**Industrial Engineering**
**Prof. Pradeep Kumar**
**Department of Mechanical & Industrial Engineering**
**Indian Institute of Technology, Roorkee**

**Module - 02**
**Lecture - 03**
**Statistical Process Control Part-3**

Welcome viewers, today in the part 3 of the Statistical Process Control, we will discuss the 7 basic quality control tools. In the part of the statistical process control, we have discussed the different aspects, that is the variability aspects, concept of variability, concepts of statistical process control, concept of statistical quality control. And the introduction of the basic 7 quality control tools we had and also two of the tools that is the histograms and the run charts, we had discussed in detail in part 2 of the statistical process control.

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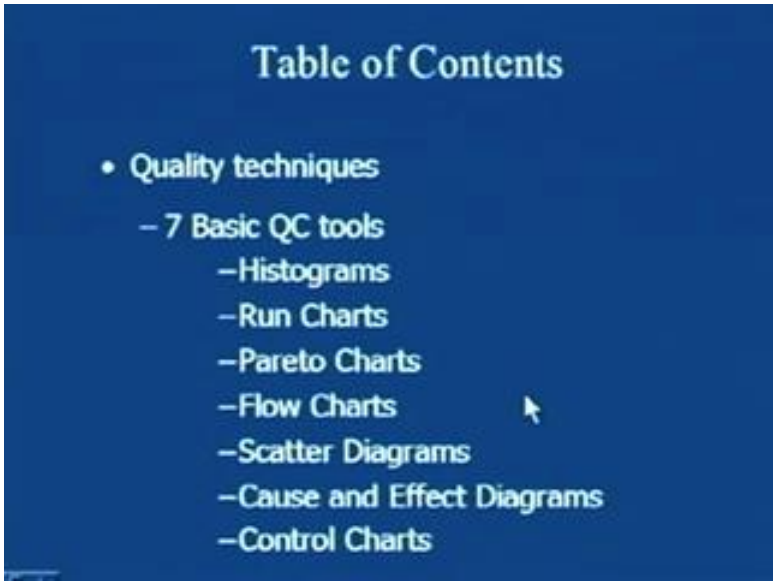


In part 3 that we are going to cover today that of statistical process control, we will cover the 7 tools, the rest of the 7 basic quality control tools, that is the Pareto charts, flow charts, scatter diagram, cause and effect diagrams and the control charts. The histogram and the run chart we have discussed the third tool in the 7 basic quality control is the Pareto chart.

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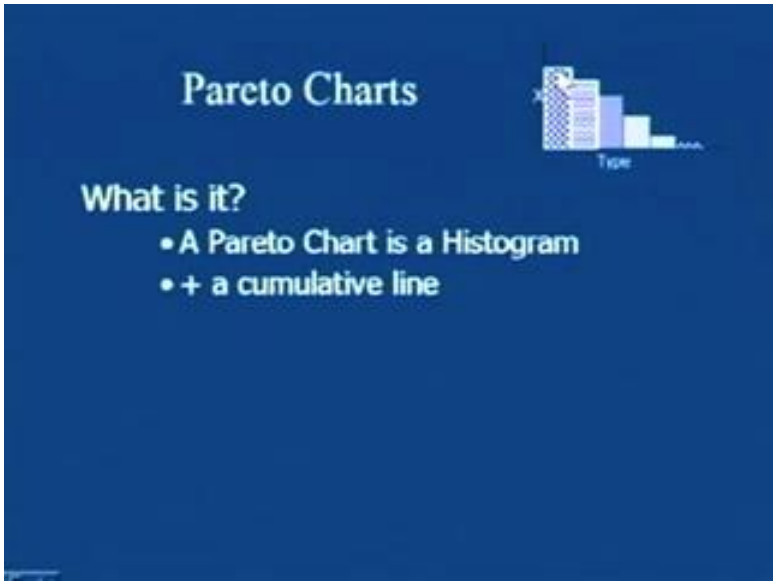


First question is what is it, it is a Pareto chart is a histogram, if you see the diagram here that it is simply a histogram, but the bars in the histograms are basically with respect to the category. But, in Pareto chart these bars are arranged in the decreasing order of the frequency of the value plus a cumulative line. Apart from the histogram arranged in a descending order, the categories arranged in a descending order will draw a cumulative line in percentage starting from at the top of the first bar. And we keep on adding all these values and it goes to the 100 percent value, that we will see in the next slides.

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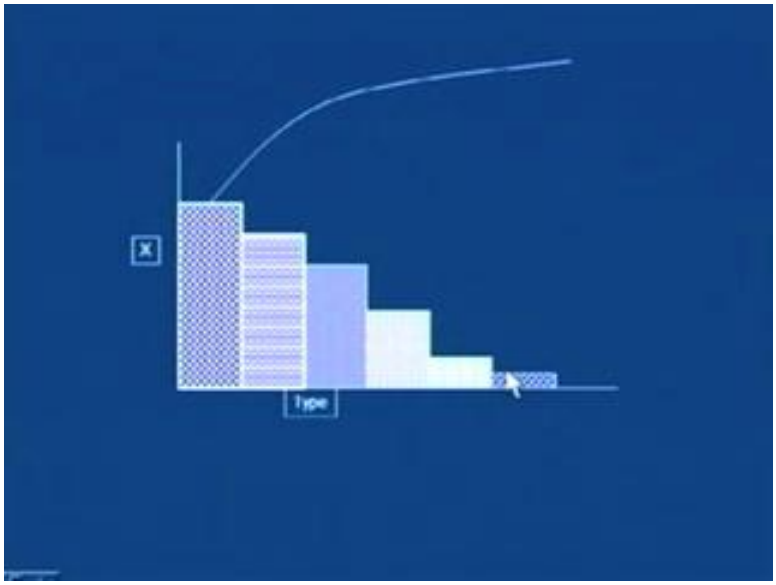

This is how the cumulative line looks like, these are the different bars, and these bars are arranged in the decreasing order of the categories and this is a cumulative line the percentage of the total, means this point has the percentage of the total. Then further the percentage of the total of this bar is added up, percentage of the total of this bar is added up and it total makes the 100 percent, so this complete diagram is called Pareto diagram.

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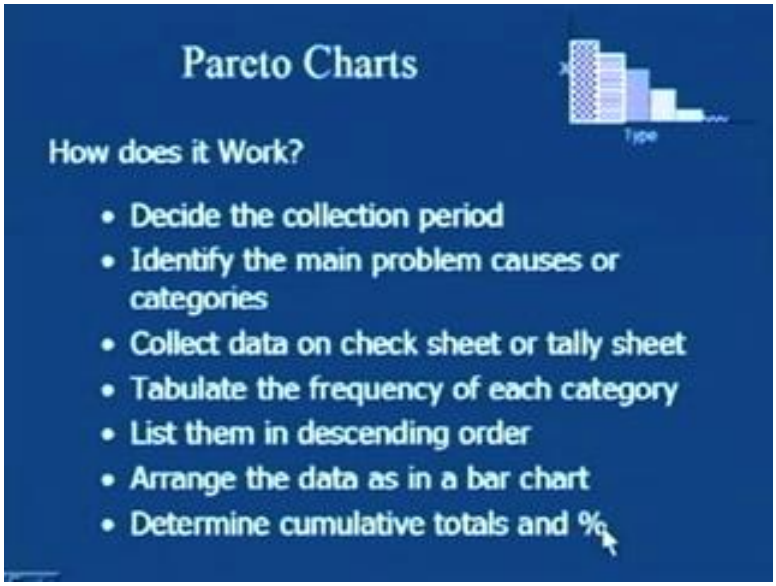


How does it work, first decide the collection period, identify the main problem causes or categories, so once you know that up to which period you need to may be if last 1 year data you want to collect may be last 1 month data, you want to collect or may be the weekly data you want to collect. Then identify the main problem causes or the categories, means if suppose we collect the last 1 year data we can find out that in last 1 year, but for the type of defects occur in a particular product that we are manufacturing.

Maybe that defect maybe the porosity in the castings that we are making, maybe the surface finish type of defect, maybe some crack or some hot tears type of defect. So, whatever happened in the last 1 year in the manufacturing process production that we count the total different type of defects and there frequency of occurrence of these defects. Then we collect data on check sheet or the tally sheet, so data collection sheet we prepare and we tabulate the frequency of each category.

All the categories we list in the descending order, we arrange the data as in the bar chart as earlier I mentioned as in the histogram, determine cumulative totals and percentage.

So, after determining the cumulative totals and the percentage, we can find out the various values and we can plot the cumulative curve over the Pareto chart.

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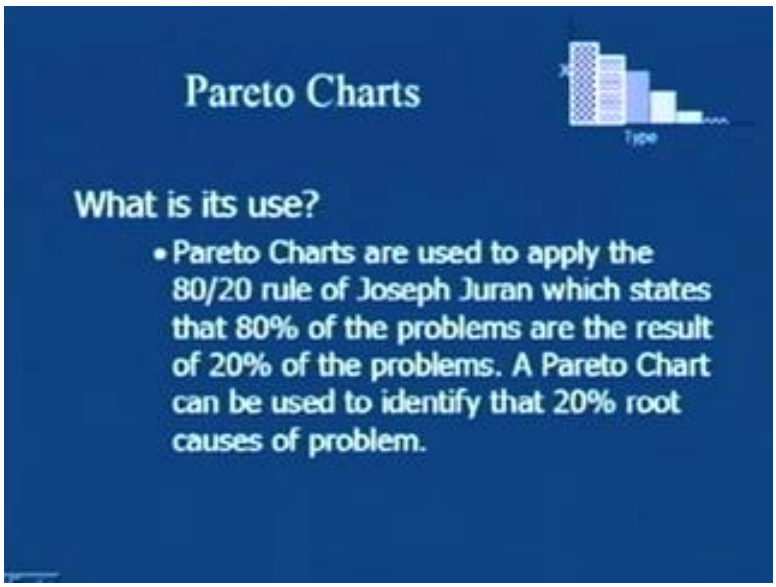


What is its use, Pareto charts are used to apply the 80 20 rules of Joseph Juran which states that 80 percent of the problems are the results of 20 percent of the problems, a Pareto charts can be used to identify that 20 percent root causes of the problems. Basically this 80 20 rule this observation was initially taken was observed by an Italian economist, he observed that 80 percent of the worlds wealth is in the hand of the 20 percent of the people.

So, when he made this observation and this Pareto chart or Pareto rule basically this is against his name he is Vilfredo Pareto, so initially this Pareto rule was framed for the business problem, for the business cases that whatever the observation the Italian economist had. Later on the Joseph Juran focused or observed that this 80 20 rule is also applicable to the quality control related problems and he mentioned that 80 percent of the problems in the area of the quality and quality related things are the result of the 20 percent of the root causes.

