UNIT IV - INDUSTRIAL APPLICATION OF LASERS

PART A

1. What are industrial lasers?
Lasers having high beam power (>1MW) and very narrow pulse width (<10
-9s) are called industrial lasers. For example mode locked or Q-switched Nd YAG laser and CO2 laser are the industrial lasers.

2. What are the industrial applications of lasers?
a) Surface alloying and surface cladding can be done using lasers to improve the hardness, water resistance, wear resistance, corrosion resistance and fatigue strength of the surface of the engineering components.
b) Using lasers welding, cutting and drilling can be done in a precious manner with less heat-affected zone. These can be done at a faster rate.

3. What are the uses of shielding gas during material processing by lasers?
a) It is used to remove the molten material and to favor vaporization.
b) It is used to provide cooling effect.
c) It is used to protect the focusing optical arrangement against smoke and fumes.
d) It is used to increase the absorption of laser energy by the material.

4. What are the two modes of laser welding process?
a) Conduction limited welding by low power lasers b) Deep penetration welding by high power lasers.

5. What are the advantages of laser welding, cutting and drilling?
a) Heat affected zone is very narrow. b) The material processing can be done even at room temperature. c) Difficult materials like titanium, quartz and ceramics can be welded, cut or drilled. d) Higher welding speed or cutting speed can be achieved. e) There is minimum residual stress and distortion.

6. What are the techniques uses for distance measurement using Laser?
The most common application of laser is distance measurement. Direct optical interferometry is used over short distances and beam modulation echo pulse technique is used for long distances.

7.What is the principle of velocity measurement using laser?
Measurements of the velocity of the fluid can be made by laser Doppler effect. The frequency of the scattered light is slightly Doppler shifted and it is proportional to the fluid velocity.

8.What is Doppler effect?
The Doppler effect, is the apparent change in frequency
or wavelength of a wave that is perceived by an observer moving relative to the source of the waves. For waves, such as sound waves, that propagate in a wave medium, the velocity of the observer and the source are reckoned relative to themedium in which the waves are transmitted The total Doppler effect may therefore result from either motion of the source or motion of the observer. Each of these effects is analyzed separately. For waves which do not require a medium, such as light or gravity in special relativity only the relative difference in velocity between the observer and the source needs to be

considered.

9.What is laser cutting?
Laser cutting is a technology which uses a laser to cut materials, and is usually used in industrial manufacturing.Laser cutting works by directing the output of a high power laser at the material to be cut. The material then either melts, burns or vaporizes away leaving an edge with a high quality surface finish. The most popular lasers for cutting materials are CO2 and Nd:YAG, though semiconductor lasers are gaining prominence due to greater efficiency.

10. What are the advantages of laser cutting?
Advantages of laser cutting over mechanical cutting
vary according to the situation, but important factors are: lack of physical contact (since there is no cutting edge which can become contaminated by the material or contaminate the material), and to some extent precision (since there is no wear on the laser). There is also a reduced chance of warping the material that is being cut as laser systems have a small heat affected zone. Disadvantages of laser cutting may include the high energy required

11.What is laser welding?
Laser beam welding is a technique in manufacturing
whereby two or more pieces of material (usually metal) are joined by together through use of a laser beam.The laser beam is a coherent (single phase) light of a single wavelength (monochromatic). The laser beam has low beam divergence and high energy content and thus will create heat when it strikes a surface.

12.What is a laser rangefinder?
A laser range-finder is a device consisting of a pulsed laser and a light detector. By measuring the time taken for light to reflect off a far object, and knowing the speed of light, the range to the object can be found. A laser rangefinder is thus a simple form of LIDAR. The distance to the target can then be used to aim a weapon such as a tank\'s main gun.

13.What is laser heat treatment?
Heat treatments for hardening or annealing have been long practiced in metallurgy. But lasers offer some new possibilities for selective heat treatments of metal parts. For example, lasers can provide localized heat treatments such as the hardening of the surfaces of automobile camshafts. These shafts are manufactured to high precision, and if the entire camshaft is heat treated, some warping will inevitably occur. But the working surfaces of the cams can be heated quickly with a carbon dioxide laser and hardened without appreciably affecting the remainder of the shaft, preserving the precision of manufacture.

14. What are the advantages of laser material processing?
•Very high accuracy in the final processed products that can be obtained without the need for polishing.
•No wearing of mechanical tools. Mechanical tools change their dimensions during the working process, and require constant measurements and feedback to adapt their position to original plan in computerized instrumentation.

