Failure Analysis & Prevention

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Lecture - 13
Industrial Engineering Tools for Failure Analysis: Fishbone Diagram and FMEA

Hello, I welcome you all in this presentation related with the subject Failure Analysis and Prevention. And we are talking about the Industrial Engineering Tools Applications in the Failure Analysis.

In the previous presentation, I have highlighted the importance of the various industrial engineering tools in failure analysis and also, I have talked about the Pareto diagram and how it can be used to identify those vital few factors which are important and have a significant effect on the performance of a product or process, and what are those useful a many items which are, they are and needs to be taken care of in subsequent stages in course of the continuous improvement season.

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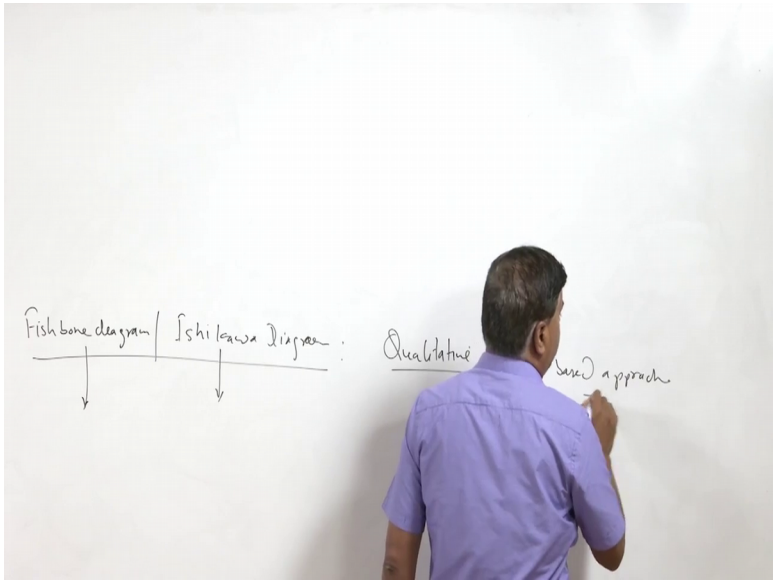

Now, today we will be talking about the Fishbone diagram, fishbone diagram or this is also known as Ishikawa diagram. So, the there are reasons for a having the names like this of these two for this diagram like. This kind of diagram was developed by a Japanese Professor Ishikawa to analyse the different causes of the failure in more systematic

manner, while the structure of the diagram is similar to the bone structure in fishes and that is why it is also termed as fishbone diagram.

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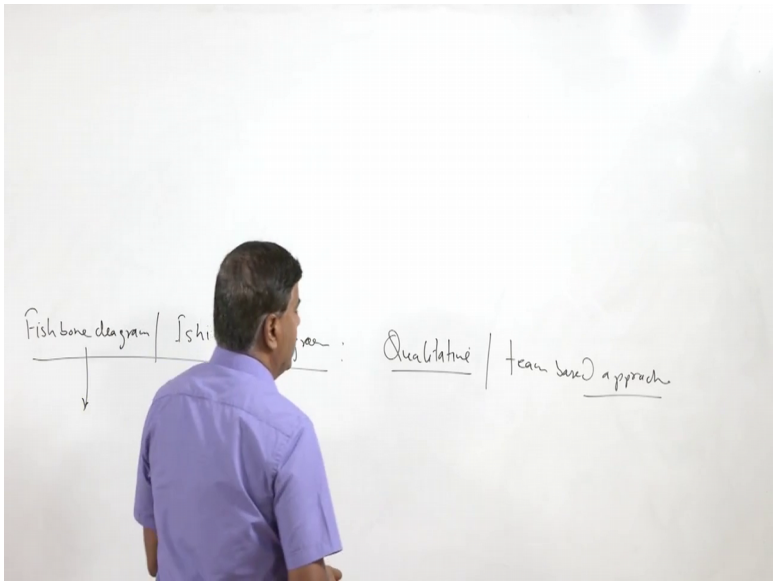

This diagram is developed it is a basically qualitative in nature qualitative in nature and it uses the team based approach to identify the major and the minor causes related with the failure of any kind of component. So, since this is a team based approach to identify the major and minor causes, so that we can really find out what are the actionable finer causes which can be taken up or which can be considered for avoiding the recurrence of the failure or avoiding the failure reducing the failure tendency.

