Inspection and Quality Control in Manufacturing
Prof. Kaushik Pal
Department of Mechanical and Industrial Engineering
Indian Institute of Technology Roorkee

Lecture – 02
Need of Inspection: Types and Principles

Hello my friends so now we are going to discuss our 2nd chapter on Inspection and Quality Control in Manufacturing. Basically, the chapter deals with the need of inspection like its types and principles. So first we have to need that why we have need the inspections? Why it is required?

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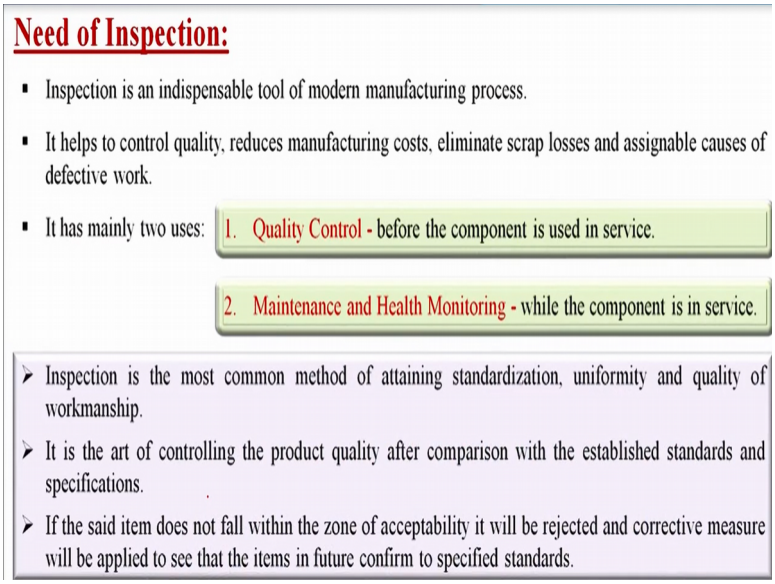

So, the inspections in an indispensable tool of modern manufacturing process. It helps to control quality, reduces manufacturing costs, eliminate scrap losses and assignable causes of defective parts. It has mainly two types one is called the Quality Control – before the component is used in services another one is called the Maintenance and Health Monitoring – while the component is in service

Inspection is the most common method of attaining standardization, uniformity and quality of workmanship. It is the art of controlling the product quality after comparison with the established standards and specifications. If the said item does not fall within the zone of acceptability it will be rejected and corrective measure will be applied to see that the items in future confirm to specified standards.

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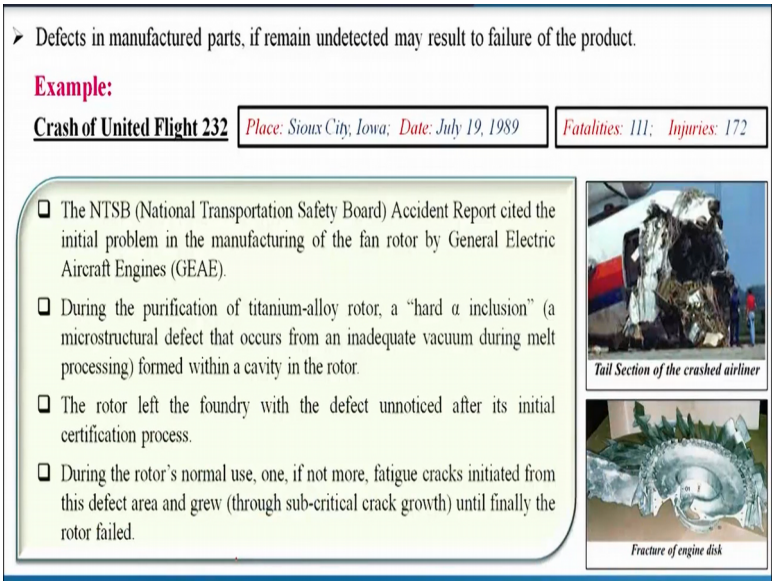

Defect in manufactured parts, if remain undetected may result to failure of the product. I can give you an very good example. Example like Crash of United Flight 232, it has been taken place in Sioux City, Iowa, date was July 19 1989; Fatalities was 111 and 172 people got injured. The NTSB National Transportation Safety Board Accident Report cited the initial problem in the manufacturing of the fan rotor by General Electric Aircraft Engines.

During the purification of titanium alloy rotor, a hard-alpha inclusions, a microstructural defect that occurs from an inadequate vacuum during melt processing formed within a cavity in the rotor itself. The rotor left the foundry with the defect unnoticed after its initial certification process. During the rotor's normal use, one, if not more, fatigue cracks initiated from this defect area and grew through sub critical crack growth and until finally the rotor failed.

So you can see that from here from where actually the defect starts and then after that one what is the severity of that particular defects

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What are the purpose of inspection? The purpose of inspection is to distinguish good lots from bad lots, to distinguish good pieces from bad pieces, to determine if the process is changing, to determine if the process is approaching the specification limits, to rate quality of product, to rate accuracy of inspectors, to measure the precision of the measuring instrument, to secure product design information, to measure process capability. So these are all the purposes of doing the inspection.

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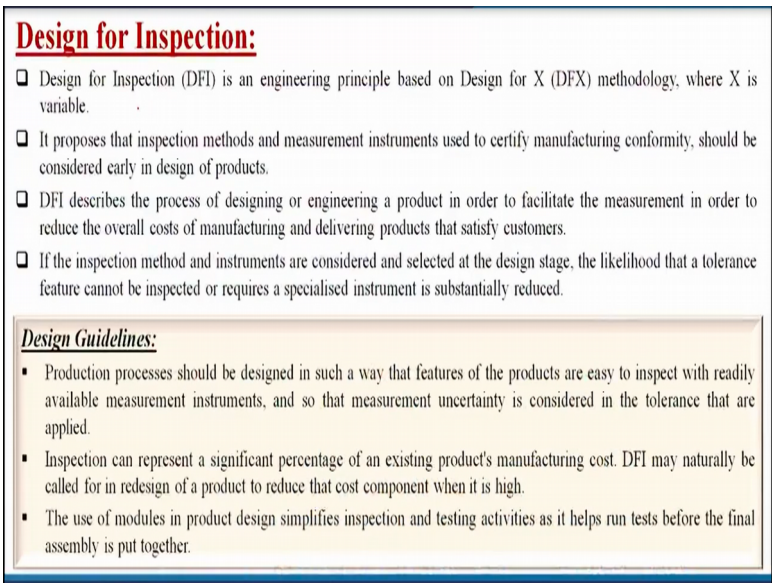

What is the design for inspection? Design for inspection is an engineering principle based on Design for X methodology, where X is variable. It proposes that inspection methods and measurement instruments used to certify manufacturing conformity, should be considered early in design of products. DFI that means Design For Inspection, describes the process of

designing or engineering a product in order to facilitate the measurement in order to reduce the overall costs of manufacturing and delivering products that satisfy the customers.

