Failure Analysis & Prevention
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Lecture - 12
Industrial Engineering Tools for Failure Analysis: Pareto Diagram

Hello I welcome you all in this presentation related with the subject failure analysis and prevention. So, far we have talked about the fundamental sources of the failure and considering these various sources of the failure.

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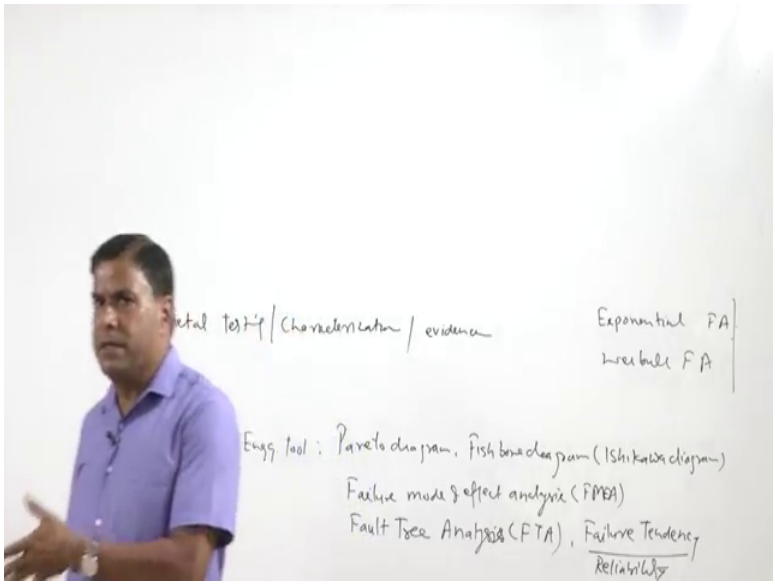

Now, there are two ways to go ahead further one is wherein the proper the metal testing characterisation, characterisation and like say development of the evidences is carried out.

So, this is what is called the metallurgical analysis of the, the field components for establishing the root causes to go ahead in more systematic manner, it will also be appropriate to consider the use of industrial engineering tools, in industrial engineering tools, there are few tools which will help us to analyse the various sources of the failure in more systematic manner.

So, that we can zero down on certain causes which will help us to improve the workability, availability and the better performance of the products which will also help

us to identify the areas which need to be focused for avoiding any kind of the failure. And if the failure has taken place then what we should do to avoid their reoccurrence, and there is one more aspect when a failure is expected to occur that is also can be estimated using the history of the failure of the components due to a particular kind of reason.

So, various industrial engineering tools like the Pareto diagram, a fishbone diagram, this is also known as ishikawa diagram, then we have very commonly used failure mode and effect analysis, failure mode and effect analysis this is also very useful in analysing the impact of the failure on the performance of a particular product.

And this is commonly termed as FMEA, and then there is another the tool which is known as fault tree analysis or development of the fault tree diagram, so the fault tree analysis. So, this is referred as FTA or FTA for fault tree diagram this helps to establish the relationship between the various subcomponents of a big system which will help us in analysing what are the key areas need to be focused. So, that root cause for a particular failure can be identified.

So, this one also helps in identifying the root causes the locations, so the zones or the sub systems which needs to be focused, and then there is like the failure tendency estimation of the failure tendency, which is normally seen in respect of the reliability. So, to predict the failure tendency to estimate when the failure can occur there are two approach is one is exponential failure analysis and we will and failure analysis.

So, these two are used to see when a particular kind of the failure is expected to occur based on the history of the failure of the component. So, we will be taking of the general approach of the failure analysis using the metallurgical characterisation and related steps, but before going into that we will try to see what are the various industrial engineering tools which can be useful in failure analysis as well as in preventing the failures; if we are able to recognise the significant sources of the failure or which will have the greater, which will pose the greater risk for the good performance of the product.