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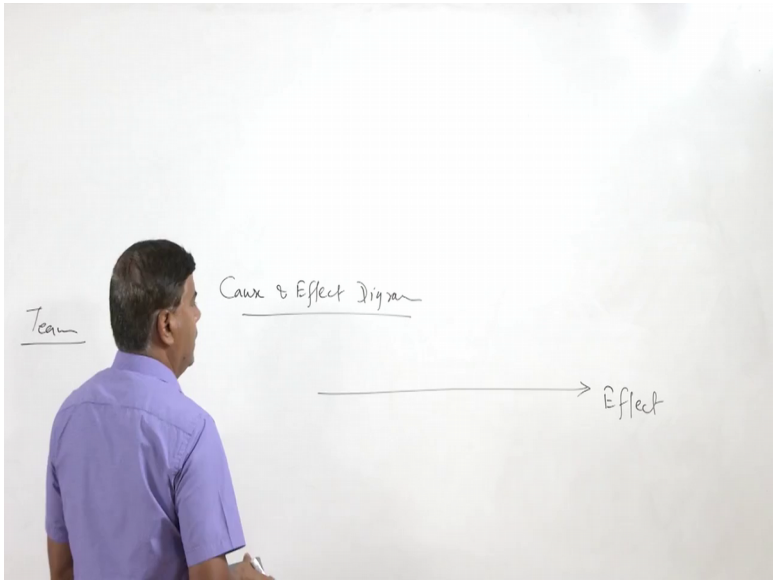

So, in the team depending upon the nature of the product which for which analysis is to be done or the causes or the fishbone diagram is to be developed, this diagram is also known as cause and effect diagram. So, basically the effect whether it is favourable or unfavourable is mentioned in one side and that is mentioned like this like in the right side we write the effect. So, this is the effect and one big line with arrow is drawn like this and so this effect is the one which either we want to avoid or one which we want to have with for improved performance of the product like.

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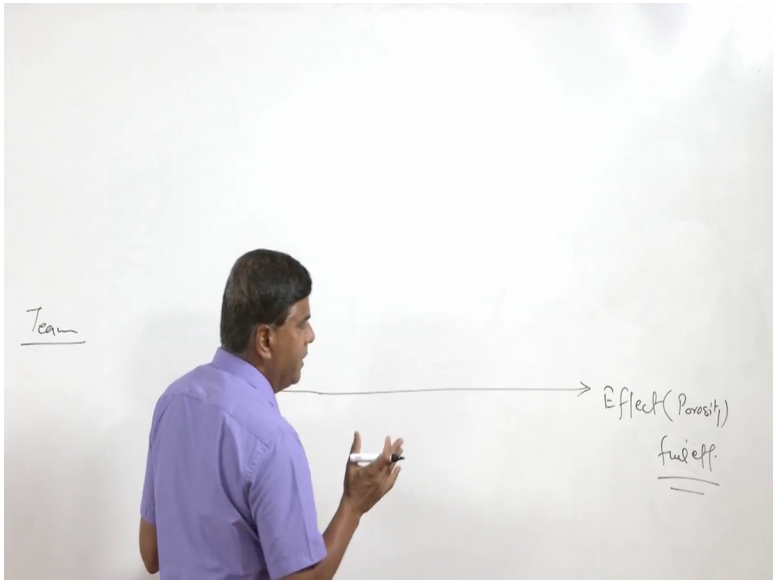

If you want to control the defect light porosity then we will mention the porosity or if you want to improve the like say the efficiency or the fuel efficiency of an engine and we will write the fuel efficiency in the right side. So, whatever effect whether it is favourable or unfavourable is written on the right side and then accordingly, we will we will try to identify first of all the major causes for this effect means what are the factors which will be leading to the either favourable or unfavourable causes.

So, initially in this case for a particular effect like in our case if it is about failure say it is the failure of the.

