diesel engine, a time and space where ignition occurs is not fixed and but in case of SI engine we have seen that it starts from the spark plug area. So, since it is not fixed the you know, it cannot be control as an ignition sparks in case of SI engine. So; that means, in a diesel engine time and space where ignition occurs is not fixed by anything. So, easily so it is easily control as an ignition sparks occurs in a SI engine. Because SI engine it is fixed that spark will occur from the reason very close to the spark plug.

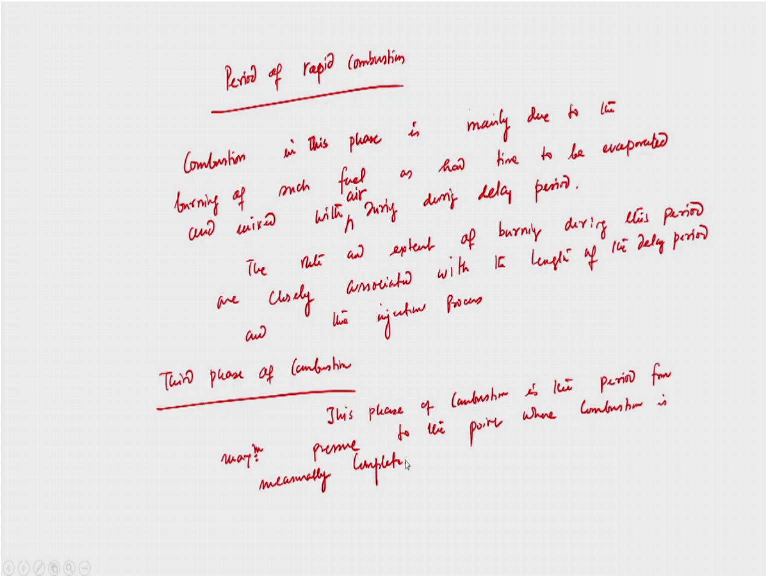
You know flame normally appears while the distribution of fuel in the in the air and residual gas mixture is extremely non uniform while a con say well part of the fuel is still in the liquid form, because whenever you are supplying fuel through fuel nozzle into the cylinder that the part of the fuel remains still in a liquid form. So, because of the liquid inertia it is not always possible that it is not in a gaseous state this is the disadvantage. And because of theses you know high compression ratio the gases in the cylinder at the time of injection are weighed above the temperature and pressure required to change reaction in the uniform field mixture.

So, what the point that I would like to emphasize that, the combustion in a CI engine is a question of local condition because it depends upon the local composition local state of the pressure and local state local you know pressure and temperature of the a charge in the cylinder. So, we cannot say that it will be it is not a homogeneous mixture of air and fuel that is that the that is the case when we discussed in the context of SI engine.

But in case of a CI engine, it depends upon it is a it is a it is a question of local state of the local co local condition of each part of the charge and it is not dependent and it and it is not dependent and although it may be by that, but we can say whenever you are having first phase of combustion that with delay period that the flame will try to propagate, but it is not it is not possible that we can have a fairly uniform speed of the flame.

It always depends upon the local state a of the charge that is a pressure and temperature of the charge. Since it is you know I mean although we are having higher pressure and temperature during the compression stroke, but since the liquid is still there are there are certain amount of fuel is still remain in a liquid form. So, it is not always possible to create chain reaction immediately, I mean the case like what we had in case of SI engine. So, this is the delay period.

(Refer Slide Time: 41:03)



We have discussed next is we will discuss about the you know period of rapid combustion. So, period of rapid combustion; so, if we period of rapid combustion; that means, very important that combustion in this phase is due to strictly burning of such fuel. So, I am writing. So, we need to give some time so, that the charge at each and every points in the combustion chamber will you go above that you know preparation phase, although the pressure and temperature is so high, but since certain amount of fuel is still remain in the liquid form we need to give certain amount of time to complete the chain reaction and after that time is over then entire charge will take part in the combustion. Since it is a local function or local rather it depends upon the local condition of pressure and temperature of the charge.

So, combustion in this phase is very important. Combustion in this phase is due is simply due to is mainly due to is mainly due to the burning of such fuel as had time to be evaporated and mixed with air during delay period. So, during delay period we have delay period with the delay period constitutes you know ah you know physical delay and chemical delay. So, the fuel the it is a burning of fuel such fuel which had time to be evaporated and mixed with air, mixed with air during delay period, the rate and extent of burning during this period this period are closely associated to the associated to the length of the delay period and related to injection process are closely associated with the length of the delay period.

So, if so until and unless the charge entire charge go you know you know over that you know we; that means, over the delay period you know we cannot have the complete com and rapid combustion; that means, we have seen that the moment when we first spray fuel drop, they that fuel drop may take part in combustion because of the high pressure and temperature of the air. But the rate of reaction is so slow because of the we cannot have a very homogenous mixture of the air fuel also the fuel is not largely in the gaseous state. So, and because of that greater is slow that we require certain amount of finite time to complete the combustion of the entire charge which is there that which is there in the rather that is there in the cylinder.

Now, the rate and extent of burning that is combustion of the rapid combustion is the combustion in the spare is mainly due to the burning of such fuel which had time to evaporated and mixed completely with air during the delay period and the rate and extent of burning during this period are closely associated with the length of the delay period and its relation to the injection period. And as it with the delay length and delay period and it's relation to the injection process and the injection process.

And third phase of combustion which may or may not present third phase of combustion. The third phase of combustion this phase of combustion is the period from maximum pressure to the point where combustion is you know you know measurably completed as I will complete; that means, maximum pressure rise we had. So, we cannot say that we can ensure or rather we can say that the en combustion will be completed. So, maximum pressure rise there thus from that time to the point when combustion is measurably completed is known as the third period of combustion.

So, delay period, period of rapid combustion and third phase of combustions are the total or overall combustion of the CI engine. And we have discussed though chemical reactions are similar in both the engines SI and CI engines, but there are certain you know physical issues which make the combustion processes to be different in both the SI and CI engines.

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

Thank you.