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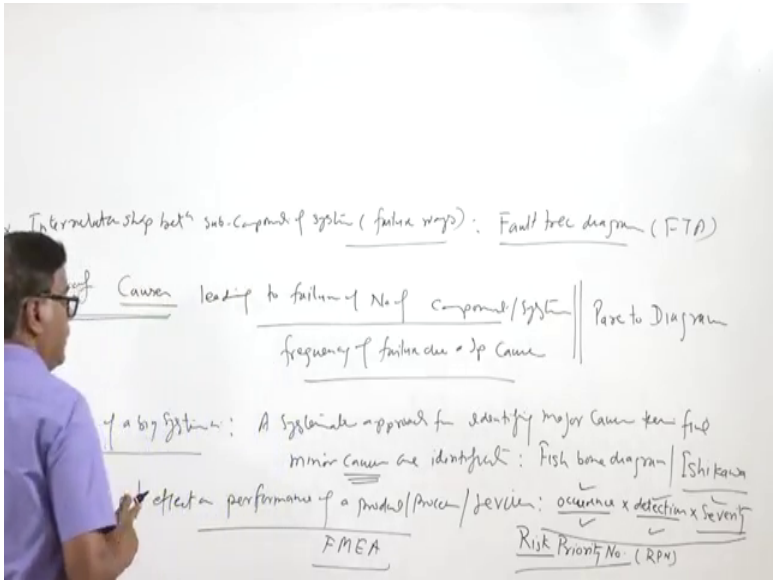

So, so the various things are addressed using the various kind of the tools as I have said and like the first one here is if there are various causes various there are various causes, which causes leading to the failure of number of components or systems in a shaft floor or the product which is been manufactured by a company.

Then how to when these number of the causes are very large then how to zero down on those few causes that should be addressed first in order to avoid the failures of the component during the service or before it is transferred to the customer. So, the number of causes, when the number of causes are more uh.

So, those which are really significant and important for the major change in the performance of the product during the service, we use one diagram called Pareto diagram then there is another approach and the Pareto diagram basically, considers the frequency of the failure due to specific kind of the cause. So, frequency is, is a major parameter which is used for the analysis using the Pareto diagram, so this is one.

And the second one is if there are you know if the failure of a big system is taking place system is taking place then we need to analyse the various possibilities related with the failures which can be there, and which needs to be addressed.

So, a systematic approach for like say identifying, the major first the major causes like the material is one major cause the manufacturing is another like, improper material is

one cause improper manufacturing is another improper servicing is another. So, I didn't so as per the nature of the product which is being considered we need to identify what can be the major causes and thereafter the fine or you can say the minor causes are identified or identified.

So, these minor causes actually will be actionable or this can be broken down further until we find that things which are actionable on or the things on which action can be taken in order to avoid the failure of a particular product or the system. So, minor causes are the actionable causes these are identified. So, for this identification purpose one tool which is used is called fishbone diagram this was developed by a one Japanese scientist ishikawa, so it is also known as ishikawa diagram.

So, this diagram actually helps us to find all those finer details related with various major category of the causes and these finer details and this micro details actually helps us to see which kind of action we should take. So, that the possibility of failure can be avoided, or the failure analysis in those actionable causes can be carried out to see if the failure has been caused by that a specific minor cause.

So, this is especially good for the big systems where the number of major and major causes and the minor causes are present. So, it uses the fish bone diagram. So, this is the use of fishbone diagram or the ishikawa diagram then there is one more, you can say industrial tool which is, which considers the tool, which considers the impact or the effect on the extent of the effect on the performance of product or process or service will be layer.

So, the impact of the failure of a particular product or some component or particular process or subcomponent of the process or the service a what if these fail then what will be the extent of damage or impact in the in the system. So, that is considered and for this purpose normally the, the analysis is carried out in considering the three aspects.

One is high how frequently the failure occurs due to failure, failure of a system occurs due to the failure of one is specific component. So, how frequently that occurs that is called frequency of occurrence of a particular failure of a component, and then how easily or how difficult to detect the possibility of failure means we have like various systems wherein we can keep on measuring the temperature and vibrations which will be indicating the condition of the equipment.