If the inspection method and instruments are considered and selected at the design stage, the likelihood that a tolerance feature cannot be inspected or requires a specialised instrument is substantially reduced. What are the Design Guidelines? So the production processes should be designed in such a way that features of the products are easy to inspect with readily available measurement instruments, and so that measurement uncertainty is considered in the tolerance that are applied.

Inspection can represent a significant percentage of an existing product manufacturing cost. DFI may naturally be called for in redesign of a product to reduce that cost component when it is high. The use of modules in product design simplifies inspection and testing activities as it helps run tests before the final assembly is put together. Next what are the classification of Inspection? So there are total number of six.

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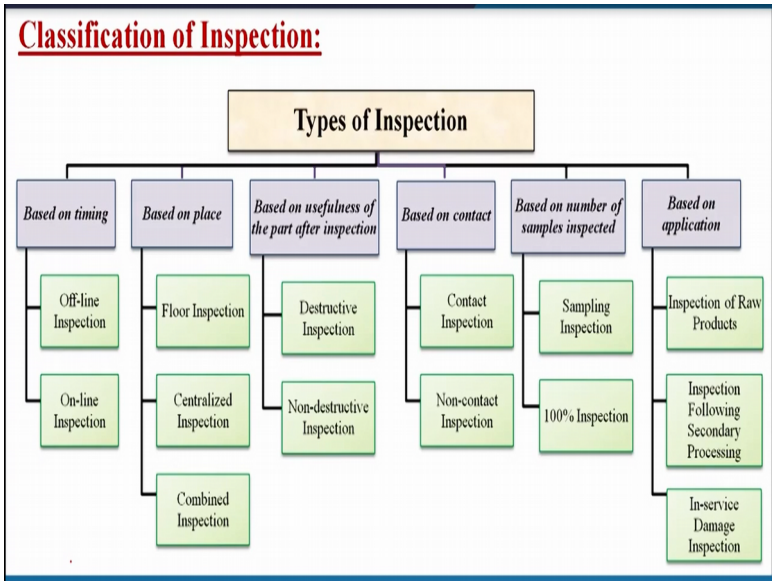

broad classifications are available for types of inspection. First one is called the Based on timing either it may be the Off-line inspection or the On-line Inspection. Next is called the Based on place either it may be Floor Inspection, Centralized Inspections or may be the Combined Inspection. Then third one is called the Based on Usefulness of the part after inspection either it is Destructive Inspection or may be the Non-destructive Inspection.

Based on Contact whether it is Contact Inspection or may be the Non-contact Inspection. Based on number of samples inspected - Sampling Inspection or may be the 100 percent Inspection. Last one is the Based on application Inspection of Raw Products, Inspection following Secondary Processing, In-service Damage Inspection.

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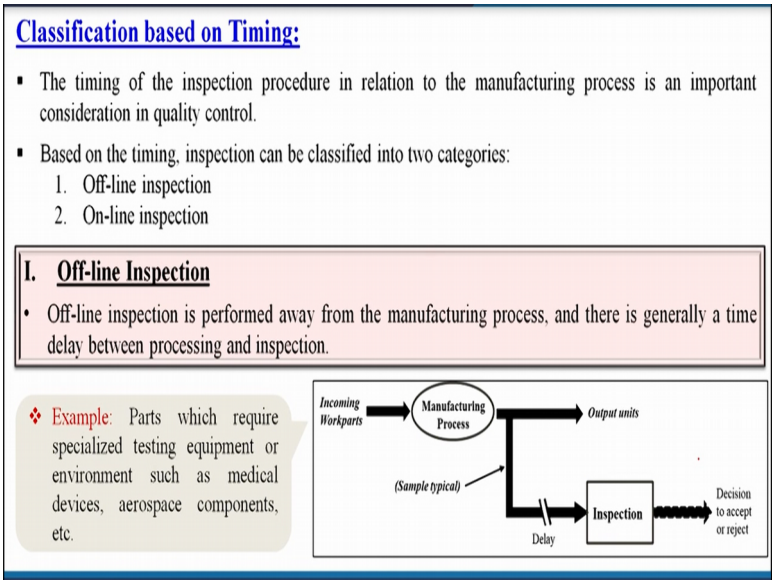

So Classification based on timing. The timing of the inspection procedure in relation to the manufacturing process is an important consideration in quality control. Based on the timing, inspection can be classified into two categories, one is called Off-line inspection another one is called on-line inspection

What is Off-line inspection? Off-line inspection is performed away from the manufacturing process, and there is generally a time delay between processing and inspection which we have discussed in detail in our previous lecture. What are the examples, parts which require specialized testing equipment or environment such as medical devices, aerospace components, etc. So from these particular image you can easily understand the Off-line inspection.

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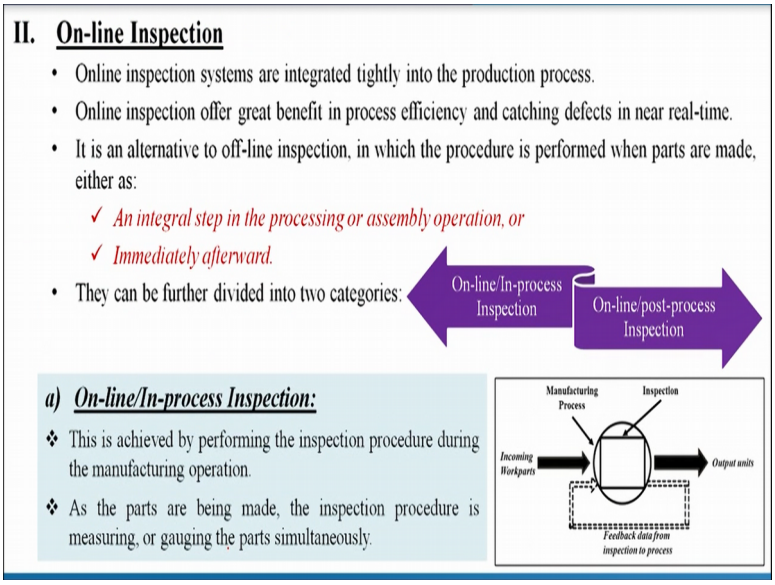

Next one is called the On-line inspection. Online inspection systems are integrated tightly into the production process. So it is a continuous monitoring process. Online inspection offer great benefit in process efficiency and catching defects in near real-time. It is an alternative to offline inspection, in which the procedure is performed when parts are made either as an integral step in the processing or assembly operation, or immediately afterward.

can be further divided into two categories Online or may be the in-process inspection, online or may be the post process inspection. What is Online in-process inspection. This is achieved by performing the inspection procedure during the manufacturing operation. As the parts are being made, the inspection procedure is measuring or gauging the parts simultaneously. So from these particular image you can understand the Online in-process inspection.

