Reason - A Technical Magazine
Vol. – IX, 2009 & 2010

LASER WELDING AND ITS APPLICATIONS

Bikash Panja[1] and Dr. Santanu Das[2]

[1]M.Tech (Production Engineering), 2nd Year Student, Department of Mechanical Engineering
[2]Professor and Head, Department of Mechanical Engineering, email : sdas_me@rediffmail com
Kalyani Government Engineering College, Kalyani

Abstract : The laser has introduced optical radiant energy as a new form of energy for industry. Laser welding offers high speed, with high joint efficiency to produce high quality weld. It can be delivered in pulse mode or continuously, to control the heat input, and hence, the heat affected zone, or the temperature near heat sensitive items. The energy can be delivered through transparent media for underwater welding. It can be used with a filler system for the thick section welding, and also it can be transmitted through air, vacuum or fibre. In the present paper, some issues on laser welding and its applications are reviewed.

Keywords : Welding, laser, LBW, applications, typical issues.

1. Introduction

Lasers are being used worldwide in a variety of manufacturing operations such as cutting, drilling, marking, welding, surface hardening, and surface alloying and cladding, surface texturing, metal forming, rapid prototyping, rapid manufacturing, surface cleaning, micro-machining etc. Effects of parameters e.g. wavelength, phase, intensity, directionality, on the etc are well established, and hence, its behavior can be predicted with certainty [1].

Laser welding of metals has become a viable, industrial alternative to well-established welding processes because of its high quality weld on a wide range of metals and alloys. Commonly used lasers for welding can be Nd:YAG, Yt-doped fibre and CO_2 laser. These have applications from very low power micro-fusion to high power thick section with high speed of welding. Given the ability of different types of commercial lasers, it is not surprising that lasers are used in the jewellery, dental, medical, tool and die, automotive, aerospace, ship building and nuclear industries. Materials being welded range from low cost steel and aluminum to very high cost gold and platinum [2]. This form of energy allows welding at high speeds with high joint efficiency maintaining high quality of weld It can be delivered in pulsed or continuous mode to control the heat input, and hence, the heat affected zone(HAZ) [3].

The aim of this paper is to introduce the lasing process, and some important issues of laser for its use in welding.

2. The Lasing Process

Lasing process describes the basic operation of laser, i.e. generation of coherent beam of light by "light amplification" using "stimulated emission". Negatively charged electrons rotate around the positively charged nucleus in some orbital paths. Each of the orbital electrons is associated with a unique energy level. At absolute zero temperature, all the electrons occupy their respective lowest potential energy. Electrons of a state can be excited to a higher state of energy by absorbing energy form external sources like increase in electronic vibration at elevated temperature, chemical reaction and absorption of energy of the photon. Fig.1. depicts schematically the absorption of a photon by an electron. The electron moves from a lower energy

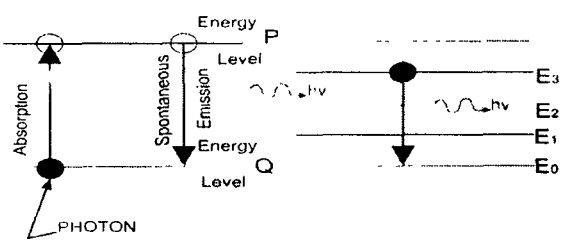

Fig. 1. Change of state of electrons and spontaneous emission

level to a higher energy level. On reaching the higher energy level, the electron reaches an unstable energy band, and it comes back to its earlier state within a very small time by releasing a photon. This is called spontaneous emission. The spontaneously emitted photon would have the same frequency as that of the "exciting" photon [4].

3. Lasing Medium

Depending on the lasing medium, lasers are classified as solid state, liquid laser and gas laser. In metal working, the solid state and gas lasers are generally used.

Solid-state lasers are commonly of the following type and are generally used in material processing

- Ruby which is a chromium – alumina alloy having a wavelength of 0.7 μm
- Nd-glass lasers having a wavelength of 1.64 μm
- Nd-YAG laser having a wavelength of 1.06 μm

Generally used gas lasers are Helium – Neon, Argon, CO_2 etc.

