Inspection Principles and Practices

L-29

Contents

The new approach of inspection

(i) 100% automated inspection rather than sampling inspection using manual methods

(ii) On line sensor systems to accomplish inspection during or immediately after the manufacturing process rather than off-line inspection performed later.

(iii) Feedback control of the manufacturing operation, in which process variables that determine product quality are monitored rather than the product itself

(iv) Software tools to track and analyze the sensor measurements over time for statistical process control

(v) Advanced inspection and sensor technologies, combined with computer based systems to automate the operation of the sensor.

1) Inspection Fundamentals

- The term inspection refers to the activity of examining the product, its components, subassemblies, or materials out of which it is made, to determine whether they conform to design specifications.

a)Types on Inspection:

(i) Inspection for variables

(ii) Inspection for attributes

Examples of Inspection by Variables	*Examples of Inspection by Attributes*
Measuring the diameter of a cylindrical part	Gaging a cylindrical part with a GO/NO-GO gage to determine if it is within tolerance
Measuring the temperature of a toaster oven to see if it is within the range specified by design engineering	Determining the fraction defect rate of a sample of production parts
Measuring the electrical resistance of an electronic component	Counting the number of defects per automobile as it leaves the final assembly plant
Measuring the specific gravity of a fluid chemical product	Counting the number of imperfections in a production run of carpeting

b) Inspection Procedure

(i) Presentation
(ii) Examination
(iii) Decision
(iv) Action

C) Inspection Accuracy

- These two kinds of mistakes are called Type I and Type II errors.
- Type I error occurs when an item of good quality is incorrectly classified as being defective. It is a false alarm.
- A type II error is when an item of poor quality is erroneously classified as being good. It is a miss.

TABLE 22.2 Type I and Type II Inspection Errors

Decision	Conforming Item	Nonconforming Item
Accept item	Good decision	Type II error "Miss"
Reject item	Type I error "False alarm"	Good decision

Contd.

In manual inspection, errors result from factors such as:

(i) Complexity and difficulty of the inspection task

(ii) Inherent variations in the inspection procedure

(iii) Judgement required by the human inspector

(iv) Mental fatigue

(v) Inaccuracies or problems with gages or measuring instruments used in the inspection procedure.

When the procedure is accomplished by an automated system, inspection errors occur due to factors such as:

(i) Complexity and difficulty of the inspection task

(ii) Resolution of the inspection sensor, which is affected by gain and similar control parameter settings

(iii) Equipment malfunctions

(iv) Faults or bugs in the computer program controlling the inspection procedure.

Example

EXAMPLE 22.1 Inspection Accuracy

A human worker has inspected a batch of 100 parts, reporting a total of 12 defects in the batch. On careful reexamination, it was found that four of these reported defects were in fact good pieces (four false alarms), whereas a total of six defective units in the batch were undetected by the inspector (six misses). What is the inspector's accuracy in this instance? Specifically, what are the values of (a) p_1, (b) p_2, and (c) A?

Solution: Of the 12 reported defects, four are good, leaving eight defects among those reported. In addition, six other defects were found among the reportedly good units. Thus, the total number of defects in the batch of 100 is $8 + 6 = 14$. This means there were $100 - 14 = 86$ good units in the batch. We can assess the values of p_1, p_2, and A on the basis of these numbers.

(a) To assess p_1, we note that the inspector reported 12 defects, leaving 88 that were reported as acceptable. Of these 88, six were actually defects, thus leaving $88 - 6 = 82$ actual good units reported by the inspector. Thus, the proportion of good parts reported as conforming is:

$$p_1 = \frac{82}{86} = 0.9535$$

(b) There are 14 defects in the batch, of which the inspector correctly identified eight. Thus, the proportion of defects reported as nonconforming is:

$$p_2 = \frac{8}{14} = 0.5714$$

(c) The overall inspection accuracy is given by Eq. (22.1):

$$A = \frac{0.9535 + 0.5714}{2} = 0.7625$$

d) Inspection vs Testing

(i) Destructive testing

(ii) Non destructive testing

(iii) Nondestructive evaluation

2) Sampling vs 100% Inspection

a) Sampling Inspection

Types of Sampling Plans: There are two basic types of acceptance sampling

(i) Attributes sampling

(ii) Variables sampling corresponding to inspection by attributes

Statistical Errors in sampling:

TABLE 22.4 Type I and Type II Sampling Errors

Decision	Acceptable Batch	Unacceptable Batch
Accept batch	Good decision	Type II error Consumer's risk (β)
Reject batch	Type I error Producer's risk (α)	Good decision

Contd.