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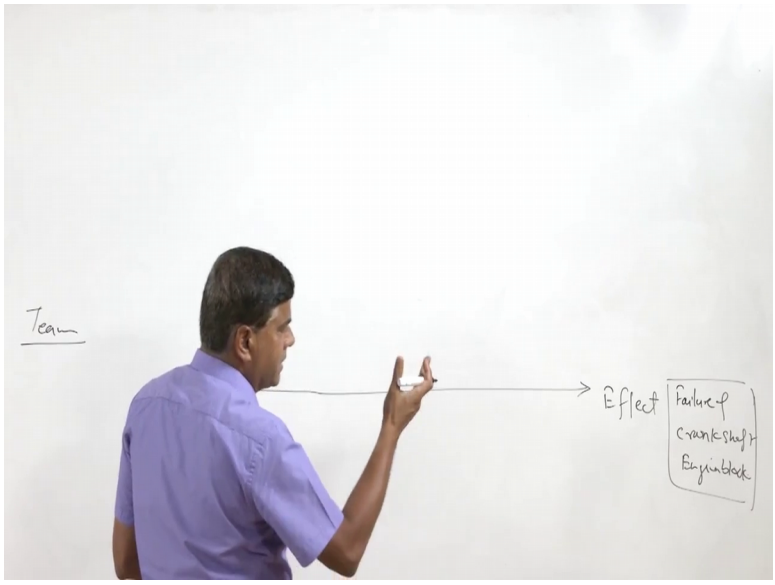

Failure of a crankshaft or it can be failure of a say engine block. So, since the since these are made by the different processes for a specific purpose.

So, we need to identify actually these are the mechanical engineering components which are used in automobiles and if they are frequent failure of a particular kind of component is taking place then analysis of the causes or identification of the causes becomes important.

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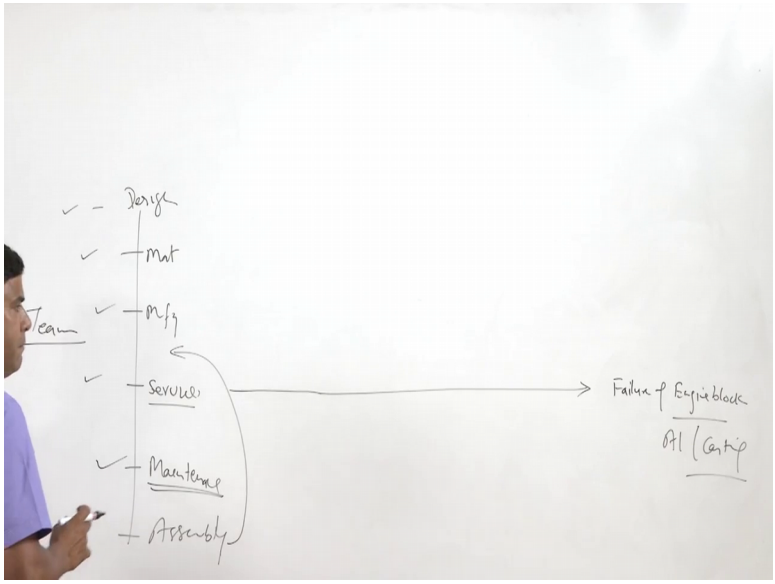

Say if we consider the failure of the engine block say it is made of the aluminium and prepared by casting and which subsequently can fill in an number of ways. So, since the job or the product is the engine block which is which will be which will be first designed then using properly proper material it will be manufactured and after manufacturing it will be inspected properly whether it is according to the design or not there after it will put into the service and during the service if it has to be it is to be used properly and it is to be maintained properly so that it can really perform the desired function for the intended life.

But since, it includes the very wide range of the causes starting from the design material aspects manufacturing service maintenance assembly. So, very wide range of the things existing. So, in order to analyse the major causes as well as their subsequent causes it is important that we have the people representing to all these groups like we need the engineers from the design group or the material engineers or metallurgical engineers those which are taking care of the manufacturing aspects or in service means the customers were using the system or the engine block in automobile and how it is being maintenance.

So, the maintenance people who are taking care of the system and in assembly of course, it is a part of the manufacturing. So, how effectively it is being assembled. So, we need to have the people of the different functions which are responsible for all these

components and if there is any kind of the deficiency in respect of design materials manufacturing service maintenance and the assembly then it will be leading to the premature failure of the component which is say in this case is engine block.