A Pareto chart can be used to identify those 20 percent root causes, because these are the 20 percent root causes are the vital causes and 80 percent of the root causes or retrieval causes. So, Joseph Juran is a first person who observed that these this 80 20 rule can equally be applied to the quality control problems and as a part of Joseph Juran

observation, he mentioned that 80 percent of the problem in the quality related situation is because of the common causes.

And he later mentioned that 80 percent, because common causes problems that is basically improvement in the process is not possible without the intervention of the management. So, he mentioned that 80 percent of the quality control problem can be solved by the management and 20 percent of the problems that is happening, because of the special reasons or the assignable reasons. And those 20 percent of the problems can be solved means, that is meant to control the process can be solved within the work line or within the production line.

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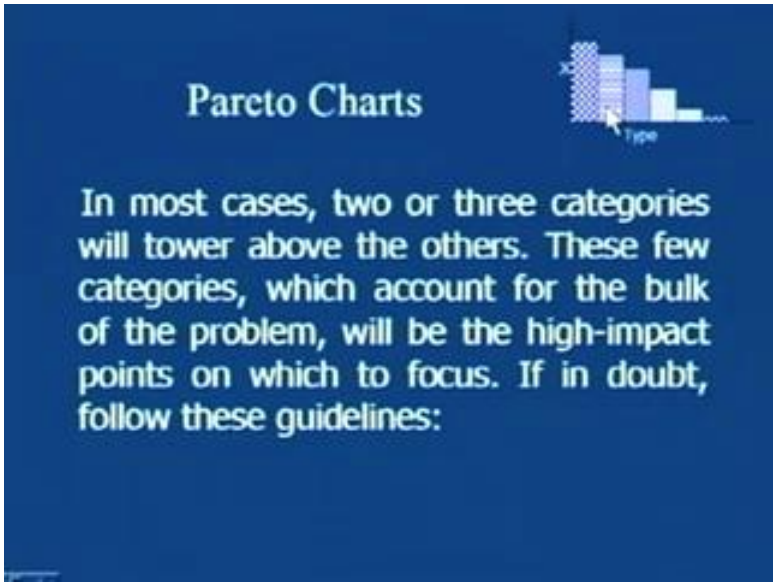


So, when we draw the histogram initially in the descending order and we draw a cumulative line, so the cumulative line plus histogram becomes the Pareto chart, then we need to identify that which are the categories, that are the vital categories. And as per the rule 80 20 rule maybe it happens that, maybe the two categories only that amount to the 80 percent of the problems, maybe the three categories may amount for the 80 percent of the problem and rest of the categories maybe come in just 20 percent.

So, the sometime it becomes difficult to identify that because all the charts or all the bars are equal in size, it becomes difficult way to draw a line that which are the vital categories and which are the trivial categories. So, some suggestions have been given in the slides, the first is the in most cases two or three categories will tower above the

others. These few categories which account for the bulk of the problem will be the high impact points on which we need to focus.

Means when only two or three categories amounts approximately to 80 percent, that is basically the important vital parameter or vital categories. So, instead of struggling and trying to find out the reasons for the trivial category it is always advisable that whenever you deal with the improvement of the process or removal of the defects or removal of the causes of the defects. We need or we should always prepare the Pareto chart and we should see that which are the problems that are the most vital one. And these few categories which account for the bulk of the problem will be the high impact points on which we need to focus, if in doubt follow the guidelines.

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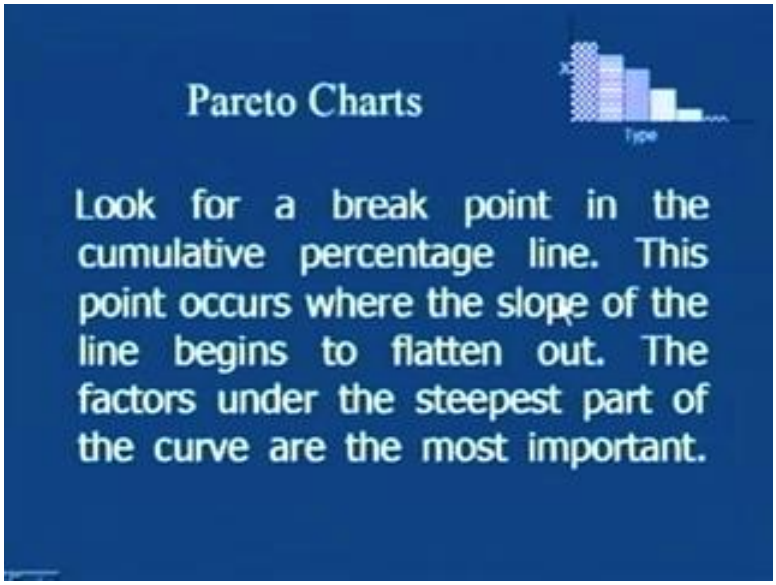


The guidelines are look for a break point in the cumulative percentage line, this point occurs where the slope of the line begins to flatten out, the factors under the steepest part of the curve are the most important. So, this is one way that when I mentioned, that when bars are almost of equal size some it becomes difficult that which categories are the vital and which are not, so we can follow this suggestion.

We have the cumulative line, where the cumulative line is flattening out whatever is before that point that basically means the factors under the steepest part, means whatever the point categories are lying before the point where from the cumulative curve is flattening out that categories are the most important category. So, we should put our most effort only on those categories and once we will put our most effort in the vital

categories we will get the tremendous improvement in the process, instead of just struggling on the trivial activities, this is one suggestion.

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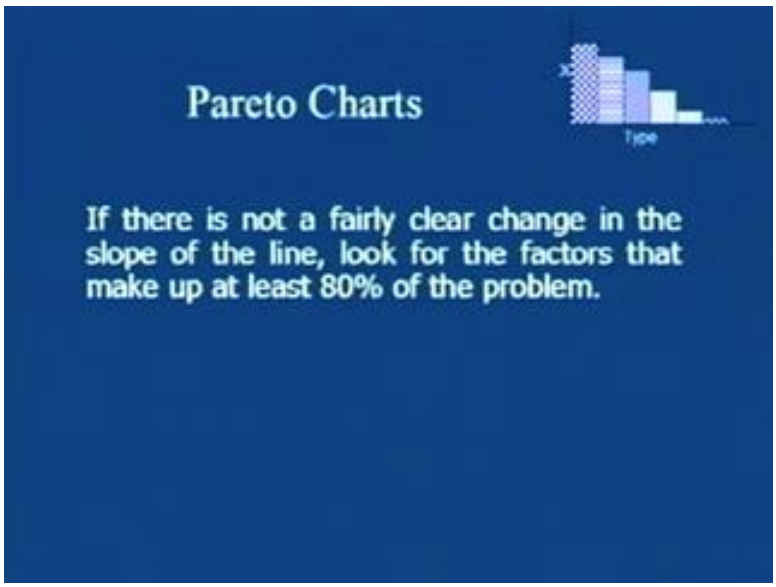


Second suggestion is if there is not fairly clear change, in this slope of the line look for the factors that make up at least 80 percent of the problem, sometime the cumulative curve is not flattening out then it is easy, it is better that you just see where the 80 percent is there draw a vertical line. Suppose, 80 percent is coming over here, draw a vertical line over here and whatever the categories are coming on the left side of this thing that we consider those category as the vital category.

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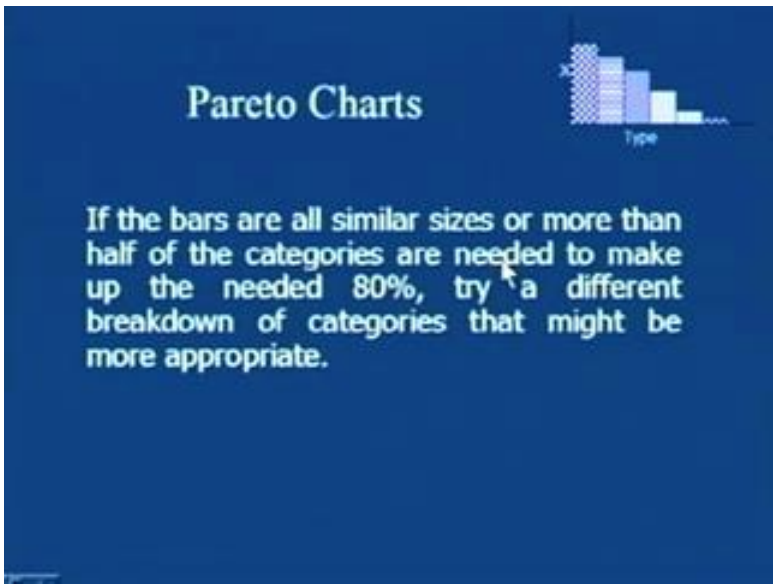

Third suggestion is if the bars all similar size or more than half of the categories and not only the bars are of similar size or most, suppose 50 percent of the categories are needed to make up the needed 80 percent, means there is something wrong, try a different breakdown of categories that might be more appropriate. So, if anytime we find that 50 percent of the categories are lying in the 80 percent of the area, this means something wrong in defining the problem or something wrong in categorization of the problem. So, we need to check it again, we need to breakdown the categories in further smaller few by way or in different way.

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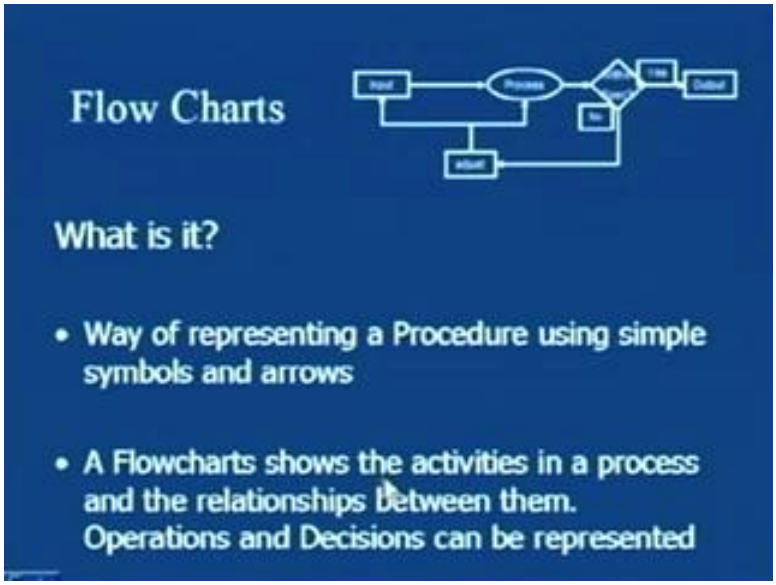


The next tool is the flow chart, it is a way of representing a procedure using simple symbols and arrows, this is just representation of the flow chart, we will talk about this flow chart in detail in the next slides. This is some input and output and in between input and output various operations and task have been listed out, so it is a flow chart shows that the activities in a process and the relationship between them; operations and decision can also be represented in the flow chart.