Operating Characteristic curve: Much information about a sampling plan can be obtained from its operating characteristic curve (OC curve). The operating characteristic curve for a given sampling plan gives the probability of accepting a batch as a function of the possible fraction defect rates that might exist in the batch.

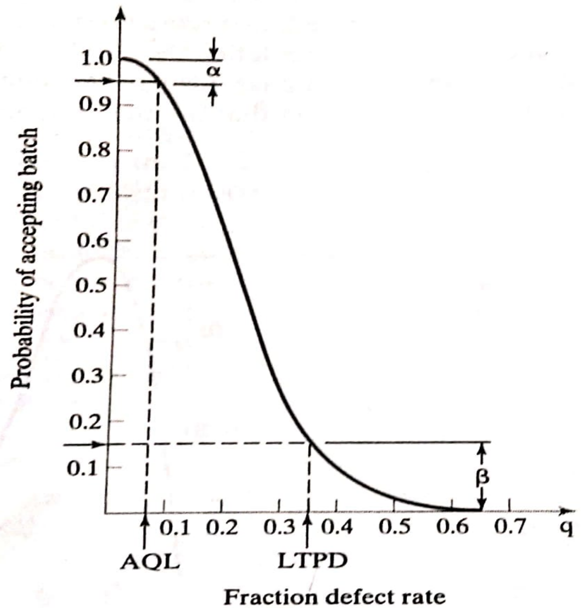

Figure 22.1 The operating characteristic (OC) curve for a given sampling plan shows the probability of accepting the lot for different fraction defect rates of incoming batches.

b) 100% Manual Inspection

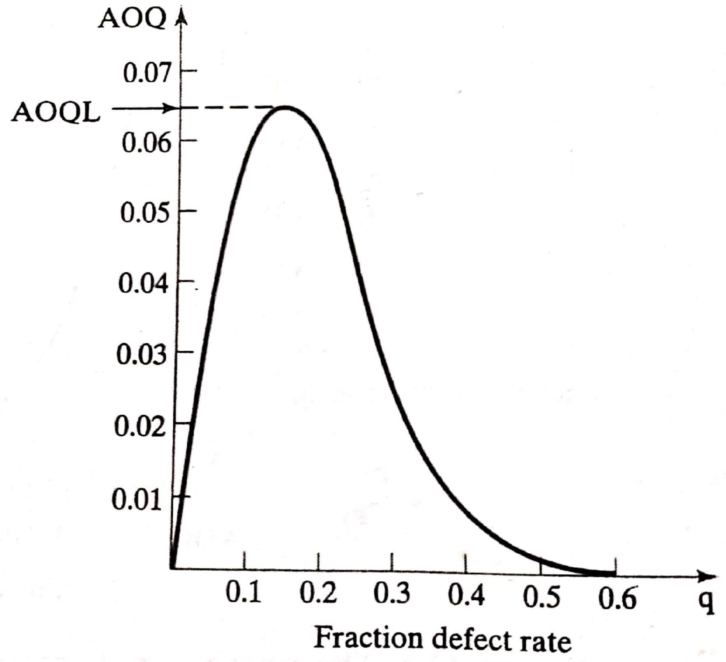

Figure 22.2 Average outgoing quality (AOQ) curve for a sampling plan.

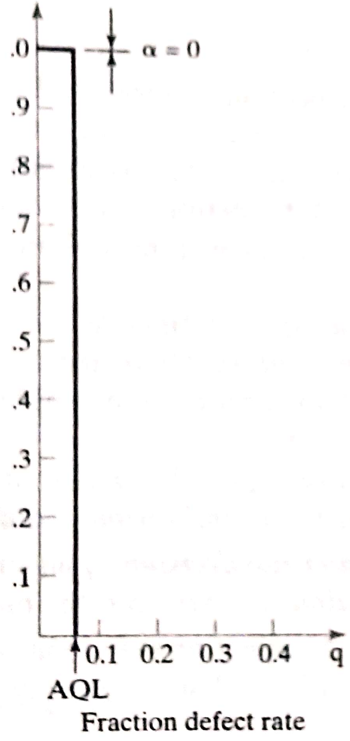

Figure 22.3 Operating characteristic curve of a 100% inspection plan.

