Why inspection and testing required?

- Inspection is normally used to examine whether a product conforms to the design standards specified for it.
- For a mechanical component, this would be probably concerned with the dimensions, surface texture and tolerances specified for the part.
- Non-conforming goods result in scrap, rework, and the loss of customer goodwill.
Why inspection and testing required?

- Functional tests under normal or simulated operating conditions
- Fatigue or wear tests to determine the product's life function until failure
- Overload tests to determine the level of safety factor built into the product
- Environmental testing to determine how well the product will perform under different environments (e.g. humidity, temperature, vibration).

Quality control
Traditional method for inspection and testing

- Manual
  - Time-consuming procedure
  - Monotonous work
  - Tolerance is higher
  - Detract from usefulness
  - Affects Economic, Social and technological factors

Computer Aided Quality control: Types

- Computer Aided Inspection
- Computer Aided Testing

Benefits from CAQC

- Improve product quality
- Increase productivity in the inspection process
- Increase productivity
- Reduce lead-time
- Reduce wastage due to scrap/rework
Benefits of CAQC: 100% testing and inspection

- In the traditional manual process, the testing and inspection is done by the sampling process out of the hundreds and thousands of products or parts manufactured by the company since it is not feasible to check each and every product.
- With CAI and CAT hundred percent inspection and testing can be accomplished without much difficulty.
- With 100% inspection the company does not have to depend on statistical quality control method in which it is assumed that anything less than 100% of quality is acceptable.
- With computer-controlled inspection, it is not necessary for the quality control department to settle for less than perfection.

Benefits of CAQC: Inspection integrated with manufacturing process

- In the traditional process there is separate quality control department where the manufactured product is taken for the inspection and testing.
- In CAQC the inspection process is integrated with the manufacturing process and it is located along the production line.
- Thus as soon as the product is manufactured it is tested immediately by the computerized process without moving it to some other location.
- This helps in reducing the overall time required for manufacturing the product.

Benefits of CAQC: Use of non-contact sensors

- In the traditional process the product or the part to be inspected is handled manually since it has to be positioned properly for inspection on the desk or suitable location.
- In CAQC non-contact sensors are used for the inspection purpose and they inspect the product without coming in contact with the product.
- The non-contact sensors operated by the computer are kept along the production line and they can check the product very quickly in the fraction of seconds.
- In future with further advancements in the technology, the robots would be used to carry-out the inspection process thus further automating and speeding the process.

Benefits of CAQC: Computerized feedback control system

- The data collected by the non-contact sensors is sent as the feedback to the computerized control systems.
- These systems would carry out the analysis of the data including statistical trend analysis.
- This helps in identifying the problem going on in the manufacturing line and find appropriate solution to it.
- For instance, the results from non-contact sensors may indicate that the parts manufactured are not within the acceptable tolerance limits.
- This would help the production or quality control personnel to find out the precise location of the problem and its exact cause.
- The corrective action taken quickly saves lots of time and money due to reduced wastages and also improves the quality of the product.
Benefits of CAQC: **CAQC and CAD/CAM integration**

- Apart from inspection and testing, computers are used in a number of other areas of the quality control.
- All the applications of CAQC can be integrated with CAD/CAM to make the whole process of designing and manufacturing controlled by the computers converted into fully automated process.
- An important feature of QC in a CIM environment is that the CAD/CAM database will be used to develop inspection plan.

**CAI: Techniques**

- **Contact type Computer Aided Inspection**
  - Use of vision system
- **Non-Contact type Computer Aided Inspection**
  - Optical type
  - Electric field to sense or say use of sensor technology

**Contact inspection Method**

- In contact inspection, physical contact is made between the object to be inspected, and the measurement device.
- Typically contact is achieved using a mechanical probe or other device that touches the item and allows the inspection procedure to occur.
- By its 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 metal parts, and for electrical circuit testing.
  - Conventional instruments
  - Coordinate measuring machine
  - Stylus measuring system
Contact inspection Method: Convention measuring instruments

- Scale
- Gauge Bars
- Slip Gauges
- Vernier Calipers
- Screw Gauge

Contact inspection Method: Coordinate Measuring Machine

- The coordinate measuring machine (CMM) is the most prominent example of the equipment used for contact inspection of parts.
- When used for CIM these machines are controlled by CNC.
- A typical three-dimensional measuring machine consists of a table, which holds the part in a fixed position, and movable head, which holds a sensing probe.
- The probe can be moved in three directions corresponding to the X, Y and Z coordinates.
- For manual operation, the control unit is provided with joysticks, or other devices which drive X, Y and Z servo motors (AC/DC).
Non-contact inspection technologies

- Noncontact inspection methods utilize a sensor located at a certain distance from the object to measure or gage the desired features.
- The noncontact inspection technologies can be classified into two categories:
  1. Optical
     - Optical inspection technologies use light to accomplish the measurement or gaging cycle.
  2. Non optical
     - Non optical inspection technologies utilize energy forms other than light to perform the inspection.
     - These other energies include various electrical fields, radiation and ultrasonic.