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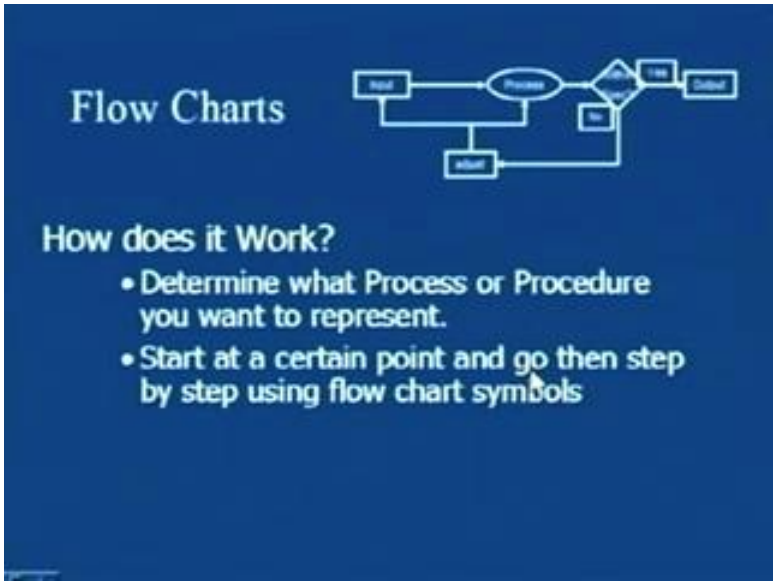


How does it work, determine what process or procedure you want to represent, so first should know that which process you are going to represent as a flow chart or which procedure you want to represent as a flow chart. Start at a certain point and go, then step by step using flow chart symbol, means you should know that what should be the first point, you should also know what should be the last point.

And whatever is happening in between the start and the last point, you keep exploring how the process moves from one step to the another and till it reaches to the output, means the final point or the stop point, documents the elements with titles let it close with an ending point.

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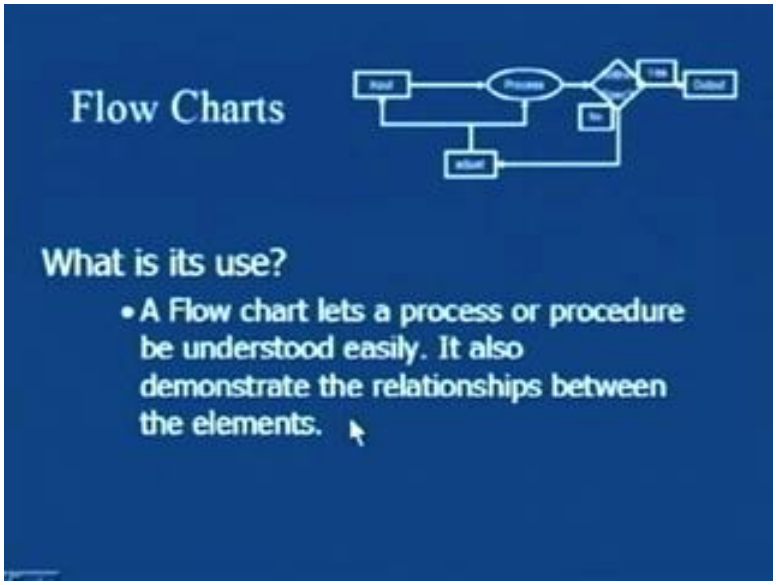


What is its use, a flow chart lets the process or procedure be understood easily, so this is a basically diagram that helps us to understand the step by step procedure of the system. It also demonstrates the relationship between the elements, also it helps in just knowing that what are the alternate route to reach to the final solution.

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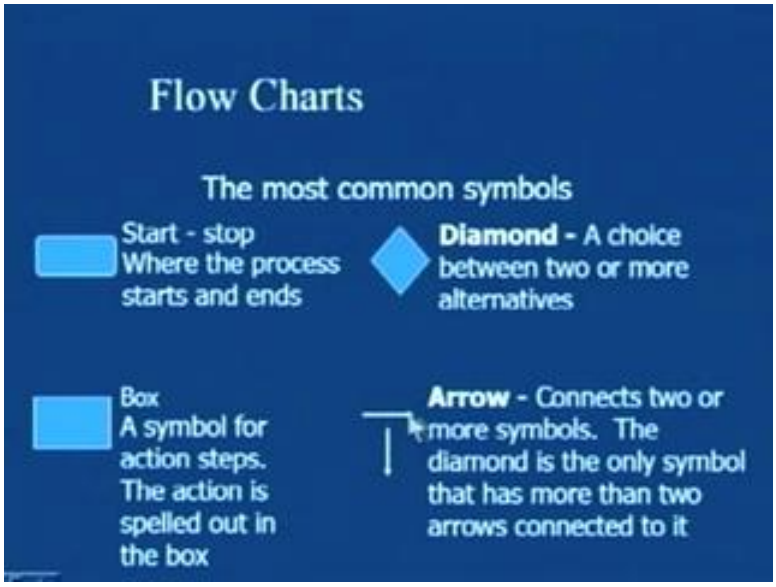


The symbols that we use in the flow charts are**,** this is the start symbol that the same symbol we use for the stop where the process starts and ends. The rectangle this is a box, a symbol for action steps means wherever some operation is going on or some inspection is going on that any activity is going on we use this symbol. This action is spelled out in

the box, we write say for example, if the box is there we write operation one, inspection one, movement of the material or fixing of the tool, fix clamping the dye, fixing the jigs and fixture etcetera.

The third symbol that is the diamond, this basically helps us to provide a choice between two more or alternatives, means if something is coming in it basically is decision symbol that we check it with the situation, if it is right it goes in one direction, if it is wrong it goes in another direction. Fourth is the arrows, arrows can be horizontal, vertical depending on the situation, arrows connect two or more symbols; the diamond is the only symbol that has more than two arrows connected to it, otherwise all the symbols have one incoming arrow and one outgoing arrow.

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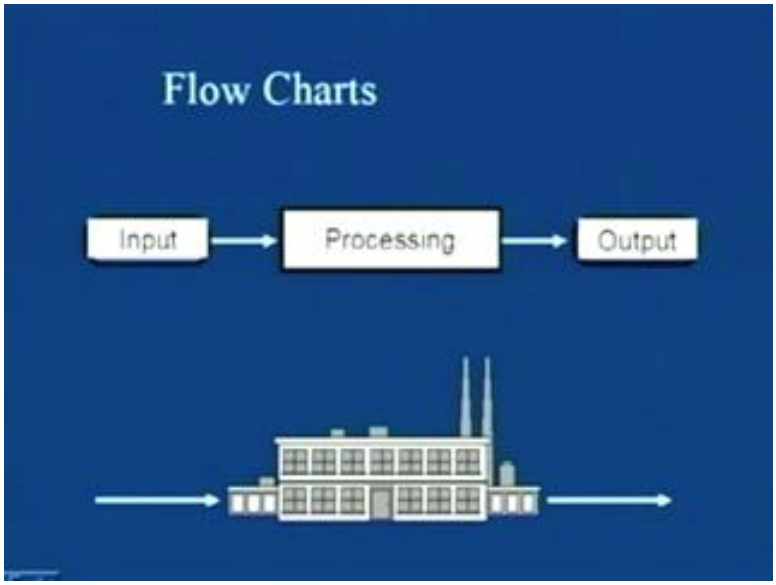


If you see this diagram, this is a block diagram of industry that something is input, some output is coming out in between the processing is going on and this is pictorial represented by the some industry figure something in, something out. So, this is when we draw the flow chart we should know the entire processing input means the raw material, what are the different type of raw material, then we should know what is our finish product.

Once we know that these the input and this is the output, then we start exploring that if you are having five type of raw material, what is happening to first type of raw material when it enters into the industry. What is happening to the second type raw material, what is happening to the third type of assembly, if you are having the assembly as an input, so

whatever the raw material or the assembly or the components you are having as an input and that is the first step.

Then we will go one more level down, then we see what is happening to this raw materials or the components or to the assembly. So, then we go further one more level down and we keep exploring are we keep exploding the situation and we try to connect that this is how the material enter and these are the seven or ten operations that happen on, that was done on this raw material. And finally, this particular component is being assembled, this is how inspected various inspection stages, various operation, various material handling all those things basically we list down and finally, we conclude that this is our final output.

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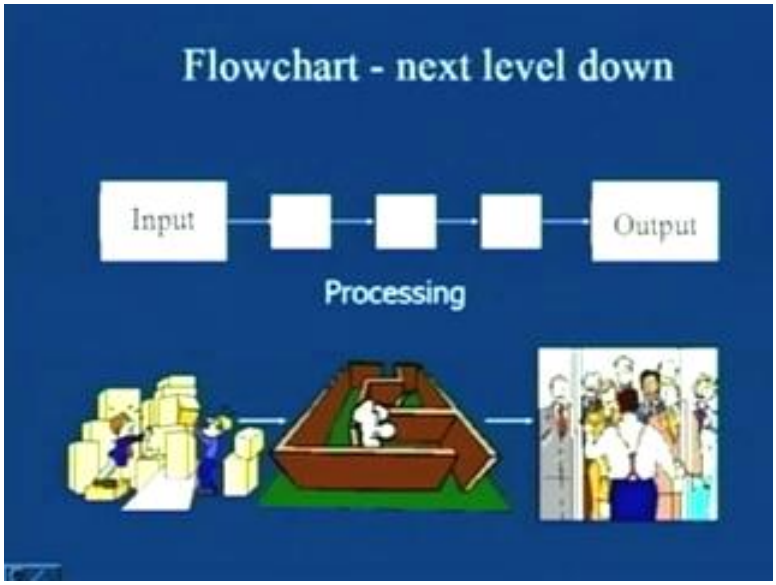


Then once this is first level is drawn you go for the next level, that input output is the same only the processing various that I earlier mentioned, that something is there something output here some processing is going on.

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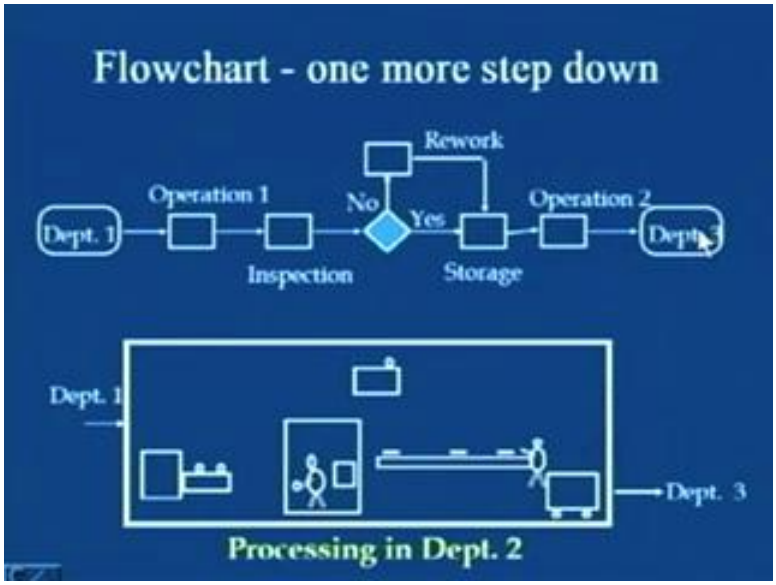


One more further level we can go down, suppose that this is a department 1 and department 3, so what is happening between the department 1 and department 3, how the material moves, operations, inspection. Something whether whatever the inspection, whether the operation one is right and wrong, depending if it is right we go for the storage, if it is no we go for the reworking of the operation and finally, it leads to the storage. Then we go the next operation and then it reaches to the department 3, this is how step by step we keep exploding the situation, we keep exploding the moment of the raw material from the starting point till the finishing point.

