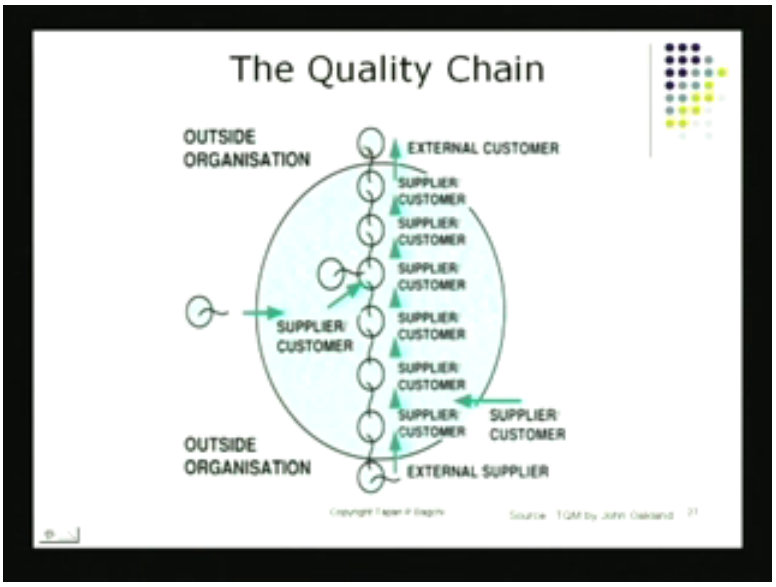
Six Sigma
Prof. Dr. T. P. Bagchi
Department of Management
Indian Institute Of Technology, Kharagpur

Module No. # 01
Lecture No. # 10
Cost of Quality and T Q M Tools

Good afternoon again. I resumed the talk right now with the recollection of a simple concept called the quality chain.

(Refer Slide Time: 00:33)

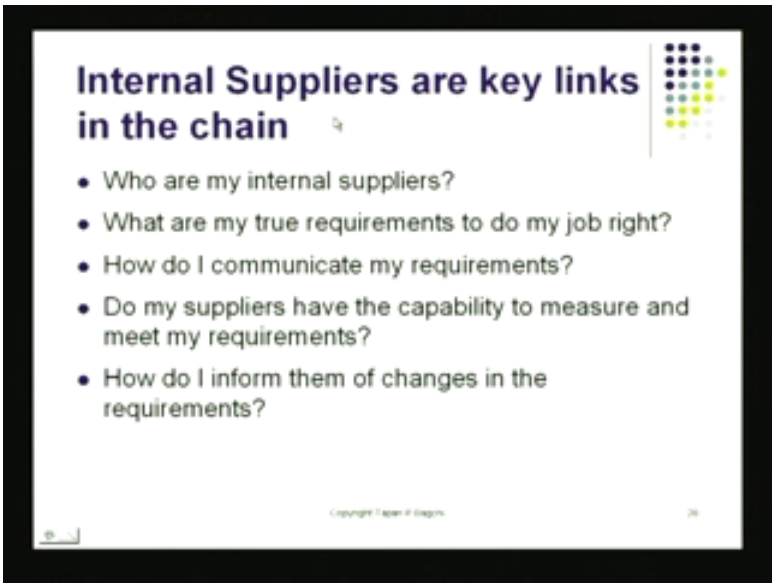


If we see the slide here I have the external customer at the top of the diagram there. Inside I have the process which is the factory or the organisation that is trying to provide the services or the products and of course, I have got the external supplier from which I receive materials labour machinery technology and so on so forth. That is the external supplier there. Inside notice I have got a whole chain of people they internal are customers, suppliers, customers, suppliers and so on so forth

So from the moment I enter the shop, I buy something from the external supplier then I do conversion. I do all these little balls there they are actual conversion balls then I ended up end up doing this. Each of these is a transfer share unit just like the total thing is a is a transfer share unit the .These little balls they are also transfer sharing units. If any of

these balls malfunctions, if any of these units if it malfunctions that means any of the suppliers is not able to do its job; ultimately the external customer is going to suffer.

(Refer Slide Time01:36)

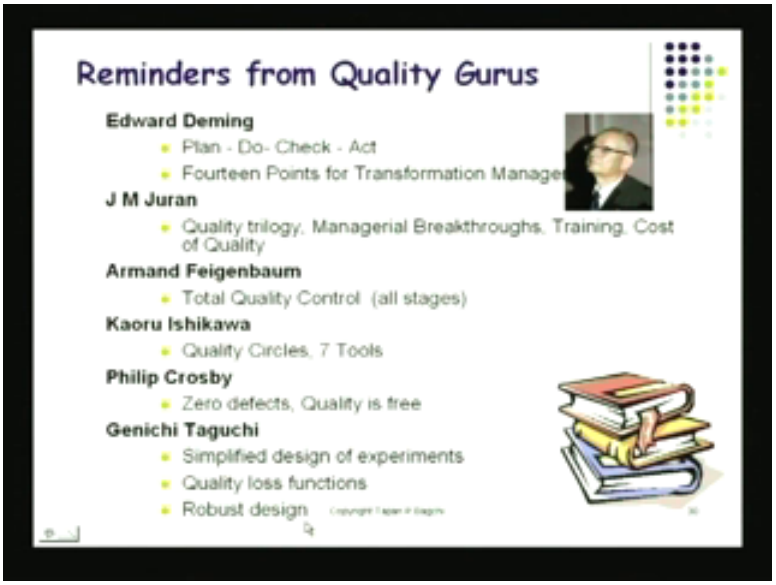


That is like something you got to remember So, what is it that we recognise here? We recognise the role of internal internal suppliers. These internal suppliers they are the people who are suppose to be taken care of all. The internal customer and there are many internal customers as I just mentioned to you. They are all sum up in a chain and these people they all have to be happy they all have to be. It is got to be make sure that their requirements are met just like we are trying to met meet the requirements of the external customers. Each of these internal customers they have to be happy in order that the final customer which the external customer is going to be happy.

(Refer Slide Time: 02:11)

Now locating quality problems where do I begin? As I mentioned to you customer complaints, warranties these are like large areas where I can find what the problems are. I can also begin my work on quality by doing benchmarking which is like my operations going on right now. I compare my performance to another company that is in top of the business and I try to find out you know how do they do their business. And are my costs comparable to his or is my productivity is comparable to his? Is my finish quality level comparable to his? If it is not, then there is something I am doing that is not good enough because he is probably going to outcompete me in the market place. I could also begin by doing seven tools training. I could also do something called the quality function deployment that is like an input major input to designs. There is of course, I can tackle problems by doing Taguchi experiments which I am going to show you sometime later in this series of talks. I could work on continuous improvement project which are like (( )) projects. I could also always do p d c a which is what Deming wanted us to do.

(Refer Slide Time: 03:16)



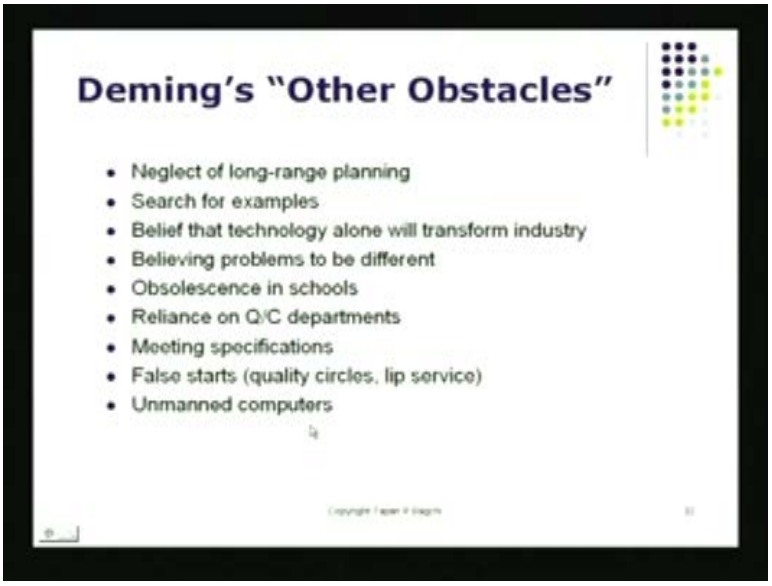
What did Deming ask us ask us to do? He gave us again trinches to remind you Deming gave us the p d c a cycle of quality improvement and he gave fourteen points for the transformation manager to worry about. Juran came along he gave us the quality trilogy that is like something were I need to focus on in order which we have to deliver and delight a customer, deliver to and delight a customer

I need managerial breakthrough that is also, the main thing that I need. I need training and I need cost of quality this is these are the trilogy. I have got the breakthroughs, training and cost of quality. Those are the trilogy there. Then of course, Feigenbaum gave us total quality control that has to be applied at all stages. Ishikawa gave gave us quality circle which is a group of people they come together voluntarily, they look at some sharp problem, they try to find the solution to it and in the process they might be using seven tools. Some of those seven tools they might be using. Philip Crosby told us its very possible for us to justify action on quality preventive action on quality. And then of course, quality becomes free because I remove defects and therefore, I do not have losses. And Taguchi gave us some simple ways of designing, experiments and conducting trials to make sure I improve processes and I produce good designs. I also make sure that I produce right on target by recognition of the quality loss function and I come out come up with something called robust design which is then the product sustain its sustain its good performance throughout its life of use.

(Refer Slide Time: 04:50)

Deming's crucial observation: They make some, he Deming actually made some crucial observation he said many times managers tend to operate by the flavour of the month, many times they tend to operate with the style of operation, many times they tend to emphasise short term profits and many times they worry too much about performance evaluation. At every stage they lose site of the fact that we are doing it all to try to satisfy the ultimate customer who is out there. And also we have may transfers and so on within the company because of which again constancy of purpose might be lost and many times we only worry about visible figures. For example, losses or scrap and that kind of thing and there may be various types of cost that I may may be worried about and I might be worried about warranty costs.

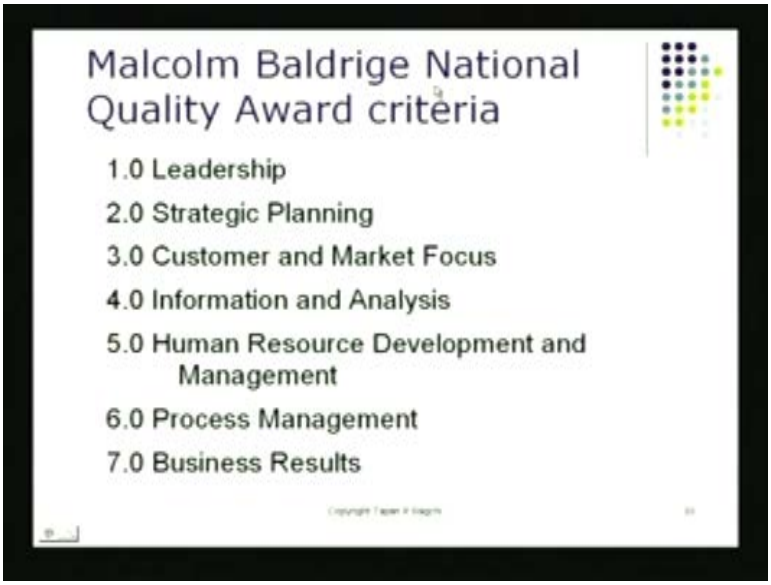
(Refer Slide Time: 05:49)



These are actually things that Deming observed and Deming said, these are actually are caused by poor quality and Deming had number of other obstacles also. They said these are the problems which are there in the company because of which they are not able to move towards quality. For example, very few companies really do long range planning. They really do not have excellence or examples of excellence that are propagated within the company then also they did not have and they believe that technology alone is going to transform everything. Nothing else, no philosophies are required, no orientation is required and so on so forth. They they also believe that problems are different. There is no real basic similarity in two different problems and so on and so forth. Similar problems are solved as if I have to reinvent the wheel everytime.

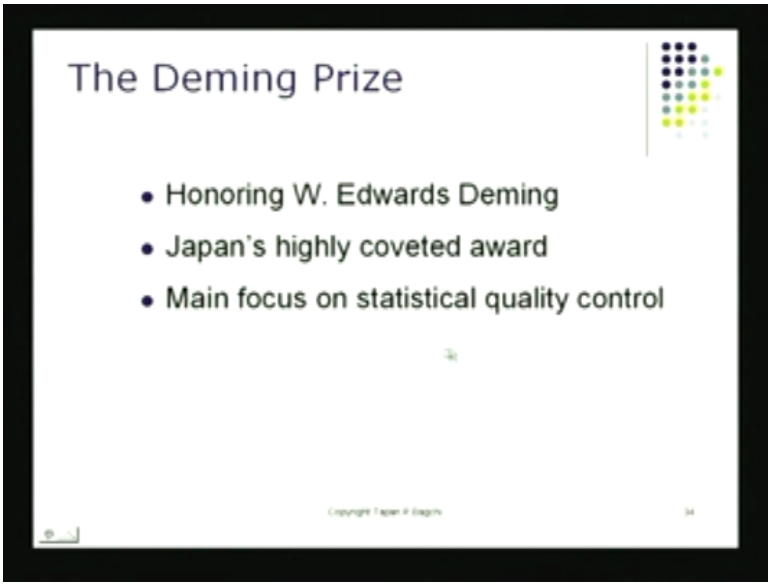
So the challenge is there to come up with the solution more than anything else. Obsolescence is there, that is there and reliance on quality control department is like these are the places where inspector basically they are the ones who are trying to assist the quality of producers the products that have already been produced or emphasis really in many places we are trying to meet specifications rather than trying to do something is fundamentally different. And many times we do false start. We start a program by do not follow through and many times actually we have all manned operations. These are problems where I really need some human intervention.

(Refer Slide Time: 07:09)



But, I do not have them. If you do do a good job and these are on various criteria you can look for an award and these are, these awards are nationally recognised for example, if you show good leadership, if you show good strategic planning in regard to quality, if you really have focussed on customers and also focus on the market, if you utilise information and if you analyse that information, if you do good HRM and if you do good process management and if you have also some linkage between your efforts and business results; you going to apply for the Malcolm Baldrige National Award.

(Refer Slide Time: 07:47)



And that is like one award. There is another award called the Deming award this is Japanese award and I am going to may giving you some more details later on. But, right now for right now I will just briefly mention that the Deming award, it is really emphasizing use of statistical methods and quality assurance.

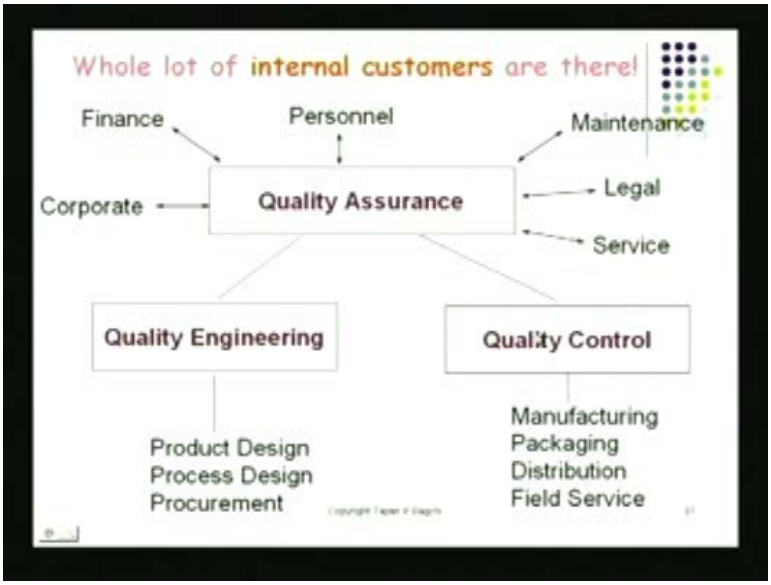
(Refer Slide Time: 08:03)

So this is like there. This is very, very important but, I should also tell you one thing awards are meaningless unless you can translate those awards into business results. Unless you are able to do that if you just get awards if you hang them on walls. That is not going to be good good enough for your business. Yes a few people will see that and a few people probably appreciate. Yes you must have must have a well managed company in place but, it does not necessarily always have a link to business results. That is something you have got to worry about.

(Refer Slide Time: 08:36)

So just winning awards is not not enough.

(Refer Slide Time: 08:40)



TQM actually is a way to try to create customer focussed organisations and for that all you have to do is look inside your company, you will find whole bunch of internal customers they are there. Just as you are worried about the external customers, also worry about internal customers and there are many of them and they spread around in the different departments because as you saw that quality chain, you saw that picture of the

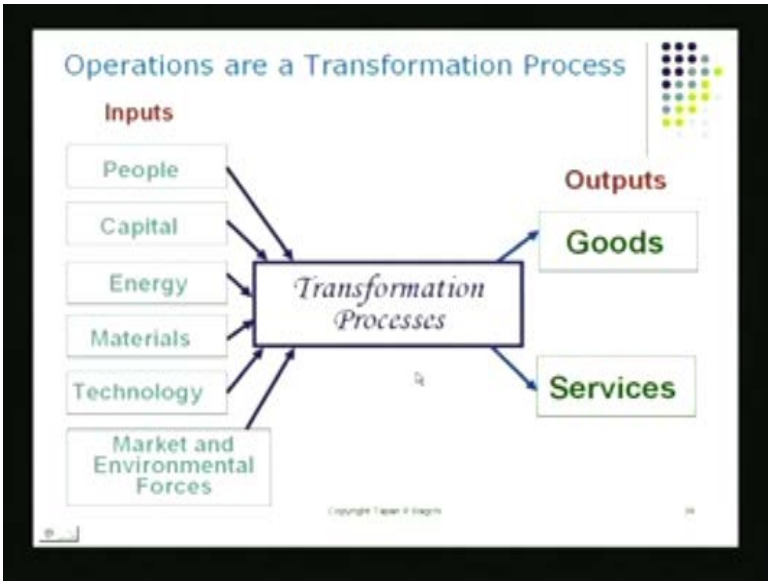
quality chain which basically detect there are whole lot of people they are dependent on what other people are doing.

(Refer Slide Time: 09:10)

Two modes of quality control are there and you can read the details; this is the detection mode of quality control which is like something goes wrong and then you find out the something has gone gone wrong and from that you get a signal that I am going to take some action. Just like one way, the other way is more proactive. The first one is reactive. The detection mode is reactive but, the proactive mode is the prevention mode. Basically very little inspection is required. Quality is Quality control is done right of the source and we try to eliminate problems and potential problems. That is what we try to do. This impacts costs directly. This also helps improve sales and it is much more competitive

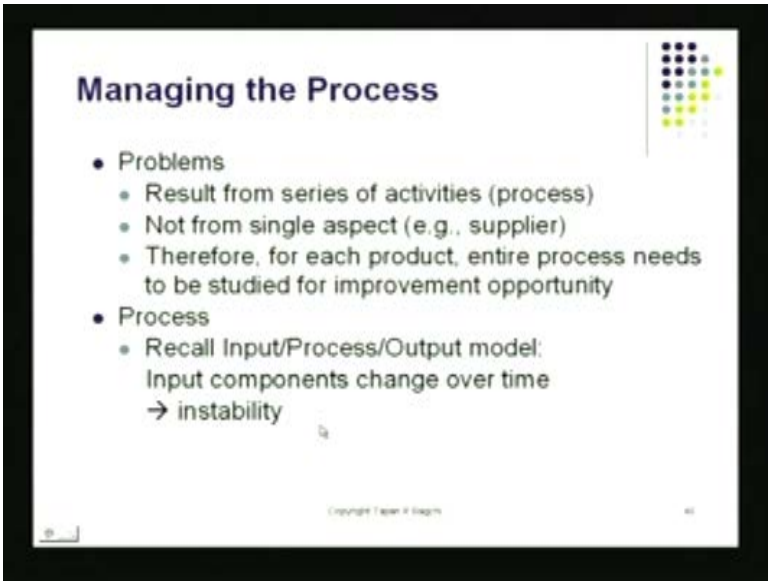
So do not do not really put too much effort on detection. Try to see if you could take some preventive steps. That in turn will remove the necessity for doing detection.