Similarly, what kind of the detections are available for seeing the condition of a particular subcomponent? And if so if we are not able to detect means the risk will be high and in that case the impact will be more So, did how, how difficult or how easy to detect the possibility of failure or the way by which a failure of particular component can take place.

So, that is also consider, so occurrence detection and then we have severity, what is the extent of effect on the effect or on impact on the performance of the impact on the company where or impact on the customer or impact on the like economical or the life of the human being which are working all around. So, severity can be seen in number of ways it can be in terms of the properties it can be terms of the products of losses it can be in terms of the life loss of life. So, these are the three aspects which are considered to see the extent of impact if failure of particular thing takes place.

So, this will be helping us to find out or prioritise the risks associated with the particular component or the subcomponent. So, this is this helps to identify like the risk priority number for a particular product which is called like say risk priority number more commonly known as RPN. So, for each component or subcomponent which will have tendency for failure the RPN number is identified, and based on this number we decide really how much importance should be given, how much attention should be given a particular product or the subcomponent?

So, this kind of approach is used in case of the failure mode, effect analysis, about. So, these are the three approaches we will talk in detail about each of the approaches and then we have one more wherein the interrelationship, inter relationship between various subcomponents, various subcomponents of system is established and it is also identified in which way various subsystems can fail.

So, the, the failure modes we, we can say failure ways or the failure modes of each of the subsystem is also identified this will help us to pinpoint the location where from failure would have taken place and that will help us to take the corrective measures. So, this is facilitated with the help of fault tree diagram, fault tree diagram this is also known as or fault tree analysis.

Ah then one more tool is available, we know that if in shaft floor we are having 100 of the machines. So, over a certain period of time say one year, what is the frequency of the

failure of particular kind of machine that is identified? So, based on the history of the failure of the different components efforts are made to see when the failure of a particular component will be taken place due to particular kind of reason.

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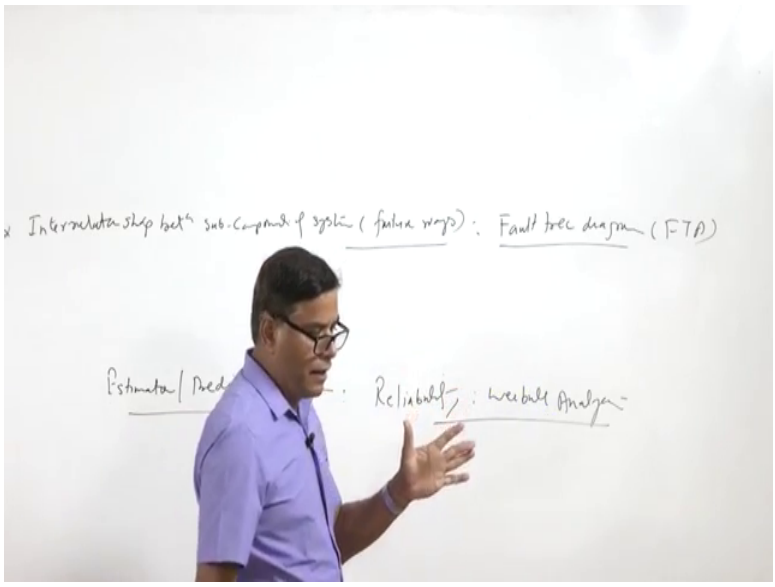

So, so basically the estimation or prediction of failure means when failure will have when the when there will be the possibility for failure to occur this is what can be estimated through the use of the reliability, principles and which includes the weibull analysis.

So, we will be talking about this tool also various aspects related with the reliability and what can be done in order to improve the reliability of the products. So, that the failure tendency is reduced and we based on the failure history of the product we can also identify, or we can estimate or we can predict when the failure develop tendency to occur.

So, when the failure is expected to occur, if we are, if we can measure that we can check that then that will help us in preventing the catastrophic failures and will be taking care of the things in much better way. So, these were some of the industry, and industrial engineering tools which are used for the different purposes. Now, we will be starting with the first tool related with the failure analysis which can be useful for the failure analysis and that is Pareto diagram.