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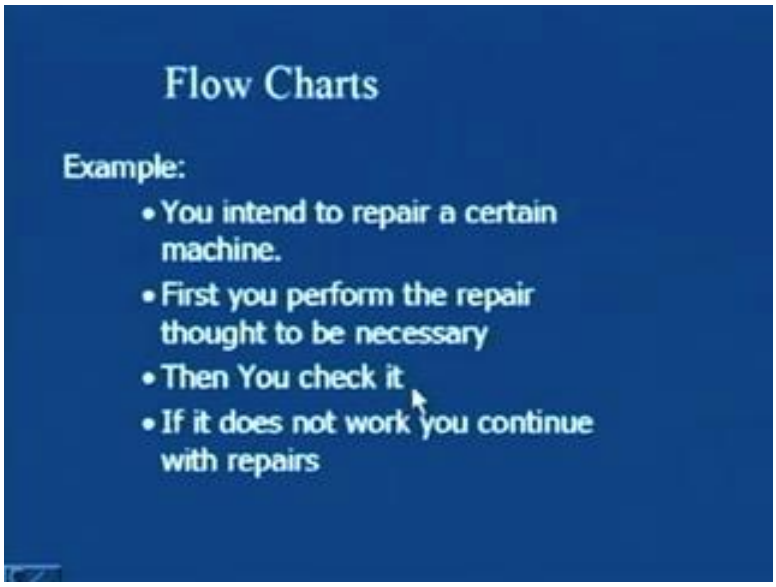

This is just a very simple example, that the first step of this example is that you intend to repair a certain machine, first you will perform the repair thought to be necessary that you consider that, in order to repair a particular machine a certain repair you will think that is necessary. Once repair is over, then we need to inspect it whether the repair has been done right or wrong, so after checking it if it does not work what we do, you continue with the repairs if it works we finish, this is the total step by step procedure.

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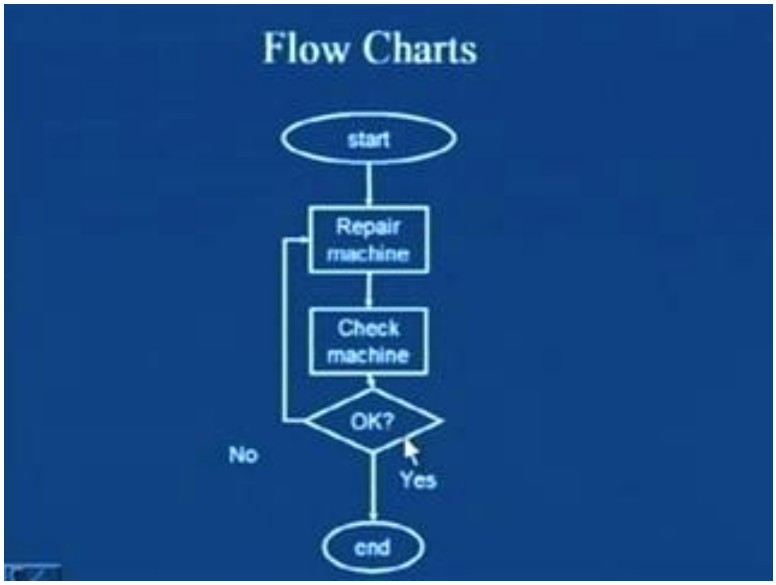


And this is how we depict this procedure in the flow chart, start this is a the start symbol, then repair machine this is some operation is going on then checking machine, so we check the machine. Then we take the decision if the machine whatever the repair we have done machine working fine, if yes we stop it if not then we go back and we continue to the repair. So, this is how basically a very simple procedure we have depicted and once the flow chart is ready it becomes very easy to understand the process.

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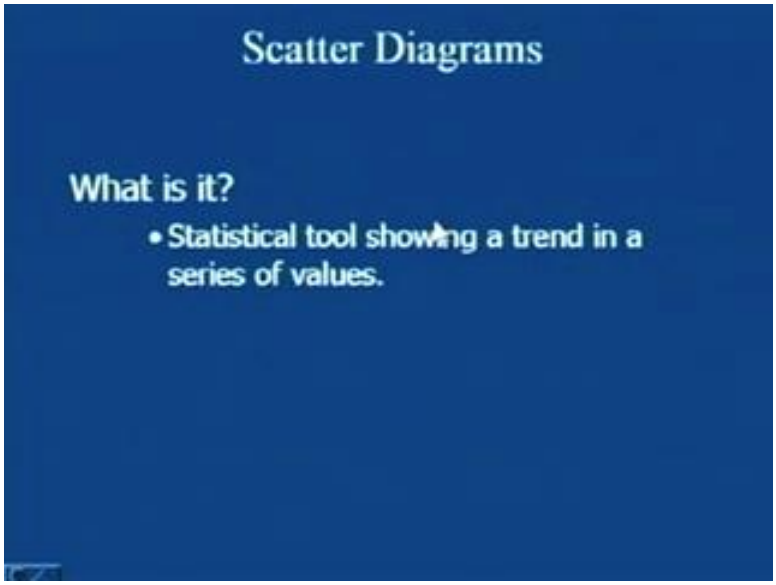


The next tool that is the scatter diagram, the scatter diagram is a statistical tool showing a trend in a series of values, means if you are having x value we need to find out what is the dependent value that is the y. Means how y is dependent on x whether there is some relationship between x and y or not, so we explore all those relationship through the scatter diagram. And once the data have been plotted, we try to find out whether this relationship that we are developing is significant enough to represent the behavior or to predict the behavior of the parameter x and y.

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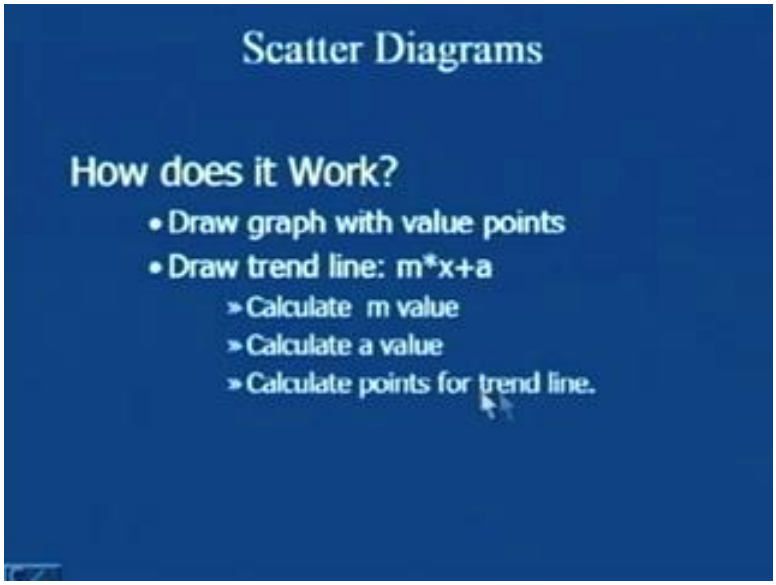

How does it work, draw graphs with value points we have the data point between x and y, so different values of x are there, different values of y's are there, we draw all the points on a simple graph. Then we draw the trend line, so depending upon the situation here in this example we are just showing the trend line as a straight line that is m x plus a. But, depending upon the system or depending upon the process it may vary that we may go for the fitting the line or we go for the drawing of the line as a second order line or third order line. Then just assuming that we are drawing a straight line calculate, because m is a coefficient, so we calculate the m value, we calculate the constant value, so once we calculate these two value we can draw a straight line and calculate points for the trend line.

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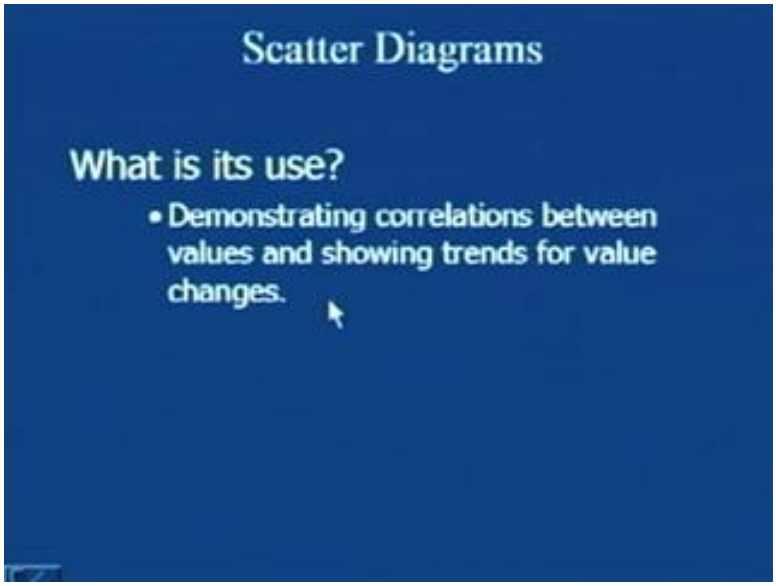


What is its use, it demonstrates correlation between values and showing trends for value change, so once you have the data you have plotted the data, you have drawn the trend line. So, once the trend line is there you can make many conclusions out of that trend line that how the data is correlated, one point I already mentioned whether the trend line is showing the relationship between x and y significantly.

Means we need to find out the correlation factor, whether the x and y are correlated means the r square value, so we calculate r square value one thing. Second is the scatter of the data, the third is we also know whether there is a positive correlation or the negative correlation. Positive correlation means if we increase x, y is increasing, if we negative correlation means if we increase x y is decreasing.

So, these information regarding the correlation coefficient, regarding the revision of the data point from the trend line and regarding the positive and negative correlation, we can find out through the scatter diagram.