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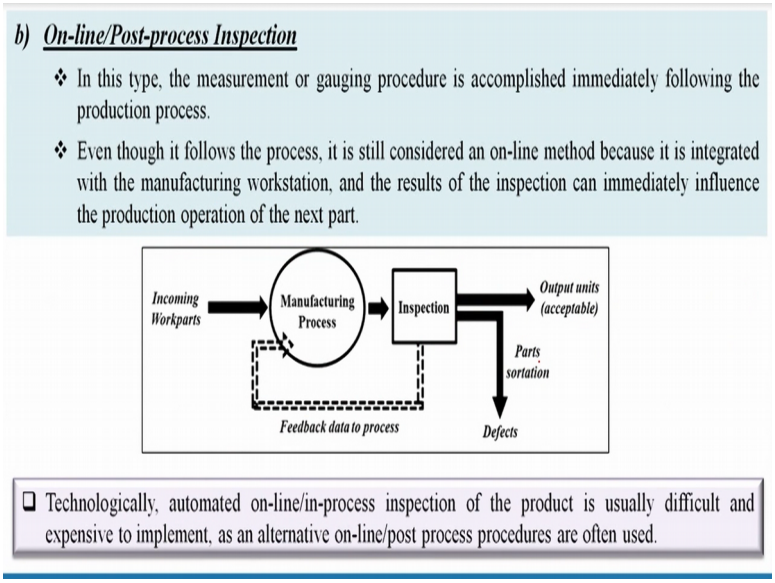

What is online post process inspection? From the name itself you can understand that in this type the measurement or gauging procedure is accomplished immediately following the production process. Even though it follows the process, it is still considered an online method because it is integrated with the manufacturing workstation, and the result of the inspection can immediately influence the production operation of the next part.

Technologically, automated online in-process inspection of the product is usually difficult and expensive to implement, as an alternative online post-process procedure are often used.

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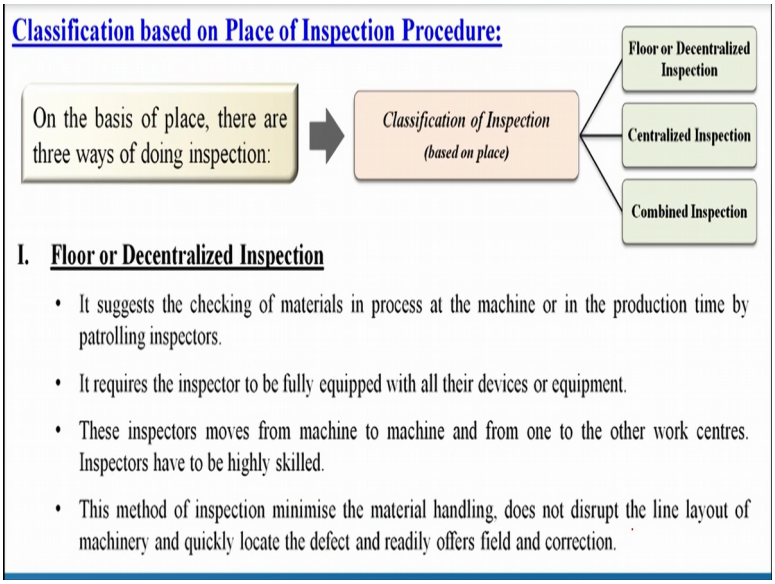

Now Classification based on Place of inspection procedure. On the basis of place there are three ways of doing inspection. Classification of inspection based on place what are those are floor or decentralized inspection, centralized inspection and the combined inspection. What is Floor or Decentralized inspection? It suggests that the checking of materials in process at the machine or in the production time by patrolling inspectors.

It requires the inspectors to be fully equipped with all their devices or equipment. That is a called a one kind of random checking. These inspectors moves from machine to machine and from one to the other work centres. Inspectors have to be highly skilled. This method of inspection minimise the material handling, does not disrupt the line layout of machinery and quickly locate the defect and readily offers field and correction.

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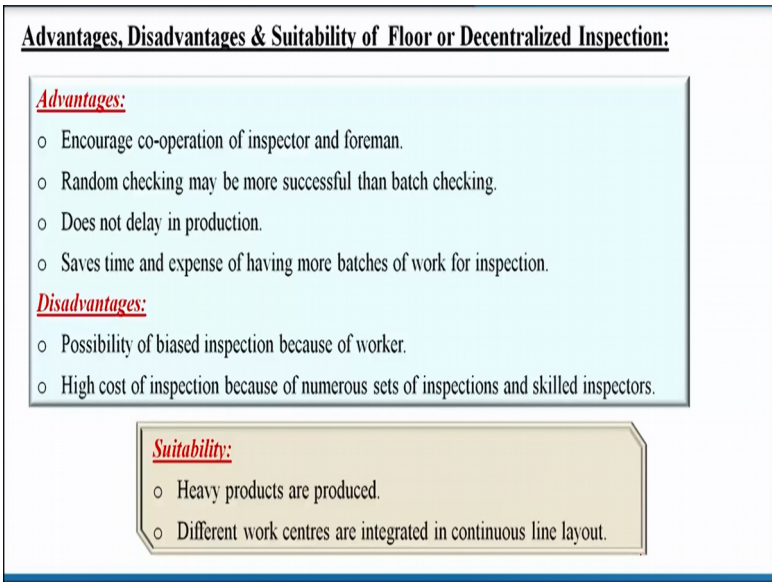

Next advantages, disadvantages and suitability of floor or decentralized inspection. What are the advantages? It encourage co-operation of inspector and foreman, random checking may be more successful than batch checking, does not delay in production and saves time and expense of having more batches of work for inspection. What are the disadvantages? Possibility of biased inspection because of worker, higher cost of inspection because of numerous sets of inspections and skilled inspectors are required.

What are the suitability? heavy products are produced, different work centres are integrated in continuous line layout. Next come to the centralized inspection.