(Refer Slide Time: 10:01)



If you look at the transformation process we got all these as inputs people, capital, energy, materials and so on and so forth. And the outputs are going to be good for services. That is all I really can sell in the market place. It is the transformation processes that are to be managed and to be able to do that I have to really have process focus. This is something I have to do. I have to look at problems issues where there are deviations.

(Refer Slide Time: 10:17)

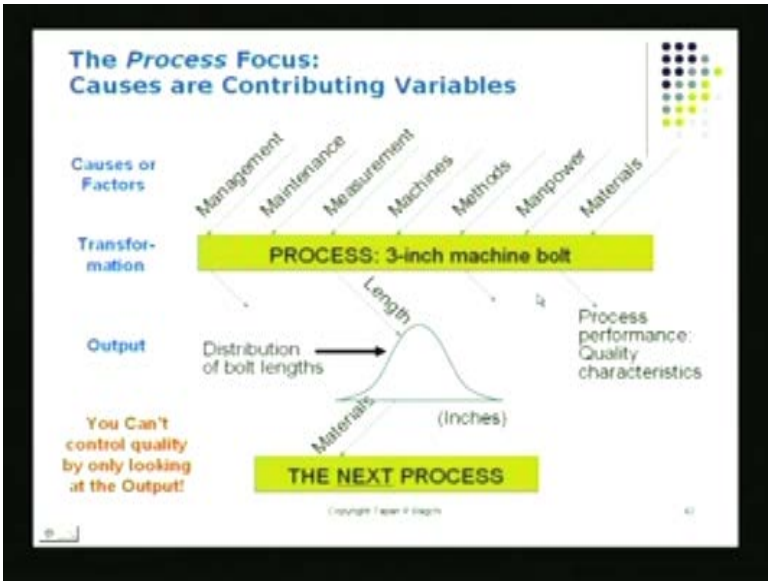


And I have to look at the transformation process itself. Is it unstable? Are there lot of fluctuations in the process? These are couple of things that I need to worry about.

(Refer Slide Time: 10:34)

If I do that, if I have process focus I have to really look at all the inputs in the process, then I have to look at the transformation box and the consequence is going to be look at the output and see if the input is doing its job and that is going to be the the efficiency or the dexterity or the expertise in fact with which I am able to damage the transformation process.

(Refer Slide Time: 10:57)

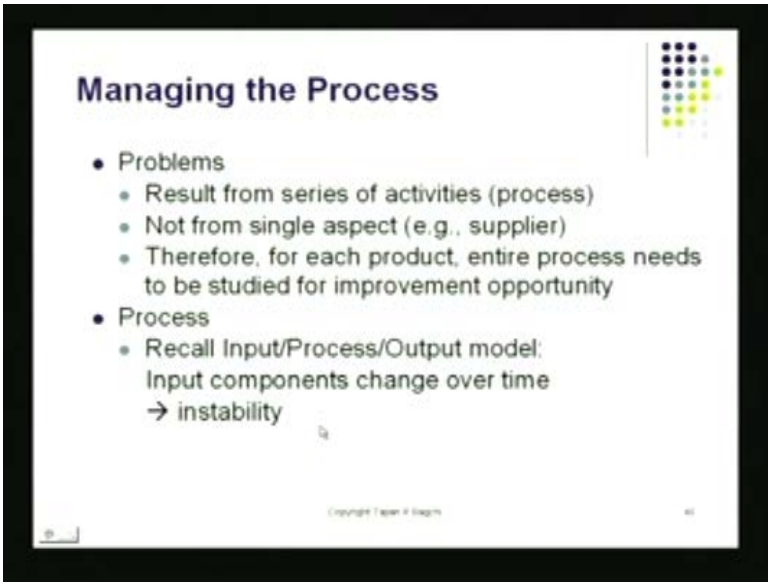


If I am able to do that it is going to be a big job done.

So there are these causes of factors for example, if you look at a a particular occasion when you have got a process to manage and all I am doing here is I am producing three inch long bolts. These are the bolts are I am trying to produce. These are bolts which are used in some machines and I am producing those three inch bolts. The inputs to produce these bolts are obviously there are some role played by management, maintenance, measurement, machines, methods, manpower and materials. Of course, these go as input into the process there what is the output the output is beginning to be the length length of the bolt and that is got to be three inches but, in effect I end up producing bolts and all variable size and this is the distribution if this is true wide of course, I will not have three inch bolt I will have some that are three and a half, there are two and a half, some there are two quarters and so on so forth. And that is not something that is going to be fit for the final use of the process. If my variation is going to be too high if my variation is going to be too high then next process is going to have trouble.

So I cannot really control quality by looking at the output only. Output is this. I have to really go back to the process. I have to look at the materials also. I have to control all the factors that go into this. This is what I call the process focus in managing quality.

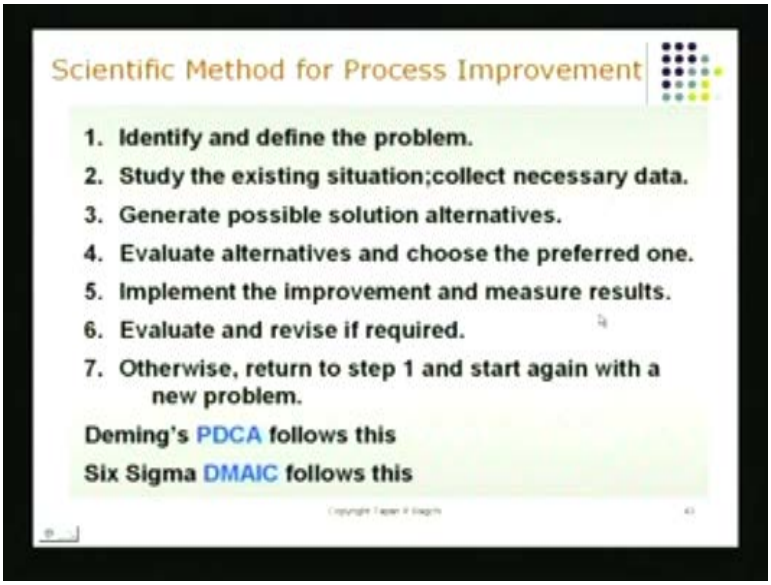
(Refer Slide Time: 12:14)



There is of course, the scientific way of managing process which is like listed out. You identify and define the problem, you study the existing solution, generate possible solutions, evaluate the alternatives and choose the preferred one you implement and and

then sort of we really do is, you implement the improvement that you have solved about and measure the results evaluate and revise it if it is required. That is like your old p d c a otherwise you turn to step one and start again. Deming's p d c a does this and the latest method which is this six sigma DMAIC it also does things that are quite similar to this except that the methods are more sophisticated. You are still approaching the whole task in a scientific manner.

(Refer Slide Time: 13:02)

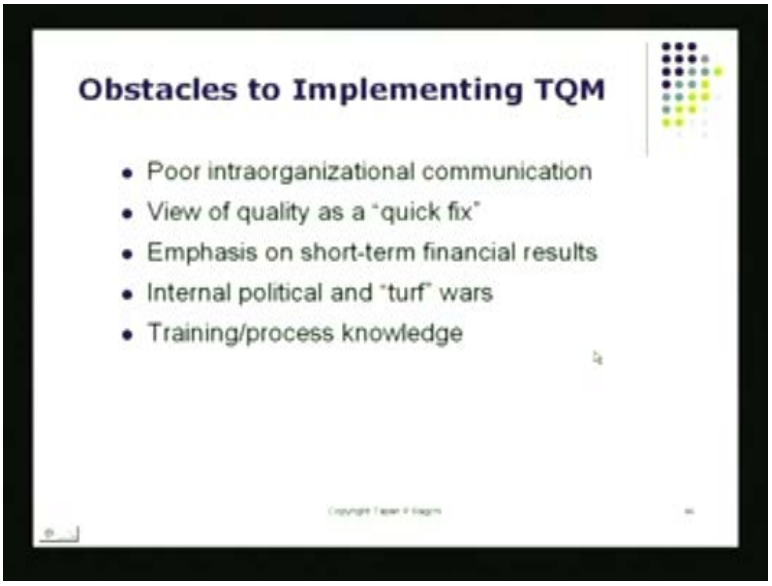


In fact I could do this, I could really do process improvement and quality control, if I could put this in a nut shell. I will say apply scientific methods and use tools, use the right tools; which is like you saw the general tools. Use some special tools and use some very fine grained tools.

(Refer Slide Time: 13:19)

And I am going to be giving an example here; the general tools like team building and so on and so forth. Those are get general tools. The coarse grained tools are process flowchart and so on. I am going to be describing these to you again.

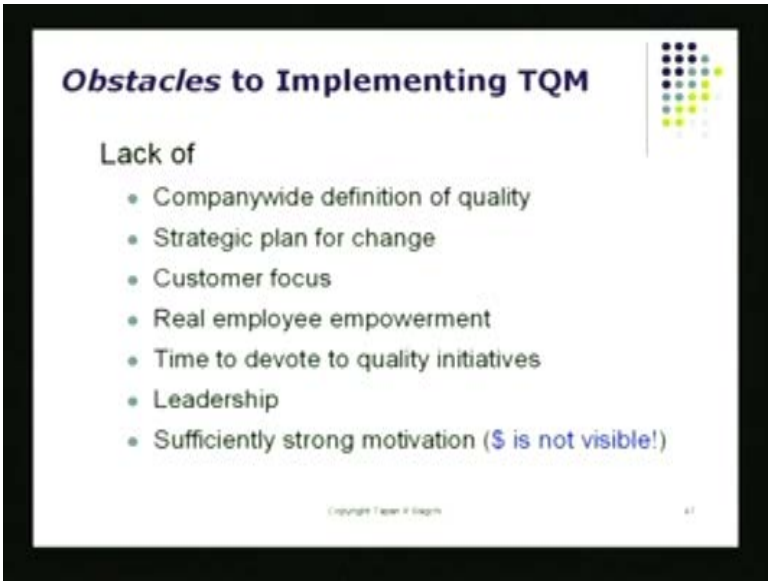
(Refer Slide Time: 13:38)



And the fine grained tools are like Pokayoke d o e design of experiments and so on so forth. These are fine grained tools these are the ones that I utilise when I get get into this. There are obviously going to be some obstacles implementing TQM. For example, communication may be poor and it is also possible people may view quality as a quick

fix for for business. They might think they may be other ways to try to fix the, you know return to good profits and so on so forth. And quality is probably just a quick fix. It should not be seen that way. Emphasis on short term financial results that is also an obstacle to TQM and there may be political reasons, why people may not support your thing and so on. And obviously there may be poor training and also process knowledge may be poor and I am going to be giving an handout for that.

(Refer Slide Time: 14:24)

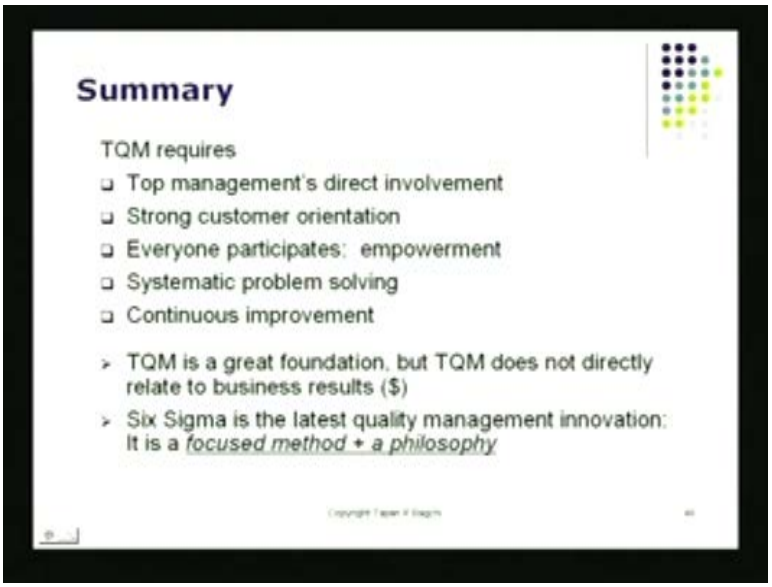


I have a full page display. I have got a full display which gives you a pretty descent idea of what it is really there in terms of knowledge of a process to be able to reach the point when the process can perhaps be automated. And that is a that is a level of knowledge that you rise to. You rise to a particular level of knowledge. That is extremely good, extremely well controlled, well understood and so on. And there is a slow climb to get there. And starting from something that is very, very basic to something there is truly sophisticated. Like the way the designed my this little digital watch.

So this is a pretty sophisticated piece of equipment and if all processes ran like this we really would not have any problem at all. And that is better than six sigma by the way. Obstacles in in implementing TQM: There is of course, these these problems are there; companywide definition of quality is lacking, strategic plan is lacking, customer focus in lacking, employee empowerment is not there, time to devote time to devote to quality

initiative that is also lacking. There is no proper leadership and there is not enough motivation because the dollar dollars are not visible. The dollars gained are not visible.

(Refer Slide Time: 15:28)



So what is the summary from all this? You can really see I have this summary of TQM right here. The four, five points right there but, TQM is the great foundation. Something you have to remember that should have moving into quality begin with TQM and obviously it is not going to give you the complete answer because TQM does not make the dollar incentive visible. For this I need to have a more focussed process which is Six sigma.

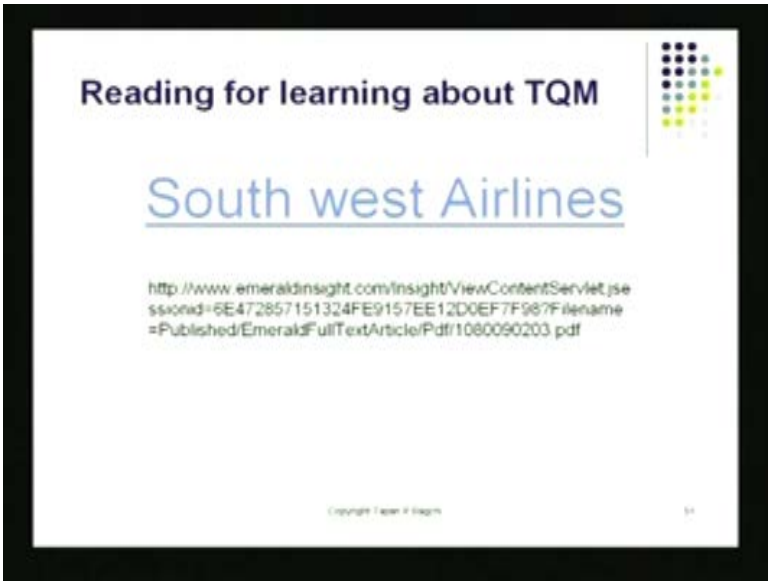
(Refer Slide Time: 15:57)

6 sigma d map and we will do that as you get into this. I provided you with some links and these are websites that you can refer to and all you have to do basically is tag these and you will be able to get some more details then I provided you here.

(Refer Slide Time: 16:09)

In a nut shell TQM is a culture and is not a program and there are some examples you can go to the website again I have given you the link there.

(Refer Slide Time: 16:13)



And find out the story of south west airlines how they become customer oriented and so on so forth.

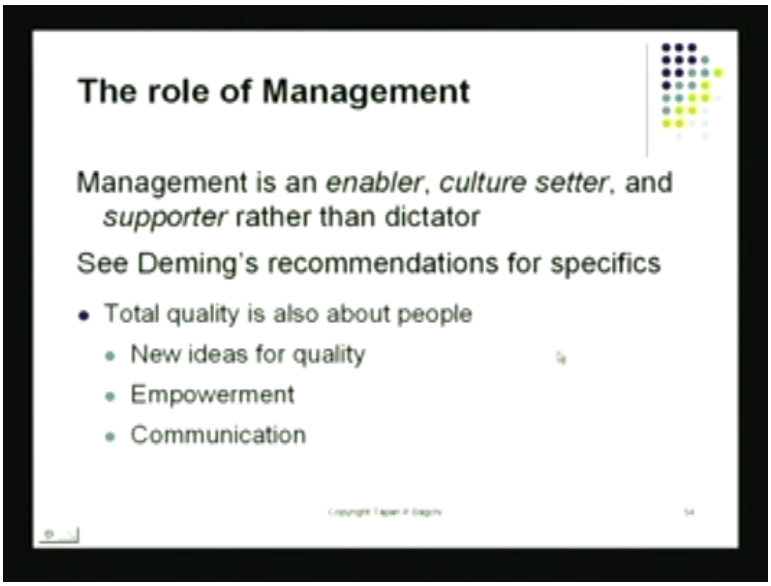
(Refer Slide Time: 16:23)

Approaches to attain quality there are there is obviously the traditional approach and there is obviously the world class approach to do in this. The world class approach is what we are really after and is it is really the result of the process. The product is the result of the process which makes it. If the process is correct, the product will be good and there will be no need to inspect the process.

(Refer Slide Time: 16:48)

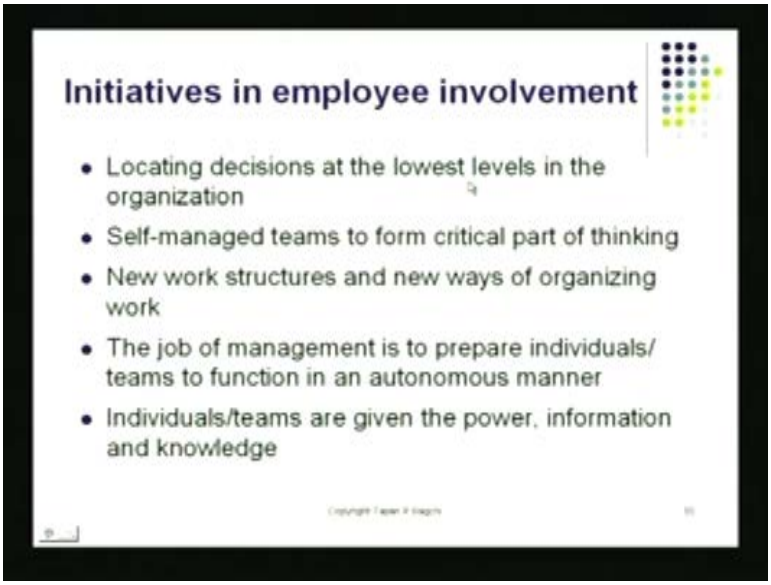
And there are some other methods also, which have been incorporated along with TQM which are also utilised. For example, lean production, teams, flexible specialisation and diversified quality production. These all have come from different places people who also worried about quality besides the Japanese many other people are also worried about the quality. It has come from there and you can also read this up on either on internet or in some good book on quality.

