3.2 APPLICATIONS OF LASER IN MEASUREMENT

3.2.1 LASER TELEMETRIC SYSTEM

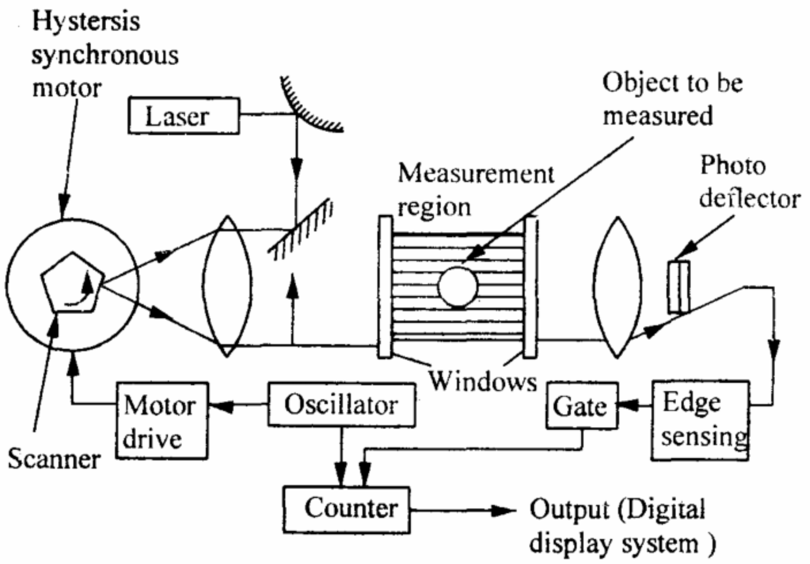

Fig. 3.11 Laser Telemetric System

[source: http://what-when-how.com/metrology/laser-telemetric-system-metrology/]

Construction:

The Laser telemetric system consist of three components.

- Transmitter
- Receiver
- Processor electronics

Laser telemetric system is a non-contact gauge that measures with a collimated laser beam. It measures at the rate of 150 scans per second. It basically consists of three components, a transmitter, receiver and processor electronics. The transmitter module produces a collimated parallel scanning laser beam moving at a high, constant, linear speed. The scanning beam appears as a red line. The receiver module collects and photoelectrically senses the laser light transmitted past the object being measured. The processor electronics takes the received signals to convert them to a convenient form and displays the dimension being gauged.

The transmitter contains a low-power helium-neon gas laser and its power supply, a specially designed collimating lens, a hysteresis synchronous motor, a mutli-faceted reflector prism, a synchronous pulse photodetector and a protective replaceable window. The high speed of scanning permits on-line gauging and thus it is possible to detect changes in dimensions when components are moving or a continuous product such as in rolling process moving at very high speed. There is no need of waiting or product to cool for taking measurements.

This system can also be applied on production machines and control them with closed feedback loops. Since the output of this system is available in digital form, it can run a process controller, limit alarms can be provided and output can be taken on digital printer. It is possible to write programs for the microprocessor to take care of smoke, dust and other airborne interference around the workpiece being measured.

ADVANTAGES

- It is possible to detect changes in dimensions when the product is in continuous processes.
- It can be applied on production machines and controlled then with closed feedback loops.

3.2.2 Laser Scanning Gauge

The scanning laser gauge is used for dimensional measurements.

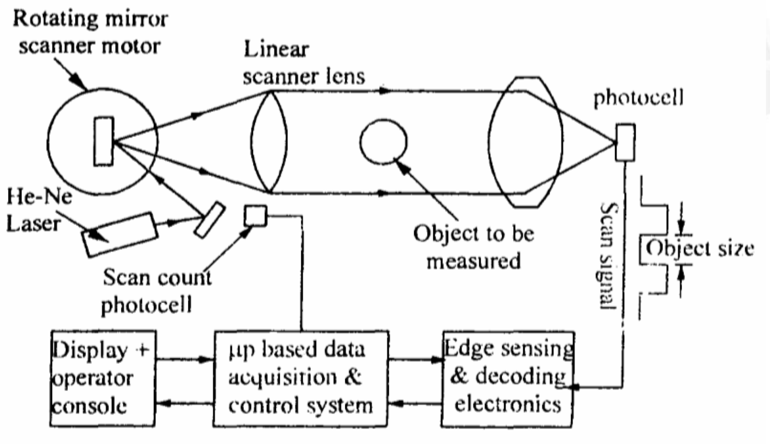

Fig. 3.12 Laser Telemetric System

[source: http://what-when-how.com/metrology/laser-inspection-metrology/]