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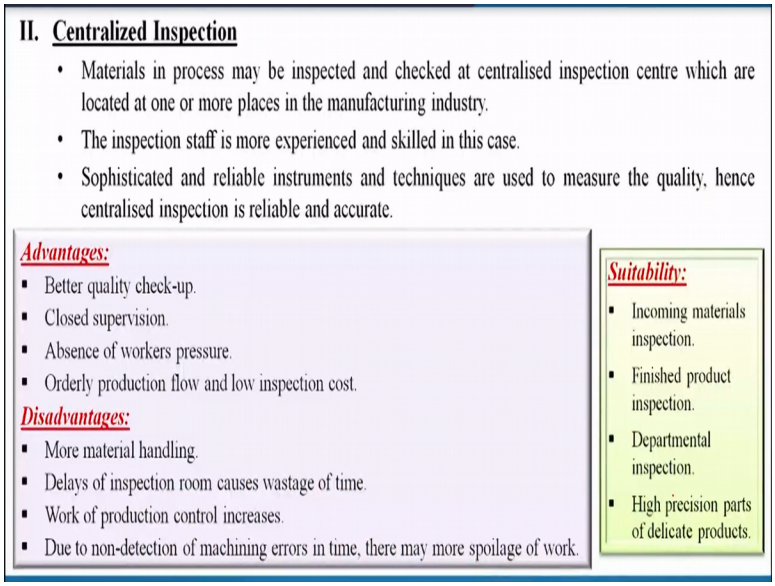

Materials in process may be inspected and checked at centralised inspection centre which are located at one or more places in the manufacturing industry. The inspection staff is more

experienced and skilled in this particular case. Sophisticated and reliable instruments and techniques are used to measure the quality, hence centralised inspection is reliable and accurate. What are the advantages? Better quality check-up, closed supervision, absence of workers pressure, orderly production flow and low inspection cost.

What are the disadvantages? More material handling, delays of inspection room causes wastage of time, work of production control increases, due to non-detection of machining errors in time, there is more spoilage of work. What are the suitability? Incoming materials inspection, finished product inspection, departmental inspection, high precision parts of delicate products.

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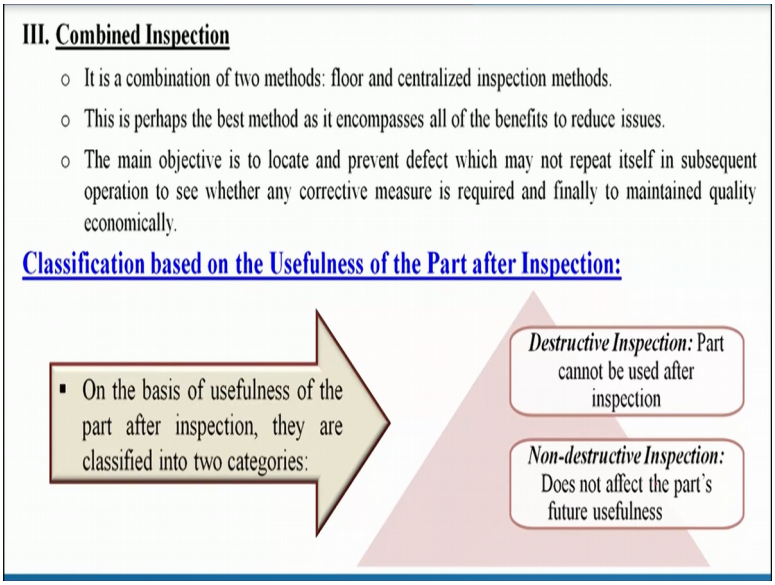

Next come to the third that is the known as the Combined inspection. It is a combination of two methods, floor and centralized inspection methods. This is perhaps the best method as it encompasses all of the benefits to reduce issues. The main objective is to locate and prevent defect which may not repeat itself in subsequent operation to see whether any corrective measure is required and is finally to maintain the quality economically.

Classification based on the usefulness of the part after inspection. On the basis of usefulness of the part after inspection, they are classified into generally two categories; one is called the destructive inspection part cannot be used after inspection so either may sometimes we need to break the parts to trace the particular material or may be we have to do some kind of materials by which the parts can be damaged.

And second one is called the non-destructive inspection from the name itself you can understand that we can measure the parts its dimensions and everything but without harming that particular material properties or may be the parts. Does not affect the part's future usefulness.

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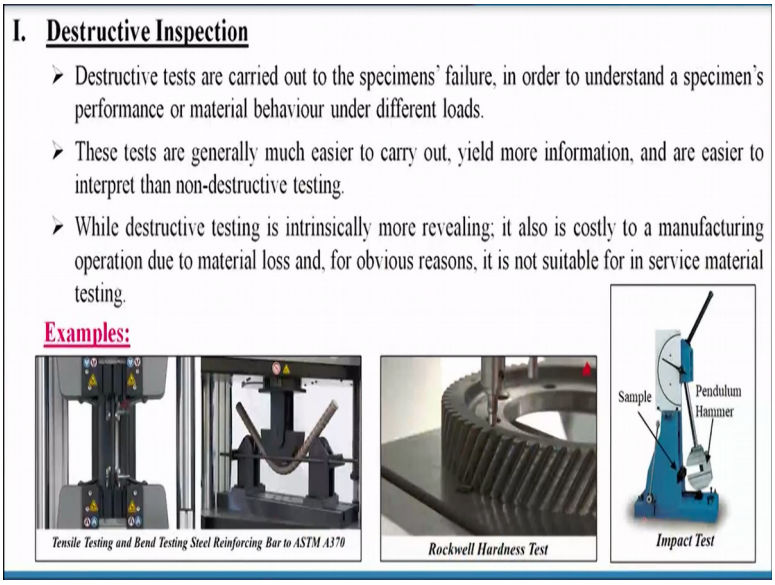

What is destructive inspections? As I told Destructive inspections tests are carried out to the specimens' failure, in order to understand a specimens' performance or material behaviour under different loads. These tests are generally much easier to carry out, yield more information, and are easier to interpret than non-destructive testing. While destructive testing is intrinsically more revealing; it also is costly to a manufacturing operation due to material loss because after that we cannot use that particular products and may be the parts, for obvious reasons, it is not suitable for in service material testing.

So, examples like, tensile testing, bend testing so we are breaking that particular materials or may be we are elongating that particular materials for Rockwell Hardness test we are just hitting that materials with some hard point or may be the diamond so it can make a scratch over there or may be some kind or impact testing.