(Refer Slide Time: 17:15)



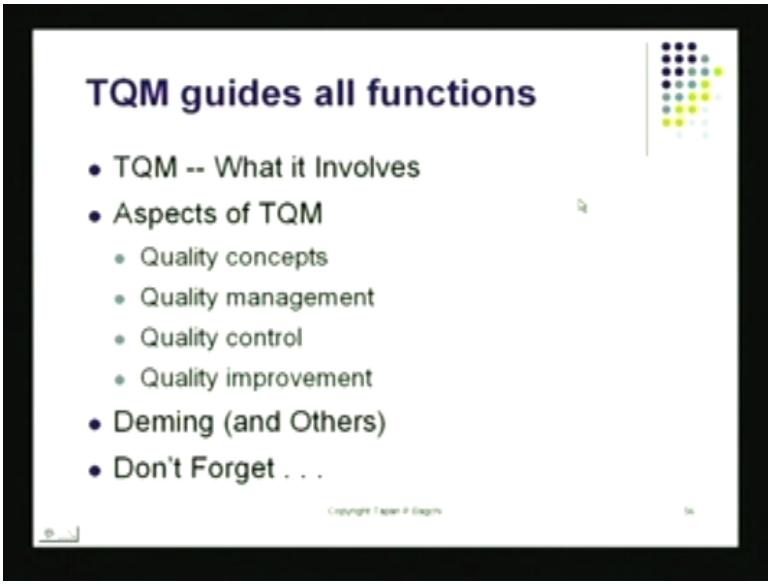
What is the role of management here? They are the enablers, they are the culture setters, they are the enablers they are the culture setters and they are the supporters. They are not dictators. And to try to get these details you have to really look up Daming's writings and Deming has spelled this out in his fourteen point that is like one place you can read up about this. And also total quality is also about people with new ideas for quality. People have to be empowered and good communication has to be there in order that people who are all probably one of the most sort of live resource, they can also participate in the delivery of quality.

(Refer Slide Time: 18:00)



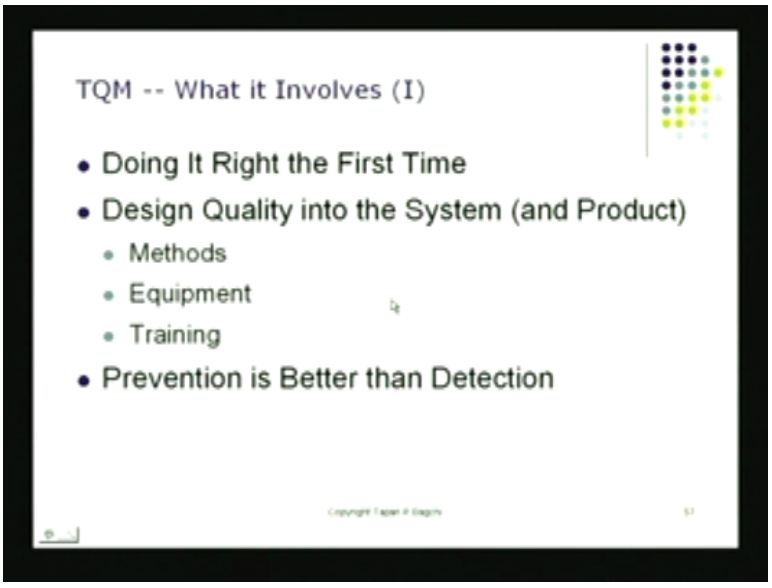
And there are several initiatives that I have listed out here which you can also utilise when you are trying to involve people. That is also going to be possible for you.

(Refer Slide Time: 18:10)



TQM really should guide all functions that you have in the company. So if you look at that, it can really get in to concept formula formulation. Finding out exactly what is that you want to deliver as a product of the service. So, you go after the concept itself proper management proper control of it and improvement also.

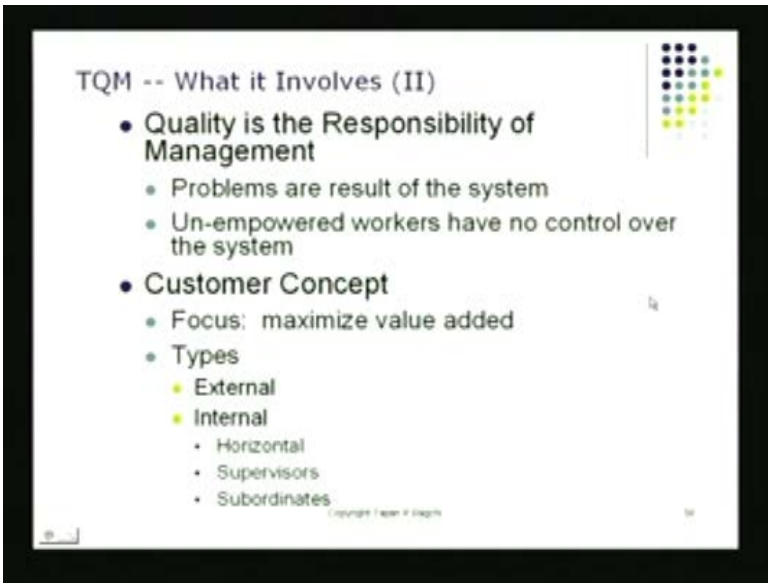
(Refer Slide Time: 18:31)



Deming and many others they gave you lot of other stuff and there are certain things that are to be done alongside. Doing it right the first time, designing quality into the system which should be through methods, through equipment and through training. And please

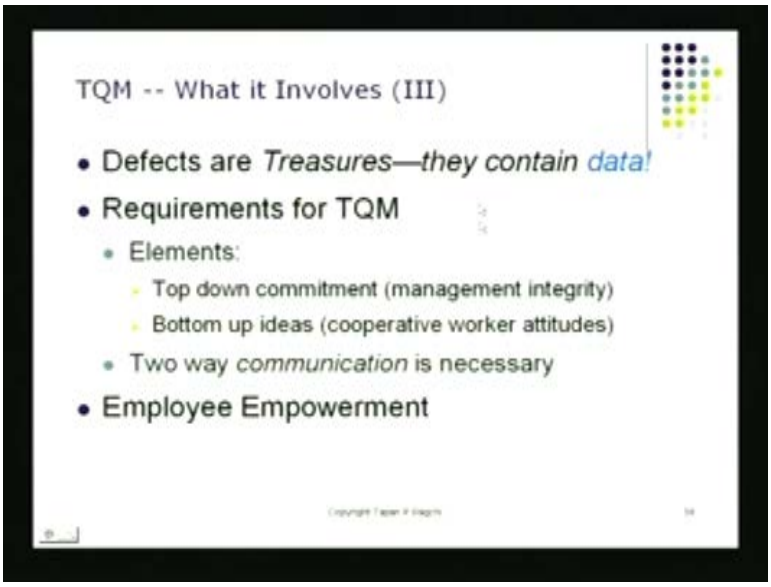
remember prevention is much better than detection. That is also something we have to do.

(Refer Slide Time: 18:47)



What is that quality involves? There are going to be two or three layers of this quality. Quality is quality the responsible responsibility of management and the emphasis on customer orientation that we cannot really skip.

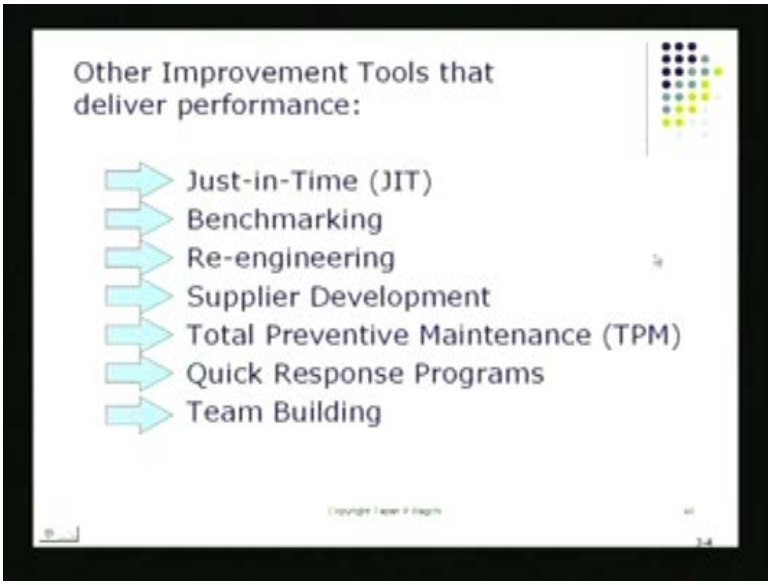
(Refer Slide Time: 19:02)



This is also something that is very important for us. Defects: Are defects really useless? Defects are really some people think they are treasures because they contain data and the

requirement in TQM is going to be a top down commitment. I mean I cannot really tell you how important it is for the top man to talk talk in terms of quality satisfaction, customer satisfaction and a perfect quality, customer delight and so on so forth. If the top person uses that language it is going to be permeating all the way down and this two way communication is very important. The top man should also verify it is being understood at the bottom line.

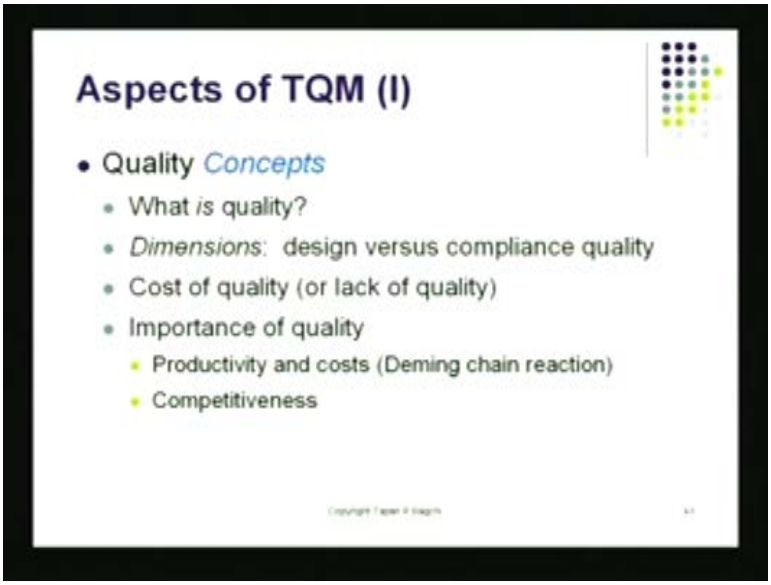
(Refer Slide Time: 19:41)



And there are going to be many different tools that will be using. Some of these tools are they are they are ingredient in TQM or t TQM or supply development or reengineering and so on. And there are other set of come from other areas like for example, JIT. JIT is basically although it counts on perfect quality. JIT requires this supply to a perfect quality and it really is big help in supply chain because you can bring in the goods and you can take those different parts, the caps of these of these pens for example, if these caps were supplied by a JIT supplier; you can take any of those caps and you put them straight on to your product. It would be a perfect fit.

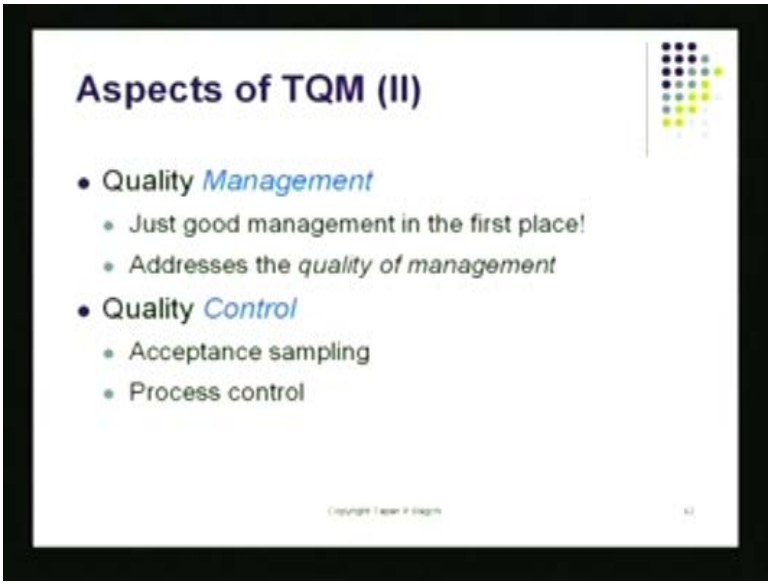
So JIT really requires perfect quality in all the components. That is something that is required by JIT.

(Refer Slide Time: 22:29)



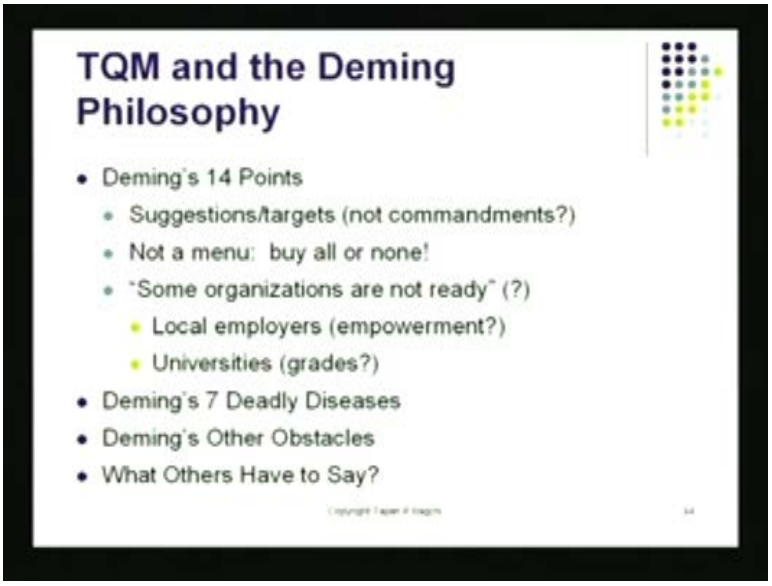
For quality to begin with; I have got have concepts, I going to have management,

(Refer Slide Time: 20:33)



I got to have control, I got to improvement.

(Refer Slide Time: 20:37)



All these are going to be there. They are really required by and again I should emphasise this. Then we spelled out the wisdom.

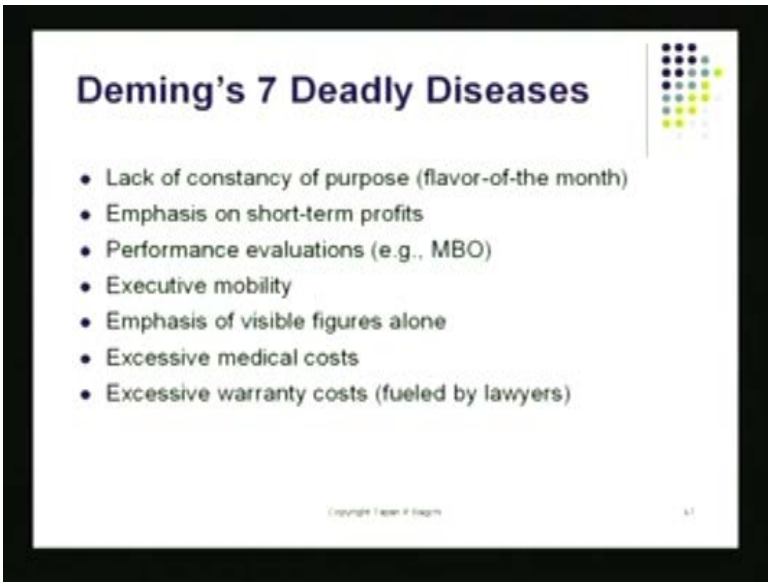
(Refer Slide Time: 20:44)

And Deming's fourteen points; if you internalise them they are listed out here and I have gone through them before and I am again showing them to you in order to you to understand that these are very, very important and any one of these could be understand if you going through literature. You will find these details on any of them.

(Refer Slide Time: 21:03)

There are of course, nine, ten, eleven, twelve, thirteen and fourteen. They are all going to be there.

(Refer Slide Time: 21:07)



These are the fourteen points that are there. Deming also talked about certain deadly diseases and these also have mentioned in the in the beginning.

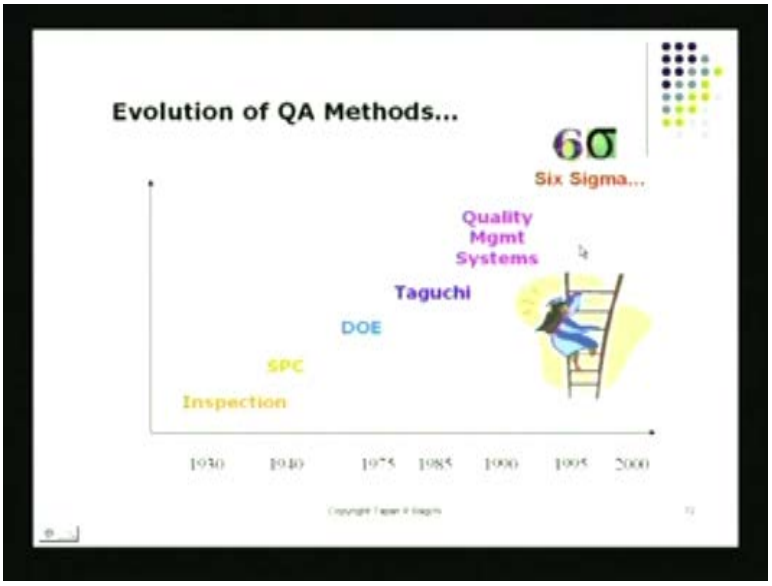
(Refer Slide Time: 21:16)

Obstacles are there and so on so forth. The quality experts they also have given us many different tools.

(Refer Slide Time: 21:22)

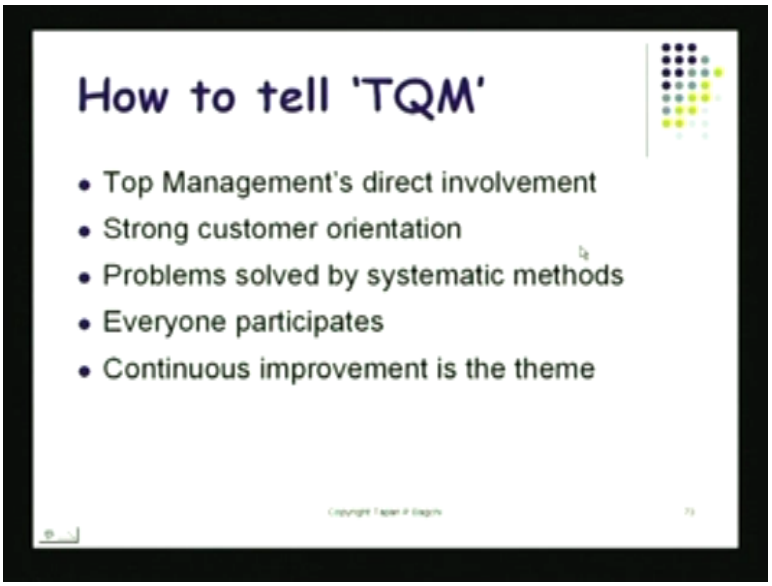
And these are all spelled out and these are my slides are going to be basically reminders.