Metrology lasers are low-power instruments. Most are helium-neon continuous-wave output lasers that emit visible or infrared light. He-Ne lasers produce light at a wavelength of 6328 A (0.6 pi) that is in phase, coherent, and a thousand times more intense than any other monochromatic source.

Laser inspection systems enable measurement of a part as it is produced, thus permitting 100% quality. Laser systems have wide dynamic range, low optical cross talk, and high contrast.

Lasers find applications in dimensional measurements and surface inspection because of the properties of laser light (bright, unidirectional, collimated beam, with a high degree of temporal and spatial coherence). These are useful where precision, accuracy, rapid non-contact gauging of soft, delicate, hot or moving parts is called for.

Various technique for dimensional measurements are:

It basically utilises a transmitter, receiver and processor electronics. A thin band of scanning laser light is made to pass through a linear scanner lens to render it parallel beam. The object placed in a parallel beam, casts a time-dependent shadow. Signals from the light entering the photo cell (receiver) are processed by a microprocessor to provide display of the dimension represented by the time difference between the shadow edges. It can provide results to an accuracy of + 0.25 um for 10-50 mm diameter objects. It can be used for objects 0.05 mm to 450 mm diameter and offers repeatability of 0.1 um.

3.2.3 PHOTODIODE ARRAY IMAGE

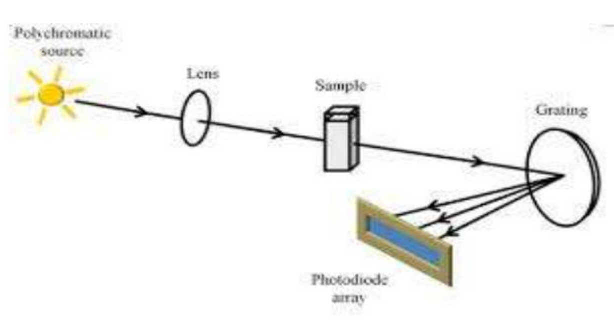

Fig. 3.13 Laser Telemetric System

[source: http://what-when-how.com/metrology/laser-inspection-metrology/]

In this method, shadow of stationary part is projected on a solid-state diode array image sensor. The system comprises of laser source, imaging optics, photodiode array, and signal processor and display unit. For large parts, two arrays, one for each edge are used. Accuracies as high as + 0.05 um have been achieved.

A Photodiode Array Detector is a microprocessor controlled multi-channel detector that permits simultaneous access to spectral data for several wavelengths simultaneously. In comparison the conventional UV-Visible detector has only a single channel detector.

Simultaneous multi-wavelength measurement

In a conventional spectrophotometer a single wavelength is recorded at any given point of time. On the other hand all wavelengths can be measured simultaneously in the diode array detector and this feature is a great time saver when several wavelengths are to be monitored simultaneously.

Wavelength precision

The required wavelength is selected on a conventional spectrophotometer either manually or using a stepper motor. On the other hand in the photodiode array data is acquired at each wavelength simultaneously. This eliminates repeatability errors that result from mechanical wear of moving parts.

High sensitivity

Diode array systems have fewer optical surfaces as a result of which the light throughput is high and results in improved sensitivities. An added benefit is time averaging feature to get several fold improvements of spectral sensitivity.

