Health, Safety and Environmental Management in Offshore and Petroleum Engineering

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Module - 03
Accident modeling, Risk assessment and management
Lecture - 05
Chemical Explosions

Friends, in this lecture which is the 5th Lecture, Module 3 of HSE practices, where we are focusing on Accident modeling and Risk assessment management we are going to talk about Chemical Explosions.

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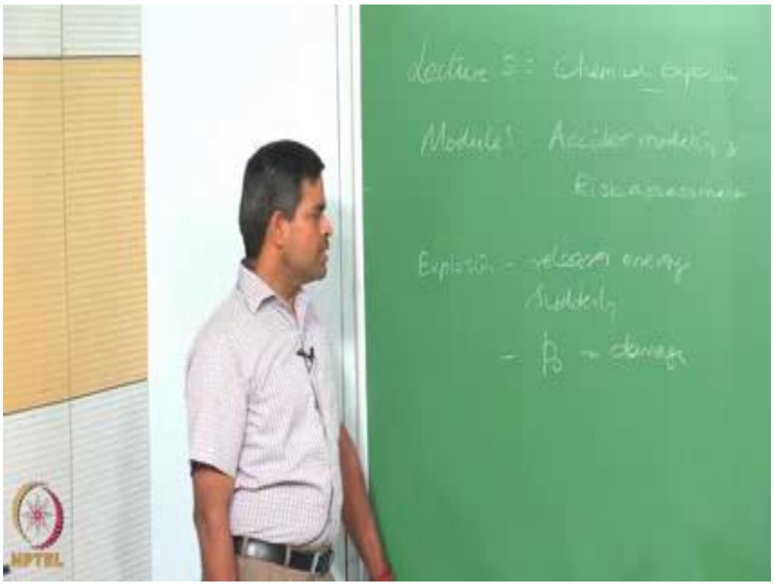

Interestingly any explosion we know releases energy suddenly this results in what we call peak over pressure which can cause damage that is what we have seen.

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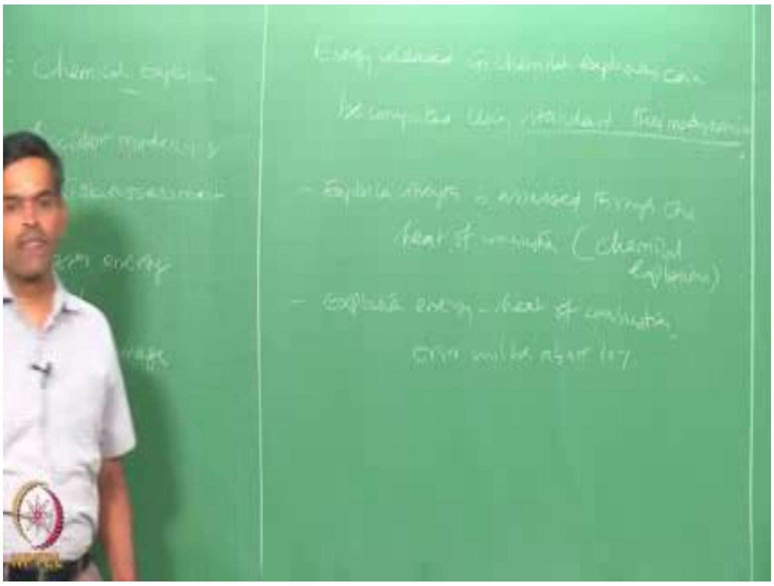

Interestingly, in case of chemicals the energy released in chemical explosions can be computed using standard thermodynamics. The heat of combustion is used as mode to access the explosion strength. So, the exploration strength or explosion strength is assessed through the heat of combustion, in case of chemical explosions.

From the past studies in the literature it is evidently seen that the explosion energy differs by over 10 percent from that of the value computed from heat of combustion. So, if you are able to estimate the explosion energy using a heat of combustion without using the standard laws of thermodynamics the error resulting will be about less than 10 percent. Therefore, explosion energy is generally determined in different techniques.