(Refer Slide Time: 21:216)



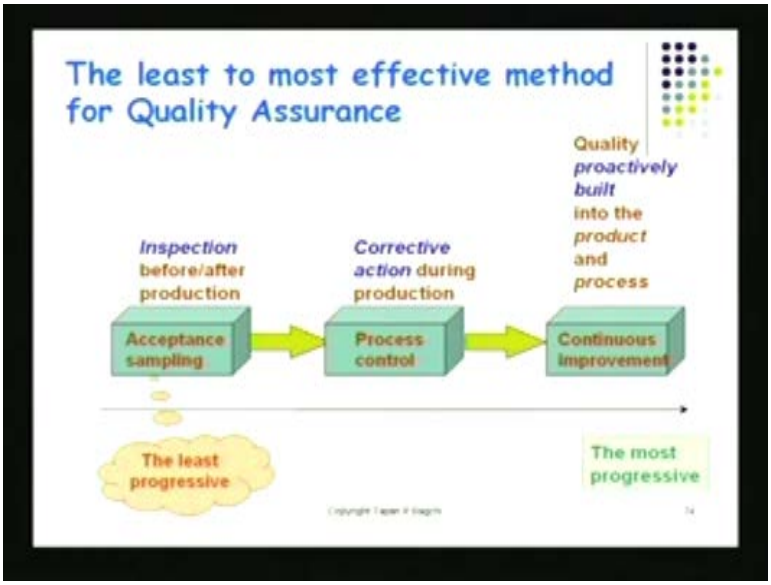
And from here, we reach the point when we actually want to judge, do we really have TQM in a company or in an organisation?

(Refer Slide Time: 21:28)



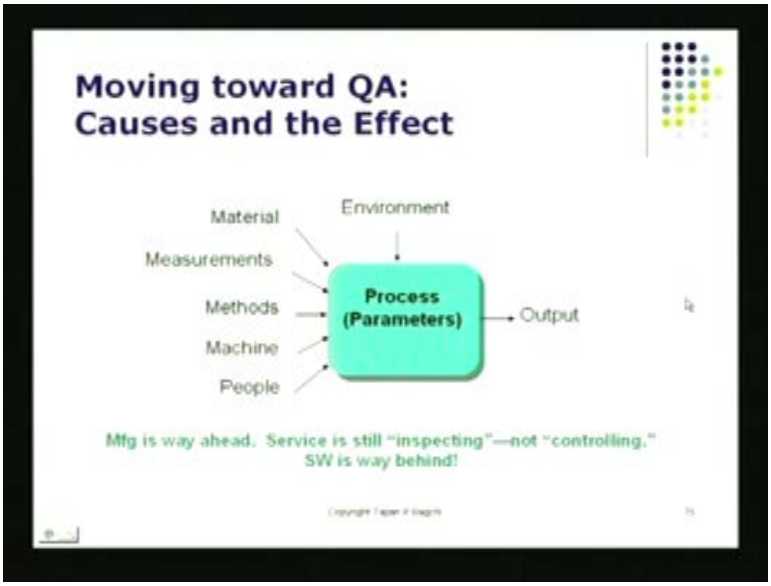
And the questions are just this; Are top people direct involved? Are they talking quality? Does this company have strong customer orientation? Are they solving problems by systematic methods? Do I see everybody involved? And is the theme of continuous improvement in place?

(Refer Slide Time: 21:55)



If it is not there of course, I do not really have TQM in that company there. There are various ways to assure quality and the least progressive one is the one that counts on inspection that is on the left hand side. This is the one that is least least progressive and the most progressive one is the one I am really talking about quality improvement proactively and there I am talking about continuous improvement I am talking about all the good things done in a preventive manner. This is really the most progressive way to try to improve quality.

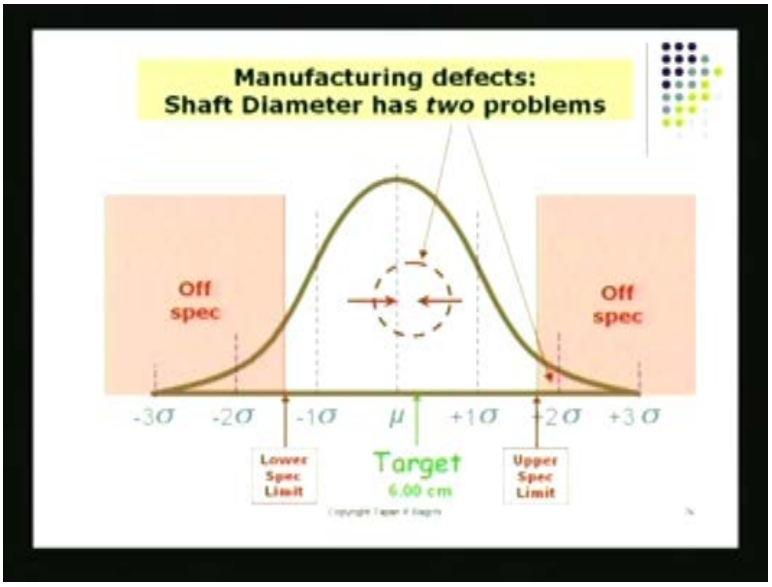
(Refer Slide Time: 22:26)



Slowly moving toward quality assurance what do I see? I see process that is affected by many different factors. It turns out that various sectors in the industry for example, if you've got manufacturing, we got services. Now the latest we got software. we got manufacturing we got service we have got software Manufacturing, it turns out is farthest ahead in terms of assurance of quality. Services for more services in most situations we are still inspecting we are doing quality control by inspection when it comes to the services. And when it comes to software, we are doing only testing we are really should not have much control on the process.

So both services and software they have really not got much into process management but, if you look at manufacturing it is farthest ahead. In many cases manufactures already exceeded Six sigma. That is like something we have to worry about.

(Refer Slide Time: 23:29)



Now look at the problems; this will be like there are two problems in this display here. This is the distribution of the output and I have shown in one of the earlier graphs. This is the area this is the region where I have really exceeded what we call the lower specification limit fallen below, the lower specification limit on the x axis here. I have got some quality characteristic on the right hand side. I also have exceeded the upper specification limits. I have got off spec material. I have got off spec material here. An off spec material here, the traditional way of quality management was; do not try to produce anything that falls in the off spec area. But, what is the modern way of managing

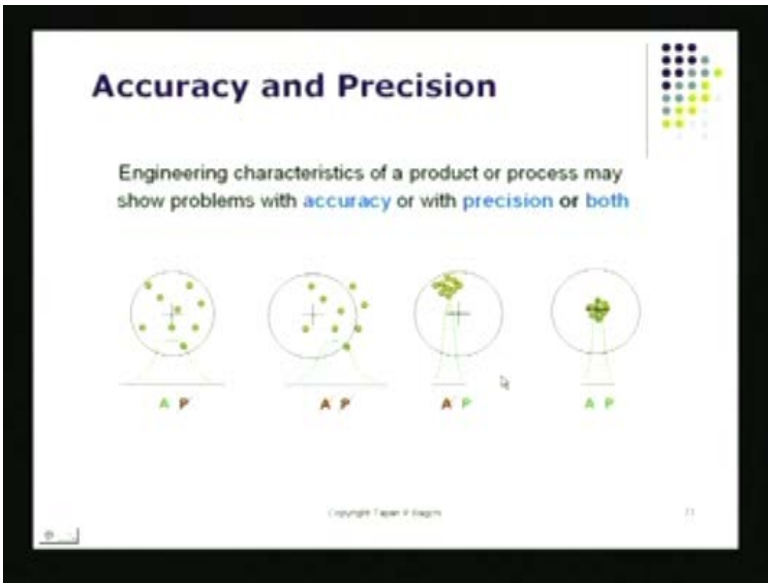
quality? It says try to locate try to locate the target, try to locate what the target is. The target is my customer satisfaction is going to be maximum.

So try to locate the target which is mu right there, which is really next to mu right here. That is what the target is. My production should be should not be off target. In fact this is the bias in the process. The bias is the lack of accuracy. This will have one problem. One problem with production is that production is not accurate. The average does not coincide with the target. Averages of the target somewhere is somewhere else.

So there is like lack of accuracy. The poor accuracy in the process. The second problem with manufacturing is this spread is wide that actually is hinting towards poor precision. Poor precision is also another problem there. So, I have got two issues here. One issue is, the first issue is I lack accuracy. The second issue in manufacturing is I lack precision.

So I have got two issues here; I lack accuracy and also I lack precision. Both of the both of these have to be taken care of. I should have proper accuracy and also as fine precision as possible. These can be achieved. These have been done. These have been studied scientifically very, very well. In fact we use control charts on line when I, production system is in operation and through that we try to get quality.

(Refer Slide Time: 25:40)



That is accurate and also that is precise. I have a picture here. Again try to distinguish between accuracy and precision and also give you an idea of what happens with an

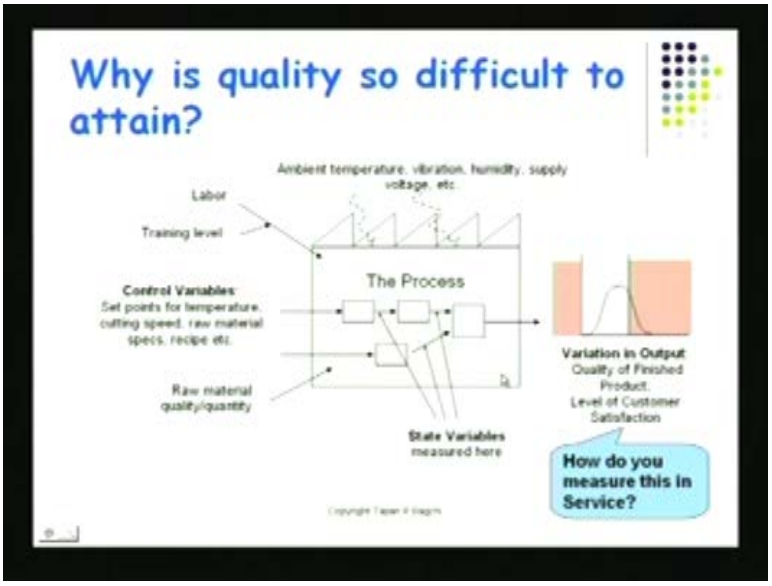
untrained troop. If I am an untrained troop unless I am shooting and the game is basically to shot to try to fire shots on the target. The target is right in the middle there. That is at the bull's eye is this. This is the picture of the bull's eye and this is the target area anything inside the dias. This this this area here is within specification. Notice here an untrained person he fires quite a few shots here.

The average actually which is shown distribution here it is off spec. It is basically of target here. Off target means some lacking accuracy and notice also some of the shots have gone beyond specification. This is because precision is poor. I have got wide variation in the shoo[ting]- in the shooting of these shots there. So, this particular performance lacks not only accuracy, it also lacks precision. Look at this process now. This is another shot who has been aimed who has been trained to aim correctly.

So therefore, he has got accuracy. But, again this spread is wide and is shots are really widely spread. This guy he fire shots and there is poor precision although he has got on the average he is on the target. This is also not good enough because I really want to shoot the bull's eye every time. Look at this guy. He is firing his shots and they are all very close by but, they are again off target. So, I am lacking accuracy here. But, my precision is pretty good. Look at this fourth guy. He is firing his shots, the average is right on target and on the shot there pretty tight, pretty pretty close to each other.

So I have got here accuracy and also I have got precision. This is what you find when you go to manufacture, if you go to manufacturing you will find sometimes the manufacturing process is losing accuracy or it does not have accuracy or it has got poor precision which is like this bell curve here. The tails are in the off spec area so, I have got poor precision. Both of these are problematic and I have got to do something about them.

(Refer Slide Time: 27:57)

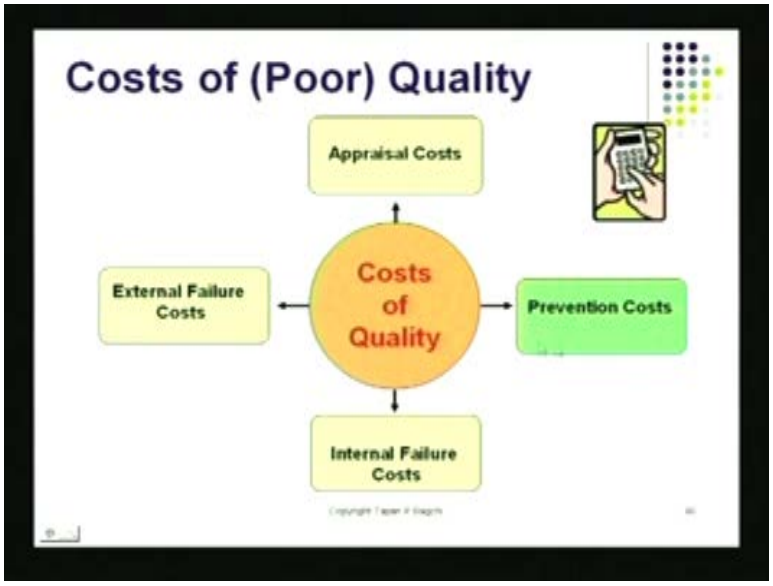


So if you look at a real process you will find that I have got really a combination and poor accuracy and also poor precision. I cannot go to a market place like this. In fact because it turns out that these red objects here which are off spec they cost me money.

(Refer Slide Time: 28:14)

What is the cost of quality now? Let us take a look at this concept called the cost of quality there are four components of it and I am going to describing them to you as I move into it.

(Refer Slide Time: 28:22)



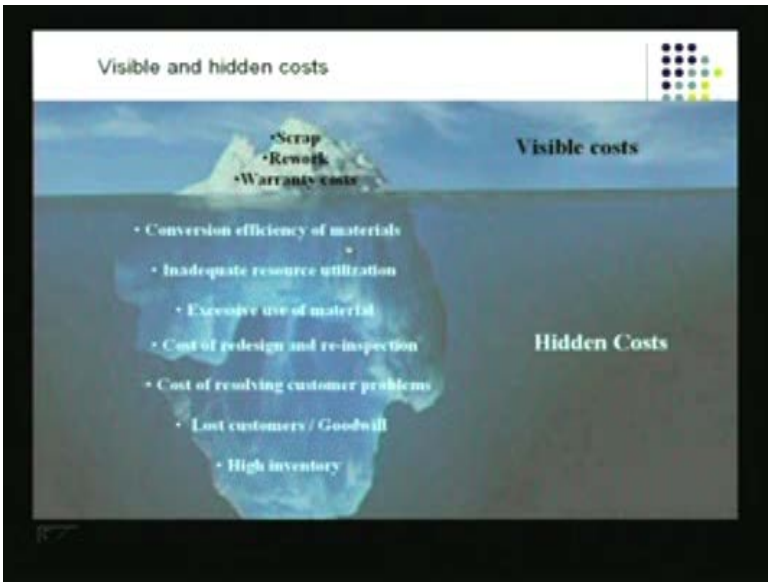
The first thing of course, we have to remember is whenever I have got quality being taken care of I involve a bunch of inspectors. I have got appraisal cost. Appraisal cost is there this is the cost of inspecting the item and there is going to be some money spent there in trying to make sure that I inspect the goods that I have produced.

So if I have got again, if I have got production done if I am producing whatever it is I produce CD's. I produce any of the objects which I am going to sell in the market place. Many a times I have got to do inspection and that is going to not that is going to be free of charge. It is going to cost me some money. So, I have got my appraisal cost here. Then, I have got something called internal failure cost. These are this is the cost of scrap and rework that I have before I make a shipment, before I ship the product out I may have some scrap that I produce or I may have some rework that I have to do because of QC people. QC people rejected some of the items which I have to rework perhaps or fix them a little bit, touch up here and there and support. Only then I can ship them.

So I have got some internal failure cost. That is your scrap and rework. Then I have got external failure cost there are the cost I am going to be giving some details. This is the consequence of poor quality products or services delivered outside. Now this is now in the hands of the customer. So I have got cost here in terms of extra inspection cost, I have cost in terms of recap. Basically it is going to be scrap and rework and then I have got these external costs which have to be suffered by the customer.

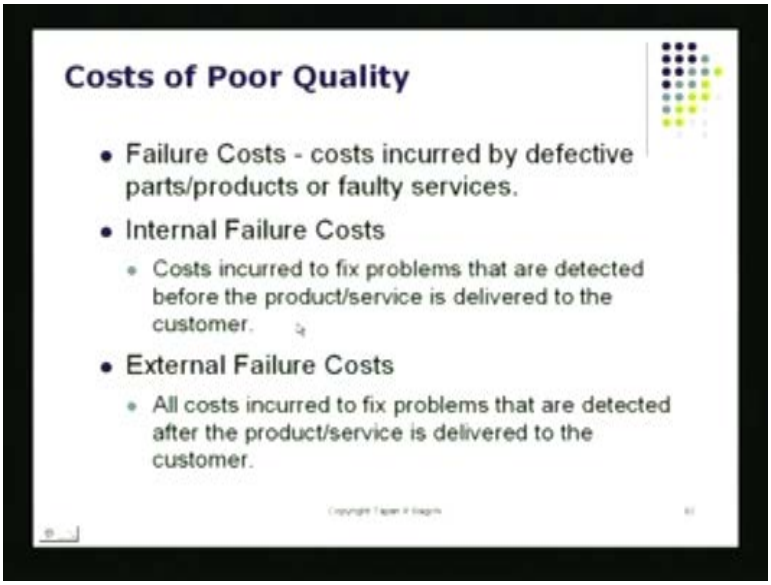
Now, if these are going to be high I am not going to be in business for too long. My profits are going to be hurt. Is there some way by by which I can reduce this? That is actually done by spending money on prevention. If I do that if I spend money on prevention. These balloons, these four, these three other balloons they are going to shrink. This is going to be costing me some money but, there is going to be a strong ROI because of the reduction. There, the reduction there in the reduction there let me show you some details.

(Refer Slide Time: 30:24)



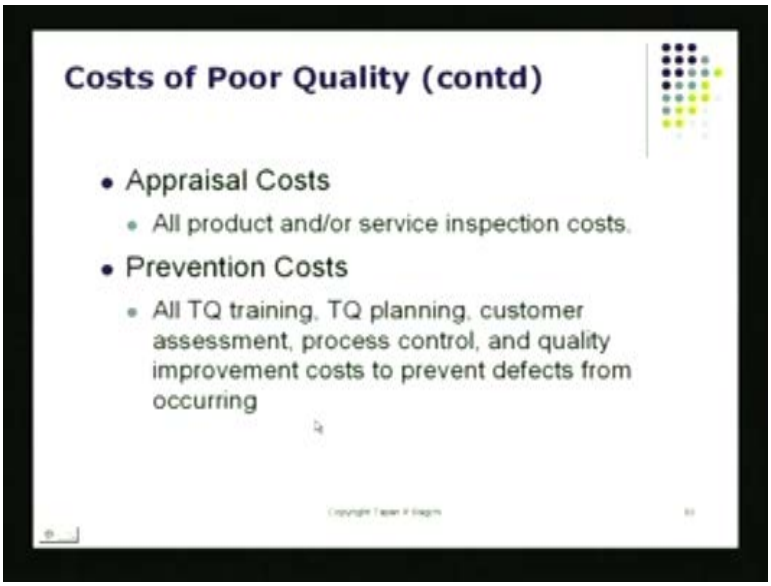
Again I will tell you that these are costs these are visible costs, these are here internal costs, internal failure cost many of the internal external failure costs. Those are here. These are your external failure cost and many times these are not visible and very difficult to quantify.

