IE 312 Fusion Welding Lab

Technical Report Submitted to: Dept. of Industrial and Manufacturing Engineering

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What are the principal advantages and limitations of submerged arc welding processes? What applications are they typically used for?

There are many advantages to the submerged arc welding process. This type of welding has a relatively high deposition rate at about 100 pounds per hour. This type of weld has high operating factors in mechanized applications and the weld penetrates deep into the metal. It is rare for there to be a defect because the strong welds are easily made when using good technique. Submerged arc welding also allows for high speed welding, at speeds of up to 16 feet per minute, when welding thin sheet metal. When working thicker metal, welds can still be completed in a single pass. This type of weld minimizes the amount of fumes and bright light created by welding. The edges of the work pieces don't need to be prepped before welding like they do for some other types of welding. The weld doesn't spatter because the arc is held under flux. 50 to 90 percent of this flux is also recyclable.

This type of welding also has a few limitations. It can only be used on ferrous metals, with a few nickel based alloys being the exception. The weld works best on straight seams and rotated pipes. The welding requires finicky and complex flux handling systems. Residue from slag and flux can be a health concern for welders. After welding, the slag that built up must be removed from the piece.

As mentioned above as a limitation, the applications of submerged arc welding include welding long and straight seams in carbons steels, low alloy steels, stainless steels, nickel based alloys, and surface applications.

Flux-core arc welding is a process that is rapidly gaining popularity and starting to replace SMAW processes for construction site welding applications. What are the main attributes of this process?

Flux cored arc welding has some advantages over submerged arc welding. If the welder uses the correct filler metals, the process becomes an 'all position' process. The welding technique doesn't require shielding gases, so it can be used in windy out door environments, such as a construction site. The weld is known for having a high deposition rate, and for being a high speed process. Operators need less skill to successfully weld, compared to SMAW welding. The metal pieces being welded require less cleaning and preparation before the weld. The flux protects the welded metal from external factors until the slag is cleaned away. The chances of porosity are low.

Flux cored arc welding is not perfect, however. The contact tip can fuse to the welded metal if the welder accidentally touches the tip to the metal. Mechanical inconsistencies can lead to inconsistent wire feeding. Gases trap in the hardened metal can leave holes in the welded metal, called 'porosity'. The filler material is more expensive than that of SMAW. The equipment is not as mobile as the equipment in SMAW, and it can cost more. The weld creates more smoke and fumes. Changing the filler metal can take longer, compared to SMAW.

The process can be used on mild and low alloy steels, stainless steels, nickel alloys, and surfacing alloys.

What are the principal advantages and disadvantages of using high energy beams for fusing welding?

Electron Beam Welding (EBW) is a fusion joining process that produces a weld by impinging a beam of high energy electrons to heat the weld joint. Accelerating electrons to roughly 30-70 % of the speed of light, which raises them to a high energy state, provides the energy to heat the weld. I will now discuss the primary advantages of using high energy beams for fusion welding.

Firstly, only a single pass of EBW is needed to weld even thick joints, if done correctly. Next, there is low distortion of the metal caused by this process, as compared to other processes such as submerged arc welding. Again, compared to other processes, both the weld zone and heat affected zone are narrow, which is preferable while welding. This also helps to reduce the distortion of the two metals. EBW also doesn't use filler metal like some of the other processes. Lastly, there is both low contamination in a vacuum and hermetic seals of components retain a vacuum when EBW is used.

However, there are also disadvantages to Electron Beam Welding. For example, the equipment cost of EBW gear is expensive to buy, maintain, and replace. On top of this, there are size constraints on the work chamber due to the design of the EBW gun. There are also x-rays produced during high fusion welding which can cause health issues and eye problems if proper precautions aren't taken. Next, there is a time delay associated with EBW when welding in a vacuum. Finally, the rapid solidification rates can cause cracking in the weld, or other complications.

Hot tears, cold cracks, residual stresses, and welding distortion are undesirable defects that result from fusion welding. Describe at least two additional defects that may result.

Porosity - this may be caused by trapped gases that are released during melting of the weld zone but trapped during solidification. It could also be caused by chemical reactions that occur during welding, or even contaminants present in any of the metals. We can reduce the chances and effects of porosity by proper selection of electrodes and filler metals, improvement of the welding operation by preheating the weld area or increasing the rate of heat input, proper cleaning of the weld zone and prevention of contaminants from entering the weld zone, lowering the welding speed to allow time for gases to escape, or shot peening the weld bead.

Slag inclusions - these are compounds, such as oxides, fluxes, and electrode coating materials that are trapped in the weld zone. If the shielding gases used are not effective, contamination from the environment may also contribute to slag inclusions. To avoid these defects one can clean the weld-bead surface before the next layer is deposited by using a brush or chisel, provide adequate shielding gas, or redesign the joint to permit sufficient space for proper manipulation of the puddle of molten weld metal.