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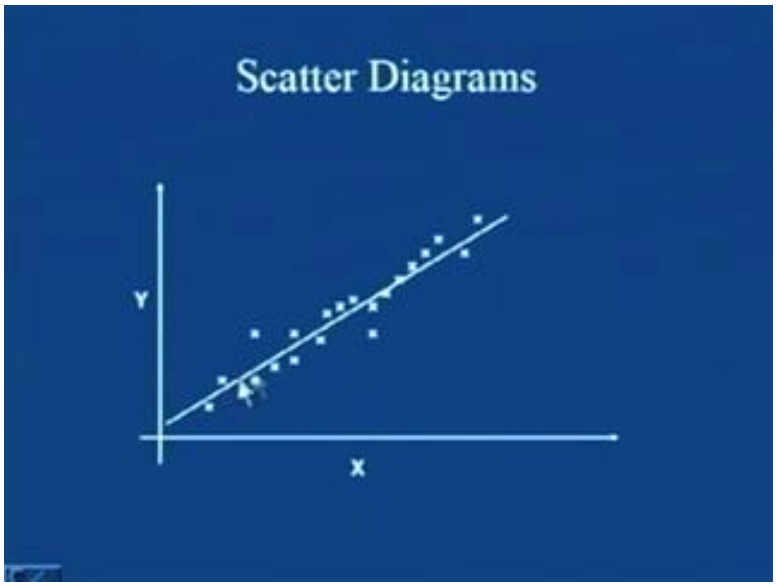


This is just a typical scatter diagram, we have on the x axis the x values, on the y axis we have the y value and all these are the data point and we try to fit these data point in a straight line. So, this straight line basically if we see this, this is the positive relationship that if we increase x, y is increasing.

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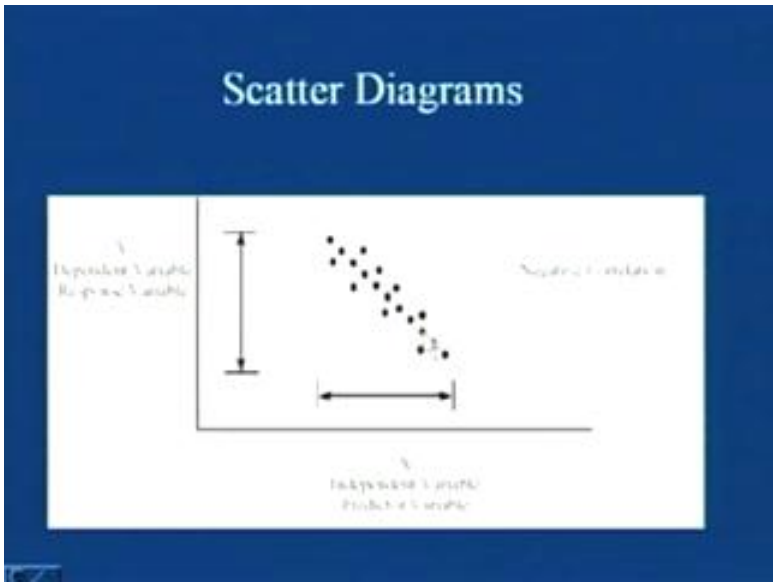

If you see this graph that these are the points and if you draw a line the trend line it will come like this and this shows the negative relationship, that if you increase x the dependent value is decreasing or the y value is decreasing.

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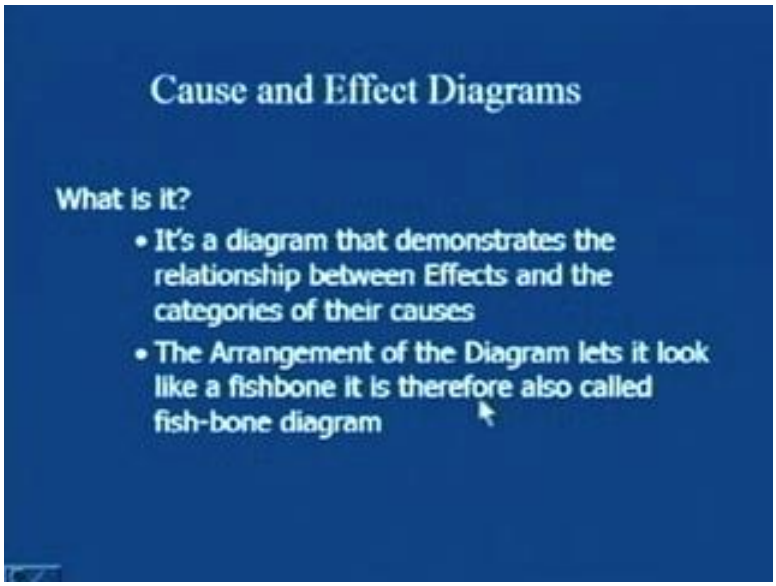


Another tool in the seven tools category is the cause and effect diagrams, it is a diagram that demonstrates the relationship between effects and the categories of the their causes. This is very useful tool that whenever we try to find out the possible causes of the problem, we should always draw the cause and effect diagram, it helps us to reveal the different aspects or different causes, at different level what are the causes that affects the problem.

The arrangement of the diagram, let us it look like fish bone, it is therefore also called fish bone diagram I will show that how it looks like. So, the structure of the diagram is like a fish bone, it is because of this reason it is also called the fish bone diagram, this also known as the Ishikawa diagram.

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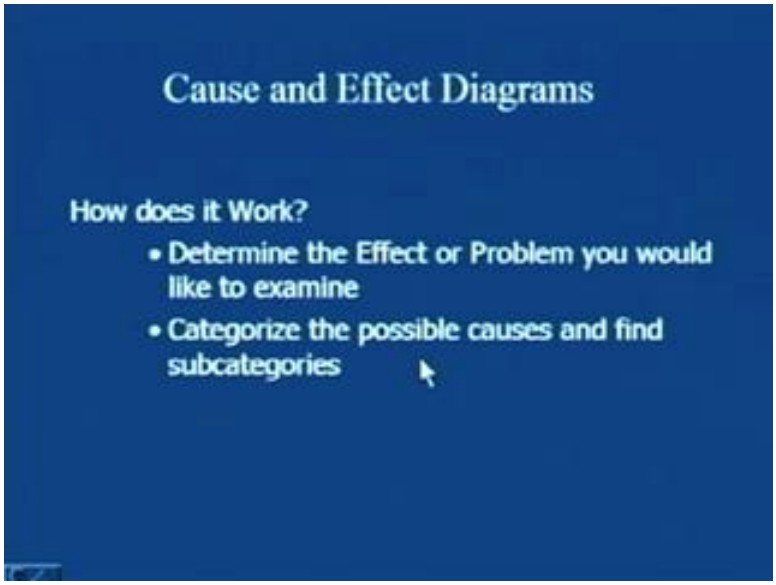


How does it work, determine the effect or problem you would like to examine, this is the first step that we should determine the effect, means suppose we say that we want to improve the quality of the product or quality of the turning operation this is the effect. Or maybe some other service example we can say that, suppose we are interested that we should improve the quality of the food in a particular hotel, so that is the effect or that is the problem.

So, first identify what is the effect of the problem, second categorize the possible causes find subcategories, means once the effect is ready and what is the effect we are going to analyze, then you should know the broad categories, that what are the possible causes that are that are affecting the problem. Possible causes maybe related with the man, maybe related with the machines, maybe related with the material, maybe related with the methods, like the example I have given you with respect to the hotel.

When we are talking about the improvement of the quality of the food, there are many things, maybe that operator, maybe the cook, he is not educated enough and he does not know much about that latest recipes. Maybe the material, maybe the spices that you are using is not right, maybe the funding or the investment that you are putting in to improve the quality that maybe the constituent.

So, we need to identify the major categories, and then we need to find out the subcategories, so once the subcategories of the main categories are there, then we find

out the further subcategories till we find the root cause of the problem. So, categorize the possible causes and find the subcategories, describe the possible causes.

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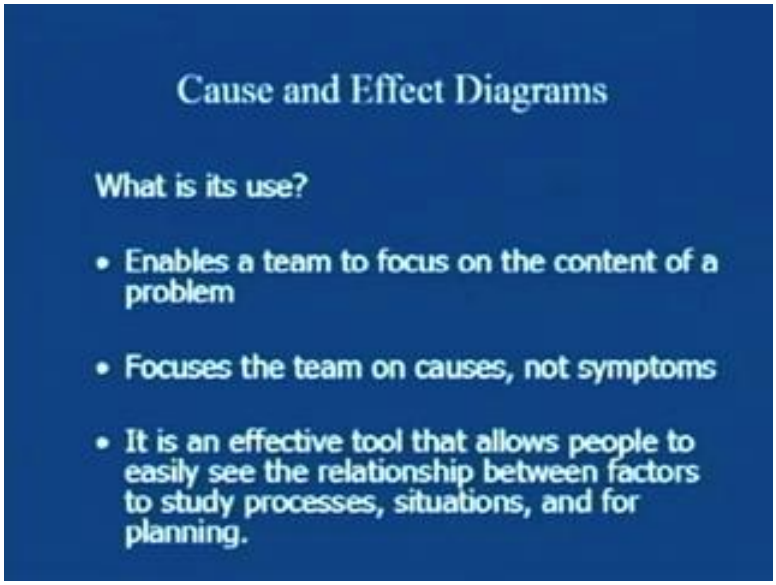


What is its use, it enables a team to focus on the content of the problem, this is not something like that a person sitting in his room and he understands there is something, some problem is going on in the turning section. And he tries to improve that, I will just find out what is the effect and what are the possible causes, why this quality of the turning is not coming right or not coming as per this expectation of the customer or expectation of the designer.

So, this is not a one man show, so what normally is the right procedure is there that a manager usually calls the persons who are basically engaged in various operations related with that section. So, once the persons are related with the various operations he calls a meeting and give them the idea that we are interested to understand, what are the root causes, what are the various causes of that are causing this particular problem.

So then they conduct brainstorming session, every person initially when they are conducting the brainstorming they should, specially the part of rule they should be agreeing to what is the final effect they are going to discuss. Once everybody understand that this is the effect that they are going to discuss and they are going to find out the causes, then every person basically gives an idea, that maybe one idea or two idea and they keep on telling that this maybe the problem, this maybe the problem.

Then once all the ideas of the causes have been just highlighted, then these ideas and causes are basically categorized into the main categories. So, once this ideas have highlighted into the main categories, then basically the first primary reasons of the problem or primary reasons of the effect have been identified. This is how the step by step we do and the benefit is that it enables a team to focus on the content of the problem, it focuses the team on causes not the symptoms that I all ready mentioned you.

It is an effective tool that allows people to easily see the relationship between factors to study processes, factors to the various situations and factors for the planning. So, it is not only, that it is the tool that we are going to, that gives the relationship between causes and effect, even this basically may help the organization for the planning purpose. Maybe if sometime we can go for the forecasting, what are the possible future scenario, what will be the possible future marketing scenario or the advertisement strategy. So, all those things different applications gives the different usage of this tool and this is the very important and very useful tool in the manufacturing organization or the service organization.