(Refer Slide Time: 30:40)



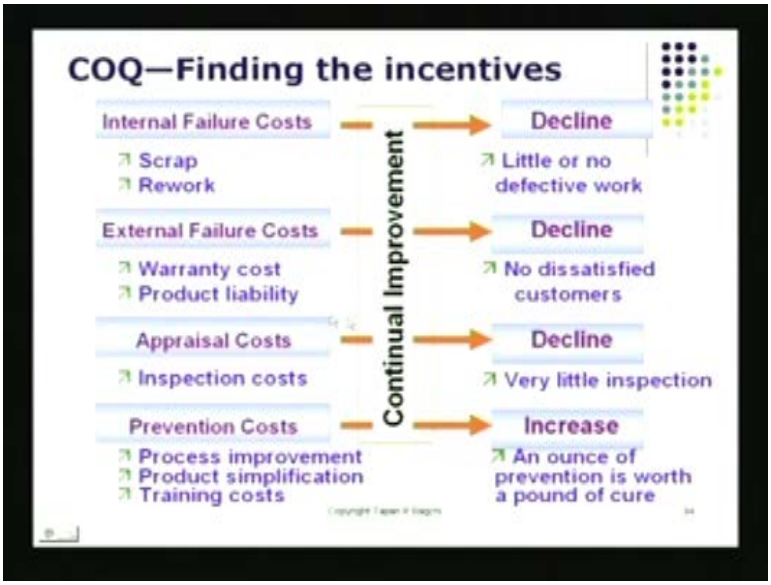
I am giving going to give you details here. So this slide here shows you what different failure costs are and I mention here the internal failure costs and the external failure cost.

(Refer Slide Time: 30:53)



Along side of course, I have my appraisal cost, I have got my prevention cost. Prevention cost is the really is really the place of the company should spend this money. Both of these lists; in fact it turns out that internal failure cost, external failure cost, appraisal cost and prevention cost, together they compose what we call the cost of quality and that is shown in this graph here.

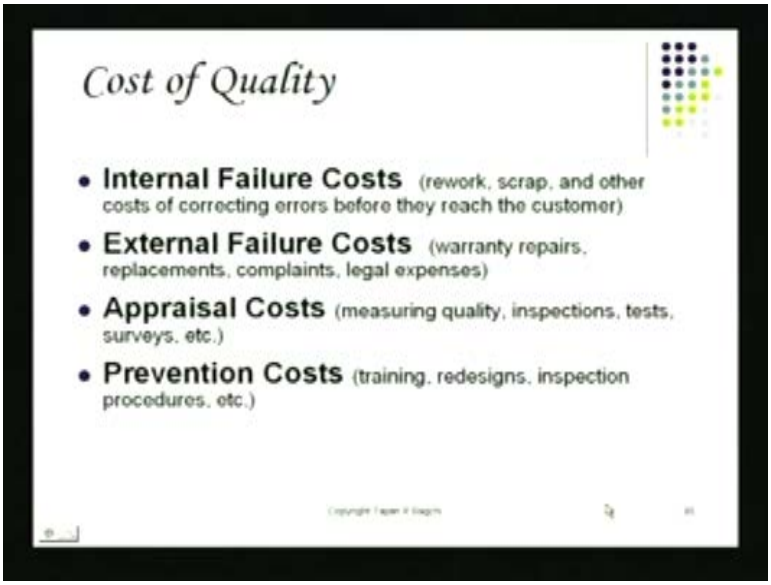
(Refer Slide Time: 31:12)



This slide here, I have got scrap, rework they are direct cost to me. They have got warranty cost and product liability cost; they are caused by external failure taking place. Then I have got inspection cost which is which comes under your appraisal cost and of course, the good cost are these process improvement cost, product product simplification cost or training cost. These are going to be my preventing cost. prevention cost If these increase, then I have got decline in appraisal cost, I have got decline in external cost, external failure cost, I have got decline in internal failure cost.

So, it is this is the best way to spend money; the best place to spend money is an ounce of prevention. And that is going to be worth of worth a pound of cure.

(Refer Slide Time: 31:59)



Again there is a there is a summary of exactly what I said earlier. So again, you can read these and you can again reinforce what exactly is going on there.

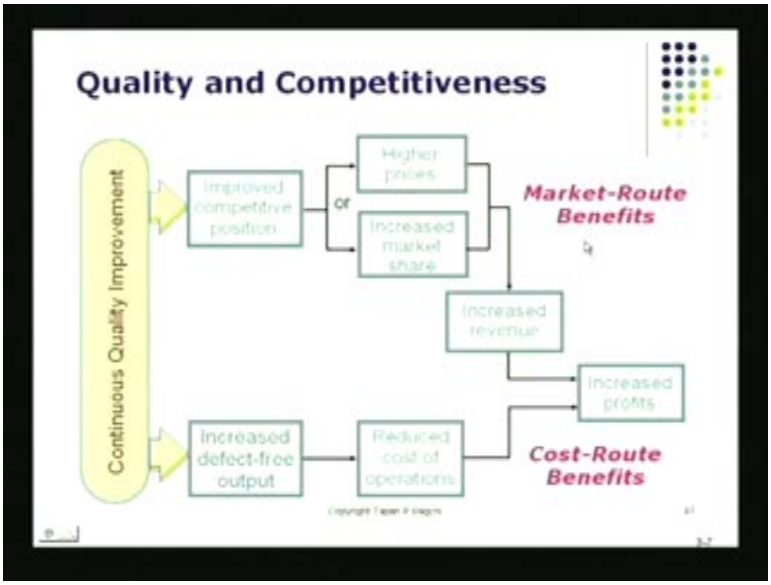
(Refer Slide Time: 32:13)

Something that is misconception in the world, in many companies is that, probably spending too much money to try to get perfect quality is not worth it. In fact, what many people do without measuring the real cost. Now, I am saying this they do this without measuring the real cost. Without measuring the costs, they draw picture they draw picture on paper and they show you look at the red curve. Look at the red curve here.

The red curve basically showing you that here I have got some cost which is the minimum. What is the cost? This is the total cost. This is what your internal failure cost, you got the prevention preventing cost, it is also got the external failure cost; it has got the appraisal costs also. All those four costs; if you put them together and you construct this total cost.

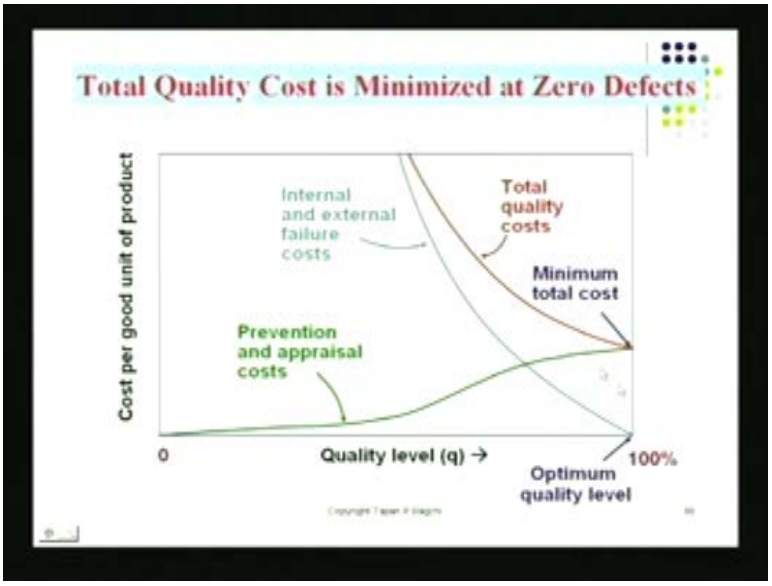
Some people do not really know what the real costs are. They will tell you that perfect quality is going to cost you too much and is better to try to compromise and provide and produce some, at some level of quality which they call optimum. That is going to give you the minimum overall cost. This is the false notion.

(Refer Slide Time: 33:26)



What was done was the Japanese looked at the real cost. What they found was they looked at the real cost what they found was, good quality will lead to lead to benefits in the market place and they they were able to benefit by expanding their sales and so on so forth. And good quality also led to lower losses both of these turned out to be savings for the company.

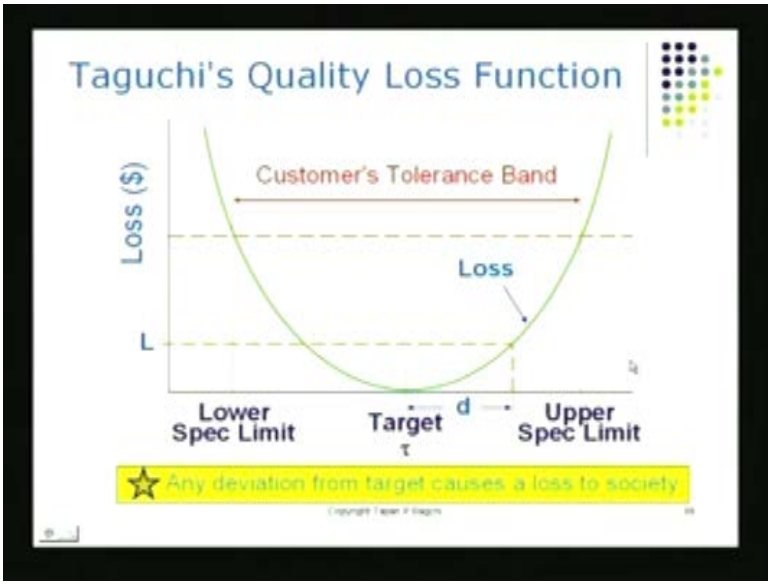
(Refer Slide Time: 33:47)



And the result was this that the total cost did not really climb up back again for the total cost got minimised as you approach hundred percent quality. As you as you reached a level of defect, that was zero. If you have zero defect that means if you had perfect quality that is where the total quality cost actually came down and become minimised

So this is quite different from the picture here. Here the picture is shown to be, the optimum point is shown to be at a place where quality level is really not zero defect. Its somewhere off. So, we are leaving with a certain level of poor quality but, for the Japanese we are able to show was as you approach perfection your total cost actually comes becomes lower and lower and lower. And the best point to be is pretty close to the perfect cost.

(Refer Slide Time: 34:34)



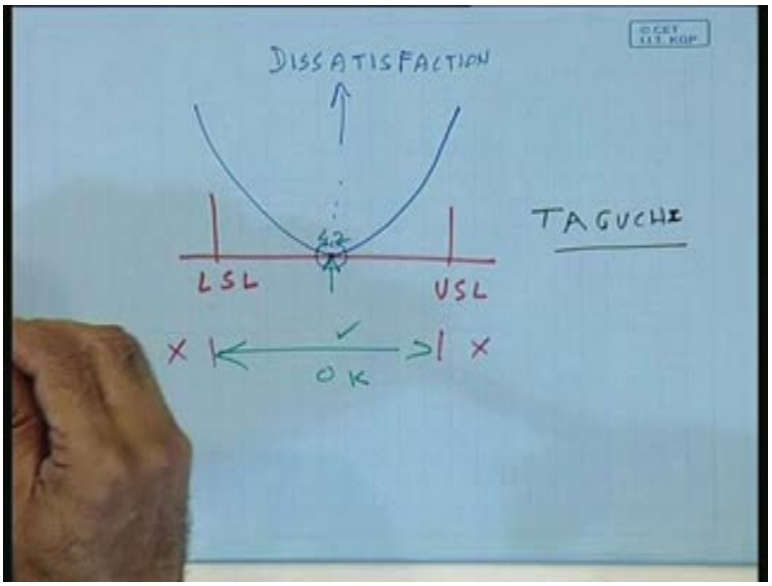
There is another view of looking at your cost and that is called what we call the Taguchi loss function. What Taguchi said was you talk to a customer and I get this example all the time. I have a shirt here which is size forty two and that was the perfect shirt I could really tie my button there and I could also put a tie there. There is no problem at all I could use the shirt which is size forty two perfectly well. But, suppose a friend of mine he went to you know Bombay and he bought me nice looking shirt, the material was good and everything else and the cut was nice and everything except he did not really know my right size and he came back with the shirt that was size forty four. My size is forty two but, he got got a short for me that is size forty four. Unfortunately, a situation is this although it is a great looking shirt, I will not be able to use it because I will have to have the collar open all the time because if you try to tighten it the collar is going to be loose, it is not going to looking so good.

The same thing might happen if you bought me a shirt that was forty instead of size forty two which is my true size. My true size is my target. If you come back to the picture here size forty two is my target. That is where my losses are minimum my satisfaction is maximum. If I go towards size forty two, then I go to size if I go to size forty, forty four, forty six and so on. My dissatisfaction with my with my shirt is going to rise. May be it will be at a point when I am going to throw away that shirt. I am going to try to find a friend; in fact I have no friend who is so fat that his size is forty six

So probably if the shirt size turn out to be forty six, I just have to junk it or I may take it to a tailor ask him somehow do some you know cut and paste, whatever they do I am not sure what the tailors do. But, they say resize a shirt and give it to me because I like the material and so on and so forth and I like to use that shirt somehow but, do adjust the collar before I use. On the other hand suppose my shirt size was loose, was tight and therefore, I ended up with the shirt that was size forty or size thirty eight or something remember size thirty six; I had never been used these shirts. Here we are able to use these shirts. The result is this again my dissatisfaction with the shirt that I bought would go up.

Now generally speaking, generally speaking what happens when he specifies something?

(Refer Slide Time: 37:11)



When you try to convey your requirements we try to sort of say, well you know, if I am buying something I am going to give you upper spec limit and I am going to give you a lower spec limit and anything in that area anything in this area is and anything outside on this side or on this side is not oaky. But, anything inside is going to be okay. This is a general perception. Whenever I am conveying my requirements or I am talking to a customer; I ask what is specification. Say give me your specification but, what do we do? We normally say, my size is forty two. That is my target.

So I really tell him the that my target is this. Please see if you could provide me something that is size forty two. If you provide me anything different from that; you

must have noticed that when you purchase shoes you know ideal size is your ideal size. It could be seven if we got something like six and a half or six you would not be use that shoe and again if it is seven and a half or eight again you will not be able to use the shoe.

So in fact your dissatisfaction your dissatisfaction is going to go up as you go away from the target. If you go this way or if you go this way, this is your dissatisfaction and your dissatisfaction is minimum when you right on target. This is a message that actually was given by Taguchi and let me spell that name for you. Taguchi is a Japanese quality expert who ended up telling us society always incurs a loss the moment performance goes off. It goes to the right or to the left of the true or the ideal value. This is something that he conveyed by using this and I am going to be using the slide that is on the screen here. The Taguchi loss function, this picture is for the Taguchi's quality loss function that is this picture there.

(Refer Slide Time: 39:15)

It is a way to try to convey convey to other people what quality really is. Then there is something that we also have to remember; there is some issue of ethics also in quality. That also is something that we got to remember. Substandard work may be there and some companies may have the tendency to pass it on to the consumer and hope that he will not notice. Defective products may be passed on substandard products, services may be provided, poor designs may be passed on, shoddy workmanship that also may be passed on, sub standard parts or materials may be used. But, you have the knowledge of

these things and if you do not tell the customer if he do not take corrected action. That is plain unethical. Not only it is bad manners; it is also unethical. You do not deserve to be in the market place. You do not deserve to be commanding the same respect that an honest businessman does because your customer has some trust in you. If you if you break that trust down you really do not deserve to be in business.

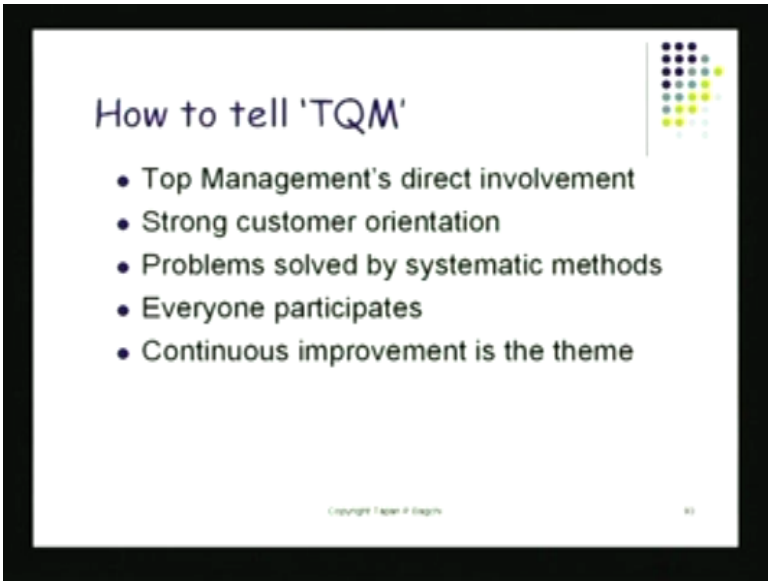
(Refer Slide Time: 40:19)

This is something you got to remember. I am now going to be entering another area where I am going to illustrating you to you some tools and techniques which are utilised in TQM. These are also the tools that are utilised by people who work in quality circles.

(Refer Slide Time: 40:35)

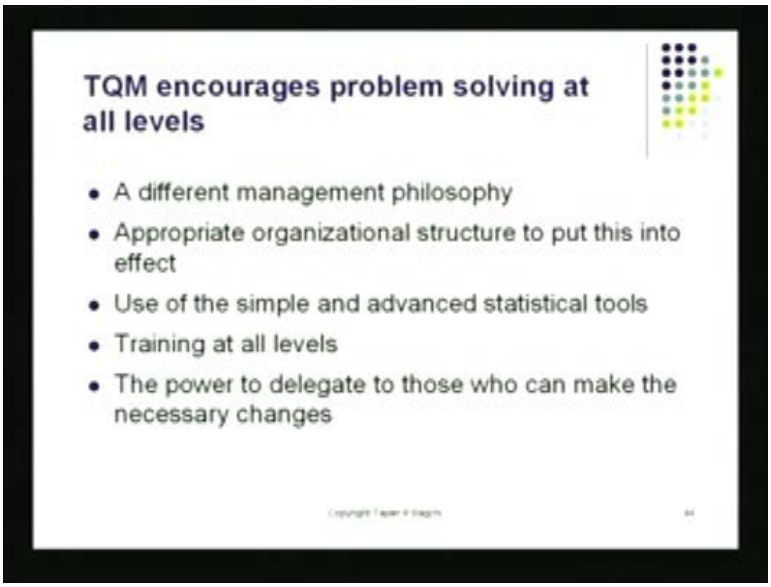
Let us start by going into what we really are after. TQM again like I mentioned to you earlier, it is a culture it is not a program and its a culture for orienting your mind you know, somewhat differently. You will start thinking of like the top plan would be involved directly. You will have strong customer orientation. The moment you have a problem you will apply basically standard methods or proven methods or systematic problem solving methods everyone in the company would be involved in trying to tackle the problem and you will have the theme of containers improvement. These are like if you practise in TQM you will be doing these things.

(Refer Slide Time: 41:14)



Let us see how we do that? Again you know, I do not have to remind you again these are the things that you should see the moment you have TQM.