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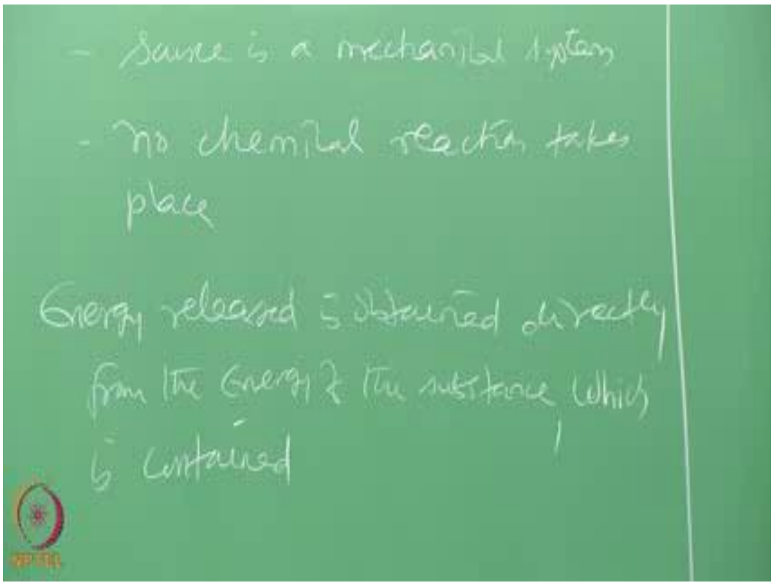

When I talk about physical explosions which essentially come from mechanical systems; the source is a mechanical system so unfortunately no chemical reaction takes place in this case. So, in that cases energy is obtained directly from the energy content or the contained substance. So, energy released is obtained directly from the energy of the substance is contained. There are common approaches available in the literature which can be used to estimate energy release caused by physical explosion.

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Different methods used to compute the energy release; one is what we call Brodes method. According to Brodes method the energy released will be equal to p 2 minus p 1 by mu minus 1 into v. Where, p 2 will be the bursting pressure, p 1 will be the atmospheric pressure, mu is a heat capacity ratio which is known for every chemical, and v is the volume of the vessel.

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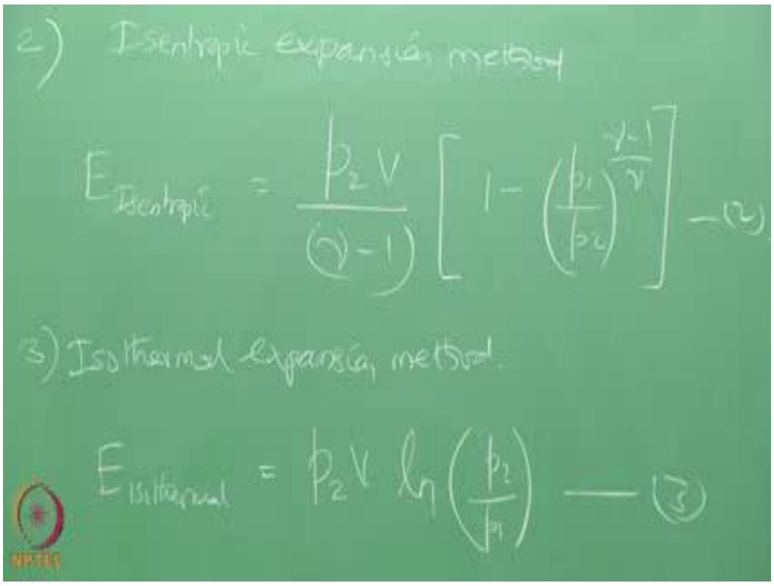

Second method could be isentropic expansion method. According to this method the energy released can be found out by this equation p 2 v by mu minus 1 of 1 minus p 1 p 2 mu minus 1 by mu. The third method could be isothermal expansion method. According to this method energy released is given by natural algorithm of p 2. Of course, the fourth way is based on the conventional laws of thermodynamics.