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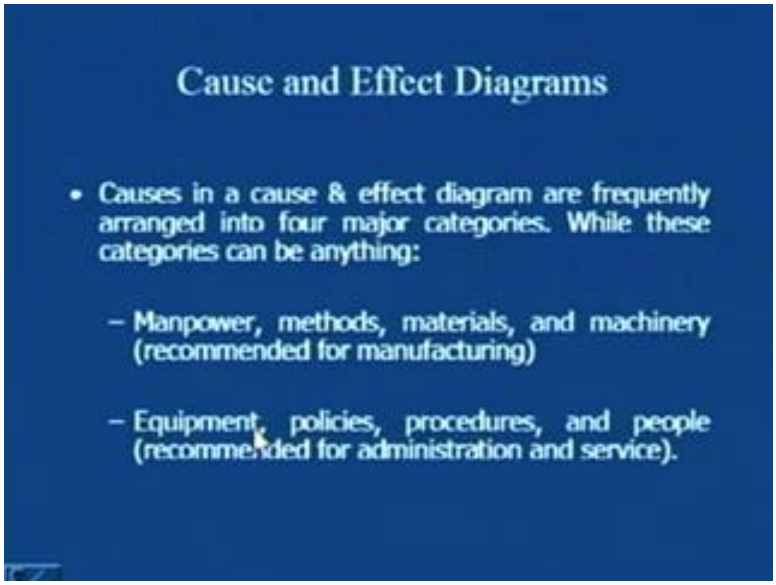


Causes in a cause and effect diagram are frequently arranged into four major category, although there is no hard fast rule, that normally the primary causes we arrange in four major categories while these categories can be anything. Just a guideline that when we talk about the manufacturing, the primary causes, the major causes we divide into the

four that is manpower, methods, materials and machinery; these are the four primary causes or primary reasons that we need to highlight.

And when we are talking about the administration and service type of a situation or when we are developing the cause and effect diagram for the administration and service type of a situation, the four factors, the primary four factors are equipment, policies, procedures and the people. So, this is the how the broad classification of the factors are there, still again I would like to repeat that these are not the mandatory, we can further divide it, because sometime the if we just have only four categories the cause and effect diagram becomes very clumsy. So, then it is better to further divide the categories of that the simplicity of the cause and the effect diagram is maintained.

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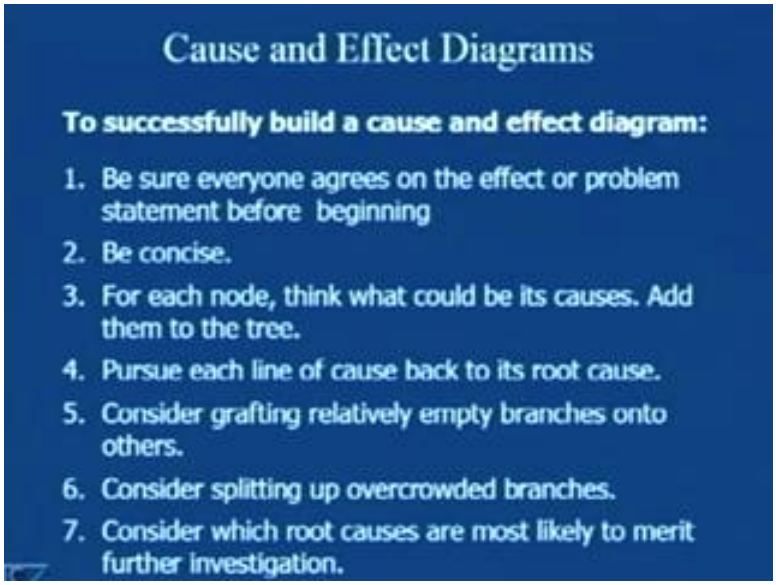


To successfully build a cause and effect diagram, actually in this from this point onward I will tell you the step by step procedure how to prepare the cause and effect diagram. First point is be sure everyone agrees on the effect or the problem statement before beginning that I all ready mentioned, that everybody before highlighting or before going for the brainstorming they should understand that they are going to discuss about this particular problem or about the effect of this particular problem.

And second is be concise, third point is for each node think what could be it is causes, means once you have identified say, for example you identified the men is a primary reason. Then find out what are the other reasons, that maybe the education, maybe the

training, maybe the skills, maybe the motivational aspects all these factors are not there, because of that the problem is there.

So, before each node means, for each limb think what could be it is causes and add them to the tree means the second stage, pursue each line of cause back to its root cause. Consider grafting relatively empty branches onto others, if some branches are just one or two causes are there, try to club those branches unnecessary increasing the branches will not give you much benefit. Consider splitting up overcrowded branches that I all ready mentioned sometime it becomes very clumsy.

So, in such cases instead of having just fixing of only four categories, we can increase the categories and we can split up the overcrowded branches also. Consider which root causes are most likely to merit further investigation, so once the cause and effect diagram is ready we know that there are six or seven main categories are there, then this will reveal the entire situation of the manufacturing organization. So, once the entire situation is in front of you, then the next question arises that in which limb that you should consider first.

Sometime what happens that like the example that I have given you the quality of the food, maybe we are struggling unnecessary with the cook, so whatever the even if you provide them training, they are not ready to learn it whatever they know it they know it. Maybe we instead of wasting time on that, we see that if you look for the other activities we can improve those activities, this is one way to look at another way to look at is that we should do suppose there are seven main categories that we should do the Pareto analysis. So, by doing the Pareto analysis we know that what are the vital limbs or vital categories and we should consider, we should put our effort on those vital categories.

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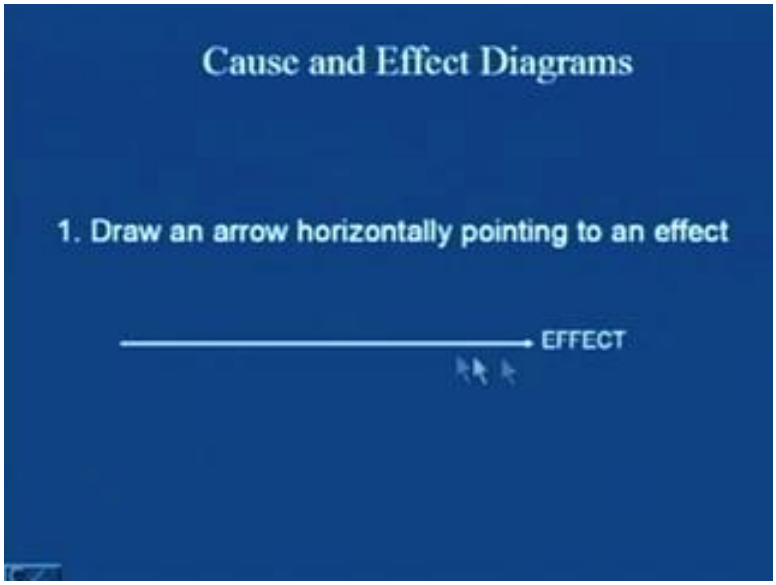


Now, I will I will tell you how to draw the cause and effect diagram, draw an arrow horizontally pointing to an effect, write the effect first and draw a horizontal arrow that is pointing towards this effect. So, as I earlier mentioned to you that first you need to identify the effect and the effect maybe the quality of the product that we are manufacturing, quality of the component, quality of the assembly or quality of the performance of the product whatever it is, first you identify it then write the effect here and draw a horizontal line.

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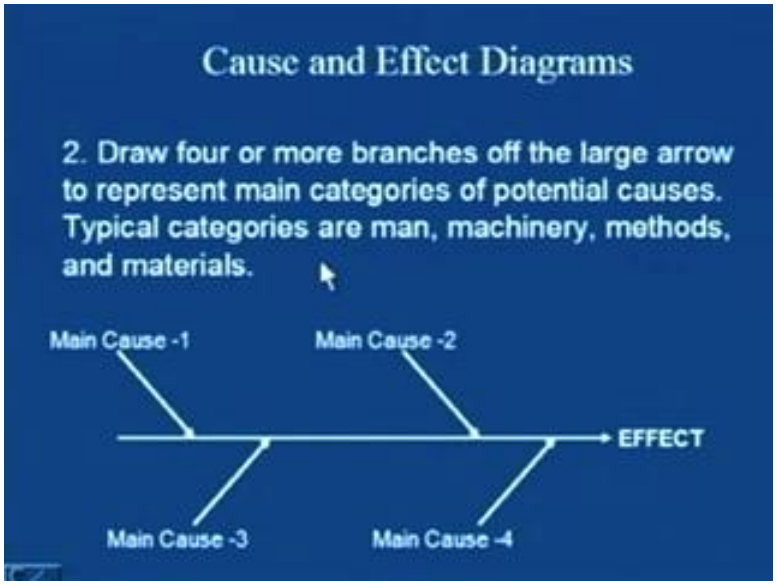

The second step is draw four or more branches of the large arrow to represent main categories of potential causes, typical categories are man, machinery, methods and materials that I mentioned earlier also. So, this is the first line that we have drawn we have written the effect, we have drawn the horizontal line, then we divide say for example, we divide into the four categories, the category one that is the main cause 1, main cause 2, main cause 3 and main cause 4.

Some people say the primary category 1, 2 and 3 and 4 or the major categories as I mentioned that if in the manufacturing, we say that the first category is the man, this is the machinery, this is the method, this is the material. So, in different way we can categorize the branches and that is coming of from the main branch, this is the second step in drawing the cause and effect diagram.

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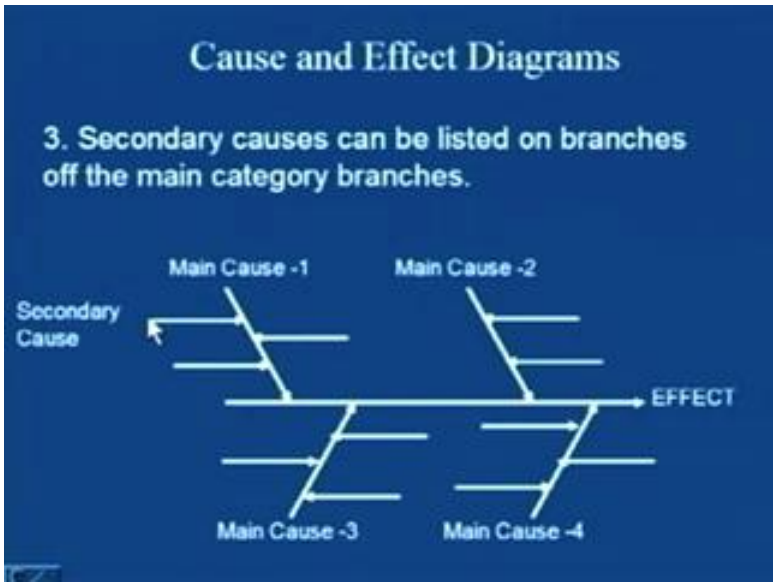


The third step the second causes can be listed on braches of the main category braches, these are the primary causes or the main causes, so once we know main causes then we need to graft, the secondary reasons in each of the main causes. So, if this is the primary reason as I given the example of the cooks for maintaining the quality of the food, then the secondary reason maybe the education or the training.