So, first of all the team of the people relevant to the product or the process which is being considered is to be formed. So, people from the different the relevant groups are taken up and then accordingly the major the causes are identified some major causes which are identified.

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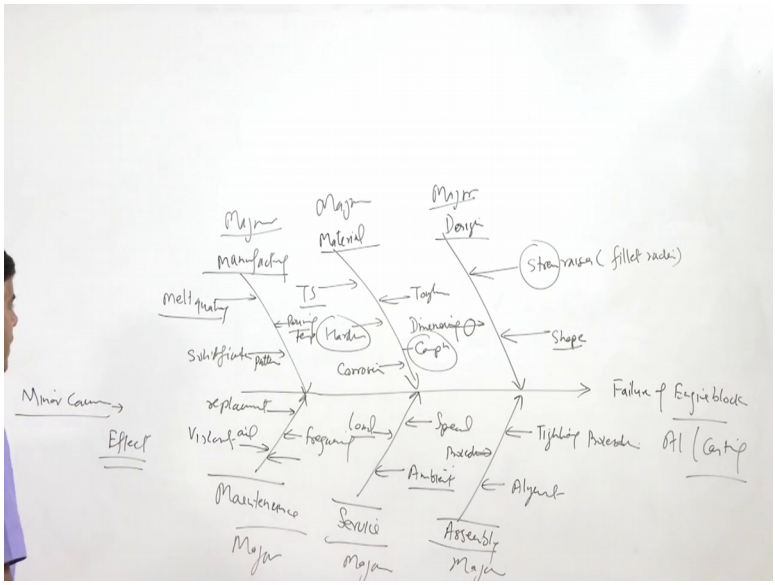

Or indicated through the lines like this as per the number of causes various lines will be plotted and all these will be connecting to the horizontal line which is showing all these are basically causes and then right side we have effect say the aluminium engine block made by casting process.

So, so, these are so, here these are the major causes. So, we will have to identify first the major categories of the causes which can lead to the failure of the component. So, the design one, then we have the material imperfection related cause and then manufacturing of the product then we have assembly service and maintenance.

So, the people from each of these major causes will be contributing towards the way by which how the various minor causes related with the each major causes can contribute towards the particular effect which is favourable or unfavourable. So, that proper

corrective action can be taken. So, all these are termed as the major causes or the major categories which can contribute towards the failure.

But these are not actionable everyone you will say assemble the things properly do the servicing properly do the maintenance properly manufacturing has to be done correctly as per the procedures established material has to be sound and free from the defects and design has to be perfect, but these are not the actionable things these broad category of the factors or the causes, but the actionable things will be more finer in the sense that we need to identify if you minor causes minor causes like this. So, these minor causes are indicated again by the horizontal line connecting to the major causes. So, all these are the major ones right all these are the major causes.

But the major causes are not actionable certainly we have to find out the finer details we on which action can be taken and which it can be like the stress razors stress razors by through giving proper fillet radius or by proper dimensioning of the product in light of the service loads and proper shape. So, that the stresses are more uniformly distributed and localisation is avoided. Similarly in the material it is tensile strength its toughness its hardness, because role of the each of the factor will be different towards the performance it can be composition, it can be its corrosion resistance or the anything else which is important for the performance of a given product. So, all these are the minor causes it there can be deficiency of the hardness or there can be deficiency of the toughness which can lead to the failure of the engine block.

Similarly, the manufacturing process since it was made by the casting. So, we need to see the proper melt quality in terms of the cleanliness of the melt the pouring temperature to avoid any kind of the defect like cold shafts etcetera pouring temperature and then the solidification pattern has to be regulated properly through the use of the chills and chaplets. So, solidification pattern and likewise there can be number of other finer details which can be actionable and which can be useful for regulating the effect as per the requirement like reducing and undesirable effects and improving the desirable effects.

Similarly in case of the maintenance we need to mention the kind of viscosity of the oil is to be used lubricating oil the frequency of the oil is to be used and like the replacement and repair of the things which need to be done after a particular period of time like say in

case of the automobile set is like 2000 kilometre or 5000 kilometre, similarly, oil is to be replaced after particular thousand kilometres of the distance.