3) Automated Inspection

- Automated inspection can be defined as the automation of one or more of the steps involved in the inspection procedure. There are a number of alternative ways in which automated or semiautomated inspection can be implemented

(i) Automated presentation of parts by an automatic handling system with a human operator still performing the examination and decision steps.

(ii) Automated examination and decision by an automatic inspection machine, with manual loading (presentation) of parts into the machine

(iii) Completely automated inspection system in which parts presentation, examination, and decision are all performed automatically.

Diagram

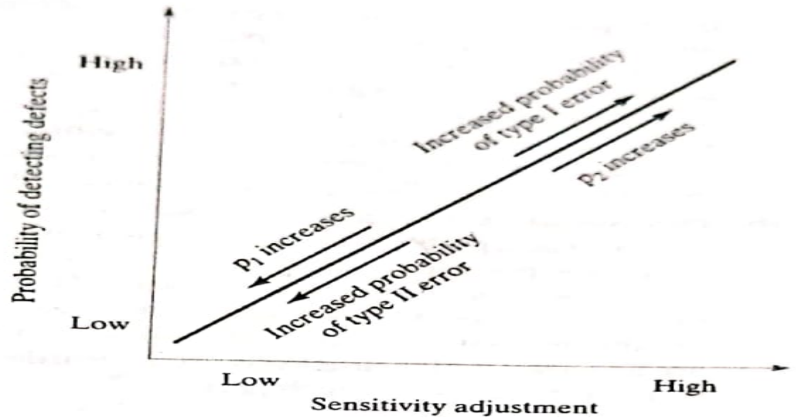

Figure 22.4 Relationship between sensitivity of an automated inspection system and the probability of Type I and Type II errors: p_1 = the probability that a conforming item is correctly classified, and p_2 = the probability that a nonconforming item is correctly classified.

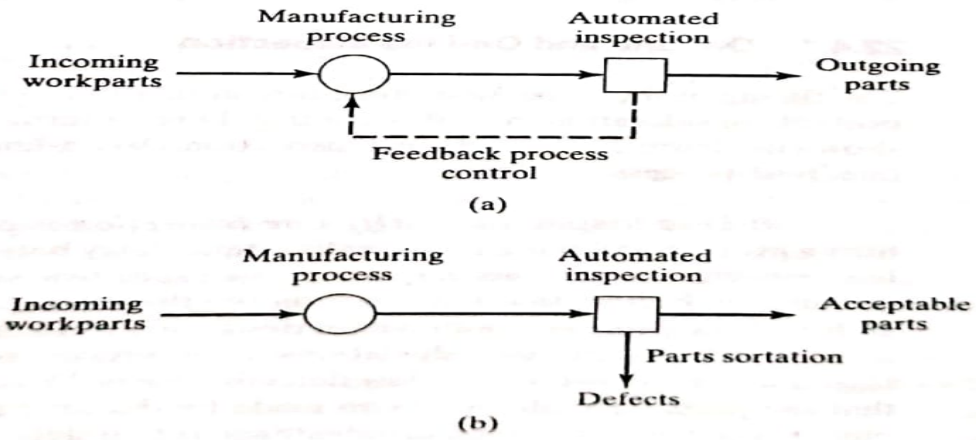

Figure 22.5 Action steps resulting from automated inspection: (a) feedback process control and (b) sortation of parts into two or more quality levels.

4) When and Where to Inspect

- Inspection can be performed at any of several places in production:

(1) Receiving inspection, when raw materials and parts are received from suppliers

(2) At various stages of manufacture

(3) Before shipment to the customer

a)off-line and on-line Inspection

Factors that promote the off-line inspection include:

(i) Variability of the process is well within design tolerance

(ii) Processing conditions are stable and the risk of significant deviations in the process is small.

(iii) Cost of inspection is high relative to the cost of a few defective parts.