So, we take first cause or first primary reason and then we go for the again discussion go for the again brainstorming sessions, then considering this main cause as an effect, then we try to find out the reasons. So, just we focus on this portion of the cause and effect diagram and the primary reason maybe the man is say for example, we consider as an

effect, then we will discuss go for the brainstorming sessions to identify the secondary reasons.

So, once the secondary causes are there, we just graph this secondary causes as an horizontal line, secondary cause 1, secondary cause 2, secondary cause 3 and these three secondary causes are related with the main cause 2. Likewise you find out the secondary causes for the main cause 2, secondary causes for main cause 3 and secondary causes for main cause 4, this is the third step.

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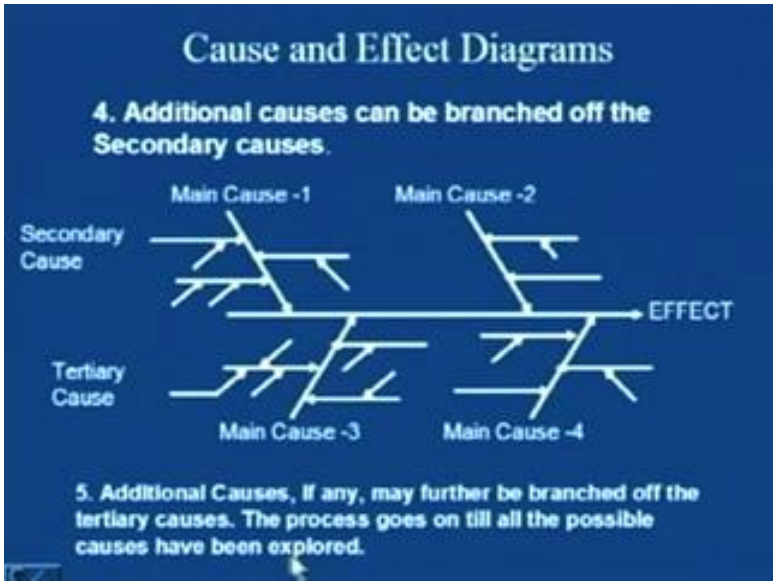


The next step is that additional causes can be branched off the secondary causes, means once the secondary causes have been identified we can further go for the classification of the tertiary causes. So, once we know the secondary cause a particular secondary cause, that particular secondary cause will becomes the effect, then we say that in order to achieve this effect or to achieve this particular effect what are possible causes we graft those causes in the secondary cause.

Secondary cause is the horizontal and the tertiary causes basically we add it here, so like that we add the tertiary reasons in all the secondary causes, wherever it is possible in all the main cause 2, main cause 3 and main cause 3 this is the tertiary causes, so like this. So, we keep on adding the causes, once tertiary causes have been identified, then we consider this as an effect we try to find out the fourth level, the fourth level causes again we try to graft on the third level branch that is the tertiary cause.

So, once fourth level is there if some branches are having the fifth level we keep on adding all this things, we keep on doing till all the possible causes in all the major limbs have been explored and that will give the complete picture of the cause and effect diagram. So, once this cause and all the effect, all the causes have been identified, then the next step simply drawing as far as the drawing of the cause and effect diagram is concerned that is over.

But, when to investigate it further, we need to consider that which cause whether we should attack the first cause first or the second cause first or the fourth cause first. So, we need to go for the Pareto analysis with respect to all the main causes and once we say that this particular cause is going is a vital cause, we first try to improve that, because that will give you the a leap improvement in the process.

As this all ready I mentioned additional causes if any may further be branched of the tertiary causes, the process goes on till all the possible causes have been explored. So, after exploring and drawing all the causes, we go the Pareto analysis and we say that which are the vital causes and which are the trivial causes. So, vital causes we need to investigate further first, the last tool in the 7 quality control tool category is the control chart.

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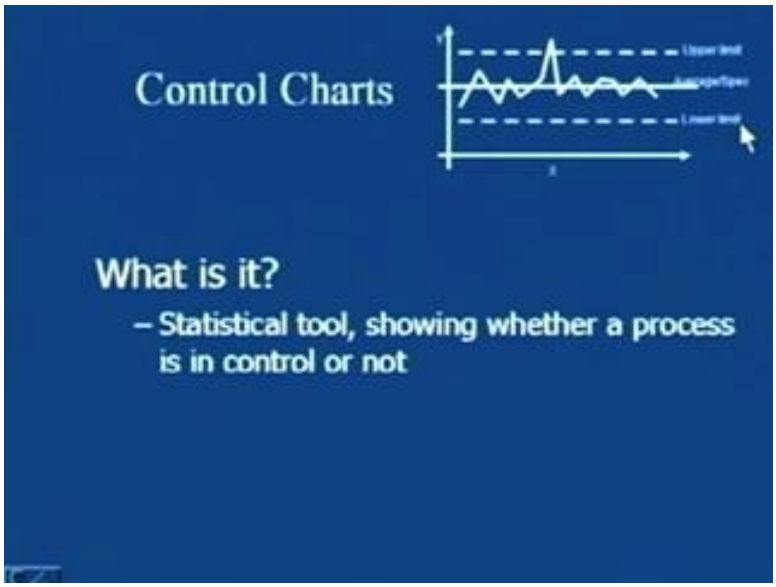


It is a statistical tool showing whether a process is in control or not, the control charts in general look like this, that this is the horizontal line I will show you this graph again, a bigger graph. So, this is the horizontal line that basically represents the x values and this

is the vertical line that is the dependent values that is y. Three lines are draw horizontally, one is the thick line that we say the average line or the mean line sometime we say the target line.

This is the dotted line, this is called the upper control limit and here it is again the dotted line this is called the lower control limit. The datas have been observation that we collect or the data that we collect we plot in the graph and like this one point is here, next point is here and we join the two consecutive points by a straight line. And if we find any point going out of the limit either this way or this way, we say that some special reason or some assignable cause assignable reason is there.

So, we once we plot the data, then we see if any point is going outside, then what we do we just check what it is records that what was happened to this product. And at the time of manufacturing, there maybe some possibility that while manufacturing this particular product the operator might have used the round die might have used the wrong tool, might have not used the coolant during the manufacturing of this product.

So, there may be some special reason, so we try to eliminate those special reasons and this data point basically we remove from the analysis and the from the remaining data points we calculate again the mean and the upper and lower control limit. You keep doing like this till we find that our process is in a state of statistical control, so that is why it is a statistical tool showing whether a process is in control or not.

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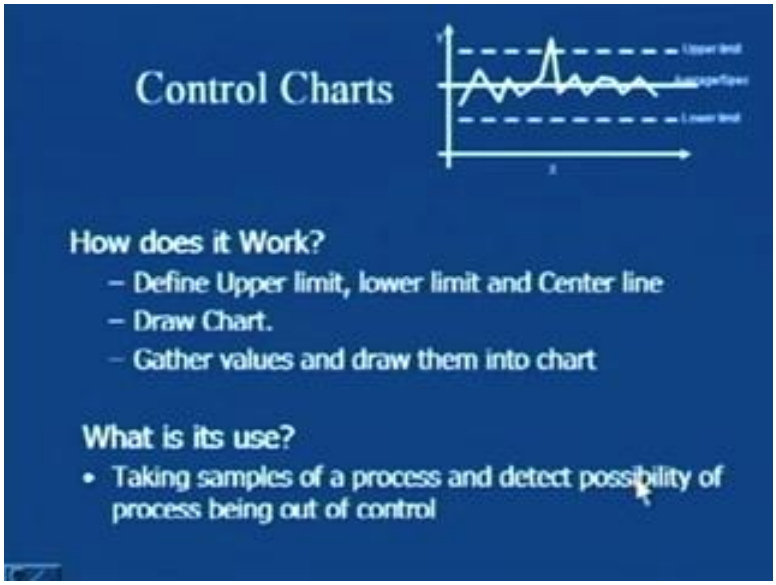

How does it works, it defines upper limits as all already I mentioned, lower limit and the center line, center line is a thick one, this is upper and lower limit that are the dotted line. Then draw the chart means the plot the values, gather values and draw them into the chart, what is its use, taking samples of a process and detect possibility of process being out of control. So, once the point is going outside this is the clear indication that process at this stage is going out of control. And there are some special reasons are there, because of that this particular product or this particular observation is going out of the upper limit.

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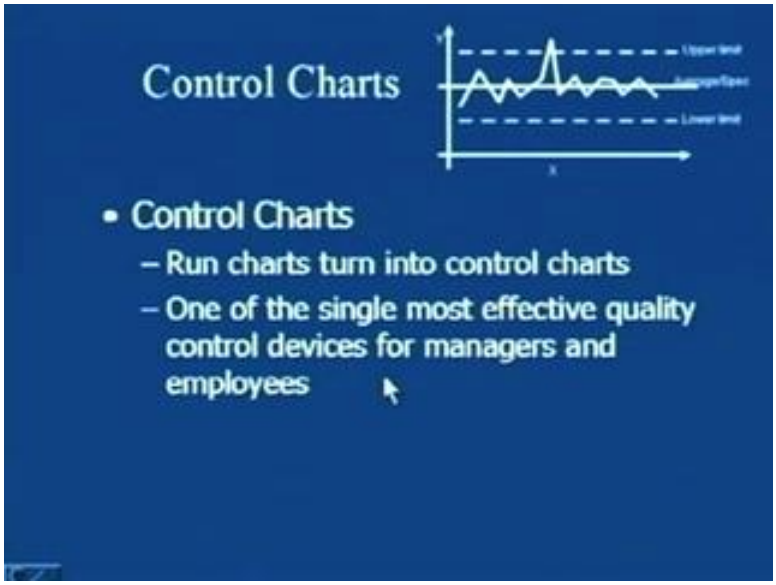


Control charts, basically these are the run charts, if you remember that second tool that we talked about in the 7 quality control tools category that is the run chart. If you remove this lower limit and upper limit this is nothing but, a run chart and run chart turns into the control chart by adding two limits that is a lower as well as the upper limit. One of the single most effective quality control device for manger and employees.