So, all those things need to be specified. So, that engine can keep on working properly or similarly under the service conditions it has to be like the working condition under which it is being used under the ambient condition or the kind of the load for which is being applied means it has to be used under the conditions for which it has been designed with regard to the load. Similarly the kind of speed in which it can be operated to high speed can be harmful for the performance of the component or the different delicate parts of the engine. So, there can be the various service related finer things which need to be identified and then, then they should be taken care of they can they should be analysed to see if the failure is occurring due which due to a particular kind of the minor causes.

Similarly, in assembly the alignment or the proper procedures for assembly and the kind of the proper tightening procedure is there along with the values and the magnitude or the sequence which is to used. So, like this a detailed diagram is made regarding the major causes and the minor causes and once we have the complete picture of the various causes which can lead to have a particular kind of effect then it will give us the venues it will provide us the venues what are the various things that we should really look into from the failure analysis point of view.

For example if the failure is occurring due to the design aspect then we need to see if there are a stress razors are present, then the they should be taken care of if the dimensions are proper or not for a given load service conditions that that should be assessed, similarly, the composition has to be checked if the material was used proper or not and the strength and hardness were proper or not also can be seen.

So, since the list of the minor causes is very large and which type of the causes really can contribute in significant way for a particular kind of effect that is to be considered so, all these minor causes are listed for their effect on a particular aspect which is good or bad. So, in very consensual manner or in with the consensus it is identified in each of the category which factor really contribute towards a particular kind of effect regarding the failure of the engine block. So, we zero down on a particular kind of the causes.

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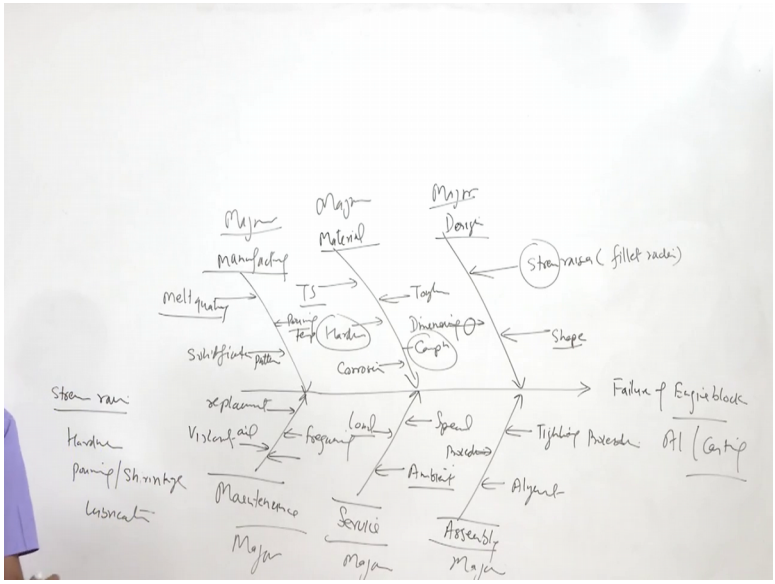

Which will have a given desirable or undesirable effect say it is coming out after the design analysis stress razor is one of the possible thing then hardness from the material side and the manufacturing side say it is coming out to be the pouring temperature which can really have the possibility of the cold shaft due to the complexity of design or it can be the like shrinkage cavity shrinkage cavity in the casting which can also lead to the failure of the component.

And then improper maintenance may be kind of the lubrication can be one of the importance. So, few big or the significant minor causes are identified which will be actionable and then investigation is carried out with regard to these whether really the things are the engine blocks which are failing are due to which of the aspect so that the proper corrective action can be taken in order to avoid the failure of the component in subsequent stages.

So, this is how actually the fishbone diagram or the Ishikawa diagram can be used to prepare a detailed list of the various major and minor causes to a particular effect which we either want to avoid or we want to increase or incorporate or we want to hack. So, based on these minor causes we try to and look the further investigations to see if the failures are being caused by these minor causes and if that is established then accordingly we can take the corrective action once the root causes for the failure of a

particular minor causes identified then we can take corrective action accordingly in order to avoid the recurrence of the failure of the component.

Now, another tool about which we need to talk is the failure.