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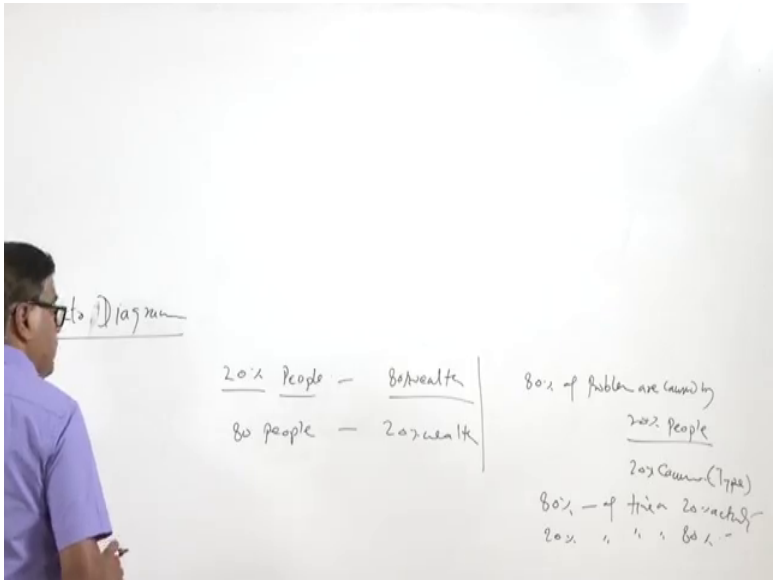

Pareto diagram this Pareto diagram actually was developed by a scientist from Italy, and he in he performed one study, in the city of the Venice in the Italy to, to see what is the wealth distribution among the various the residents in citizens of that particular city.

So, what he found that when after the study he observed that about 20 percent of the people 20 percent of the people of the city they have the 80 percent of the 80 percent of the wealth of the level in that city, while the 80 percent of the people had remaining 20 percent of the wealth. So, there were very few very rich people and there were many people with very poor wealth very limited wealth.

So, this was the first finding and when he, applied this aspect to the other facets of the life also then he found that like say 80 percent of the problems are caused by 20 percent of the people, or 20 percent of the causes type of causes like a specific 20 percent of the specific type of causes lead to the 80 percent of the problems, or we can say we spent oh 80 percent of our time on 20 percent activities that we do in 24 hours, while if 20 percent of the time is spent on the 80 percent of the activities.

So, this 20, 80 proportions or the percentages were found to be applicable by and large in various facets of the life and therefore, one Japan scientist quoined that this rule is universal and its applicable in a variety of the situations if we also see that the same, same thing is also connect to some extent in our daily life also like our 80 percent of the budget.

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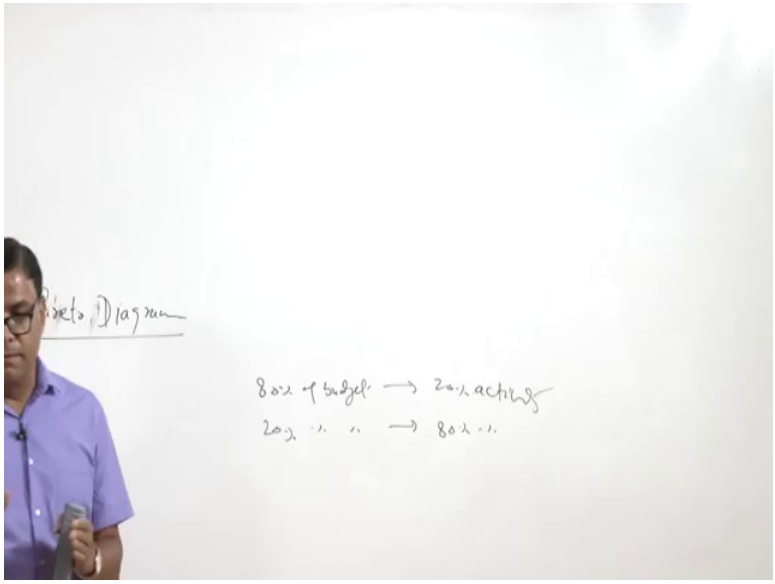

Goes on the 80 percent of the activities or the events that to be come true in our daily life monthly. Similarly, 20 percent of the budget will be going on 80 percent of the activity that we need to do.