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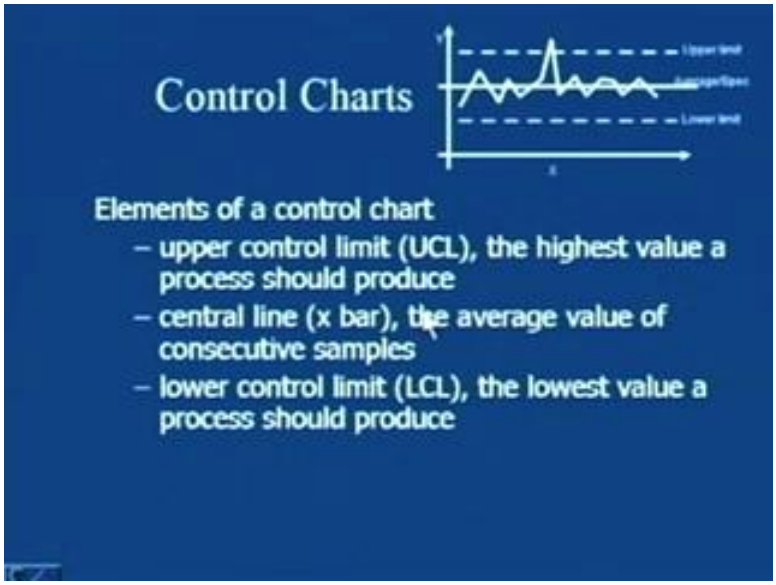


Elements of the control chart, this already I mentioned the first is the upper control limit, the highest value of process should produce means this is a upper limit. Central line the average value of the consecutive samples, means most of the value should be near the average line or the central line. The third element is the lower control limit LCL, the lowest value a process should produce, anything above the upper control limit, anything below the lower control limit is not acceptable.

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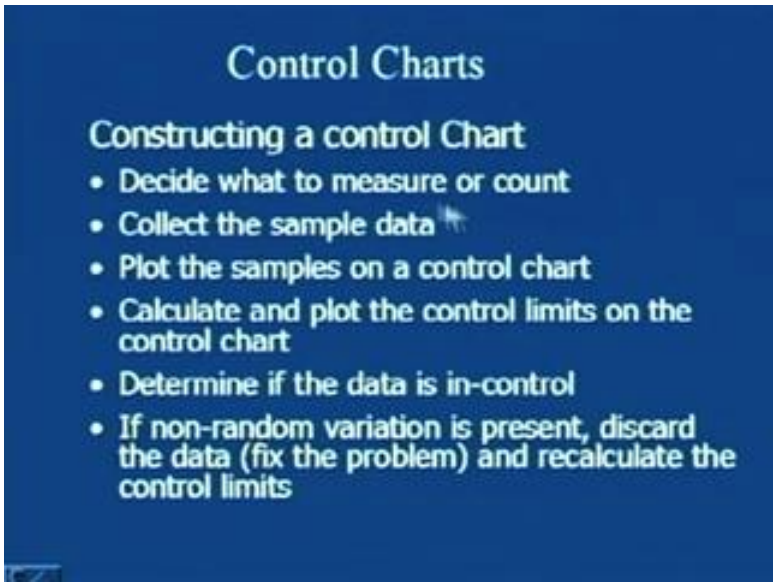


How to construct a control chart, decide what to measure or count, there are charts available depending upon whether we are measuring the characteristics or counting the

defect or the defectives. Collect the sample data, plot the samples on a control chart, calculate and plot the control limits on the control chart, determine if the data is in control. If non random variation is present discard the data and recalculate the control limits.

Now, I will like to repeat this points that I mentioned that the charts are available with respect to the characteristics that we can measure, and the charts are also available for those defect or defective type of situation when we count the data. So, the charts that basically we the characteristics or the charts that we measure for the data that we will measure, that we use for the measurement of the characteristics those charts are called variable type of charts.

And the charts that we use for counting of the data like defect or defective, those charts are called attribute type of charts, we will discuss in detail the variable type of charts as well as the attribute type of chart, in detail in the part 4 of the statistical process control. The last point that if non-random variation is present discard the data, basically the example that I have shown you earlier in the previous slide, that one of the point was going out of the upper control limit that is basically a non-random variation. So, in that case it says fix the problem and recalculate the control limit, means you discard that particular observation first find out the reason what is the special reason there. Once you find out the reason then discard that particular data, then recalculate the limits.

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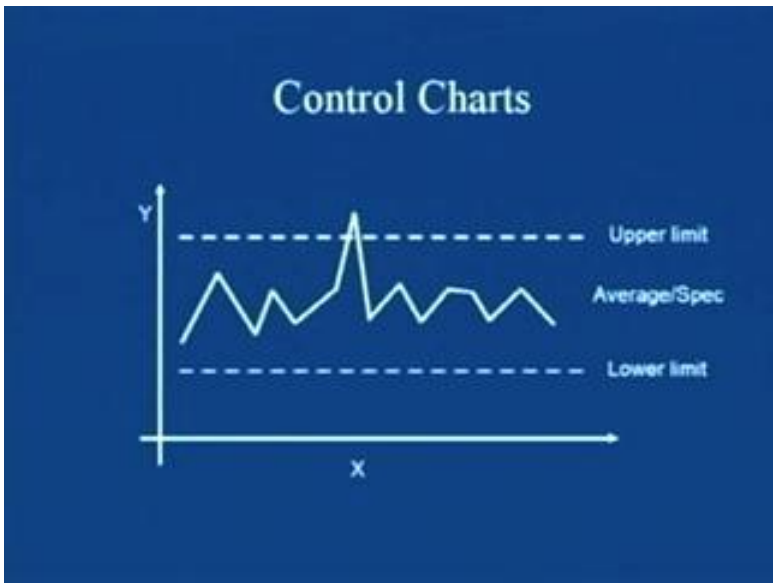

This is how the chart looks like that I have shown you the smaller version of this chart earlier, and this is basically the lower control limit upper limit and the average line. Average line has not been clearly shown here, the average line is here and these are the data points.

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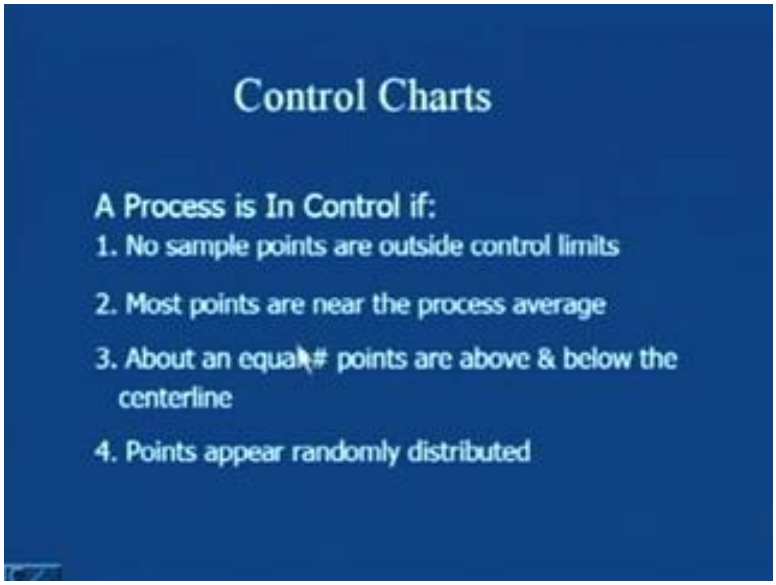


When we will say that our process is in control, so whenever we talk about control chart and we say that our process is in control this means, we are saying that our process is in a state of statistical control. These are the some of the points that we need to be carefully seen that no sample points are outside the control limits, this is the first observation that we should consider that there should not be any point that is beyond the limits, either above the upper control limit or below the lower control limit.

Second point is most points are near the process average, means that all the points should lie near the average, it should not be although if the point is just above the two sigma line or just below the upper control limit. Statistically or mathematically it seems to be ok, but as far as the stability of the process in concerned that most points should lie near the process average, about an equal number of points are above and below the centerline.

And it is not like that the first 7 points should be above the centerline, next 7 points should be below the centerline, but these points appear randomly distributed. Means there should not be any trend that first 7 are above the upper line, next 7 are below the centerline, further next 7 is are above the centerline this will clearly show that there is a

cyclic nature of the data. So, that is why that equal number of point should be above and below the centerline and all the points should appear randomly distributed.

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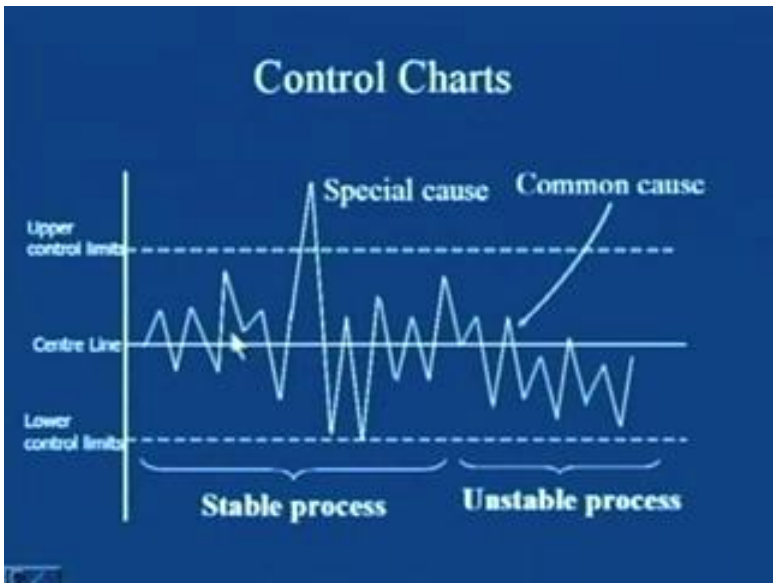


This is the graph chart showing various things or various data point with all the other reasons, that these are the, I am just repeating that this is the lower control limit, this is the upper control limit, this is the centerline. Many data points have been shown here and the two consecutive points have been joint by a straight line. And if you see that, there is one point going out of the limit, you just consider that any point going out to the limit means process is not in a state of statistical control, means there is only one point that is going out of the limit.

And as I mentioned earlier also that try to find out some assignable or special reasons for this and remove this point, so after removing this particular point and recalculating the upper and lower control limit, this be more or less can say it is a stable process. Although it is not a stable process, but just for the beginning of the control chart as a beginner we can consider as a stable process. And if you see from this point onward that, if you see that all the points are basically going down and down one point up, one point down, one point up, one point down.

And if we calculate the average from this point onward for rest of these datas, means if we calculate the average certainly the average will not be here, the average line will come over here. So, this 7, 8, 10 data basically shows that the average value or the target value of the process has been reduced, although they are still in the limits that is between

the lower and upper control limit, but it shows that some common causes are there that are the reason is not clearly visible.

So, these type of causes when we see that trend, decreasing trend or increasing trend or the cycle while the data is within the limit, all those trends basically are because of the common causes. Some of the things we can improve, maybe suppose if this is the decreasing trend, maybe might our tool is wearing out, so this maybe the reason, maybe the machine vibrations are increasing whatever the reasons are there. So, that is if some special reason is there we can remove it and we can bring our process back in control.

If not there may be some special common reasons that are inherent in the process, we try to improve, so that not only our process comes in the status statistical control, but also some improvement in the process takes place. Dear viewers, I am finishing my lecture at this point, means the part 3 of statistical process control I am finishing here. In this part three of statistical process control, we have talked about the 7 quality control tools. That starting from the histogram, run chart, Pareto chart, scatter diagram, flow chart, cause and effect diagram and the control chart.

Thank you viewers.