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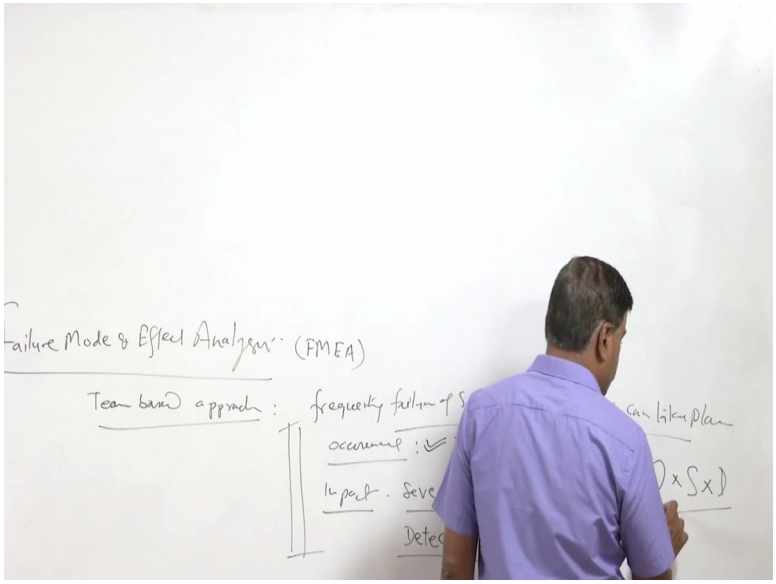

Mode and effect analysis failure mode and effect analysis this is known as FMEA and this is more systematic this is also a team based approach where the people from the different relevant groups are brought in together in order to give their contribution and opinion with regard to our the various possibilities related with how frequently how frequently the failures of specific component or subcomponent can take place can take place.

So, this frequency is to be opinion about the possible frequency of the failure is identified. So, this is what is called occurrence and if the failure occurs what will be the impact of the failure in terms of the loss of property loss of life loss of production or loss of the customer satisfaction or loss of the good wheel. So, all those things need to be identified with regard to the impact.

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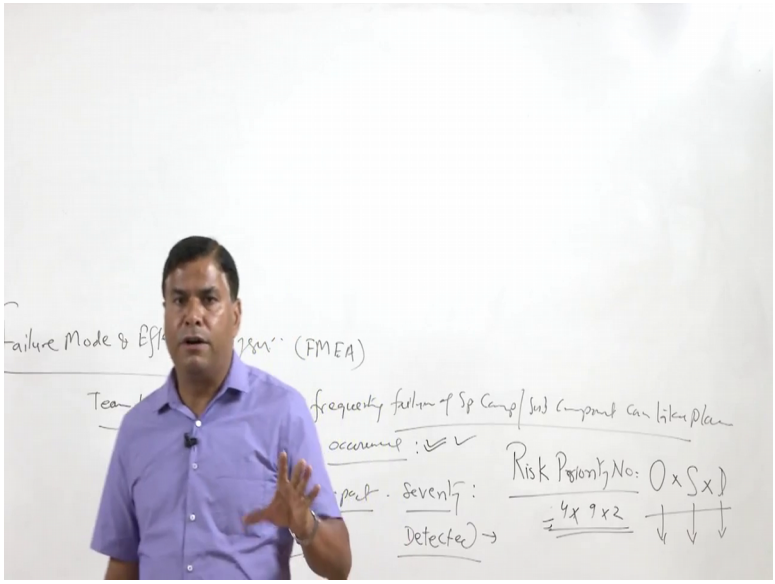

So, this is what is characterised in terms of the severity of the effect of severity with regard to the failure of a particular component or the subcomponent.

And then the third one to avoid the failure to avoid each type of failure we we set in the procedure we set in the devices. So, that we will have a idea about what is the condition of a particular component or subcomponent which we can say as a condition monitoring to see the actual condition of product during the processing or during the use we put in different things in place.

So, what about the sensors what the sensors say regarding the possibility for detection of for the failure tendency of particular component. So, how easily the failures can be detected or the condition of the product can be detected. So, if the detection is difficult, then the possibility for the risk possibility of risk will be more if something can be detected easily then the risk of related with the failures are less

Similarly, if the severity is less, then the risk related to the failures are also less and if the occurrence is less, then the risk related to the failures are less. So, these are the three aspects which are considered in the failure mode effect analysis to see the extent of impact which will be there if failure of a particular component or subcomponent takes place.

