CHARACTERISTICS OF LASER CUTTING

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Abstract: Laser beam is a new universal cutting tool able to cut almost all known materials. Laser cutting is new attractive process for contour cutting thin sheet. Laser cutting process offer much advantages as like: narrow, straight-edged kerfs, minimum heat affected zones adjacent to the cut edge, no mechanical distortion of the work piece, absence of tool wear and hence replacement, the ability to cut materials regardless of their hardness. Laser cutting is applicable for final working of work pieces. Application of laser cutting made possible good quality of products, flexibility of production and enlargement of economy.

Keywords: Laser cutting, workpiece, heat-affected zone

1. Introduction

The term laser is used in a general way for there are many different types of laser with quite different characteristics. All lasers emit radiation with special properties which enables the laser to be used in a much wider range of applications. From medical applications, research and metrology to telecommunications, lasers have become a part of everyday life. One of the areas that lasers have made a significant impact is in industrial materials processing, primarily cutting, welding and marking.

The first laser, a ruby laser, was invented 1960. The first industrial application of a laser was making holes in diamonds used a beam from ruby laser. Since that beginning, the use of laser technology has continued to be an impressive and successful story. Laser processing is fast becoming essential in nearly all manufacturing industries. For many applications, laser processing is the most precise, economical method available. For some, laser processing is the only method.

Many types of lasers have been developed, but very few may be employed in a practical sense by industry. The two most commonly used lasers for materials processing are the CO₂ lasers and the Nd:YAG lasers. It is probably fair to say that of these two, the CO₂ laser is the most versatile. Today, there is no doubt that the CO₂ laser is the most useful one for metalworking. CO₂ laser became available for commercial applications in the early 1970's.

Material processing with high-power CO₂ lasers began nearly 20 years ago. CO₂ lasers have become well-accepted tools in the manufacturing industry. It is available with a wide range of output powers and at reasonable cost. There are, however, some areas in which the Nd:YAG has a number of advantages because of its shorter operating wavelength.

The ruby laser was at one time widely used for materials processing but it is now very common. Another possibility is the alexandrite laser which would appear to have some advantages over Nd:YAG, it has a shorter wavelength, but it has not been available for long enough for many commercial applications in this area to emerge. The ability to achieve high output power and the flexibility are the key reasons lasers have had an impact in the metal working. Material processing by lasers occurs by heating of a workpiece to various levels.

The heating levels required depend upon the application. For heat treatment, the temperature must be sufficient to obtain the required solid-state transformations. For welding, alloying, cladding or glazing, it is necessary to exceed the melting point. For material removal processes (cutting or drilling) still higher temperatures are required. The efficient manufacture of high-quality metal components is not possible without laser technology.
2. Laser cutting

Laser cutting is one of the largest applications of lasers in metal working industry. It is based on the precise sheets cutting by focused laser beam. The laser beam is a new universal cutting tool able to cut almost all known materials. Laser cutting is the process of vaporizing material in a very small, well defined area. Laser cutting process utilizes coherent light developed within an optical resonator cavity. An electrical discharge, through premixed He, N2, CO2 causes photon emission between reflecting mirrors mounted perpendicular to axis of the resonator. Beams exit a 50 percent reflecting, 50 percent transmitting mirror at one end of the resonator cavity. The photon energy derived from the excited CO2 molecule has a 10.6 μm wave length (infrared), phase aligned to permit focusing through processing optics.

The output beam typically focused to a spot diameter of 0.1 mm using a 63.5 mm focal length lens. Cutting temperature is approximately 18000 F and energy concentration is 10 MW/cm² (enough to vaporize most materials). However, 90 percent of the light beam is reflected from the surface of steel, necessitating an oxygen assist. Cutting speed ranges from 2 to 10 m/min for laser power 1.5 kW.

![Fig. 1: Laser cutting](image)

The laser beam' effect upon a workpiece material can be divided into several characteristic phases:
- Absorption of the laser radiation in the workpiece surface layer and transformation of the light energy into the heat one,
- Heating of the workpiece surface layer at the place subjected to the laser beam,
- Melting and evaporation of the workpiece material,
- Removal of the break-up products, and,
- Workpiece cooling after the completion of the laser beam' effect.
Part of the laser beam power is lost due to its passing through the workpiece, by the molten material and process gas. Still, its greatest part is absorbed and used for inducing melting and evaporation of the material at the cut point. The absorbed energy quantity is mostly depending on thermal and physical properties of the workpiece material; the choice of material also depends upon them. Absorption is essential only at the first moment of the interaction between the laser beam and the workpiece material. Later on, heat diffusion is of crucial influence. In cutting, the aim is to vaporize the material as quickly as possible and to produce as narrow a heat-affected zone as possible with minimum distortion of the workpiece.

