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Fiber Laser Welding

Benefits and Industrial Applications

Ujjwal Singla
Indian Institute of Technology, Delhi, India

***Abstract* — Welding is a large part of manufacturing industry and new research and inventions are continuously happening in this field. One of the new technologies in this field is 'Fiber Laser Welding'. This is just a research paper highlighting, what fiber laser welding actually is, its advantages over other techniques and its industrial applications.**

Keywords* — *Fiber; Laser; Welding

I. Introduction

Evolution of the procedures for joining should be in pace with the advancements in materials and applications demand. Lasers have played an important role in the joining of materials since their invention. Diode lasers have been developed in the last decade. Development for anything is done so as to decrease product price, increase quality and design, and decrease human labour. Same is the case with laser welding. The recent development in the high power laser range is the Fiber Laser. Fiber lasers have been developed so as to replace the solid state and carbon dioxide lasers for different joining processes.

Fiber lasers were first developed in the early sixties. The recent developments in this field led these lasers to have multiple advantages over other joining processes:

- Higher efficiency
- More compact design, which simplifies the installation process
- Better beam quality, due to the use of thin fibers
- Small beam focus diameter

Since these lasers use low wavelength that allows them to be absorbed by almost all metals and alloys, they can be used for deep penetration welding. The productivity achieved with these lasers exceeds those achieved with high power CO2 lasers for welding of sheet metal joints.

II. Fiber Laser Characteristics

Laser beam welding joins multiple pieces of metal with the help of laser technique. The laser beam provides a concentrated source of heat which can be utilised to produce narrow and deep welds. In laser welding, when the medium is excited, it emits photons and forms the laser beam. The fibre lasers use optical fiber as the medium. Specifically, the doped core of the fibre is the active medium. The beam of light is pumped longitudinally along the length of fiber where it is guided by the core itself or by an inner cladding around the core.

In a fiber laser, a silica core doped with rare earth metals is excited by a laser diode source. The incident light penetrates in the inner cladding. Wherever it is caught by the core, the doping elements present in the core cause a high refraction coefficient. The loss of strength of the signal is prevented by the outer cladding which is made of low refracting glass or polymer. The eventual laser emission results in an efficient, compact laser source. This when fitted with an collimator produces an extremely parallel beam which can be focussed using an appropriate lens (see Figure 2).

Corresponding Author: Ujjwal Singla

The high power fiber lasers available in the market are made from coils of multi-clad fiber doped with ytterbium, which emits wavelengths of 1.07 to 1.08 microns. Or, the device can be made from coils of multi-clad fiber doped with thallium, which emits wavelengths of 1.8 to 2.0 microns. The energy pumped by the diode is delivered to the active medium which passes through the multimode fibers, that are joined to the multi-clad coil. The cavity in the laser is generated directly in the active fiber. The passive single-mode fiber (usually with diameter of core of about 6 microns) acts as the exit route for the laser emission to exit the fiber laser. When the resulting laser beam (which is crucially diffraction limited) is equipped with an integral collimator, it produces an extremely parallel beam. A 1000 watt unit comprises of 10 individual fiber lasers joined together into a common cabinet. The resulting beam of M 2 of 7 to 10 is much better than high powered solid state lasers, even though the beam is no longer single mode. A 6kW fiber laser generates a beam that can be delivered by a fiber of diameter of 200 to 300 microns. The wall plug efficiency of the ytterbium fiber laser is 16 to 20 percent. While erbium and thulium fiber lasers have low wall plug efficiency, but still are more efficient than the usual YAG (yttrium aluminium garnet) lasers.

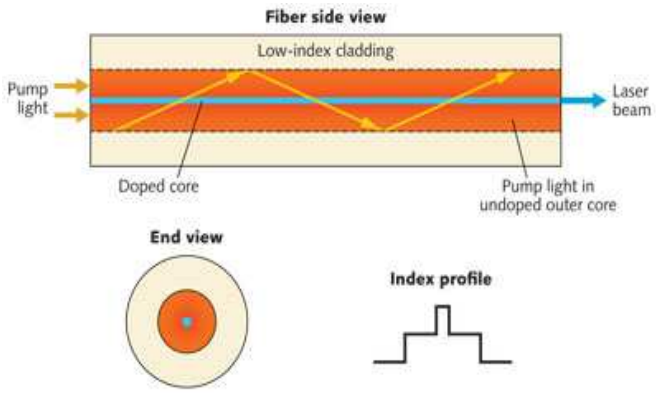

Figure 1 : The structure of a fiber laser includes a doped inner core, which is the laser itself; an undoped outer core (also called an inner cladding) through which the pump light is channeled; and an outer cladding.[9]