So, once if we are able to know that impact then it will help us in prioritizing the components or subcomponents that should be focused more as compared to the others. So, this is just of the failure mode effect analysis and if you see it helps us to identify the risk priority number related with the failure of a particular product which accounts which is obtained from the occurrence multiplied by the severity multiplied by the possibility of the detection. And all these values are identified based on our judgement of the team. So, and rating for all these things can be given 1 to 10 scale or 1 to 5 scale it is better to use the higher scale as compared to the lower one.

So, possibility of occurrence say for a particular product is rated four possibility of severe uh severity of failure of that particular product is very high then it may be rated nine and if the detection is easy means we can detect the possibility of failure easily then it will be rated less.

So, this product of all these three will be used to identify the risk priority number of related with the particular product since the big systems are made of number of subcomponents. So, RPN or risk priority number for each of the component is identified. So, that we can really prioritize which one is to be used first and which one is to be given more attention as compared to others. So, this is the main thing related with the failure mode effect analysis.

Now, we will go in detail about the FMEA and its various aspects. So, here what are the benefits once if you are able to prioritize the risks associated with the various components in a big system first of all it allow us to identify the areas of our process or of a product that will have the maximum impact on the performance of a product or of a service it helps us also to identify in which way the process is likely to fail. So, how the process is likely most likely to fail that is also identified and it also points that what are the failures which will be easy to detect what are the failures which will be difficult to detect.

So, based on the application areas there are different types of the FMEAs and which are termed as like the product based 2 broad groups or the process based, but this is one we like product is mostly taken care of by the design aspects and the process is taken in light of the manufacturing aspects. So, but apart from this like there are the stage in which

FMEA is applied can be the design the manufacturing then the then there is software then there is a service and likewise.

So, depending upon the area in which FMEA is applied, it is called FMEA design or manufacturing process or software service or anything else according to the area of application in the and when these are applied like we are trying to come up with something new can be product can be process. So, we need to really look the look into the product or processes in different ways to see; what are the various ways new product can fail what are the various ways the different processes the new procedure or the process can fail.

So, that we are better prepared to avoid those kinds of failures or whenever there is relocation or shifting of the products or the facilities. So, in that case also it is applied then in the manufacturing like if something has happened like a one big system has failed at that in that case also the FMEA we can apply to see; what are the focus areas that we need more attention as compared to the others.

But more importantly FMEA approach is the preventive technique which helps us to see the process and products or the softwares in different ways in order to assess the way by which they can fail say a product is assessed in number of ways to see the various ways by which it can fail a software is analysed to see what are the various ways it can create the troubles and it its failure can occur especially when it is used under the different set of the conditions.

So, the possibilities of the failure of a product process or the software in different ways is analysed and then based on our understanding different steps or the corrective measures are also identified so that we are better prepared to avoid the occurrence of the failure due to those reasons.

Say these are the some of the application examples of the FMEA like in manufacturing a manager is responsible for moving a manufacturing operation to a new facility then he wants to be sure that the move goes as smoothly as possible and there is no surprises. So, he will explore various possibility by which there can be problems in this transformation or transition from one facility to another.

In the design stage, designer wants to think all possible ways by which a product being design can fail so that the robustness can be built into the product to avoid any possibility of the failure by all those possible ways by which the failure has been thought off. And similarly software, a software engineer wants to think of the possible problems a software product could fail when scaled up to the large databases and this can be a problem. So, the software is strengthen to take care of all those possible issues which can occur when it is in actual use.

Still if some of the issues are identified then nowadays it is common to update the software so that the problems can be resolved. So, these are some of the; this is just introduction of the FMEA and what are the benefits and the application areas where it can be applied. I will talk about the FMEA in detail about the different procedural steps for applying FMEA.

And now, I will summarize this presentation in this presentation. I have talked about the Ishikawa diagram to see what are the major causes and what are the minor causes and how to build up those major and minor causes to identify the things that need attention to avoid the failure tendency, and to have the particular kind of favourable or unfavourable effect, and similarly I have also talked little bit about the failure mode effect analysis.

Thank you for your attention.