Minimal Stray Light

A photodiode array spectrophotometer has reverse optics design which minimizes stray light which is a common interfering component in conventional spectrophotometers. In case of photodiode array system, the sample is placed before the polychromator (reverse optics) whereas in case of conventional spectrophotometer sample is positioned after the monochromator. As the measurements are unaffected by stray light observations can be made with the sample chamber open without interference from outside light. This feature also permits analysis on a wider range of sample sizes and use of special sampling accessories

Ruggedness

The reliability and ruggedness is higher for photodiode array detector due to absence of moving parts and mechanical simplicity. This also eliminates virtually need for maintenance or re-calibration. As photodiode array detector is a solid-state device it is more reliable and secure than the photomultiplier tube. A polychromator gives consistent performance as the light dispersion element is locked in its position whereas in case of conventional spectrophotometer scanning requires movement of the grating inside the monochromator.

3.2.4 Diffraction Pattern Technique

These are used to measure small gaps and small diameter parts. In this method, a parallel coherent laser beam is diffracted by a small part, and the resultant pattern is focussed by a lens on a linear diode array. Since diffraction is not suitable for diameters larger than a few millimeters, its use is restricted to small wires, etc. The measurement accuracy is more for smaller parts. The distance between the alternating light and dark bands in the diffraction pattern is a direct function of the wire diameter, wavelength of laser beam, and the focal length of the lens.

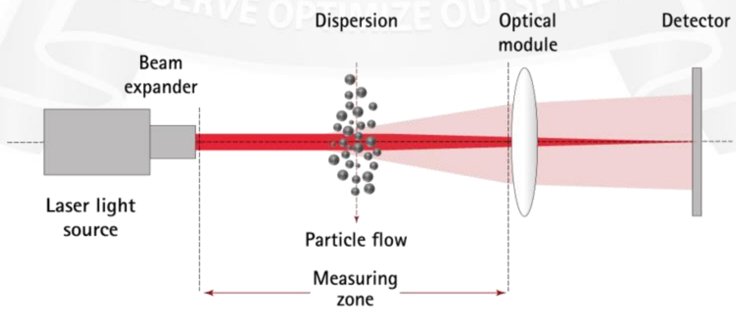

Fig. 3.14 Diffraction Pattern Technique

[source: https://www.sympatec.com/en/particle-measurement/sensors/laser-diffraction/]

3.2.5 Laser Triangulation Sensors

In this sensor a finely focused laser of light is direct at the part surface and this light comes from the laser source.

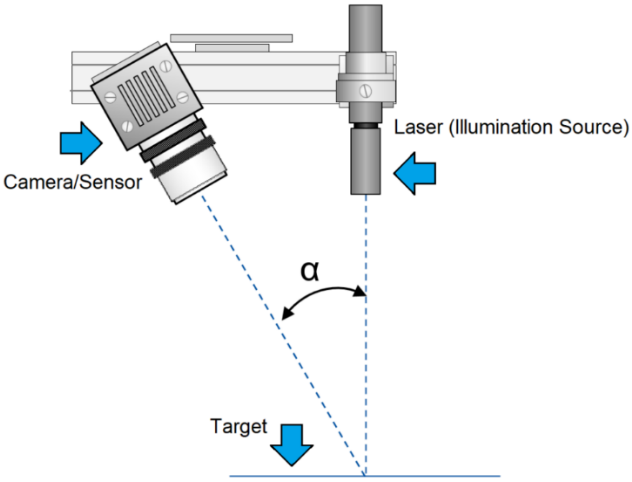

Fig. 3.15 Laser Triangulation Sensors

[source: https://www.movimed.com/knowledgebase/what-is-laser-triangulation/]

Laser Triangulation is a machine vision technique used to capture 3-dimensional measurements by pairing a laser illumination source with a camera. The laser beam and the camera are both aimed at the inspection target, however by adopting a known angular offset (α) between the laser source and the camera sensor, it is possible to measure depth differences using trigonometry.