Similarly, the 80 percent times the failure of particular component will be taking place due to the 20 percent of the causes. So, this 80, 20 percentage or this proportion is applicable in a very universal way, and this is broadly connect to a greater extent for the various facets of the life also and therefore, this has been quoined in different way by the other scientists like the vital few and useful many.

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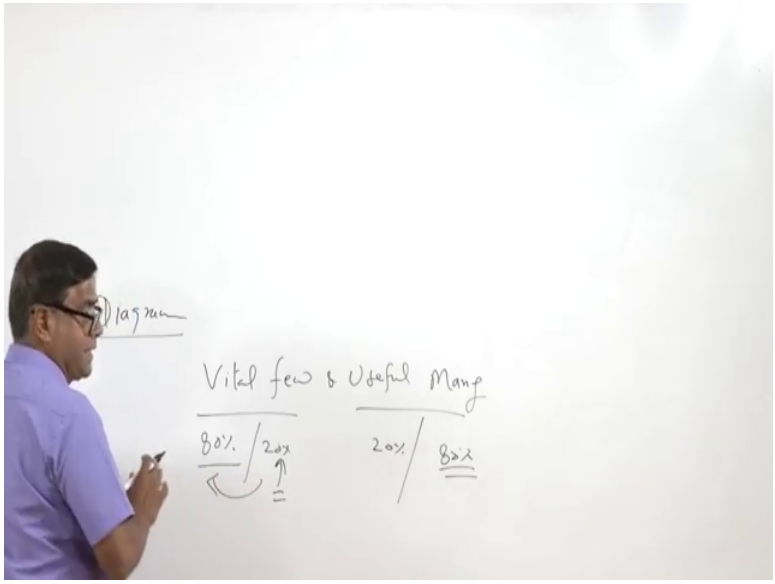

So, vital few are like those which have 80 percent effect, or just 20 percent regions effect is 80 percent and the regions are 20 percent, or you can say on the other side it is useful means the 20 percent is good regarding the effect, but it comes from our 20, 80 percent of the events.

So, it is good to focus say these many events because they have the effect of 20 percent, but it is more important to focus on those 20 percent of the events and activities, because they have very significant 80 percent effect on any kind of the facet of the life.

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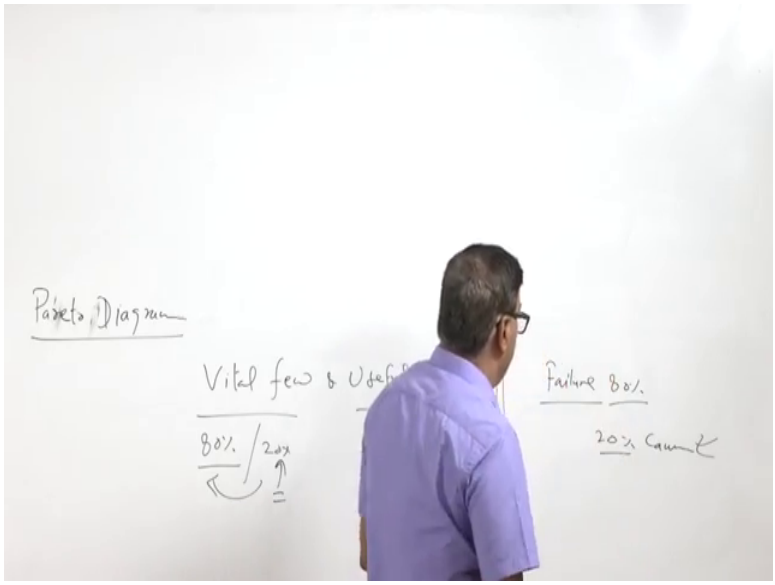

So, if it is about the failures or the failures then 80 percent times of the failure will be caused by the 20 percent causes. So, this 20 percent causes is need to be focused because these continue to the significant percentage of the failure.