Figure

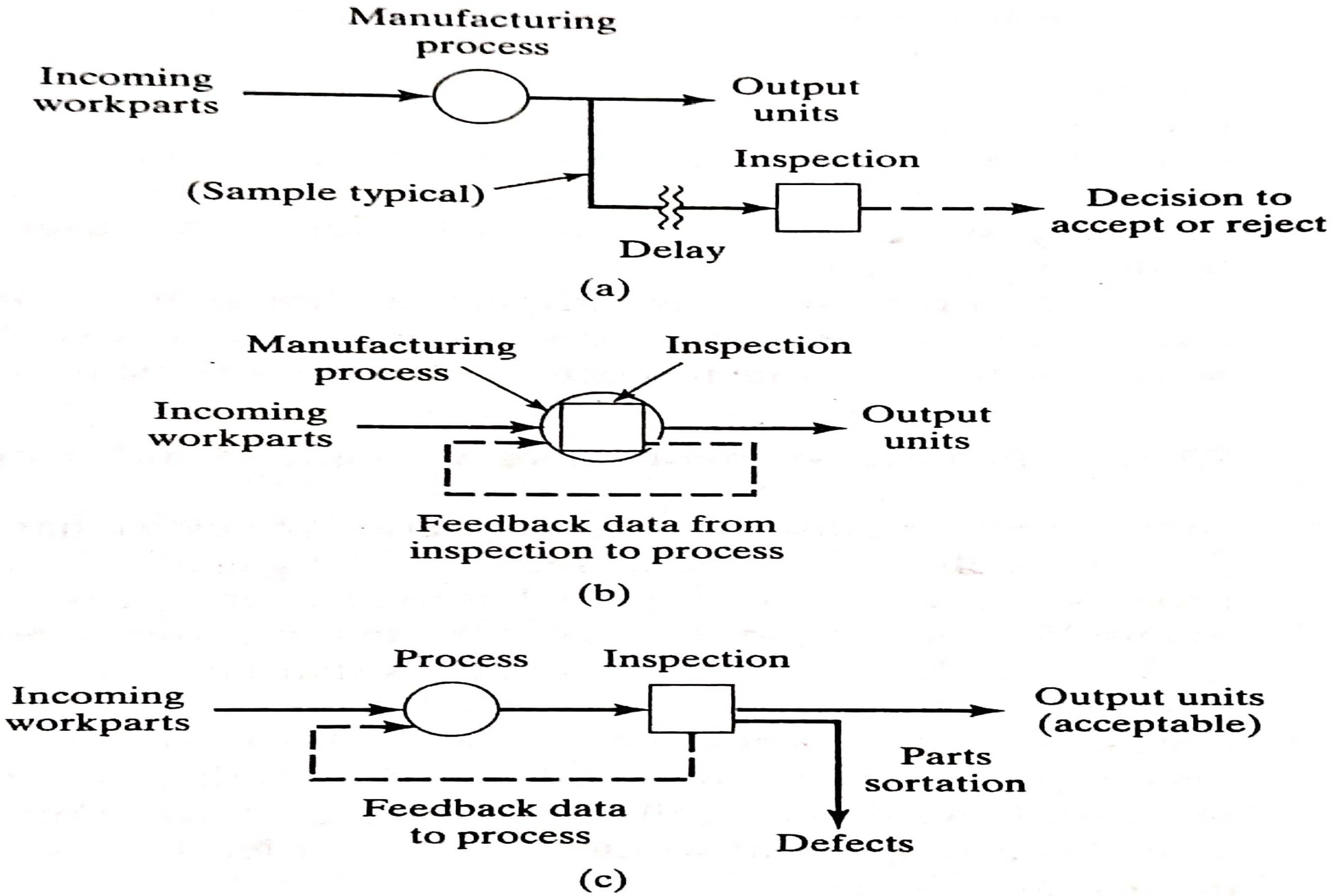

Figure 22.6 Three inspection alternatives: (a) off-line inspection, (b) on-line/in-process inspection, and (c) on-line/post-process inspection.

b) Product inspection Vs process monitoring

- It was previously assumed that it was the product itself that was being measured or gaged, either during or after the manufacturing process. An alternative approach is to measure the process rather than the product, that is to monitor the key parameters of the manufacturing process that determine product quality. The advantage of this approach is that an on-line/in-process measurement system is much more likely to be practicable for process variables than for product variables.
- Use of process monitoring as an alternative to product inspection relies on the assumption of deterministic manufacturing. This means that a fairly exact cause and effect relationship exists between the process parameters that can be measured, and the quality characteristics that must be maintained within tolerance.

C) Distributed Inspection Vs Final Inspection

- When inspection stations are located along the line of work flow in a factory, this is referred to as distributed inspection. In its most extreme form, inspection and sortation operations are located after every processing step.
- Another approach, sometimes considered an alternative to distributed inspection, is final inspection, which involves one comprehensive inspection procedure on the product immediately before shipment to the customer.

5) Quantitative analysis of Inspection