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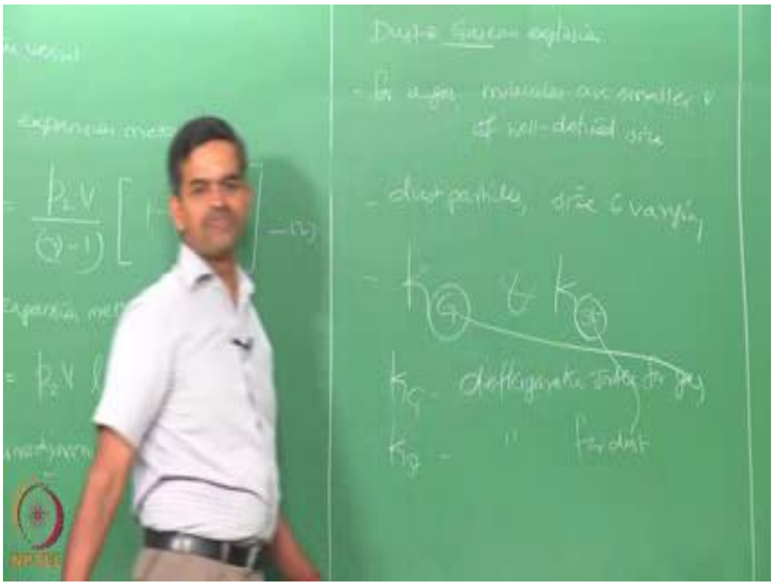

When we talk about dust and gaseous explosion because they can also cause explosion, interestingly for a gas molecules are smaller and have a well defined size. For dust particles the size is varying. This variation magnitude is larger than the molecules therefore we used to calculate what is called K G and K st. So, K G is called Deflagration Index for Gas, K st is called Deflagration Index for Dust. So, G stands for gas and st stands for dust.

Interestingly, variation in pressure which is caused by the dust or gaseous explosion with respect to time is shown in this figure. Please pay attention to the figures shown on the screen now.

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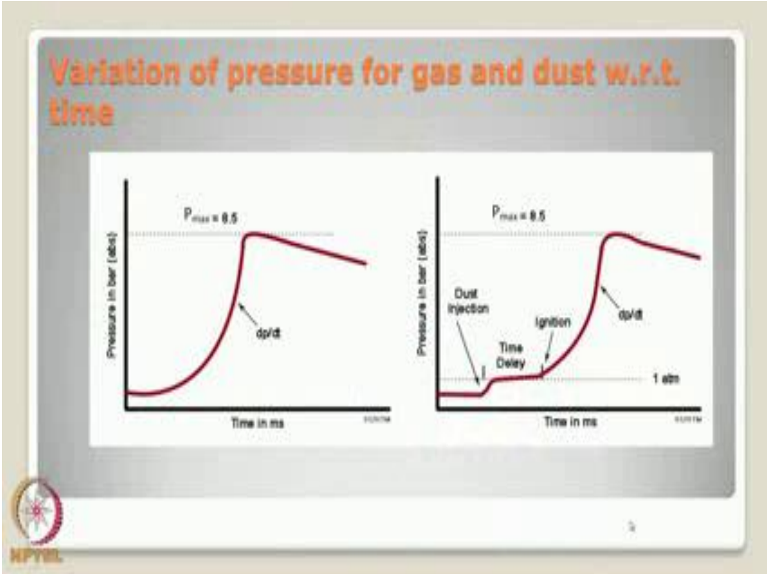

The left side figure shows the variation of pressure for gas respect to time, whereas the right side figure shows the variation for dust. So, the pressure gradient is different in case of a gaseous release on an explosion caused by gas compared to that of dust.

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Let us quickly compare these two and see what are the observations we can make we are trying to write the explosion damage caused by gas and dust. Let us say gas and dust explosion. The first difference one can say is the dust particles size of the particles varies, whereas in gas more or less they are smaller in size and well defined. The second could be in both the cases the maximum pressure reached because of the explosion release energy is same; in both the cases it is same. You can see from the figure in both cases p max is approximately about 8.5.

