Fundamentals of Automotive Systems
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Lecture - 28
Emissions Control Systems Part 02

Now, if you recall in compression ignition engines or diesel engines one of the main components of the engine exhaust was also the soot particles, why because diesel is basically has a higher molecular weight and when it dissociates you know some of the carbon in the high molecular compound may remain unoxidized it can essentially remain in the form of carbon, which then joined together and form these particulates, the soot particles.

So, if one wants to remove them the solution is to use what are call as particularly traps. So, as we discussed in the previous lecture particularly even if you look at a heavy vehicle a truck or a bus right, when it starts accelerating from rest or from slow speed it goes to start at moving. So, we can see that you know like the treatment system is not proper or the entire system is not working properly we would see this black smoke coming out of the tailpipe right those are particulates okay. So obviously very harmful so the question is how do we address them.

So, particulate traps are used to remove particles in the exhaust of CI engines so, that is the main role. So, they are nothing but filters that are in the form of a ceramic mat or a metal wire mesh okay. So that is a particulate trap. So, what happens is that like these particulate traps are installed in the exhaust and when the exhaust gases with the small particulates come through they get caught in the caught in these meshes right. So, the particulates can be removed from the exhaust before there are before the exhaust gases reach that atmosphere.

But what is the flip side of this process as the particulates start getting collected in this mesh, they are going to block the flow of exhaust right and that is going to increase the engine back pressure which will then potentially affect the engine operating conditions and performance. So,

we need to ensure that these trap are periodically cleared of the particulate matters. So, that is a what to say challenge for the operation of these particulate filters.

So, as the particulates accumulate the trapped particulates restrict the exhaust flow process and thus increasing the back pressure. So, what is typically require is that the traps need what is called as regeneration. So, this term regeneration in this context is used to refer to the process by which the particulates are oxidized okay. So, this means that you know like we need to subject the particulate filter itself to high temperatures to and provide with enough oxygen to oxidize this carbon soot right particles.

So, there is a process of regeneration and that is going to be a very, not a very ideal scenario. But that is a limitation of using a particulate filter but in modern diesel engines if you look at modern CI engines, one uses advanced injection technology right and well-designed combustion chambers to promote proper combustion right. So the amount of particulates in the engine exhaust by design of proper injection and combustion chamber has been greatly reduced in modern diesel engines.

So in modern CI engines with advanced injection technology and well-designed combustion chambers have greatly reduce the particulate filter concentration so that is one feature of modern CI engines okay. So that is as far as particulate traps are concerned you know like that are addressed to reduce the content of soot in the engine exhaust. So the next technique which is used to reduce NOx in engine exhaust is what is called as exhaust gas recirculation EGR.

So what is this exhaust gas recirculation? Okay so exhaust gas recirculation typically is a process by which the amount of NOx is reduced by mixing the exhaust gases with the fresh fuel air mixture burnt in the cylinder why would anyone want to do that you know that at first glance you know, why would we want to mix burned gases with fresh fuel air mixture that is going to reduce the combustion efficiency is a not. However, mixing the burned fuel exhaust gases with the fresh fuel air mixture particularly will reduce the peak cylinder temperatures during combustion.

And if we recall, NOx formation is the highest when the cylinder temperatures are the highest okay and it takes place very near to the stoichiometric fuel air ratio with a slightly leaner mixture right. So that like we have enough oxygen for oxidation of nitrogen. So, under such conditions adding these exhaust gases would be beneficial although it is a tradeoff now at the expense of reducing NOx we are slightly going to reduce the engine performance. So, that is a tradeoff which we have to live with.

So, what do we what is the idea behind this you know like reducing peak cylinder temperature implies lower NOx right but reduced thermal efficiency also that is the flip side of reducing the peak cylinder temperature? So, how can we do this we can dilute the fresh fuel air mixture with a non-reacting gas and in the engine, you know like the exhaust gases fit this requirement. So exhaust gases are added to the fresh fuel air mixture in EGR okay so typically they are taken from the exhaust system and added somewhere in the inlet section okay inlet manifold of the engine.

Right so, exhaust gases are direct to the fresh fuel mixture in this process of exhaust gases gas recirculation okay. So, as we have already discussed one main limitation is that it reduces the engine efficiency right. Another limitation if not properly done it can also significantly increase hydrocarbon emission because in the fresh fuel air mixture at the expense of not increasing the cylinder temperature to a high extent if he had too much exhaust gases what may happen is that the unburned hydrocarbons in the fresh fuel air mixture themselves will not combust in the first place.

Because we need for proper combustion we need hydrocarbons we need oxygen and a mechanism for initiating combustion. So, if we diluted the fresh fuel air mixture it is too much of exhaust that may potentially prevent proper combustion of the incoming fresh fuel air mixture. So, it may potentially increase hydrocarbon emissions. And typically, due to this reason, and also based on points that we have already discussed, EGR is typically not used, when we want a rich fuel air mixture.