Fusion welding processes work by melting the substrate materials to be joined so that they can be intermixed and solidified at a joint. How do cold welding processes permanently join substrates? Provide an example of an economically important cold welding process.

Cold welding is a type of solid state welding, which means that there is no liquid or molten metal involved at all during the joining. Instead, cold welding occurs when two clean, flat pieces of similar metals are brought together with very high pressure. This is done in a vacuum or vacuum like environment. This process is typically done on very ductile materials, and the pressure can be achieved with hand tools or a press. This process requires significant deformation at the weld. Because this process is extremely simple and only requires high pressure, there are many applications at the nanoscale level. Since these materials are extremely small and are often single crystalline, they can be joined with little pressure and are nearly perfect welds. Therefore, one example of an economically important cold welding process is those to create wire stock and electrical connectors, as well as those involved in nanotechnology. Also, cold welding is often used in space missions because of the vacuum environment.

Friction welding processes include ultrasonic welding, friction welding, and friction stir welding. What is the fundamental difference between a frictional welding process and a cold welding process?

Although frictional welding and cold welding processes both are solid state processes in which there is no molten metal involved, there are several differences. Cold welding only requires room temperature and a lot of pressure in order to create a weld. Friction welding requires heat, which comes from mechanically induced sliding or rubbing contact between two metals. Although this processes also requires a significant amount of pressure, it also requires motion between the surfaces. One positive of this process is that it does not require the metals to be as clean and perfect. In friction welding, often times on metal is rotated on the other with considerable speed in order to generate the heat. Otherwise, one metal vibrated on the other such as in ultrasonic welding. In the end, once a considerable amount of heat is generated, the motion is stopped and pressure is applied in order to weld the two metals. Therefore,

the primary difference between the two processes is that cold welding requires a significant amount of pressure as well as the correct environmental factors, but no heat, while friction welding requires heat and pressure but can be done in more common environments. Both processes have their benefits and drawbacks, and friction welding is often quite expensive because of it's requirement of a machine to achieve the correct rotational speed, and cold welding is more difficult as it requires more pressure and a vacuum like environment.

Similar to classic fusion welding, resistance welding melts and intermixes substrates at their interface. How is heat supplied to the substrate interface? What are the main advantages and limitations of resistance welding processes? Identify at least two economically important resistance welding processes as well as the typical applications that they are used for.

In resistance welding heat to form the weld is generated by the electrical resistance of material combined with the time and the force used to hold the materials together during welding. Some advantages to resistance welding include, short heating time of tool, simple metallurgical process, can adapt to more varieties of different metals, simple process with high productivity and low cost. Some disadvantages are complex equipment which raise the cost of the machine greatly, and large capacity so an even larger grid is needed. Resistance welding refers to two different processes that accomplish a couple of different goals. These two types of resistance welding are spot welding and seam welding.

Another resistance welding process is that of spot welding. Spot welding is typically used for welding metal sheets together by single spot welds. Other uses for spot welding include studs, projections, electrical wire hangers heat exchanger fins and tubing. Spot welding is very energy efficient, it provides little workpiece deformation, high production rates, automation is easy, and no filler materials are needed to create the weld.. Another resistance welding process is that of seam welding. Seam welding is typically used for welding two similar metals together at their faying edge This makes the seam a butt joint or a overlap joint. A common use for seam welding is in the production of round or rectangular steel tubing.

How do brazing processes and soldering processes fundamentally differ from fusion welding processes? What differentiates a brazing process from a soldering process? Identify at least eight different methods by which heat is supplied to a brazed/soldered joint? Provide at least one example of an economically important application for which brazing is used. Do the same for soldering.

Brazing and Soldering processes differ from fusion welding processes in that no melting of the base metal occurs in brazing and soldering. The technical differences between brazing and soldering is that in brazing, the filler metal melts at a temperature above 450°C and in soldering the filler metal melts at a temperature of 450°C or below. Soldering is a method of using a filler metal for joining two metals without heating them to their melting points. Sources for heat for a soldered joint are soldering coppers[1], filing and tinning coppers[2], forging soldering coppers[3], electric soldering[4], and gas torches[5]. Brazing is the process of joining metal by heating the base metal to a temperature of around 450°C and adding a filler metal that melts below the base metal. The heating source for brazing depends on the amount of brazing required. If the pieces are small enough, the pieces can be put in a furnace[6] and brazed all at once. Individual torches[7] can be mounted in groups for assembly line brazing. Another type of heat source for brazen is using Mapp-oxygen torches[8] to braze individual items.

An economically important application of Brazing is its easy adaptation to mass production. It is easy to automate because the individual process parameters are less sensitive to variation. Therefore, complex and multi-part assemblies can be brazed cost-effectively. An economically important application of Soldering is its use in electronics and jewelry. Soldering is important in maintain and restoring electrical circuits to enhance their longevity.

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