So, now what we can do actually to identify these causes, what are the causes which are really significant and needs to be focused for this purpose one systematic approach is used in where we first of all like if it is about the failure, failure of like say a particular automotive being manufactured by a company.

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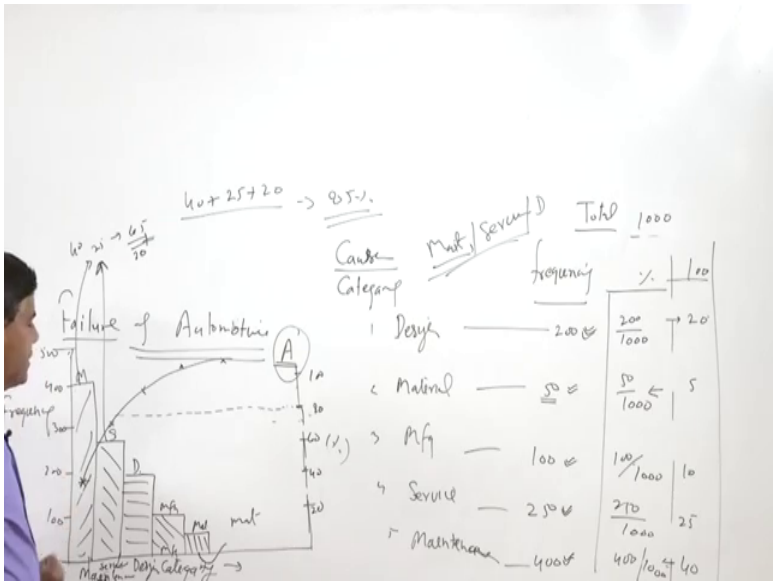

So, company is interested in doing the Pareto analysis to find out what are the really those big causes significant causes which become the primary source of the failure. So, the one company say carried out the, it collected the data about the various causes which led to the failure of the product that it was manufacturing to see what are the zones that they need to work in. So, that such kind of failures can be avoided.

So, like the product A, it may be scooter motorcycle car or anything. So, say company for a product A it try to collect the various causes for the failure. So, like these, these causes we can say these causes as category these causes as category. So, there may be like as I have said the fundamental sources of failure or fundamental causes like the manufacturing design then there is a material related issues then manufacturing and then we can say service and maintenance etcetera.

So, these are the say five, there are five categories one, two, three, four, five, and the it was analysed from the, the data which was collected that the a failure of a was occurring due to the particular kind of frequency say it was like 150, failure of the material was responsible for, for 50 and for manufacturing it was 100 or for service it was like say 250, and the maintenance was 400.

So, it was found from the analysis of the data which was collected regarding the various factors that contributed towards the failure, what was found that the data collected for a one year, for a particular product was say like this wherein failure was caused 400 times failure was caused by the poor due to the poor maintenance, and 250 times the failure was caused due to the improper use or operation of the equipment 100, times failure was caused by the manufacturing improper manufacturing related issues material was found defective or improper or improperly selected.

This kind of the failure was cause for 50 times and 150 times due to the deficiency in design like stress razors or the improper sectioning, and improper sizing, or shaping shipping of the product. So, say this is the kind of data for the different category was collected. So, what we need to do this is indicating just the frequency of occurrence frequency of occurrence. So, what we need to do is we need to make a total of all this, so where will be the total like 150, 50, 200, 300 550 and 400, 950.

So, the total is, total number of failures are 950 in one year, now we need to now we need to identify the percentage contribution due to the a particular category. So, here 150 divide by 950, 50 divide by 950 and 100 divide by 950 so likewise 250 divide by 950, and 400 divided by 950. So, this is how we can see that percentage contribution; obviously, if we see the data the minimum contribution is due to the faulty material, and the maximum contribution is coming from the coming from this what we can say from this the improper maintenance.