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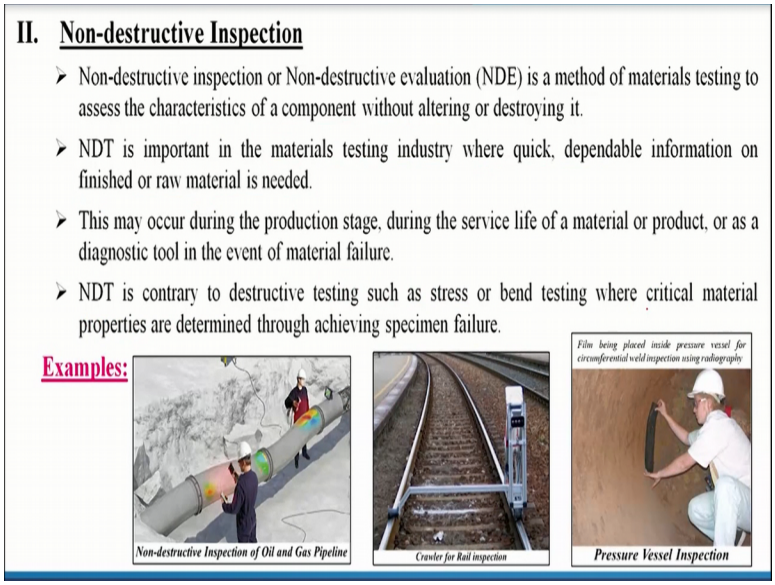

When you are talking about the non-destructive inspections, so from the name itself we can understand that the non-destructive means we are not going to harm that particular parts or we may be the equipment. So Non-destructive inspection or Non-destructive evaluation is a method of materials testing to assess the characteristics of a component without altering or destroying it. In short non-destructive inspections is sometimes known as NDT.

So, NDT is important in the material testing industry where quick, dependable information on finished or raw material is required. This may occur during the production stage, during the service life of a material or product, or as a diagnostic tool in the event of material failure. NDT is contrary to destructive testing such as stress or bend testing where critical material properties are determined through achieving the specimen failure.

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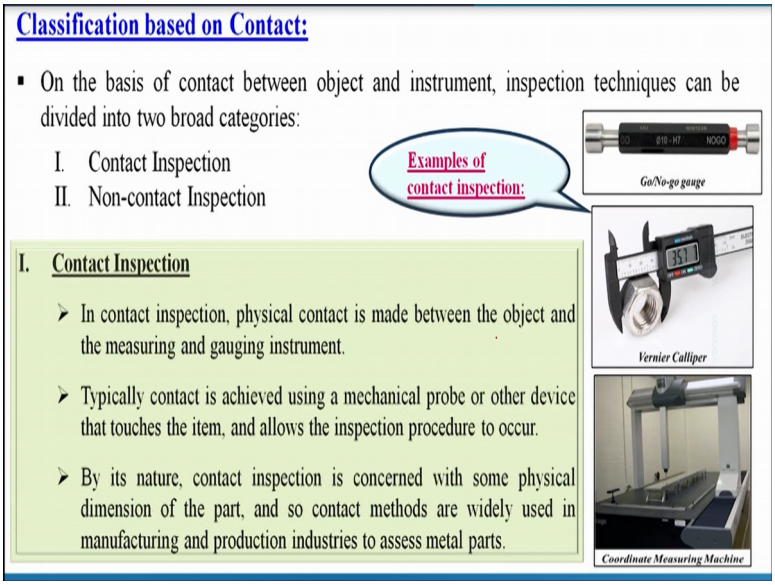

So here you can see we have given so many examples of the non-destructive testing. Now classification based on contract. On the basis of contact between object and instrument, inspection techniques can be divided into two broad categories; one is called the contact inspections and another one is called the non-contact inspections.

So, Contact inspections; In contact inspection, physical contact is made between the object and the measuring and gauging the instrument. Say suppose I want to measure the diameter of any particular tube or may be the pipe so I am going to use some kind of Vernier calliper or may be some kind of measuring techniques in which I have to touch that particular parts. So that is why it is known as the contact inspection.

Typically contact is achieved using a mechanical probe or other deice that touches the item, and allows the inspection procedure to occur. By this nature, contact inspection is concerned with some physical dimension of the part, and so contact methods are widely used in manufacturing and production industries to assess the metal parts. So here we have given some examples of the contact inspection.

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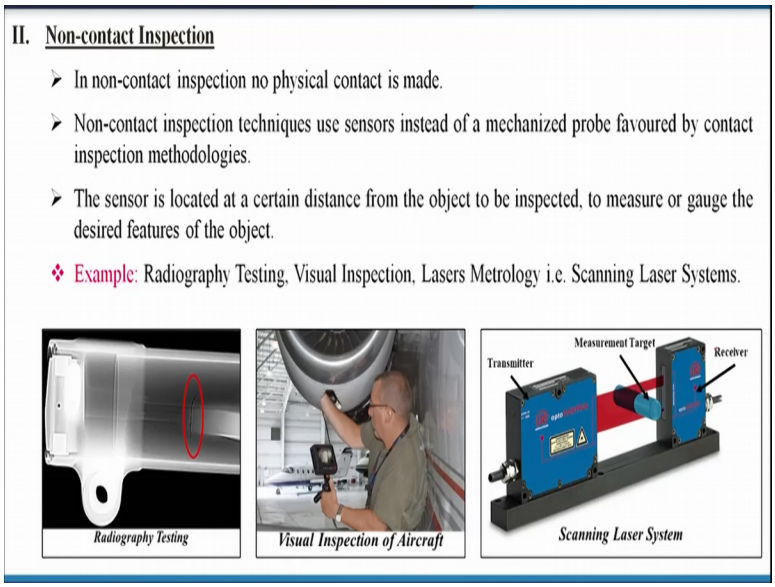

Now, what are the non-contact inspections? In Non-contact inspection no physical contact is made with the parts or may be the products. Non-contact inspection techniques use sensors instead of mechanized probe favoured by contact inspection methodologies. The sensor is located at a certain distance from the object to be inspected, to measure or gauge the desired features of the object. What are the examples? radiography testing, visual inspection, laser metrology that means scanning laser systems.

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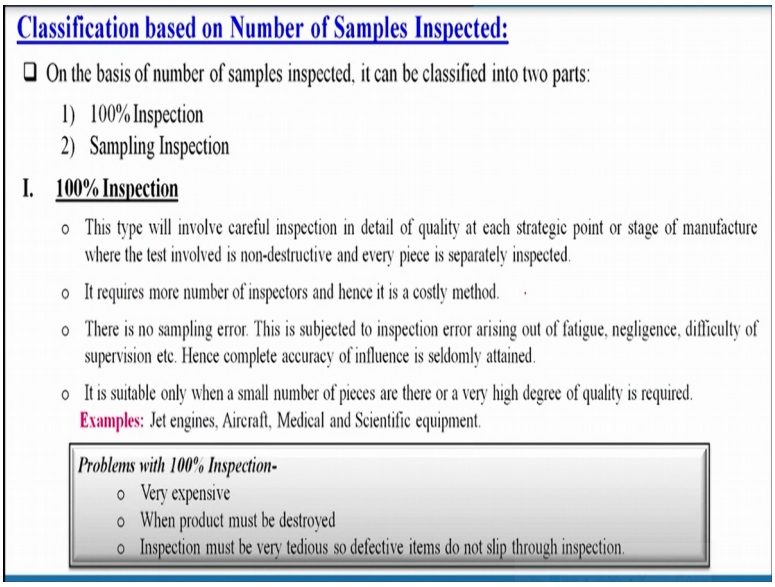

So, these are all the examples of the non-contact inspections. Now, classification based on number of samples inspected. On the basis of number of samples inspected, it can be classified into two parts one is called the 100% inspection and the other one called the sampling inspections. So what is 100% inspection? Generally, this type will involve the careful inspections in detail of quality at each strategic point or stage of manufacture where the test involved is non-destructive and every piece is separately inspected.