Lasers can be operated in continuous mode or pulsed mode. Typically, CO_2 gas laser is operated in continuous mode, and Nd – YAG laser is operated in pulsed mode [5].

4. Application of Laser Beam Welding

Laser beam welding (LBW) has wide range of application and some important applications are listed below ;

4.1 Plastic Welding By Laser

In laser welding of thermoplastics known as "laser transmission welding" or IR welding, transparent and absorbing plastic parts are bonded together. The laser beam penetrates the transparent plastic and

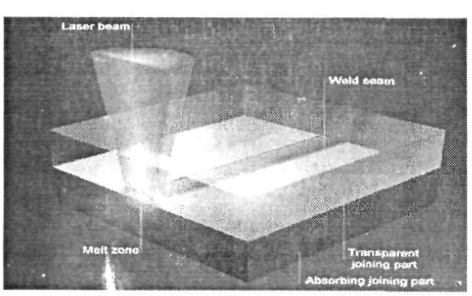

Fig.2 : Plastic Welding

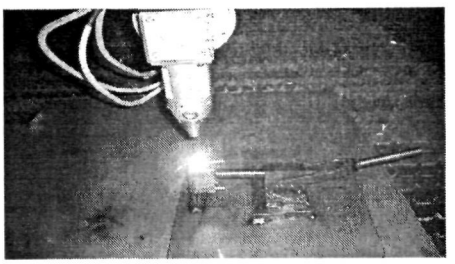

Fig.3 : Steel Welding

is converted to heat in the absorbing plastic. This process is shown in Fig. 2 [6].

4.2 Laser Welding of Steel

Low-carbon steels are readily laser weldable provided that sulphur and phosphorus levels are kept below 0.04%. A higher content can promote solidification cracking. In low-carbon steel, the welding zone is martensitic and exhibits increased hardness depending upon the content of carbon and alloying elements. A typical process is shown given in Fig. 3 [7].

In laser welding, the manufacturing environment is safe, productivity is increased by eliminating the need to pre-heat and post-weld treatment. [8]

4.3 Laser Welding in Automotive Industry

The majority of high power laser welding installations

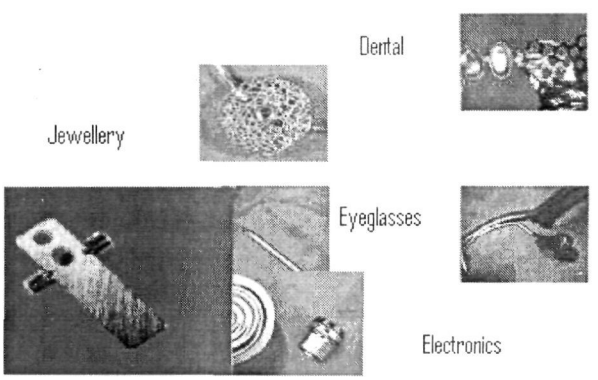

Fig. 4 : Micro laser joined components

in the automotive industry consist of cross flow CO_2 lasers in the power range of 3 kW to 5 kW. The laser beam is directed to the workstation and focused on the part by the use of copper mirrors. Weld depth and width depend on laser power, speed, focus spot size and position, shield gas flow and direction. The laser weld is a non-contact

process, easily controlled and well suited to automation [9]

4.4 Micro Joining By Laser Welding

Of all metal joining methods, micro joining of metals and alloys are commercially done running micro laser joining (Fig 4) [2]

Various types of applications in medical sector include orthopedic instruments, spinal implants and instruments, intravascular tubes, endoscopic tools, biopsy instruments [10]

5. Advantages of Laser Beam Welding (LBW)

One of the largest advantages that pulsed laser welding offers is the minimal amount of heat that is added during processing This makes laser welding ideal for thin sections or products Low heat input of LBW being an optical and not electrical process means greater flexibility in tooling design and materials [11]

Some of the significant advantages are given below

1 Deep and narrow welds can be done
2 Absence of distortion in welds created
3 Minimal heat affected zones in welds created
4 Excellent metallurgical quality will be established in welds
5 Ability to weld smaller thinner components
6 Increased travel speeds
7 Non-contact welding
8 Low porosity of welding [12]