What are the conditions under which we want a rich fuel air mixture the first one is during idling, because during idling anyway the fresh fuel air mixture is diluted by exhaust gases, you know, like why would anyone want to add more exhaust gases to the fresh fuel air mixture. And then like, what is called is wide open throttle. That is like when we press the throttle towards its full maximum position where we want the maximum power right. Even then we want a rich mixture to get more energy from the engine.

So we would not want to essentially add more exhaust gases to reduce itself okay. So EGR is typically not used under what is called as wide open throttle when maximum power is desired and at idling low speeds under these conditions when there is already significant dilution by exhaust gases right so, that is the process of exhaust gas recirculation okay. So, the main purpose is to reduce NOx by bringing down the peak cylinder temperatures okay.

Another way of reducing NOx you know like which is also like applied in particularly heavy vehicles is what is called as selective catalytic reduction. So, what is this so, these are various tools you know like available to reduce the engine emissions, so, selective catalytic reduction abbreviated as SCR okay, so, selective catalytic reduction is also used to decrease NOx content in exhaust by reducing NOx to N_2 in this process, the reductant which is a chemical that is used in the in this process is usually automotive grade urea okay.

So what is this automotive grade urea, so it is also commonly called as diesel exhaust fluid so abbreviated us DEF which is typically an aqueous mixture of around 32.5% urea and 67.5% deionized water so that is what is called as the automotive grade urea or diesel exhaust fluid so this is the reductant which reacts with NOx and then like, reduces to N_2. So to enable this process typically catalysts are used, which are Vanadia and Zeolite based catalysts are typically used to accelerate this reduction reaction, so that is selective catalytic reduction.

So this pretty efficient in reducing the NOx levels by up to 90%. But of course, a main requirement is that one needs to replenish the supply of this DEF right there is automotive grade urea that is a separate tank for that it gets spent right as we treat NOx, so we need to replenish that supply okay. So the main requirement is, the need for filling or replenishing DEF

periodically. So that is selective catalytic reduction. So these are the main tools that are available know for treating engine exhaust okay.

So, the last topic I want to briefly touch upon as far as emissions and that control is concerned other emissions typically you know like involved evaporative losses. So, whatever we have looked at till now or what are called as tailpipe emissions or engine exhaust emissions okay. So, they come from the engine exhaust systems and only what are other emissions there are other emissions in an engine predominantly from evaporative losses you know like evaporative losses to take the form of hydrocarbon emissions in fuel tank and carburetor if a carburetor is present.

So, what happens in a fuel tank is that like as the temperature of the fuel tank increases right, fuel vaporizes, and what happens is that like if the fuel tank is vented to the atmosphere as the vapor pressure increases in the fuel tank, the mixture of vaporized fuel and air escape through the vent due to increase in temperature and corresponding increase in pressure they went escape to the atmosphere when the fuel tank cools down air from the atmosphere will enter into enter through the vent in the fuel tank, but anyway we have lost the fuel vapour.

So this is how evaporative hydrocarbon loss takes place in the fuel tank. So, now how do we address this? Okay so, in fact, evaporative losses in fuel tanks are more when the fuel tank is partially filled so that like we have more space for vaporization and the escape of fuel and air vapors right. So, of course, the level of the fuel in the fuel tank varies with operation so it is really difficult for us to maintain fully full tank all the time is not it so today you know like people use you know, like what are called as evaporative loss control systems.

Where typically a charcoal canister is used to absorb, the fuel vapors from the fuel tank and then purge the vapors back to the engine when required, so that is the evaporative loss control system which is used to address.

This vaporization in the fuel tank another case of this unburned hydrocarbon emissions is what is called as crankcase blow by where in the fuel vapors escape through the crevices around the piston rings in the cylinder and due to the high pressures that exists in the cylinder and on the

escape to the piston rings, oil rings creases and into the crankcase and of course, this becomes more as the engine becomes older because these crevices become bigger with wear and tear.

So this is nothing but leakage of fuel paste the piston rings into the crankcase that is what it is called crankcase, okay so these are the other emissions that can occur in engine crankcase globally obviously increases engine age as wear and tear occurs. So this completes discussion of emissions and tools to regulate engine emissions because that is very important today in the current context, because emission standards are becoming tougher and tougher to essentially protect our environment right.

So our system just a broad discussion to understand what these are right and how do we address them at least in concept. So with this, I stop right, conclude our discussion on engines. So from the next lecture, we will start looking at the transmission. So how the energy is going to be transmitted from the engine to the wheels and we will start the discussion in the next lecture. Thank you.