However, the gradient dp by dt in this case for dust and in this case for gas they are different. I can say this is more or less instantaneous, but this is more or less gradual. This occurs without any time delay, this occurs after significant time delay. Please pay attention to the curve shown on the screen. So, the right hand side curve shows the pressure variation in terms of time for the dust explosion. You can see when the dust is injected there is an injection time again the pressure comes to one atmospheric, so there is a delay time and at this point when ignition occurs it picks up to the peak. So, the time taken for dust explosion to reach the maximum is much more compared to that of time taken by a gaseous explosion it is same maximum absolute value, because this is more or less instantaneous does not have any time delay rather this has a time delay.

In this both the cases more or less it can be a same gradient, but it has a time delay therefore dust explosions are caused after significant time delay which can be easily controlled if the control mechanisms are in place to mitigate or to control the explosion phenomena happening in the process industry. So, we have been talking about explosion damage estimate.

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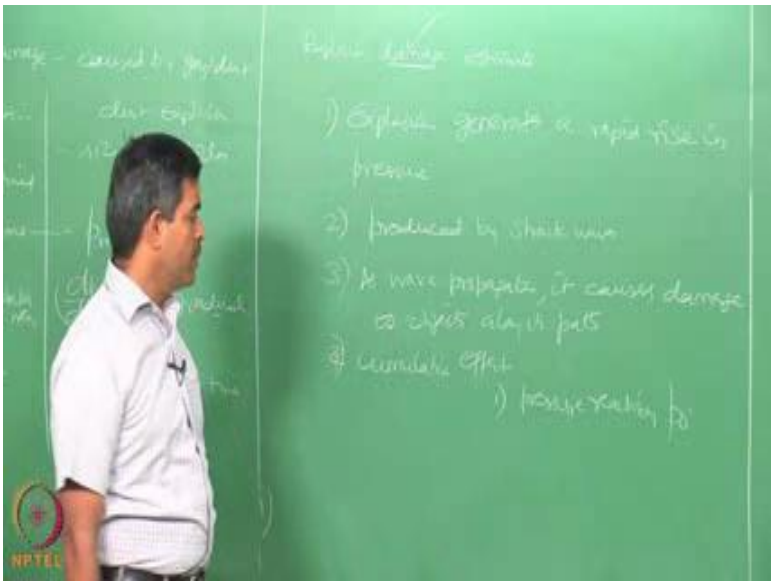

Because one is interested in doing the damage rather than actually knowing how to model the explosion, we all know that there are certain facts which you have understood now – one, the explosion generates a rapid raise in pressure that is the first order of understanding to know the damage caused by explosion. This essentially produced by shock waves. Then as the wave propagates, it causes damage along its path to objects along its path, it has a cumulative effect one caused because of pressure reaching peak over pressure value. Second is due to negative pressure, negative pressure results in section effect which is quite dangerous and very vulnerable in terms of damage.

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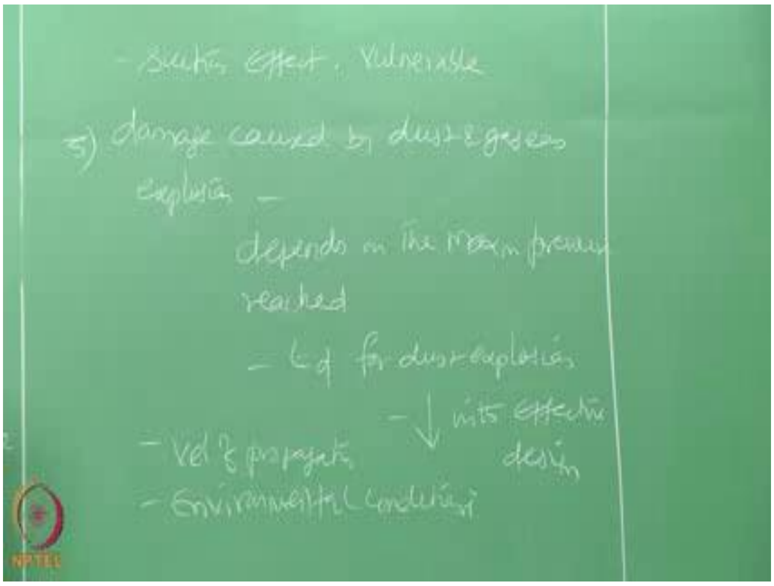