15. What is hardening?

Hardening is the process of heating specific areas of the material. When laser hardening is done the laser irradiates the work area and causes very quick heating of a thin layer of material near the surface. When the laser beam is removed form the heated area, the area gets cooled abruptly due to heat transfer by conduction. The cooling creates hardness of the material which occurs by metallurgical transformation.

16. What are the types of laser hardening techniques?

i)Shock hardening, ii)Surface glazing, iii)Surface alloying.

17. What is shock hardening?

In this method a shock pulse of very high peak power density of more than 109 W/cm2 is made incident on the surface. This produces rapid surface vaporization. This is accompanied by an absorption wave, which is supported by laser. This wave drives a shock front into the material. As the shock crosses the material, the material gets surface hardened.

18. What is laser glazing?

In this process the surface of the material gets melted by the CO2 laser. When he laser beam moves away from the spot, there occurs a rapid solidification, which results in surface microstructure with unique characteristics. Since the rate of quenching is quite rapid, the size of the grains near the surface is quite tiny. The surface appears to be glassy and this process is known as 'surface glazing'.

19. What is mechanism of interaction between the laser beam and the processed material?

•Thermal Effects - Most of the applications of lasers in material processing were based on the absorption of the laser radiation inside the material, and the effects were thermal in nature. The absorption process transfers energy to the material. As a result, there is a rise in the temperature in that region to high temperatures.

•Photochemical Effects - Breaking the bonds between the molecules in the material. The Excimer laser (see chapter 6.1.7) emits in the Ultra-Violet (VU) part of the electromagnetic spectrum, and its photons are very energetic. It can be used to cut very delicate and accurate structures without causing thermal damage to surrounding areas.

20.What is the principle of laser gyroscope?

The principle of Operation of Optical Gyroscope is that Two laser beams are moving in opposite directions in the same ring path. Any change in the direction of the system will cause a difference in the path of these two beams. By using inteferometric measurements it is possible to detect very small changes, so the laser gyroscope is a very sensitive device.

UNIT - IV

INDUSTRIAL APPLICATIONS OF LASERS.

1) Explain the principle of laser for measurement of distance & velocity with neat diagram.

Measurement of distance - Interferometric technique.

⇒ Monochromatic source parallel by lens L_1.

⇒ Rest of light is reflect at rear face.

M_1 & M_2 ⇒ perpendicular to each other, a set of circular fringes of equal inclination.

⇒ $P\lambda = 2D\cos\theta$.

Measurement of velocity : Scattering a laser beam from liquid (or) gas.

Particles scattered in all direction

⇒ Magnitude & velocity of fluid.

Working - Dual beam mode approach.

Lens focusses the beams to the same position

⇒ $\delta = \frac{\lambda}{2\sin\theta/2}$. $f = \frac{2nV_T \sin\theta/2}{\lambda_0}$

2) Explain the working principle of laser for measurement of current & voltage with neat diagram.

Current & voltage - diagram

- Faraday magneto - optical effect.

$\theta = VNI$.

Working: faradays effect.

⇒ passed thro polarising filter.

⇒ aligned at 45°

⇒ plane of polarisation rotated clockwise.

3) Explain in detail the principle of laser welding & melting.

Laser welding – Continuous / seam welding

Pulse / spot "

⇒ High power laser radiation incident

⇒ Electron & ion emition.

⇒ Thermal & X-radiation upto 2 KeV.

⇒ Ultrasonic vibration in metal due to periodicity of heating.

Laser melting – ↑ in temp - Local melting.

Methods – conduction limited.

Deep penetration melting.

⇒ $dE/dt < dH/dt$.

Keyhole melting – $dE/dt >> dH/dt$.

4) Explain the application of laser in trimming of material.

– Manufacturing process of using a laser to adjust the Operating parameters of electronic circuit

Laser trimming - Controlled alteration of the attributes.

Types of trim: passive trim
Active trim.

Advantages: Better control of final resistance.
Better cleanliness.

5) Explain the application of laser in Removal of Vaporization of materials.

- Variety of industrial operation,
- Application - welding, hole drilling, cutting.

Process of material removal,

* Vaporization.
* plasma production.

Absorption of heating
* melting.

Types of laser: Nd: YAG
* Nd (YAG)
* CO_2
* Excimer.

Material removal functionalities
*
* flushing of liquid material.
* particulate ejection.