It requires more number of inspectors and hence it is a costly method. There is no sampling error. This is subjected to a inspection error arising out of fatigue, negligence, difficulty of supervision etc. hence complete accuracy of influence is seldomly attained. It is suitable only when a small number of pieces are there or a very high degree of quality is required. Examples like, jet engines, aircraft, medical and scientific equipment where we cannot put or may be tolerate the 0% error also.

Problems with 100% inspection. It is very expensive, when product must be destroyed, inspection must be very tedious so defective items do not slip through inspection, where we need the very very high accuracy and precision.

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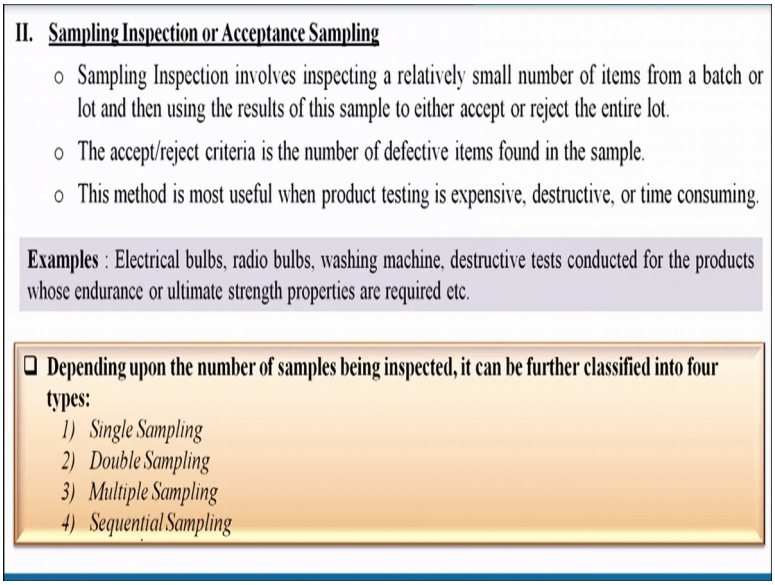

Next sampling inspections or acceptance sampling. Sampling inspection involves inspecting a relatively small number of items from a batch or lot and then using the results of this sample to either accept or reject the entire lot. The accept or reject criteria is a number of defective items found in the sample. In this case we can put some kind of consideration, if it is exactly not accurate as for the design part also but we can think ok some plus minus value within the allowance or with the tolerance it can be accepted and it will not give any kind of light threat or may be a total equipment failure kind of things.

This method is most useful when product testing is expensive, destructive or may be the time consuming. What are the examples? Like electrical bulbs, radio bulbs, washing machine, destructive tests conduct for the products whose endurance or ultimate strength properties are required. Depending upon the number of samples being inspected, it can be further classified into four categories, one is called the single sampling, next double sampling, then multiple sampling and the sequential sampling.

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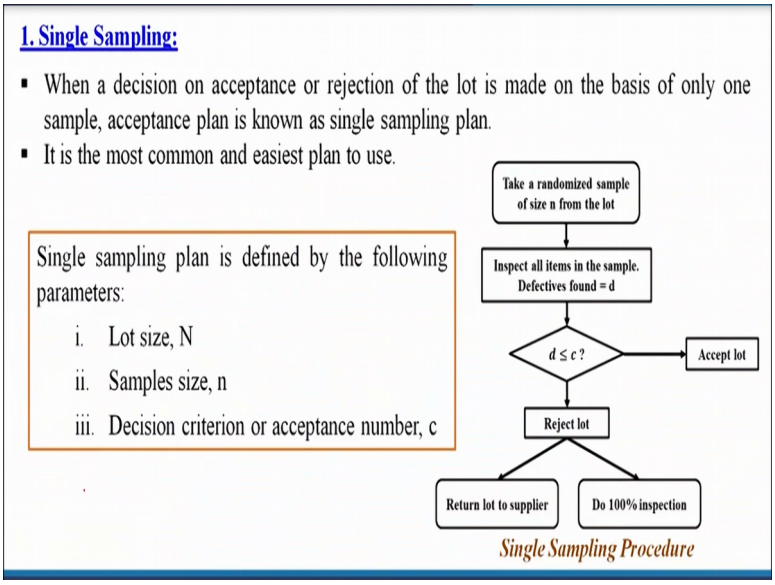

What is Single sampling. When a decision on acceptance or rejection of the lot is made on the basis of only one sample, acceptance plan is known as single sampling plan. It is the most common and easiest plan to use. Single sampling plan is defined by the following parameters. First one is called Lot size that is the N, samples size that is the small n third one is the decision criterion or acceptance number is the small c.

So, this is the single sampling procedure. So first, take a randomized sample of size n from the lot and then some kind of decision making then with the reject lot do 100% satisfaction or maybe it can be return to supplier.

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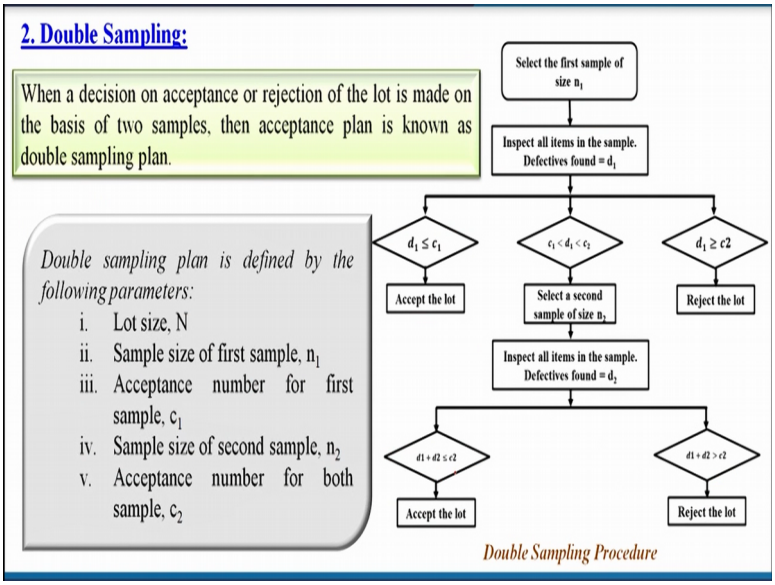

Next is called the double sampling. When a decision on acceptance or rejection of the lot is made on the basis of two sample, then acceptance plan is known as double sampling plan. So

double sampling plan is defined by the following parameters, one is called the lot size capital N, sample size of first sample small n 1, acceptance number for first sample small c 1, sample size of second sample small n 2 and acceptance number for both sample small c 2.