On the other hand the damage caused by dust and gaseous explosion, the damage caused by dust and gaseous explosion depends on the maximum pressure reached. Out of these two time delay will be there for the dust explosion therefore, damage caused by dust explosion can be controlled with effective design, but damage caused by gaseous explosion or instantaneous and rapid release of energy occurs therefore, there are more catastrophic in nature of course, they also depend on other factors velocity of propagation which we already saw (Refer Time: 16:39) depends upon environmental conditions.

So, there are two cases here what we saw one is detonation, other is the deflagaration both are process of explosions.

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Deflagaration can result in raise in pressure which is approximately 8 times of the initial pressure whereas, detonation - the increase in pressure can be even more than 8 times p initial. In both the cases the rate of pressure depends on mixture characteristic, degree of containment of explosives and the environment conditions which include velocity of propagation, wind direction, etcetera as said by Roberto and Mauro 2008.

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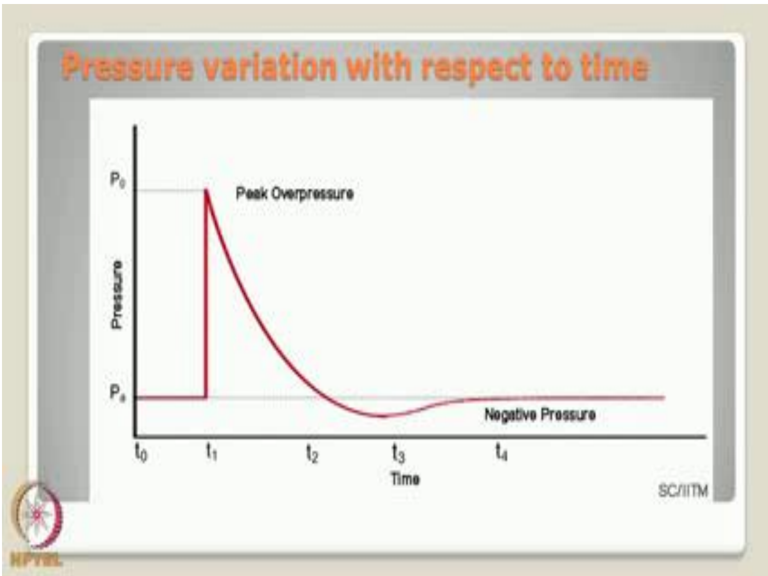

Please pay attention to the figure shown on the screen which has already been discussed in the last lecture, just for completion sake we are referring to this figure back again. This shows the pressure variation with respect to time. So, the peak over pressure which occurs instantaneously in an explosion release causes damage followed by which the damage is further caused by the negative pressure. Area under this curve will actually indicate me the damage extent, if you really wanted to prevent the fire and explosion which can occur from any flammable mixture.

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So prevention of fire and explosion from any flammable mixture depends on how can you reduce the ignition sources, or the presence of ignition sources, how to ensure safe design procedures. So, that electric short circuiting things like that can be avoided one can also think of how to reduce the flammable inventories, one can also think of how to replace flammable construction materials with alternate composites.

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One can also think of how to reduce the temperature and pressure. In fact, we should say instead of reducing how to release excessive temperature and pressure which is built during the process. You can use pressure relief valve, you can use temperature sensors, you can have cool and circulators, etcetera.

So, one can also look at different fire and explosion preventive measures. So, these are some of the based on this one can design a variety of fire and explosion preventive system which anyway will see in the next lecture.

In this lecture we tried to understand what would be the energy release computed for chemical explosion, dust and gaseous explosion, what would be the difference between two types of explosions like detonation and deflagaration. What are the factors which should be focused we really want to work at prevention of fire and explosion from any flammable source or material which could lead to ultimately how one design a variety of fire and explosion preventive systems which can be in place in order to mitigate risk arising from fire and explosion which is a very important segment in terms of offshore industry is concerned.

Thank you very much.