So, actually this is making it complex, so what we can do we can just round off some figure like say instead of this one we can make the design related failures just for example, design related failures were like say 200 times. So, 200 was the frequencies. So, the so the our total will change and it will increase by increased to 2 sorry 1000. So, here it will become 1000, this will become 1000 this will be 1000 this will be 1000 and this will also be 1000.

So, now percentage we can easily calculate here like say it is 20 percent, 5 percent, 10 percent, 25 percent and 40 percent. So, this is how it will be leading to the now the 100 like 20, 40, 60, 30, 90, and 10, 100, so this how it will be leading to the hundred for the percentage. So, now, we have got the percentage contribution of the different factors related the failure of a particular product.

So, now what we do basically, now we will be developing a chart, constructing a chart in x axis what we mention the category, this category is mentioned in the x axis and in y axis in one side we mention the frequency of occurrence of failure and maybe here we can mention the percentage contribution, percentage contribution in other side.

So, since our values are going like this 100, 200, 300, 400 and 500. So, the maximum frequency is for which factor is that is what we can see for the maintenance will be arranging these things in the descending order. So, the, the one category having the maximum frequency is for which factor is that is what we can see, for the maintenance will be arranging these things in the descending order.

So, the, the one category having the maximum frequency is the maintenance. So, the maintenance will be brought in first for maintenance the frequency is the is 400. So, this is for maintenance then the second category for which we have the service just 250.

So, next category is service will mention service and it is 250, like this is for maintenance this is for service, then third one is for design corresponding to the 200 this for design and this is 200. So, a kind of bar chart is made which will indicate what are the thing is really important and then we have other things like 150, 100, 100, 50.

So, now we have 100 for 100 is for manufacturing mfg, so what we can see here mfg and may be likewise there can be other factors also. So, if, if we have other factors then the it can put at the and like other factors or if it is identified like here it is material. So, material is again 50 and this is the chart, this is the bar chart the column for the material here we can mention here.

So, now if we see if we just club one and two, then it will be no there is one more thing which we can do is the percentage contribution coming from the different factors. So, the percentagewise the, the percentagewise the contribution is like this here we can mention like 10, 20 30 or we can go like this 20, 40, 60, 80, and 100.

So, the 40 percentage contribution is coming from our design sorry the maintenance then 25 percentage contribution above, 25 percentage contribution is coming from this service. So, 25 will be here and then 20 percent contribution is coming from the designs. So, 65 plus 80 that will be somewhere here for the design and then we have 100 for manufacturing. So, 85 plus 95 for manufacturing like this and then very limited one for the material. So, the curve will be going like this regarding the percentage contribution.

So, now we know that varies roughly this point 80 contribution is varies like this. So, we draw corresponding to the 80 percent we draw one line. So, there are two factors which are falling in this category one is the maintenance and another is service. So, maintenance contribution is 40 and a this one is having like say 25. So, it will be 2 total is 65 if we take in the 25 percentage contribution, may be our this point will also be coming which has the 20 percent contribution.

So, in that case our three points three factors will be falling in this category like 40 plus 25 plus, 20 this will be leading to the 80 percent. So, the in, so the three factors like maintenance, maintenance and service and design these are the three factors which are having the significant contribution towards the failure which is accounting to the 85 percent. So, what we have identified maintenance service and design are the major factors as compared to the material and the manufacturing.

So, we need to focus more on the, so what we will do since the percentage contribution of the maintenance is poor. So, we need to devise proper a strategy to see that the users are properly aware of the importance of the maintenance, and which can be in form of like proper maintenance procedure is to be established and awareness of the operators is increased so that they can follow proper procedures for the maintenance in order to avoid any kind of failure due to the poor maintenance.

So, one by one each factor is taken care of like first we will be taken care of the maintenance thereafter will be taking up the service then design. So, we are able to prioritise the various fundamental causes of the failure to see what are the things need to be focused first, and what are the other things need to be taken up subsequently for improved performance of the product and reduced possibility of the failure. So, here I will summarise this presentation, in this presentation basically I have talked about the

importance of the various industrial engineering tool in the failure analysis and in detail I have talked about the Pareto diagram

Thank you for your attention.