(Refer Slide Time: 41:21)



TQM encourages problem solving at all levels. In fact this could start right at the shop floor; this could go all the way depending on the level of or the seriousness of the problem. It could rise right to the right to the level of where strategies are formed by top management. It could do that.

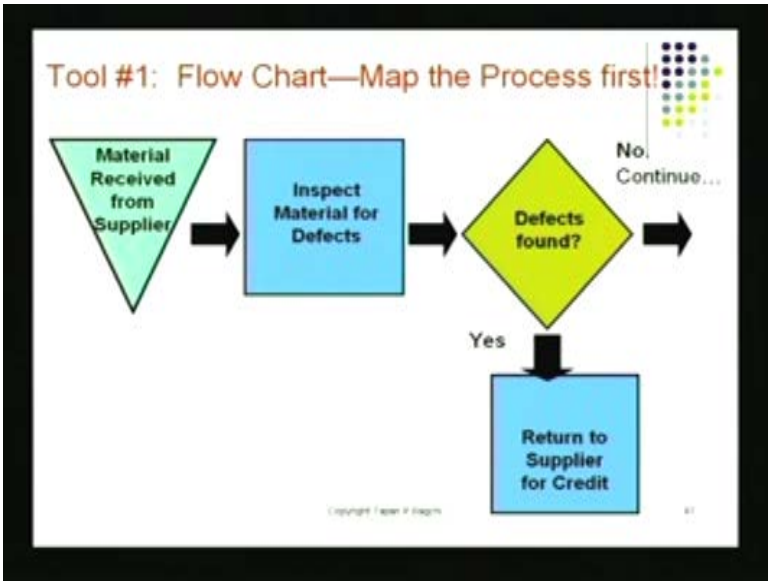
(Refer Slide Time: 41:36)

There are certain techniques which you utilised. What is the focus of these techniques? They all try to reduce variability. There is something that every every each one of these tools try to do tries to do. They are data based and saw the fancy techniques or techniques like statistical process control SPC. There are some really fancy methods like design of experiments. That is also there but, the bottom line is you must have management commitment to be able to supply to be able to supply these tools, the trainings and so on.

(Refer Slide Time: 42:08)

What are some of the tools? I will list here. I am going to giving you examples of each of these two tools. There is a flowchart then, there is a check sheet and the histograms and so on so forth.

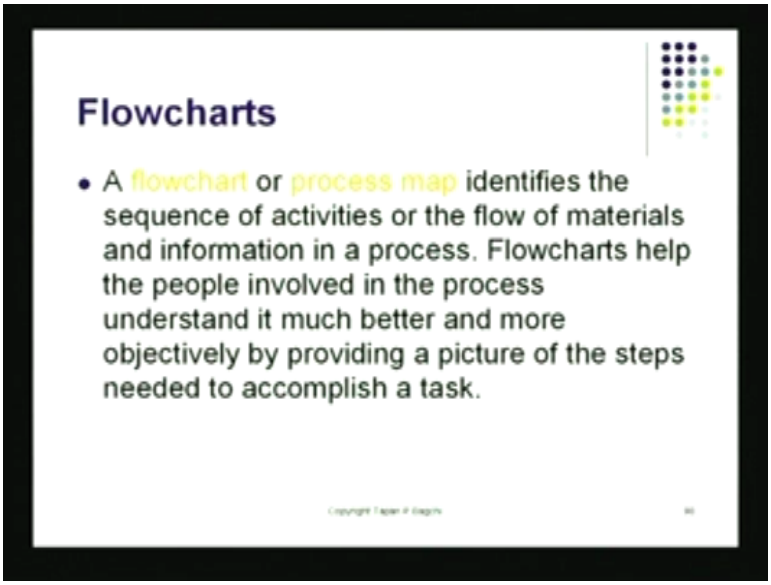
(Refer Slide Time: 42:19)



Let us start this journey. The very first tool is the flow chart is the flowchart and what is it really? It takes you from the left to the right, showing you the steps of the process.

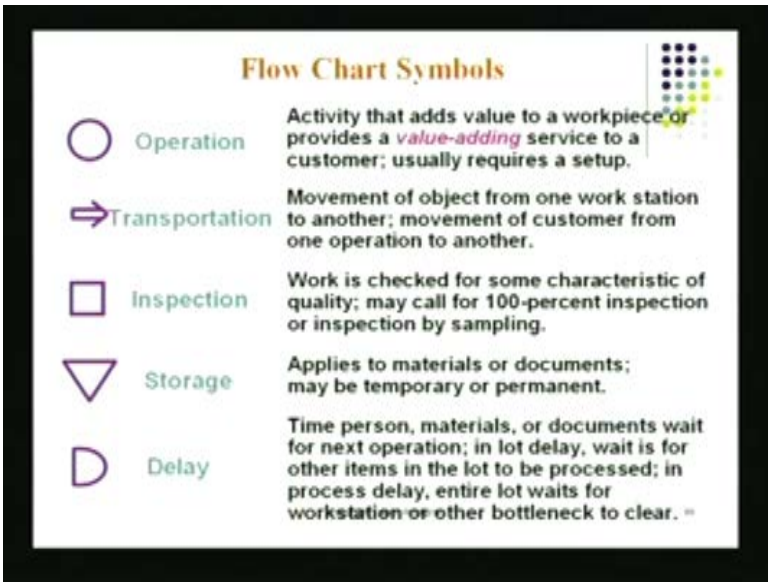
So I have material received which is stored somewhere, then I do some inspection, then I make some decisions, then basically I return if I found some defect I return it to the customer or to the supplier or I move on to the next step of the process. So flow chart can be used quite easily to find quality problems. You flowchart a process and then locate all those points where there might be a quality check being done. What is happening at in the quality check? What kind of data is being gathered? It is very possible they will be collecting some reports, there some data there. Take a look at those things and you can do that only if you locate the right spot for the data has being collected and that can be done only when you charted the, flowcharted the flow of the either information or of material.

(Refer Slide Time: 43:21)



So in flowchart or a process map really identifies the sequence of activities or the flow of materials information and process. Flowcharts help people the people involved in the process understand it much better and more objectively by providing a picture of the steps needed to accomplish the task.

(Refer Slide Time: 43:40)

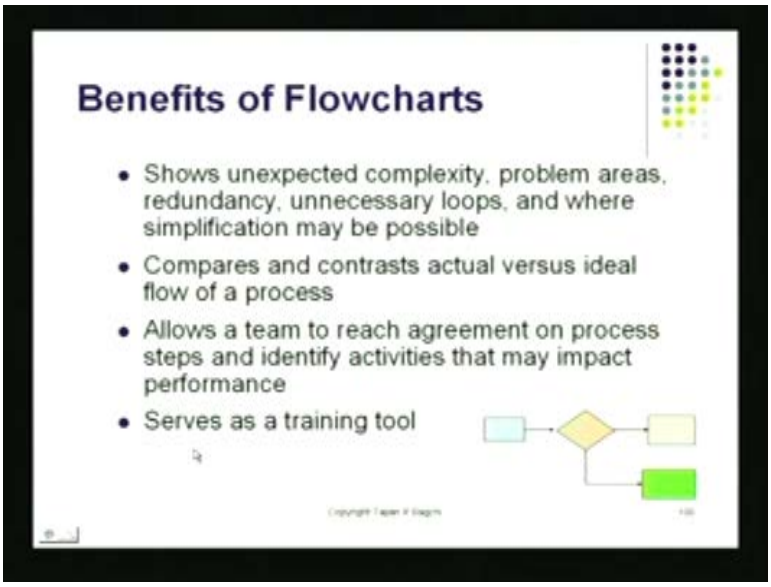


Certain symbols are used and the symbols are given as operation, transportation, inspection, storage and delay. Out of all these things the one that is really important is

your operation. The rest of it is all really supportive. Everything else is supportive. Except for the operation, no other place is adding value.

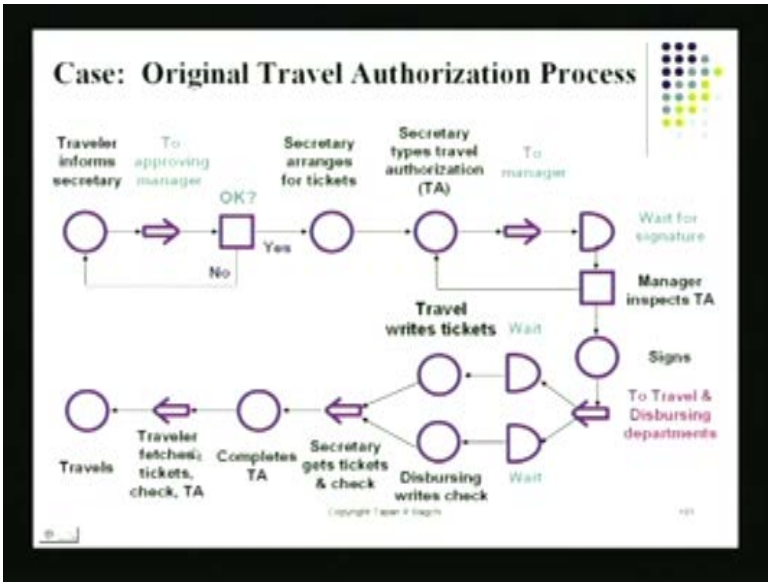
So, this is the part that I should really be focussing on. If there are any of these other things involved in the process; I should try to eliminate them. Yhat is what I should try to do.

(Refer Slide Time: 44:08)



I will give you an example and I list out some of the benefits which you can really look up by just reading them.

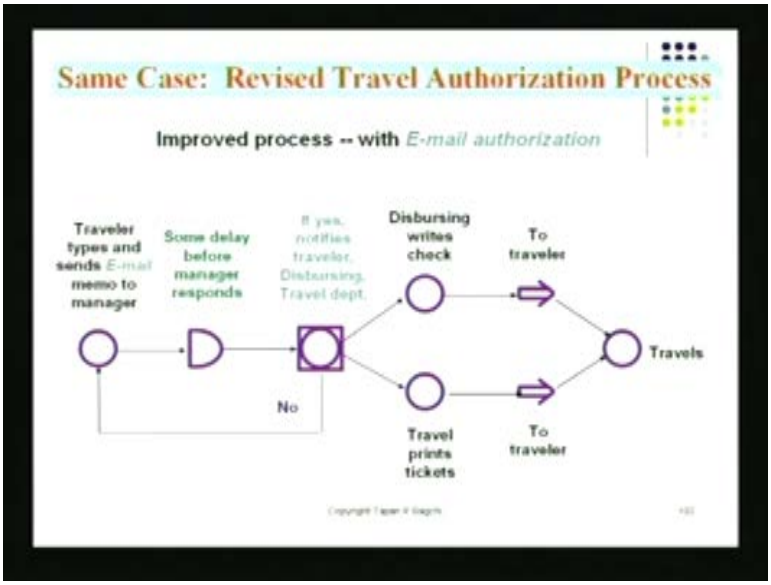
(Refer Slide Time: 44:15)



Just take a look at look at one of these examples. There was a simple travel authorisation process in the company and these authorisation problem process has been used for many years. For five six years people have been using it and no one had complained about it, the people followed these particular track and it went like there was an operation and there are transportation, then there was inspection done against some operation was there. Some operation was there, some transportation and this, what is being transported here? Some piece of paper some piece of paper actually which is picked up from somewhere, a little piece of papers on on which some material has been written and in that piece of paper is floated through this system and it goes from one end to the other. And that piece of paper is flowing through and it is following. This particular chart here, piece of the paper paper is flowing. The paper is flowing right from the beginning beginning to the end. In the original process, it take about four five days for authorisation to come back. It took about four or five days, if there are no problems it took four or five days for the authorisation to come back. This is the very cumbersome and bad process. Someone drew this flowchart before the flowchart was drawn of course, nothing was really done and let me tell you how this was done.

Some particular person has a rush job had a rush job he has to visit a customer in a rush manner. So, what he did was he filled out the form and when he came to his manager and his manager said leave it on my table, leave it in the inbox. Letter was left there but, then this person he is sort of hinted that no he really wanted to get out quickly so could he really ask for this little favour there and could this paper be then taken could this paper be when walked through the various department and perhaps he could do it himself or the secretary could do it. But, he really wanted this paper to go through the total process as quickly as possible so he could really call up and tell the customer, yes he was coming or he is not coming or whatever he wanted to confirm that date there. It turned out that when the paper was (( )) it found out it was found that in normal course of things it would take five days. Five days for the people to travel from one end to the other for the authorisation to be complete because some top implement has verified a lot of things. If it had any bill, any outstanding bill, if he hadn't really you know, settled your previous years account so on and so forth. All those checks have to be done by accounting people bunch of other people. They have to be done.

(Refer Slide Time: 46:44)

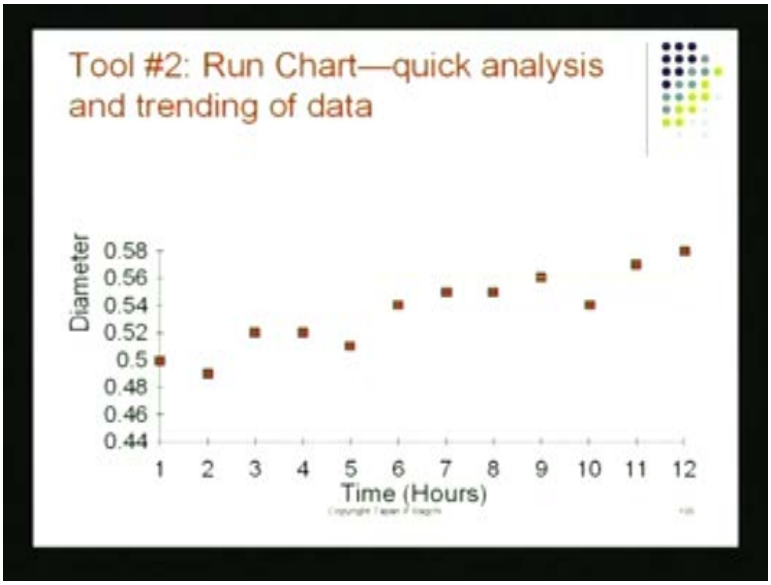


It turned out that when somebody took it good look at the process, he could combine many different steps and this authorisation could be done in twenty seven minutes and this, what is show here is the revised process. Clearly this was the result of a re-engineering but, of course,, the starting point was this flowchart the starting point of the flowchart from which this re-engineering could be done.

(Refer Slide Time: 47:06)

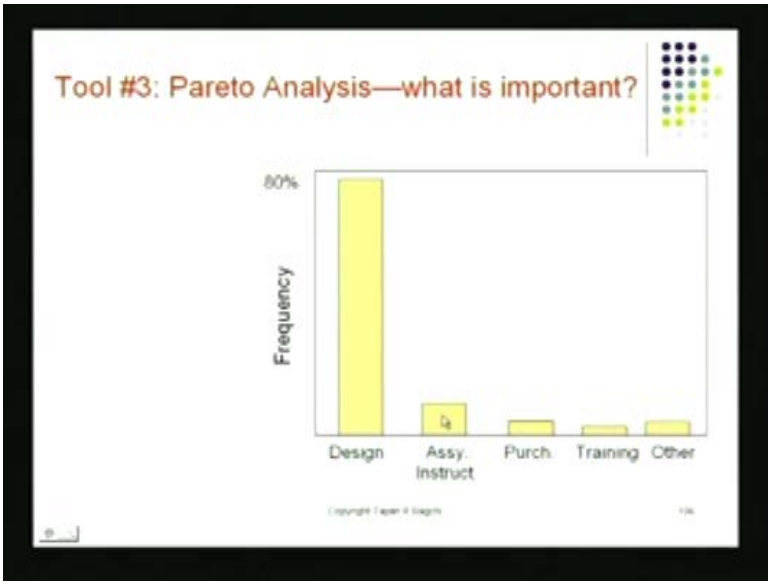
This was one tool and I have got couple of other examples of process flowcharts which you can see on the screen.

(Refer Slide Time: 47:10)



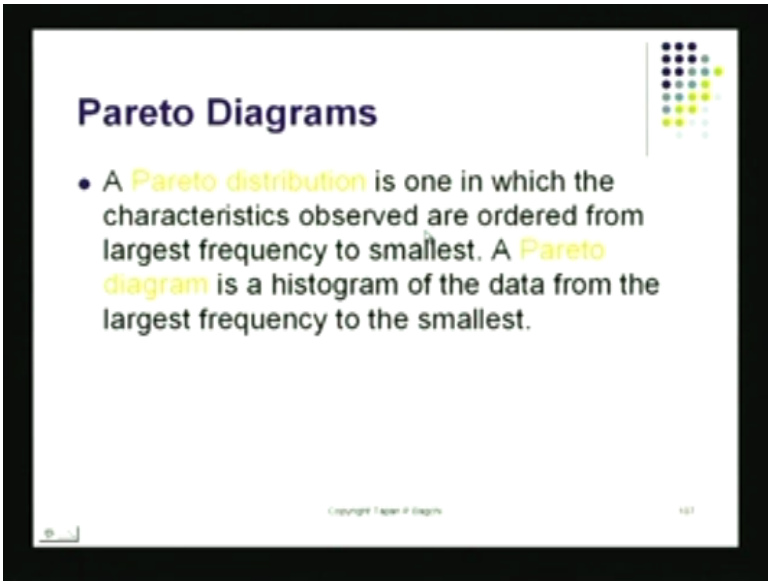
Then next tool is the is the run chart. Basically this is a chart when you start plotting the data as it occurs. Anything that you begin to plot; the moment you start making data visible, you will find action. This is so easy to see. In fact it turns out in many cases the moment I start drawing a chart; other people start noticing these things and there are any kind of acceptable limit, some tolerance limit set up on the chart there. That is like a high value and the low value anything above the high is no good anything below the low value is no good. Then people many people they will say and you yourself will start noticing oh, there is a trend there. It is very possible that these things is going to go beyond beyond the limit there and therefore, what we do is you basically get into the habit of plotting these things. Many times these things are not done and we do not study react till the things are really out of control altogether. So this is a run chart. It leads to quick analysis and trending of data.

(Refer Slide Time: 48:14)



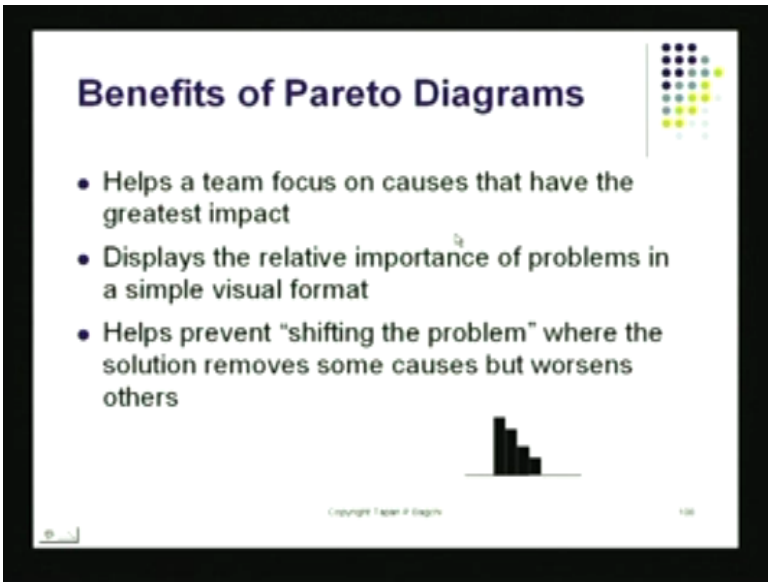
Then, there is something called the Pareto chart. This is also a simple TQM tool and what it really helps doing is, if there are various types of complaints; let us say there all kinds of complaints of customers then you do some diagnostics, you try to find out what could have gone wrong, you do the diagnostic and you classify the different complaints into various types of sources, various types of root causes and then you find that it turns out in this case that it many many of the complaints they could be routed to design. There is some issue with the design, there problem severe not severe but, it turns out to be design has caused most of the problems there. This is a very very important sort of message. Then you do not you do not really need to worry about all the other issues there. Focus first on design and get that fixed if you do that it would be leak out problem eighty percent of the problem. This is done by something that we call the Pareto analysis.