So in this particular case you can see there is one way here and another way is here. So that, that is why it is called the double sampling. So inspect all items in the sample defective founds d 2 then what we are going to see then when there d 1 + d 2 is less than equal to c2 accept the lot, if d 1 + d 2 is greater than c 2 then reject the lot.

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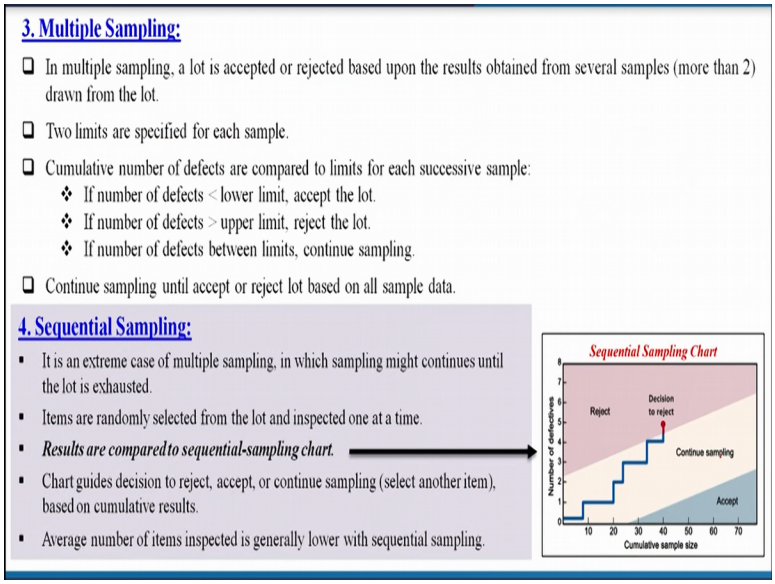

Next one is called multiple sampling. So in multiple sampling, a lot is accepted or rejected based upon the results obtained from several samples more than 2 drawn from the lot itself. Two limits are specified for each sample. Cumulative number of defects are compared to limits for each successive sample. So what means, means if number of defects less than lower limit, accept the lot. If number of defects is more than upper limit, reject the lot. If the number of defects between limits, continue sampling.

Continue sampling until accept or reject lot based on all sample data. Next last one is called the Sequential sampling. It is an extreme case of multiple sampling, in which sampling might continues until the lot is exhausted. Items are randomly selected from the lot and inspected one at a time. Results are compared to sequential sampling chart so like this, so here in the x axis you can see the cumulative sample size and y axis is the number of defectives.

So, in this way just we are taking more than this is the reject in this zone that is the continue sampling and in this zone is called the acceptance. So how the decision coming to rejection. Chart guides decision to reject, accept or continue sampling select another item based on cumulative results. Average number of items inspected is generally lower with sequential sampling.

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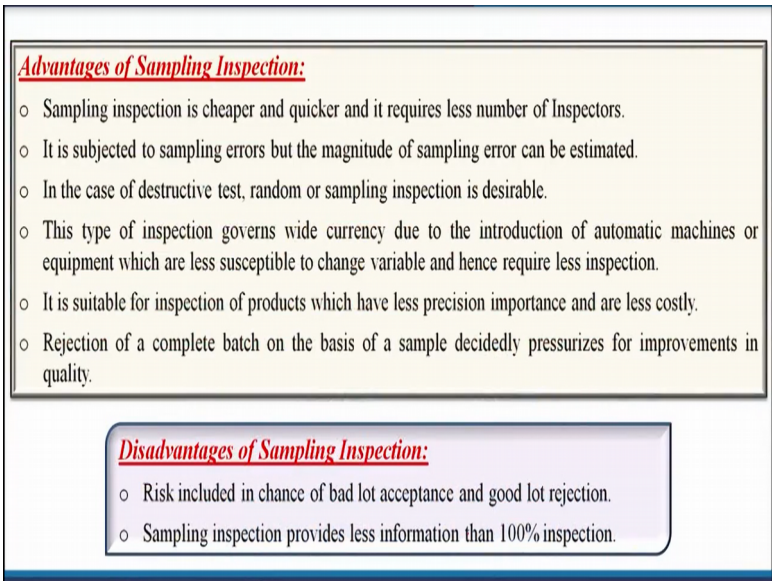

Now, what are the advantages of sampling inspections? Sampling inspection is cheaper and quicker and it requires less number of inspectors. It is subjected to sampling errors but the magnitude of sampling error can be estimated. In the case of destructive test, random or sampling inspection is desirable. This type of inspection governs wide currency due to the introduction of automatic machines or equipment which are less susceptible to change variable and hence require less inspection.

It is suitable for inspection of products which have less precision importance and are less costly. Rejection of a complete batch on the basis of a sample decidedly pressurizes for improvements in quality. Disadvantage of sampling inspection. Risk included in chance of bad lot acceptance and good lot rejection. There is always a risk factor. Sampling inspection provides less information than the 100% inspection.

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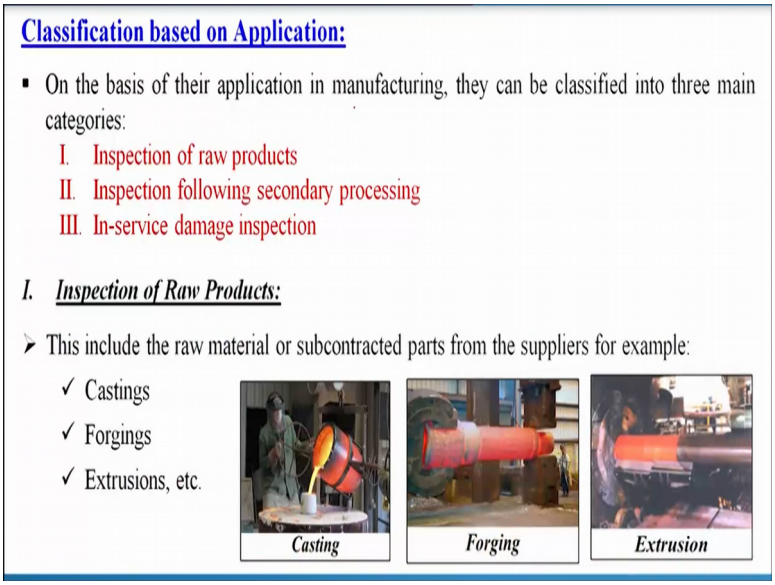

Now, classification based on application. On the basis of their application in manufacturing, they can be classified into three main categories. First one is called the inspection of raw products, second inspection following secondary processing and third one is the in-service damage inspection. What is Inspection of raw products. This include the raw material or subcontracted parts from the suppliers for example casting, forgings, extrusion etc.