Non-contact inspection technologies: Advantages

a) It eliminates the need to reposition the workpiece.
b) Non-contact inspection is faster than contact inspection.
c) There is no mechanical wear encountered in the contact inspection probe.
d) The possibility of damage to the surface of a part due to measuring pressure is eliminated.

Non-contact inspection technologies: Optical

- There are a variety of optical sensing techniques used for inspection work.
  - Machine vision
  - Scanning laser beam devices
  - Photogrammetry

P-Q chart for inspection technologies
Optical Non-contact inspection technologies: Machine Vision

- The creation of an image and the collection of data derived from the image, and the subsequent processing and interpretation of the data by a computer from some useful application.
- Machine vision systems are a set of integrated components that are designed to use information extracted from digital images to automatically guide manufacturing and production operations such as go/no testing and quality control processes.
- Machine vision systems, also called automated vision systems or vision inspection systems.
- Machine vision exists in two-dimensional (2D) and three-dimensional (3D) formats, with 2D being most common in industrial applications.

Working of Machine Vision

- First, the sensor detects if a product is present. If there is indeed a product passing by the sensor, the sensor will trigger a camera to capture the image, and a light source to highlight key features.
- Next, a digitizing device called a frame-grabber takes the camera’s image and translates it into digital output, which is then stored in computer memory so it can be manipulated and processed by software.

Machine Vision Components

The machine vision systems typically include the following five elements:

i. The lighting system
ii. The optical system or lens
iii. The sensor
iv. The vision processing system
v. The communications system
Machine Vision Functions

Machine vision systems perform tasks that can be organized around four basic categories or functions, which are:

- Measurement
- Counting
- Decoding
- Location

Machine Vision Functions: Measurement & Counting

- Measurement functions are done through the comparison of a recorded dimension from a digital image against a standard value to establish a tolerance or to determine if the observed value of the dimension is within acceptable levels of tolerance as called for in the design specification for that part.
- Counting functions are used to establish whether the correct quantity of product is in place or whether the proper number of components or elements in a design has been produced.

Machine Vision Functions: Decoding & Location

- Decoding functions are used to decode or read one dimensional and two-dimensional symbologies used to uniquely tag products, such as linear bar codes, stacked symbologies, data matrix codes, QR codes, or Optical Character Recognition (OCR) fonts.
- Location functions deal with establishing the position and orientation of a part in a process. This type of capability is valuable in automated assembly operations, as it can be used to verify that the component needed is in the correct place and is properly aligned within allowed tolerances, for the next step in the assembly process to occur.

Specific applications of Machine Vision

**Automotive manufacturing**
- Guiding assembly or welding robots
- Verifying orientation of parts
- Counting the number of welds
- Checking for surface defects prior to painting

**Electronics**
- Verifying the shape and position of connector pins
- Parts selection and orientation for robotic pick & place systems
- Checking for solder connection issues or other conditions on PCBs
- General inspection of manufactured components such as LEDs

**Food and Packaging**
- Verifying the seal integrity on bottles
- Validating labeling, packaging and lot numbers
- Checking the fill levels on a product
- Detecting the presence of tamper-proof safety seals

**General Manufacturing**
- Verifying the correct part orientation for automated assembly operations
- Establishing the integrity of an adhesive bead or gasketing material
- Monitoring of plastic injection molding processes

**Semiconductors**
- Inspecting wafers and masks using deep ultraviolet wavelength light (DUV) to achieve the needed high speed and high resolution.
Advantages and Benefits of Machine Vision Systems

Machine vision systems provide several direct benefits to manufacturers and production line processes. The benefits of using machine vision technology include:

- Reduction in the number of defects
- Increase in production yield
- Reduction in downtime
- Improved ability to track and trace parts and products in a production process
- Facilitation with compliance to regulations that apply to specific product classes

Optical Non-contact inspection technology: Scanning laser beam devices

- Scanning beam devices use lasers as the light source
- The advantage of the laser is that it is a coherent light beam which can be projected great distances without significant diffusion.
- The scanning laser beam device relies on the measurement of time rather than light although a light sensor is required in its operation.

Scanning laser beam devices: Working

- A laser is used to project a continuous thin beam of light.
- A rotating mirror deflects the beam so that it sweep across the object to be measured.
- The light sensor is located at the focal point of the lens system to detect the interruption of the light beam as it is blocked by the object.

Photogrammetry

- Photogrammetry is a technique which may gain in usage in inspection work as it is perfected
- The term refers to a procedure which was borrowed from aerial reconnaissance and geological mapping applications.
- Photogrammetry involves the extraction of three-dimensional data from a pair of photographs taken at different angles.
- The two photographs can be combined much in the way that a stereoscope uses a pair of photographs to form a three-dimensional image for the viewer.
Photogrammetry:

Working principle:

• The two photographs are read by a device called a monocomparator to establish coordinates and positions of objects.
• These data are then computer-analyzed to extract the desired information.

Non-contact type inspection method: Non-Optical

Non-optical inspection technologies utilize energy forms other than light to perform the inspection. These energies include:
1. Electrical field techniques
2. Radiation techniques
3. Ultrasounds

Summary

- Concept of Computer Aided Quality Control, Types and Benefits
- Various techniques of computer aided quality control
- Contact type
- Non-contact type