Advantages of Laser Welding Compared to Other Processes

There are distinct advantages of laser welding than other welding process is a given Table 1 [13]

6. Typical Issue of Laser Welding

In recent years, application of LBW of lightweight alloys metals (titanium alloys, magnesium alloys etc) are explored through a process of optimization Joining of plastic with the pilot laser welding system by controlling the heat, in under water condition becomes possible [14]

Nowadays the most important research area of laser welding is Zinc Coated Steel Welding of zinc-coated steel sheets in lap configuration poses a challenging problem to the researchers A new method of using two tandem laser beams for lap welding of galvanized steel sheets is being discussed and modeled along with its comparative study This involves a pre-cursor beam and a higher-power actual beam, generated independently or otherwise split from the same source The first beam cuts a slot, thus making an exit path for the zinc vapours while the second beam performs the needed welding The ideal solution should firstly solve the technological problem of the residual zinc vapors trapped in the joint weld due to the lower boiling point of the zinc (907°C) with respect to melting point of steel Fe (1530°C) The solution should also be practical and economical enough to be installed on the production lines For this purpose, this dual beam solution is proposed [14]

Laser welding of plastics can offer flexible seam contouring, minimal heat input, mechanical stress and consistent weld quality Therefore the laser welding represents an alternative to conventional joining techniques for plastics Typical configuration for CO_2 plastics welding is the buttone The latter is not the ideal configuration for polymers welding

Table 1: Advantages LBW over other welding processes.

Competing Process	Advantages of Laser Beam Welding
Gas Metal Arc	Faster welding rates by an order of magnitude, low distortion, no filler metal required single-pass two-side welding
Submerged Arc	Faster welding rates, low distortion, no flux or filler needed
Resistance Welding	Non-contact, eliminating any debris buildup, can reach otherwise inaccessible locations, faster welding rates
Electron Beam	Does not need to be performed in a vacuum, on-line processing, shorter cycles and higher uptimes, welds magnetic materials, does not require radiation shielding

In order to achieve a strong weld seam, a melt has to be created throughout the whole joining volumes, which limit the plastics pigmentation [15].

Through Transmission Laser Welding (TTLW) of plastic material is an emerging area of research and welding of plastic. For better control of the process, extensive research work is necessary to explore various aspects of this relatively newer joining process for plastics. This will lead to more effect utilization of the process yielding better weld quality. Conventional plastic welding techniques are not efficient enough in some of the above mentioned aspects. Laser welding of plastic is fairly a new alternative to fulfill these requirements of the industry compared to the conventional welding techniques [16].

The high strength to weight ratio and excellent corrosion resistance of titanium alloys allow diverse application in various fields including the medical and aerospace industry. Several techniques have been considered to achieve reliable welds with minimum distortion for the fabrication of components in these industries. Of these techniques, laser welding can provide a significant benefit for the welding of titanium alloys because of its precision and rapid processing capability [17].

During underwater laser beam welding (LBW), the welding quality is severely influenced by the shielding condition of the local dry cavity. Comparing with the other underwater welding methods, underwater Nd:YAG laser welding has remarkably low heat input and high cooling rate, and a small heat affected zone (HAZ) and lower residual Stress is of importance to the structures used in nuclear plant. In addition, Nd : YAGlaser beam can be easily transmit to the position to be welded by using optical ûber, which is very easy for control and flexible to precision repair welding [18].

Modern technology is advancing so quickly that the average person simply cannot keep up with it. Even some scientists are occasionally unaware of discoveries being made in laser welding. So now a days laser welding is wide range of future.

This new laser procedure moves the welding spot at very high speeds to increase welding cycles by up to 40 percent or more.

Welding is a laser application that, historically, represents about 15 percent of the total units sold each year. Considering that laser installations have grown at an average rate of about 15 percent per year since 1970, welding has just kept pace, while other applications such as cutting and marking have, in recent years, each reached around 33 percent of the annual installations.