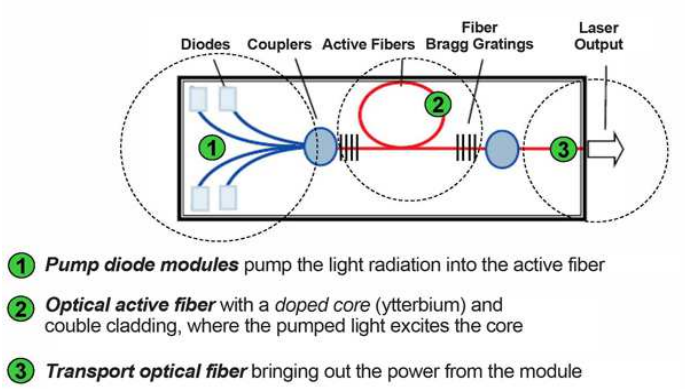

Figure 2 : processes under which an incident light goes through.[10]

III. Welding With Fiber Laser

Figure 3 above shows a typical setup for fibre laser welding. The parallel laser beam is focussed using a focusing lens to the workpiece to be welded. The material to be deposited is fed in its powder form using the powder delivery nozzle. The concentrated heat of the laser beam melts the laser beam powder and heats the workpieces to be welded. Eventually the powder fuses in the workpiece and gets deposited at the joint.

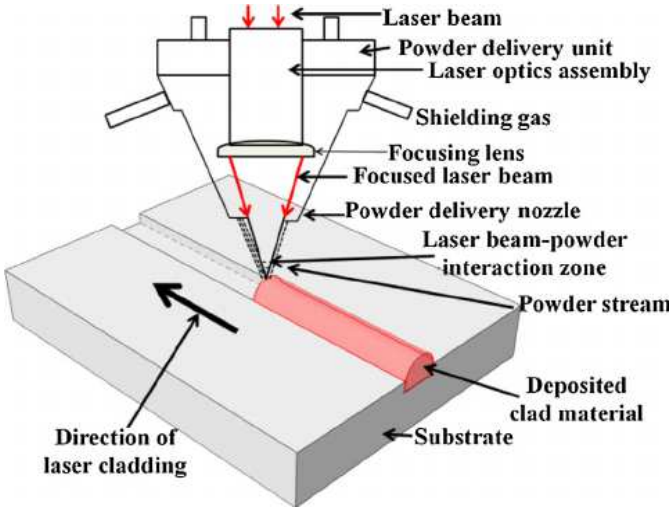

Figure 3: Fibre laser welding [11]

IV. Fiber Laser Benefits

The fiber laser has the following benefits and advantages:

1. When compared to CO2 laser beam, it provides simplified beam delivery using fiber-optic cables without having to deal with alignment of mirrors.
2. It is absorbed more by metals, especially good conductors, and is less absorbed by plasma vapours formed above the weld pool.
3. Fiber lasers give increased power intensity owing to its ability to be focussed to smaller sizes.
4. Light can be easily transferred to a movable workpiece because it is already present in a flexible fibre. This fact is extremely useful for laser cutting and welding.
5. Optical fibers can be several kilometers long, hence fiber lasers are capable of providing extremely high power output.
6. Large surface area to volume ratio accounts for continuous power output due to efficient cooling.
7. Fiber lasers are very stable with respect to temperature and vibrations. Fibers protects the optical path from thermal distortion.
8. Better beam quality also give cleaner welds.
9. They have very low ownership and maintenance costs and also use low electricity.

These factors allow deeper penetration and faster welding speeds in comparison to other welding processes.

V. Industrial Applications

1. The fact that it does not require workpiece to be transported anymore in the workstation allows its use in welding of thick sections and large steel structures.
2. Vital in welding of gas tube lines
3. High welding speed and flexibility makes this process an excellent choice for core welding applications.
4. Automotive, aerospace, medical and electronic industries utilise the benefits of fibre laser welding the most.
5. Requires no coolant, once they are air refrigerated, as the heat is dissipated throughout the overall fiber length.
6. Are practically maintenance free during their lifetime because there is no need to replace the flash lamps or diodes etc.
7. Industries like automotive,electronics or Solar Cells, Medical, Aerospace, Defence industries laser weld a variety of applications by using **fiber** laser welding
8. Some fiber laser welding examples are radar components, sensors, conductors,insulin pump cases, battery housing, pacemaker cases, etc.

VI. Results

Fibre laser welding provides great opportunities to improve the quality, productivity, product performance and design. But, there is still room for further improvement of process. When the performance level before welding is quite high, there is a need to improve the beam quality to get it as good as we can. The variations in part manufactured may cause problems that make it necessary to vary the beam quality. Various results show nice possibilities to improve the performance and quality by improved tools and strategies in penetration & greater depths with certain power levels. Fibre laser welding can be used to get higher welding speeds. Actually, in the 6 mm thickness range, the speeds achieved are competitive. In the power level of 30 kW, the performance is very nice.

The results show that there is still a need to find the appropriate power value for different
material, depth, environment etc.

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