The red, green, and blue dotted lines in Figure 2 illustrate how the reflected laser light will strike different sensor locations, depending on the distance between the laser source and the inspection target (or "surface"). Notice that the position where the reflected laser light strikes the sensor's surface is dependent on the vertical offset of the target from the laser/camera assembly. In other words, as the distance between the laser light source and inspection point changes, so changes the location on the sensor where the light is detected. Changes from the nominal vertical distance will produce proportional changes in position (d') at the sensor. Larger changes in vertical distance will result in a larger positional deflection at the sensor.

Advantages:

- Quick measurement of deviations is due to change in surface.
- it can perform automatic calculation on shell metal stampings.

Two- frequency laser interferometer

This consists of two frequency laser head, beam directing and splitting optics, measurement optics, receivers, and wavelength compensators and electronics. It is ideally suited for measuring linear positioning straightness in two planes, pitch and yaw.

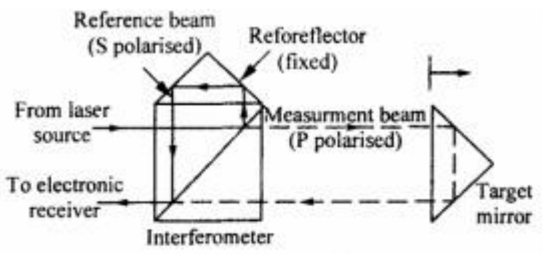

Fig. 3.16 Two- frequency laser interferometer

[source: https://www.brainkart.com/article/Use-of-Laser_5836/]

The two-frequency laser head provides one frequency with P-polarization and another frequency with S-polarization. The laser beam is split at the polarizing beam splitter into its two separate frequencies. The measuring beam is directed through the interferometer to reflect off a target mirror or retro reflector attached to the object to be measured. The reference beam is reflected from fixed retro reflector. The measurement beam on its return path recombines with the reference beam and is directed to the electronic receiver.

Gauging wide diameter from the diffraction pattern formed in a laser

Figure shows a method of measuring the diameter of thin wire using the interference fringes resulting from diffraction of the light by the wire in the laser beam. A measure of the diameter can be obtained by moving the photo detector until the output is restored to its original value. Variation in wire diameter as small as 0.2% over wire diameter from 0.005 to 0.2mm can be measured.

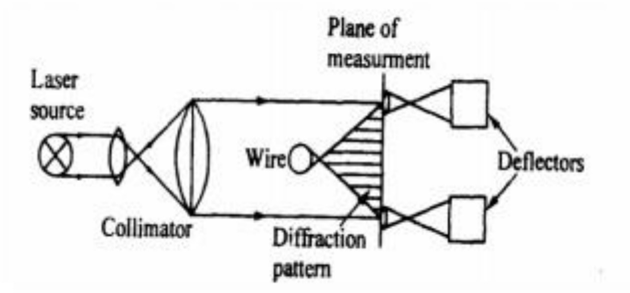

Fig. 3.16 Diffraction Pattern

[source: https://www.brainkart.com/article/Use-of-Laser_5836/]

Figure shows the length measurement by fringe counting. The laser output, which may be incoherent illumines three slits at a time in the first plane which form interference fringes. The movement can be determined by a detector. The total number of slits in the first plane is governed by the length over which measurement is required.

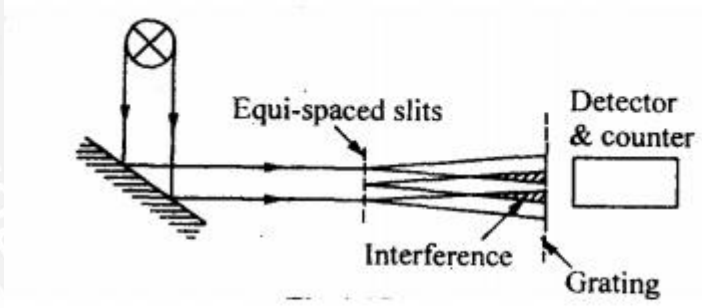

Fig. 3.16 Laser interferometer

[source: https://www.brainkart.com/article/Use-of-Laser_5836/]

The spacing between the slits and distance of the slit to the plane of the grating depend on the wavelength of the light used.