This apparent lower acceptance rate is not cause for concern because welding is, for the most part, very much a part sensitive process. Think about it, whereas sheet metal cutting applications are pretty much the same around the world, laser welding is material and design specific. Outside of a select few applications, laser welding is not a process that generates large volumes of equipment sales for a specific product, globally. One exception could be in the automotive sector, namely, body-in-white spot welding [19].

7. Concluding Remarks

Different methods of welding have been a joining part of metal industry in use by humans but Laser welding is a better performance due to computer control or robot control. It has excellent metallurgical quality, less heat affected zones in welds, absence of distortion in welds and higher reliability of welding machine with high joining efficiency. Laser welding opens up many opportunities for designing and economically joining. It has help reached in inaccessible area succeed in plastic material, thermoplastic plastic material, zinc coated steel, various types alloys, dissimilar metals welding and also underwater welding. As mentioned, the heat source provided by the laser beam is highly concentrated. Most of the advantages offered by the laser welding process stem from this feature. These advantages include high productivity, low heat input/ low distortion, deep penetration, repeatability, and ease of automation.

So the laser welding will be supported and improved by such advanced engineering techniques as fabrication. As a result laser welding is challenged in mechanical engineering department.

References

[1] Nath, A.K., 2010, From basic to updates of high power lasers in manufacturing, Workshop on Application of Laser in Material Processing, pp.1-2

[2] Shanker, K., 2010, Laser welding of metals, micro to hybrid, Seminar on Application of

Laser in Materials Processing, pp.98-100
[3] Pal, T.K., 2010, Laser welding, Workshop on Application of Laser in Materials Processing, pp.65-66
[4] Paul, S., Chattopadhyay, A.K., Chattopadhyay, A.B., Manufacturing Processes II, NPTEL Courses, Module : 9, Lesson 40
[5] Mishra, P.K., 1997, Nonconventional Machining, Narosa Publishing House, Kolkata.
[6] http://laser-industrial.com/plastic_welding.html, accessed on 17.05.2010
[7] http://www.linde.com/international/web/lg/us/likelgus30.nsf/docbyalias/ind_mv_laser6, accessed on 17.05.2010
[8] http://www.alspi.com/lsrweld.htm, accessed on, 17.05.2010
[9] Hamill, J.A., 1994, Laser welding P/M for automotive applications, Proceedings of the SAE International Congress and Exposition, Detroit, Michigan USA, pp. 2-3
[10] http://www.mlpc.com/files/Laser%20Welding%20for%20Medical%20Applications.pdf, accessed on 17.05.2010
[11] http://www.northeastlaser.com/Laser_Welding_processes.htm, accessed on 17.05.2010
[12] http://physicsnobelprize.net/, accessed on 18.05.2010
[13] http://www.uslasercorp.com/envoy/welding.html, accessed on 18.05.2010
[14] Iqbal, S., Gualini, M.M.S. and Grassi, F., 2007, Laser welding of zinc-coated steel with tandem beams Analysis and comparison, Journal of Materials Processing Technology, vol. 184, pp.12–18
[15] Casalino, G. and Ghorbel, E., 2008 Numerical model of CO_2 laser welding of thermoplastic polymers, Journal of Materials Processing Technology, vol. 207, pp.63–71
[16] Barma, J.D., Pal, P.K., and Bandyopadhyay, A., 2010, Study on the effects of different process parameters in through transmission laser welding, Seminar on Application of Laser in Materials Processing, pp.193-195
[17] Akman, E., Demir, A., Canel, T. and Sýnmazcelik, T., 2009, Laser welding of Ti6Al4V titanium alloys, Journal of Materials Processing Technology, Vol. 209, pp.3705–3713
[18] Zhang, X., Ashida, E., Shono, S. and Matsuda, F., 2006, Effect of shielding conditions of local dry cavity on weld quality in underwater Nd:YAG laser welding, Journal of Materials Processing Technology, Vol. 174, pp.34–41
[19] http://www.optoiq.com/index/lasers-for-manufacturing/display/ils-article-display/148886/articles/industrial-laser-solutions/volume-17/issue-7/features/remote-welding.html, accessed on 18.05.2010.

The best thing about the future is that it comes only one day at a time.

– Abraham Lincoln