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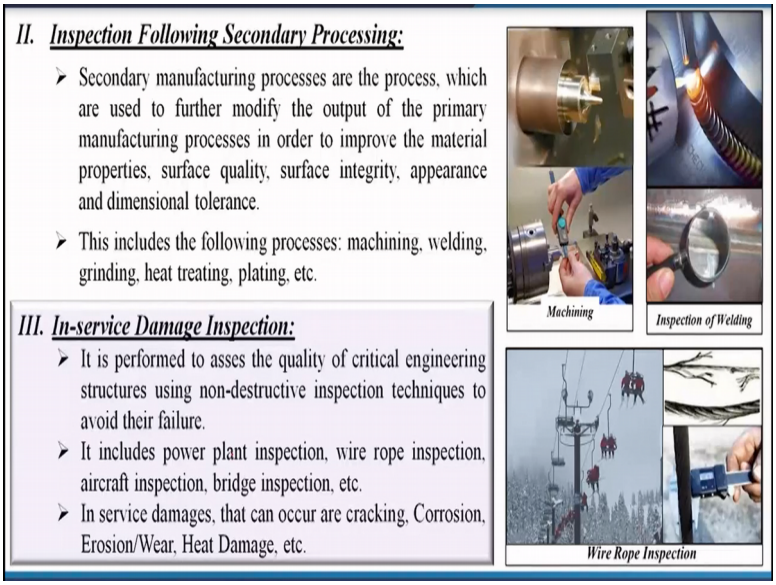

Second inspections following secondary processing. Secondary manufacturing processes are the process, which are used to further modify the output of the primary manufacturing processes in order to improve the material properties, surface quality, surface integrity, appearance and dimensional tolerance. This includes the following processes, like, machining process, welding process, grinding process, heat treating process or may be the plating process. So there are so many also.

Next is that, In-service damage inspection. It is performed to assess the quality of critical engineering structures using non-destructive inspection techniques to avoid their failure. It includes power plant inspection, wire rope inspection, aircraft inspection, bridge inspection etc. In service damages, that can occur are cracking, corrosion, erosion wear, heat damage etc.

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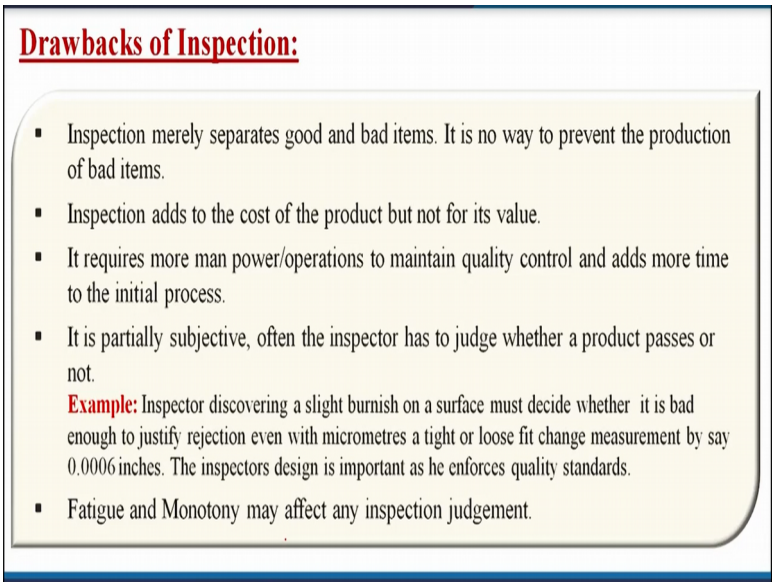

So now we are going to discuss about the drawbacks of inspection. Inspection merely separates good and bad items. It is no way to prevent the production of bad items. Inspection adds to the cost of the product but not for its value. It requires more man power, operations to maintain quality control and adds more time to the initial process. It is partially subjective, often the inspector has to judge whether a product passes or not.

Example inspector discovering a slight burnish on the surface must decide whether it is bad enough to justify rejection even with micrometres a tight or loose fit change measurement by say 0.0006 inches. The inspectors design is important as he enforces quality standards. Fatigue and monotony may affect any inspection judgement because it is done by the human being. So sometime the human error may come into the picture.

Now, we have come to the last slide of this particular lecture. So we have to summarize the whole lecture. In this particular lecture we have discussed about the inspection

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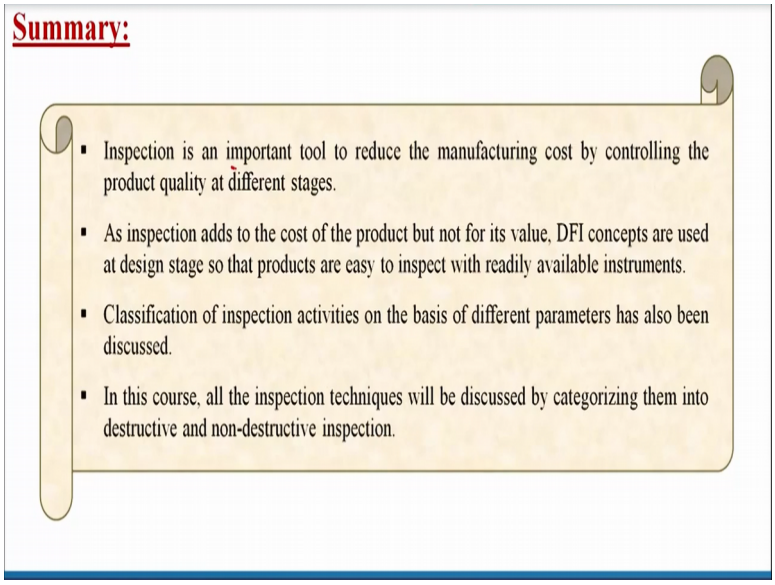

which is nothing but an important tool to reduce the manufacturing cost by controlling the product quality at different stages. An inspection adds to the cost of the product but not for its value, yes of course say suppose for engines, for aircrafts, for space shuttles if due to the 100% inspections if the cost will be little bit higher but we are very pleased to take that one, because it will save the thousands of life.

DFI concepts are used at design stage so that products are easy to inspect with readily available instruments. Classification of inspections activities on the basis of different parameters already we have discussed in this particular lecture. In this course, all the inspection techniques in details has been discussed by categorizing them into destructive and non-destructive inspection. And in future also we are going to discuss in details about the destructive testing and about the non-destructive testing of the parts. Thank you for your patience.