Most industrial laser cutters employ a gas stream coaxial with the laser beam. The gas stream helps to remove molten material from the region of the cut. In the laser cutting operation, in addition to the heat obtained by focusing the laser beam, the process gas is used for removing the molten material from the cutting zone, to protect the lenses from evaporation and to aid the burning process. The useful power can be increased in the case that the process gas is oxygen due to the exothermic reaction. The gas blowing increases the feed rate for as much as 40%. By combining the laser as the light radiation source and the machine providing motion, in addition to the applied numerically controlled system, it is possible to provide for a continual sheet cutting along the predetermined contour.

The laser is a cutting tool has been successfully applied to a large number of materials. Since the laser beam exerts no force on the part and is a very small spot, the technology is well suited to fabricating high accuracy parts, especially flexible materials. The materials which are currently being cut by lasers include: metals, wood, cardboard, fabrics, plastics, composites, ceramics, glasses and quartz. The part keeps its original shape from start to finish.

Laser cutting systems have enjoyed the reputation of producing parts that are below 0.1 mm tolerance with narrow heat affected zones and cutting speeds to 5 m/min and greater in gauge thickness materials. The downside of laser technology was it's relatively high capital cost. While current developments in laser technology and motion systems have not reduced the capital cost, capabilities have improved in areas of system reliability, speed, material thickness capacity and even tighter tolerances in finished parts.

In industrial application nowadays various types and constructions of laser cutting machines can be met. By contour cutting two dimensional formed thin sheet workpieces the use of machines with X-Y table coordinate is effective and real when CNC control unit is used for control. By contour cutting three dimensional formed thin sheet workpieces the laser robots are often used. Technological problems related to the application of laser machines to continual sheet cutting are in insufficient knowledge of the laser technique application as well as due to absence of sufficiently reliable practical data and knowledge about the parameters influencing the work process itself.

3. Advantages and disadvantages

Laser cutting do offer a number of advantages, however, when compared to more conventional techniques, for example:

• Laser radiation is a very "clean" form of energy, in that no contaminating materials need come into contact with the workpiece. In fact, the working atmosphere can often be controlled to suit a particular task;
• Laser beams, because of their high spatial coherence, may be focused onto very small areas. This intense local heating can take place without neighboring areas being affected;
• It is comparatively easy to control the beam irradiance;
• The beam is readily directed into relatively inaccessible places; it can pass through transparent windows and be directed round sharp corners;
Most of the laser energy is deposited very near the surface of the target, thus enabling shallow surface regions to be treated without necessarily affecting the bulk. There is almost no limit to the cutting path; the point can move in any direction unlike other processes that use knives or saws. The process is forceless allowing very fragile or flimsy parts to be laser cut with no support. Since the laser beam exerts no force on the part and is a very small spot, the technology is well suited to fabricating high accuracy parts, especially flexible materials. The part keeps its original shape from start to finish. The laser beam can cut very hard or abrasive materials. Sticky materials that would otherwise gum up a blade are not an obstacle for a laser. Lasers cut at high speeds. The speed at which the material can be processed is limited only by the power available from the laser. Cutting with lasers is a very cost effective process with low operating and maintenance costs and maximum flexibility.

Disadvantages of laser cutting are:
- Very large resonator cavity required per cutting head, therefore, not normally used in multiple-head configuration;
- High capital equipment cost;
- Requires isolation of cutting head for safety;
- Mirror alignment critical and power level reduces as mirrors degrade;
- Double material thickness is equal to one-half the cutting speed;
- Generally not used for steel above 20 mm.

4. Conclusions
With respect to various other processes, such as gas cutting, plasma cutting, sawing and punching, CO2 laser cutting has numerous advantages, namely, a narrow cut, a proper cut profile, smooth and flat edges, minimal deformation of a workpiece, the possibility of applying high velocities, intricate profile manufacture and fast adaptation to changes in manufacturing programs. They can cut almost all known materials. Laser cutting systems have enjoyed the reputation of producing parts that are below 0.1 mm tolerance with narrow heat affected zones and cutting speeds to 5 m/min and greater in gauge thickness materials.

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