(Refer Slide Time: 49:10)



A Pareto analysis is great way to try to prioritise the different action that you could be taking.

(Refer Slide Time: 49:16)

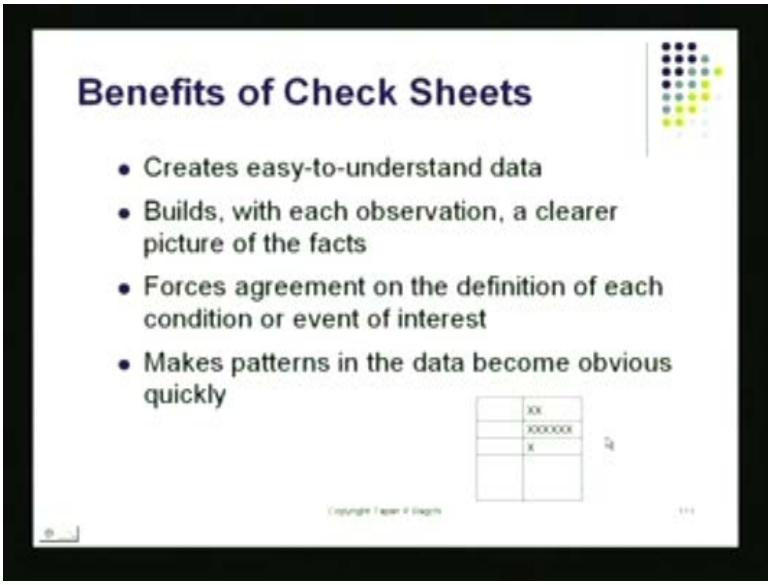


And there are certain benefits there that are also listed in the in the chart here you can actually see that on your screen there. You can read them later on also if you wish to.

(Refer Slide Time: 49:27)

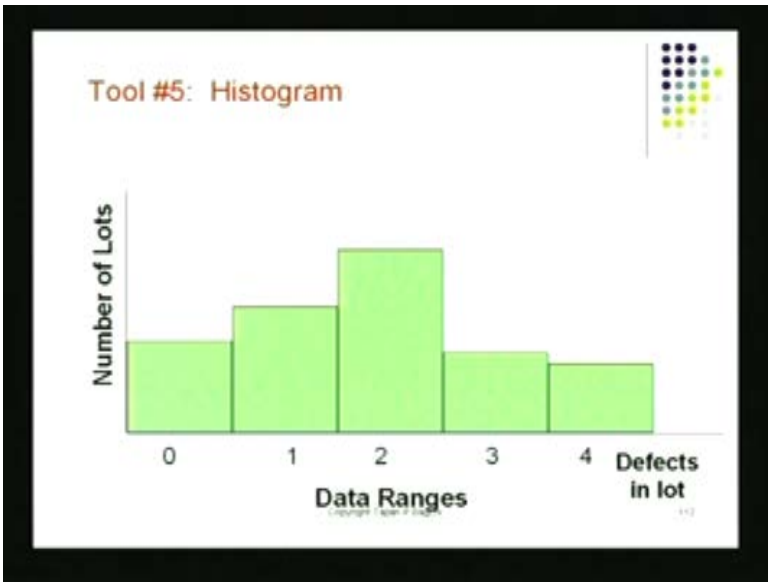
Then there is something called the checklist. The check sheet is also a easy data collection method. It is a very easy way to collect a lot of data and this is done some times when you are trying to classify (( )) between good and bad or you doing some traffic study or something and you want to categorise the data. And to do it very quickly you could just create these little check boxes and you start checking them. Notice here, I have put marks here I put him marks here, one two three four and fifth one goes like this. Then again, I go to one two three and then I wait for four and five, fifth one is going to go like this and so on. With these I can easily do quick count also five plus three is eight. I do not have to count all the bars from one end to the other. I get a block like this that is a five the next is three, five plus three that is going to be eight. Here I have got exactly five here got three you want get five plus two that is seven.

(Refer Slide Time: 50:22)



So this is easy way to do counting. Also check sheets and are again easy way to collect data and this is also something that you could really look out quite easily. And again you can replace by the tape here. You can replace the slide here and you can really see how you can utilise the check sheet.

(Refer Slide Time: 50:37)

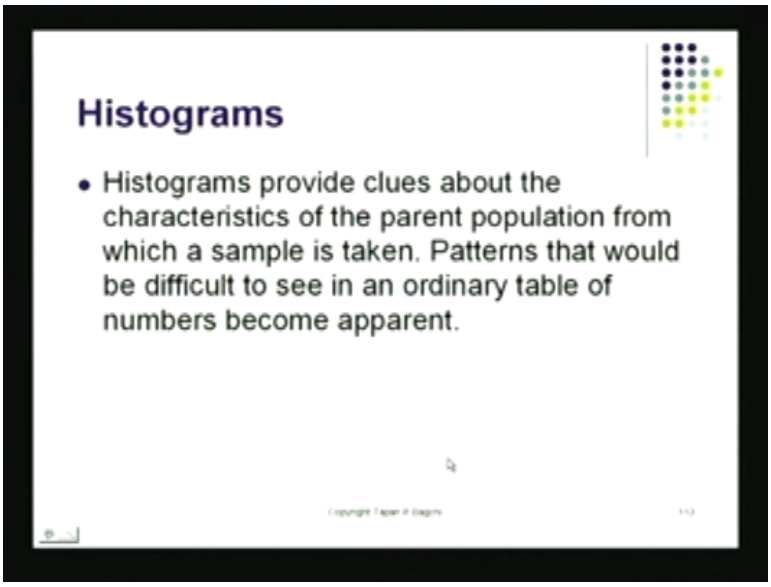


Then there is something called as histogram the histogram is a crude distribution of the output. Notice here the shape of the graph there. These steps are pretty well how the output is distributed. Output anything in fact; if you want to have, if you get some data

collect coming coming to you and you want to just get an idea, an overall idea the distribution of thing itself produce a histogram.

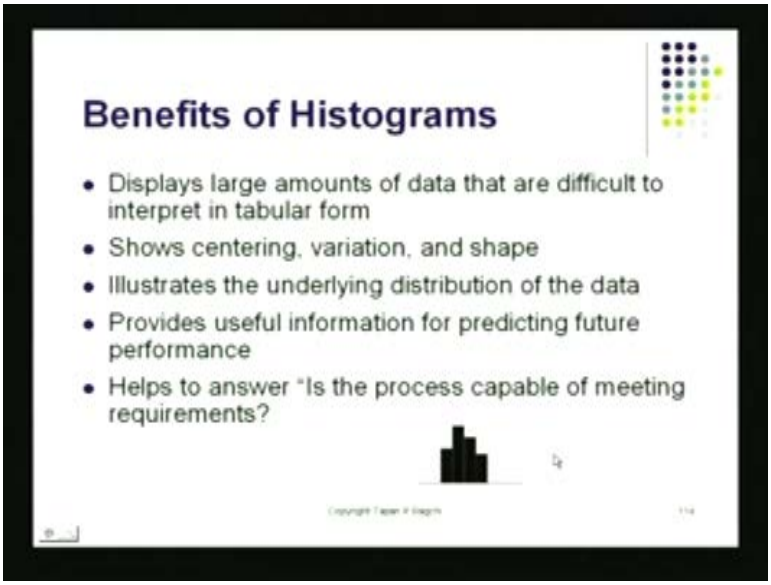
We do that quite often you know. When you do quality control, we do lot of histogram plotting and this is the real easy way to try to find out the frequency of various categories, figures of data in the various categories.

(Refer Slide Time: 51:10)



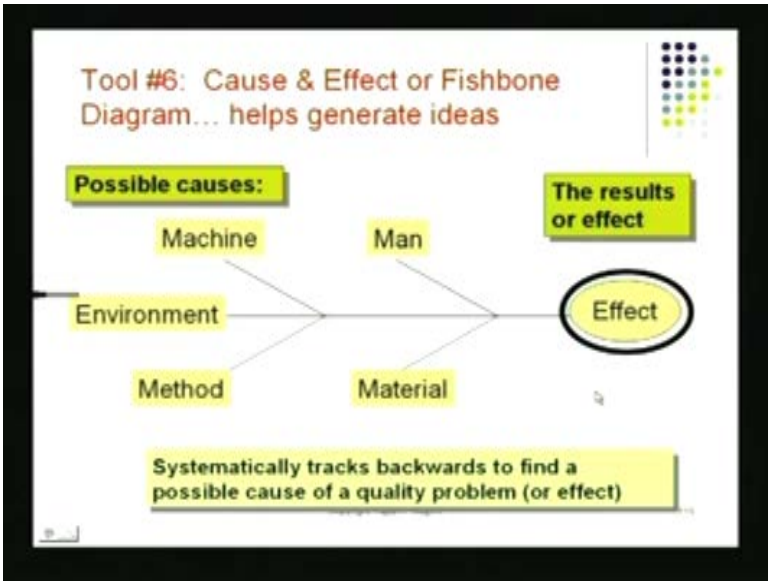
So there again I have given you the benefits.

(Refer Slide Time: 51:14)



And you can easily group them up and that will give you a pretty decent idea of whether the distribution is very wide or it is going to be peaking or it is going to be spread like this or whatever it is we will get a pretty descent idea of this. One advanced use of the histogram is to try to get an idea of something called process capability. That is like what fraction of production is beyond the specification limit. That also can be done if you if you plot the histogram if you find the tails are outside spec limit you know right away your process capability is not good enough. They are producing some material that is going to be off spec.

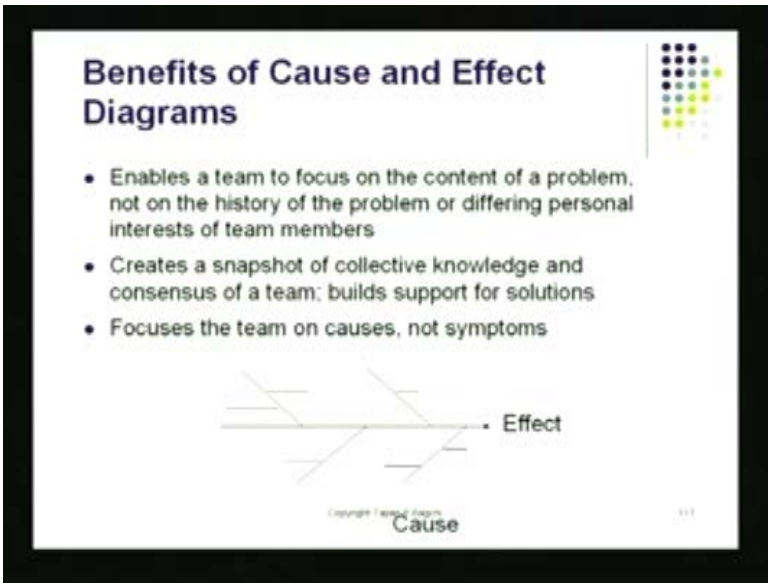
(Refer Slide Time: 51:47)



Then I am going to be having the tool. There is a tool called the cause and effect diagram. I must tell you this is probably the most important tool that we have in the tool kit of seven tools and let me show you the picture here and you will know right away now this is something you probably already seen. This is also call the fishbone diagram. I have the effect on the right hand side and the effect on the right hand side. I have got possible causes, this tool is used for brainstorming also. You have got categories like machines, man, environment, method and material. There could be man related factors that could be causing that effect, machine related factors that could causing the effect and environment related factors that could be causing the effect or method factors causing the effect or materials. This is the real easy way to generate ideas what might have caused that problem there. If there is a quality issue the cause and effect diagram or the fishbone

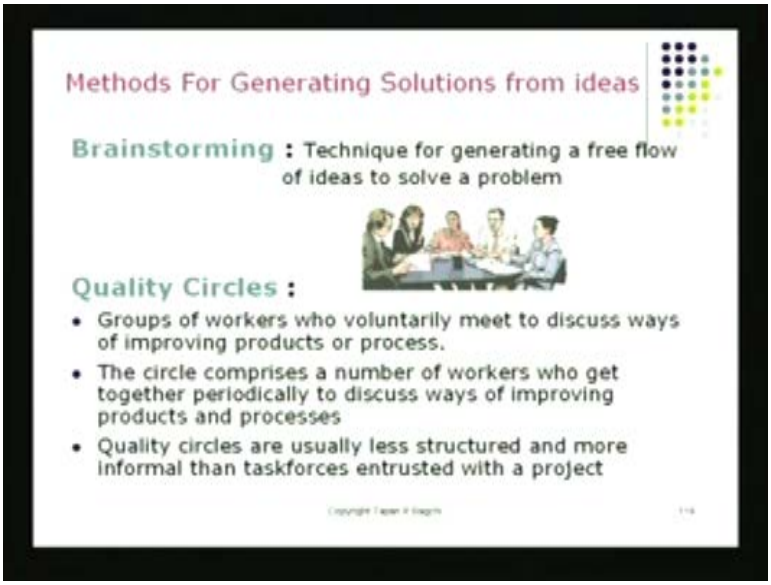
diagram is really easy way to you try to sort of brainstorm about this. I will give a couple of examples. I will give you an example and example is coming right now.

(Refer Slide Time: 52:52)



The effect is right to the right hand side and the possible cause is those are put out on the left hand side. I have got the effect on the right hand side. I have got the possible causes on the left hand side. This is the start of your troubleshooting. We are not solving the problem here but, you are brainstorming about factors that have might have contributed to the quality problem there. Remember what is important here is you are speculating at this point you are not solving the problem but, your brainstorming and this is used then in the brainstorming and here is a little brain storming group and they are using, they are they are formed a little quality circle.

(Refer Slide Time: 53:22)

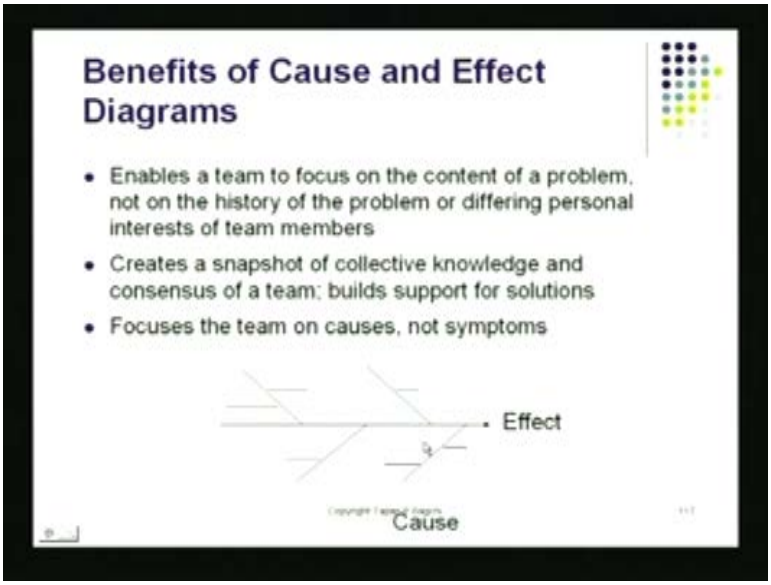


And their brainstorming and the tool they are using

(Refer Slide Time: 53:31)

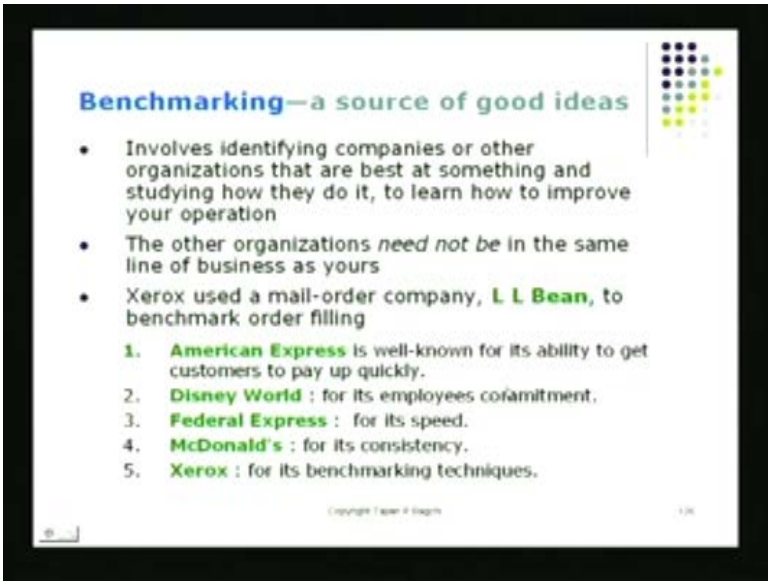
Is now the cause and effect diagram that is what they are using.

(Refer Slide Time: 53:34)



So they are using the cause and effect diagram to do their brainstorming.

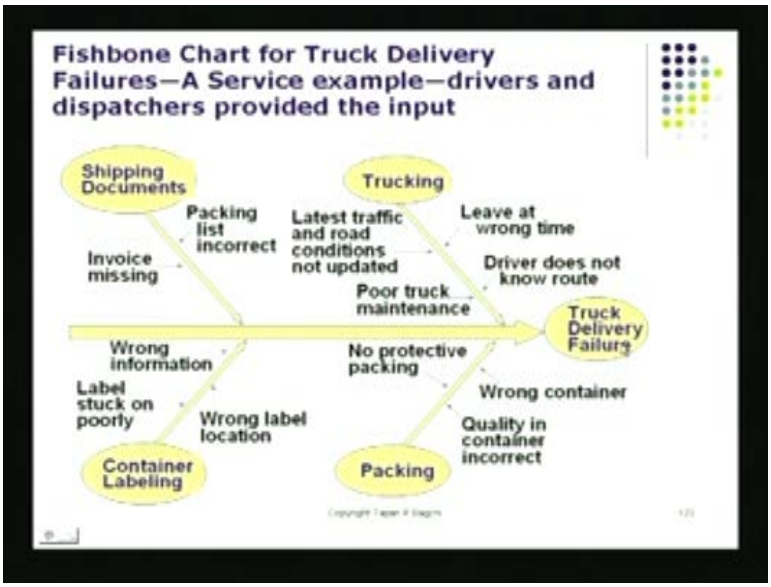
(Refer Slide Time: 53:38)



Then of course, many times there are ideas that can come from benchmarking. This also is another great way to generate good ideas. So, besides brainstorming by cause and effect diagram; you could also look at other processes which are running much better than yours and from that get ideas and I have given you names of some of the companies who which actually stand out as role models in benchmarking. Suppliers can also

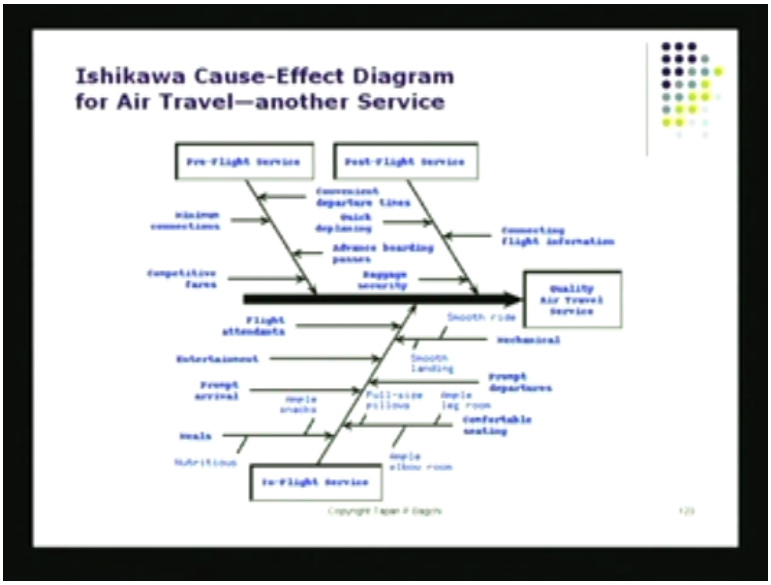
give a lot of ideas and that is like another place where you can solve where you can find ideas to toward solving your problem. That is also there.

(Refer Slide Time: 54:12)



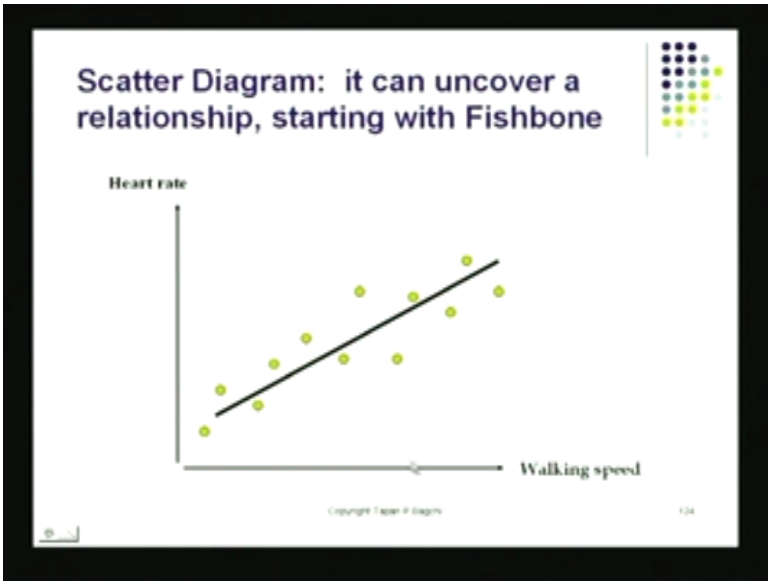
Again, if you come back to the cause and effect diagram; here is an example where there was there were delays in a companies delivering goods to the customer. What is that did they do? They got to the people who are closest to action. These were the drivers, the loaders and the drivers and what they found was my god there were whole lot of factors that nobody thought of and that could have any of those could have caused a delay in the delivery of the truck. If the track down, any of them shipping documents could be followed up, the trucking operation itself could be fouled up, the packing could be bad or the container labelling that also could be bad because of which you have delays in delivering the customer. This was generated by the drivers. What is here drivers and dispatchers, they provided the input and people were able to generate this thing. This would be the start. What I have go here as the cause and effect diagram, this is the start of solving the problem. This might itself is not a solution it might lead to a solution. What what we are pointing about, pointing out is that; this is the brainstorming tool you look at you basically speculative about possible causes.

(Refer Slide Time: 55:22)



And here is another example, where we have got some problems with air travel and we want to really try to improve the, we want to really improve the level of the air travel quality there.

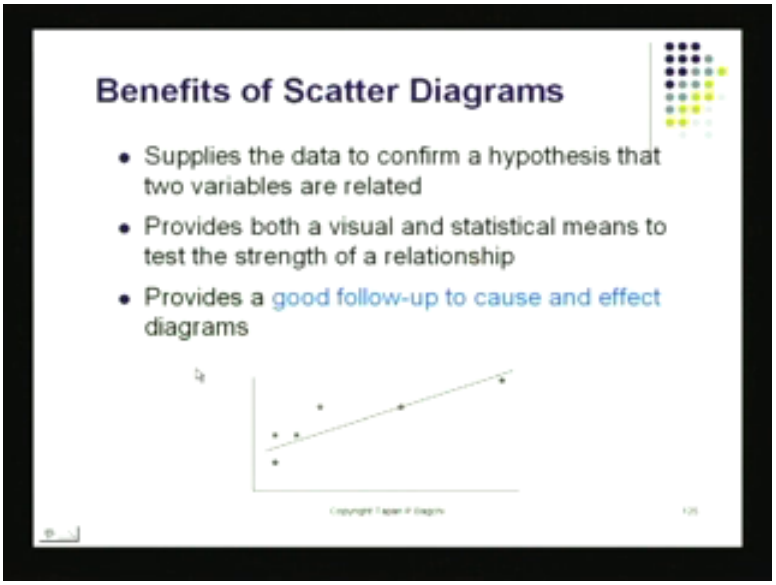
(Refer Slide Time: 55:33)



And for that you go after that. Now suppose I have got a cause and effect diagram and I look at one of the factors there I look at for example, some aspect that is there some aspect that is there and that could have caused a problem; I could draw a quick what we call a scatter diagram. I put the factor down here I could put the effect down here up here

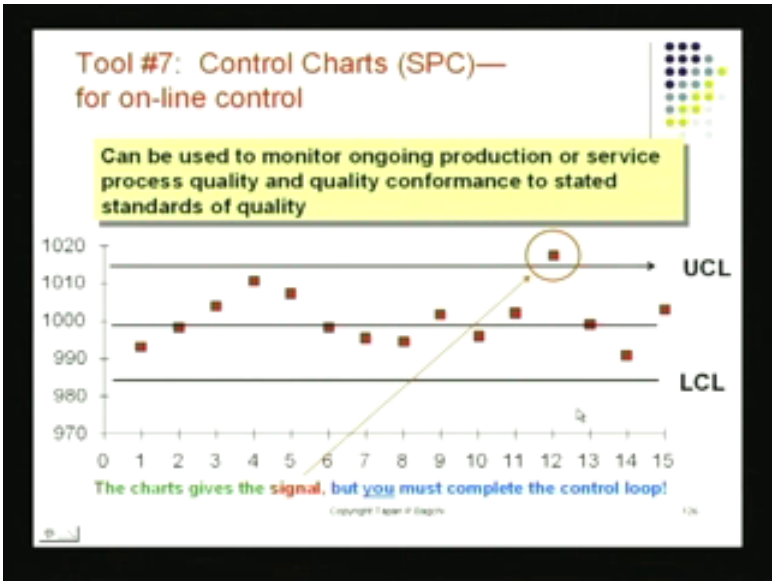
and I could really see is there a relationship between these two. If there is some relationship then I have to handle now on the problem. The problem is here the problem on the y axis and I have got my control factor from the x axis with this I am I am likely going going to be able to control the effect.

(Refer Slide Time: 56:13)



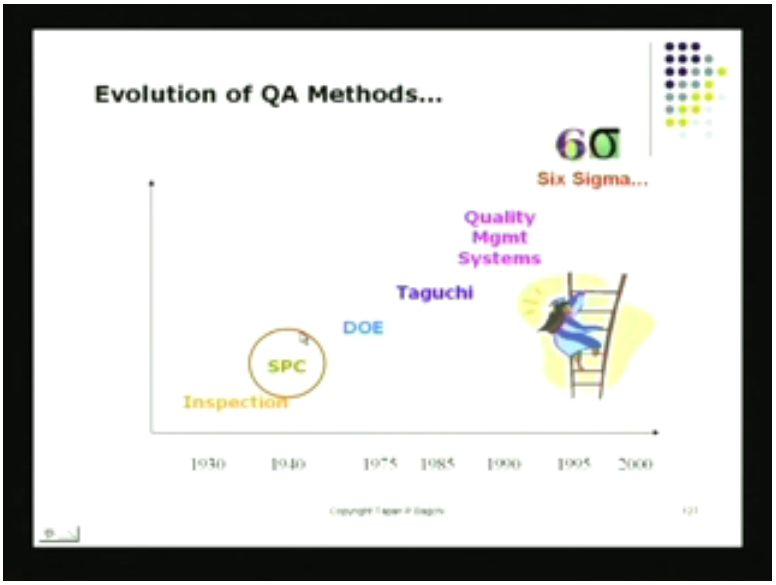
That is like 1 great way to try to tackle quality. I have given you couple of examples here for doing this.

(Refer Slide Time: 56:13)



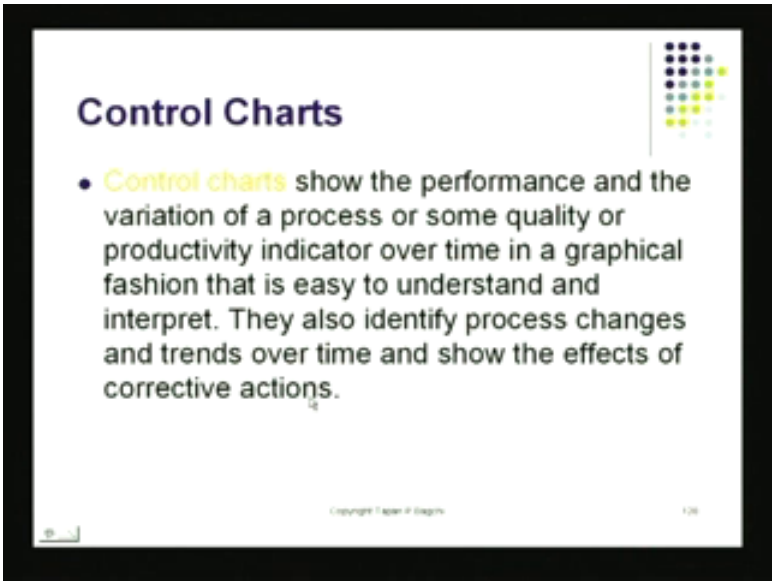
Then this last shot this is called the control chart. This is SPC; statistical process control chart. This I am going to be discussing great detail when I discuss SPC with you but, it is a way to try to, remember two things we mentioned. We mentioned the issue of accuracy and also we mention the issue of precision. In a general manufacturing process both of these could be problems; I could have problems on accuracy, I could also problems on precision. Both of these can be got in control by use of the control chart. The control chart itself becomes the greatest tool for doing the, there are two types of charts used here the x bar chart and the r chart. I am going to be giving you details on them.

(Refer Slide Time: 56:56)



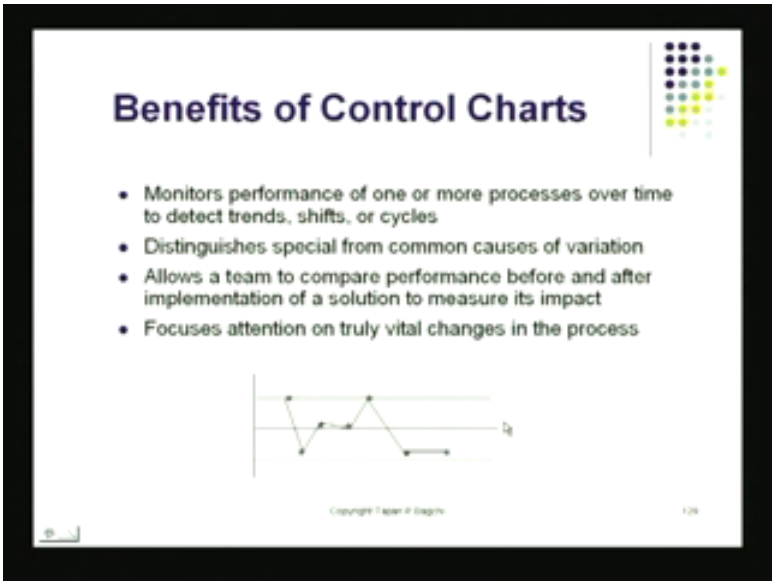
So where I am now? In regard to march on quality I am right down at SPC. Then I am talking about control charts.

(Refer Slide Time: 57:04)



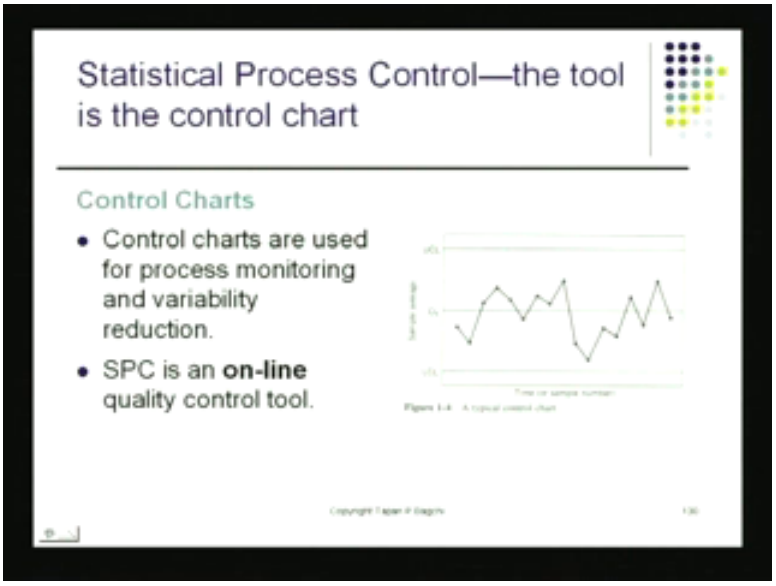
And control charts, they are a great way to try to keep a process in control online.

(Refer Slide Time: 57:11)



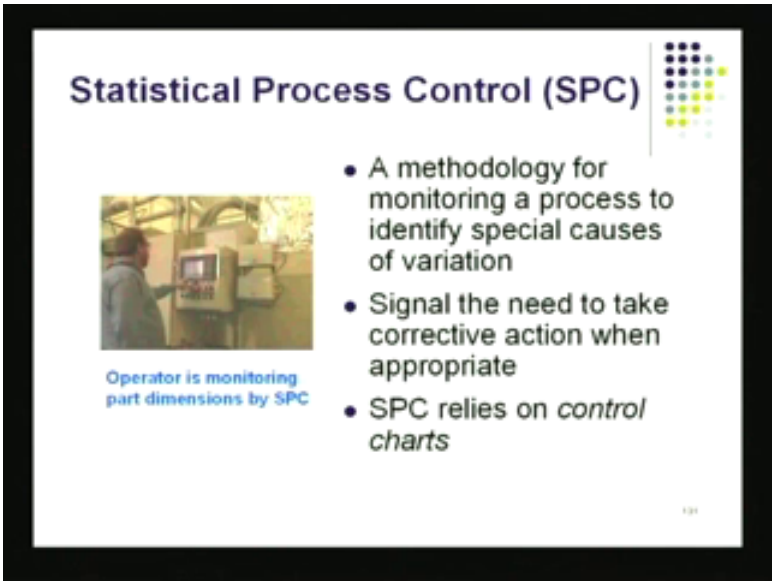
Very, very important and there are certain signals that are provided by the control chart.

(Refer Slide Time: 57:15)



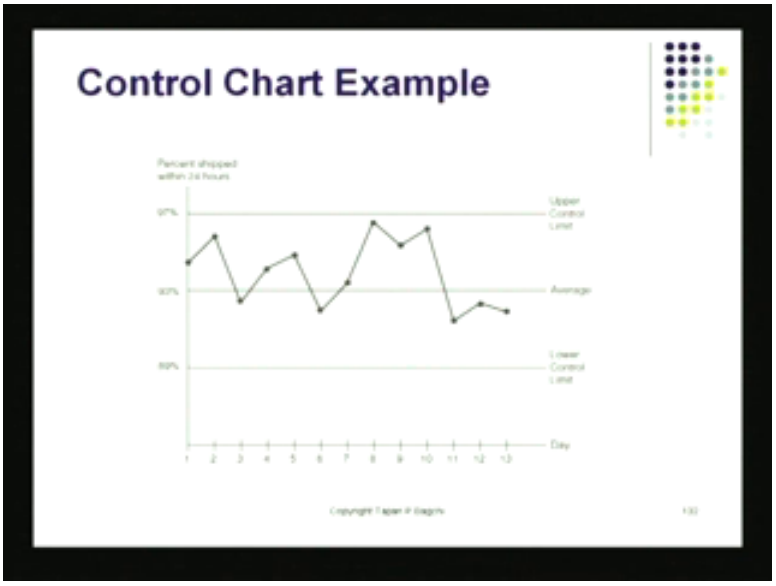
And if you keep going this way; you have a control chart that is also partially automated

(Refer Slide Time: 57:17)



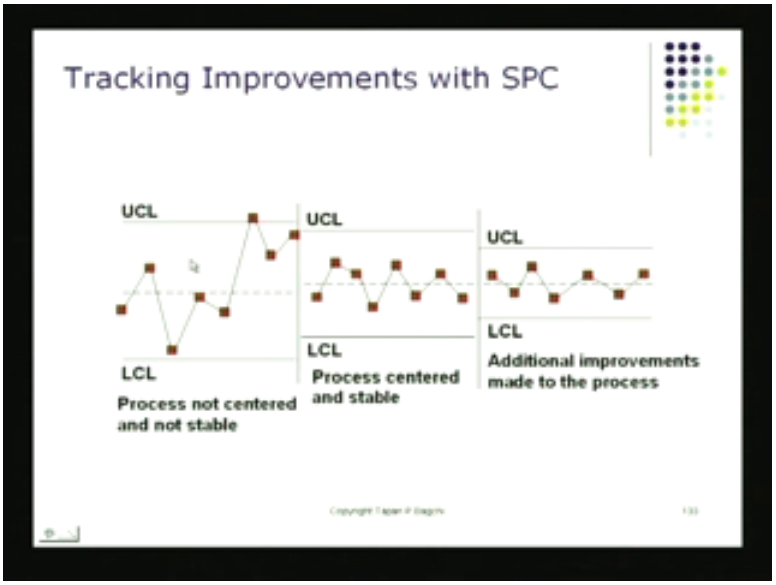
because automated data collection is possible in many cases.

(Refer Slide Time 57:23)



You must start with the chart that is start with the wide variation showing.

(Refer Slide Time: 57:25)



Initially, there is poor precision and also poor accuracy. As you move slowly toward it; your precision may improve and also your accuracy may improve and you end up with the much, much better process. This is where you would really like to go to.

(Refer Slide Time: 57:42)

So the seven tools that we looked at; this is basically a summary of it. We have got the run chart, histogram, control chart, Pareto chart, flow chart, scatter diagram and the cause and effect diagram. They are the tools that can be used by almost anyone on the shop floor and the Japanese make sure their workers are trained on each of these tools and they use it. I will continue with this and let us just take a small break and then we go on with the next lecture.

Thank you very much. Thank you.