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Contamination in Welding

One of the many contributors to weld defects is contamination. Presence or introduction of contaminants disrupts the established welding process and produces discontinuities in the weld that could be categorized as defects. There are numerous sources of contamination which need to be carefully considered and monitored to maintain a robust process.

The most obvious source of contamination resides on the surface of parts to be welded. Such surface contamination can come from prior process steps, storage, and/or transportation which can lead to presence of dust, oil, and metal shavings adhering to the surface. Machining or stamping often leads to oil on the surface, which then attracts dust and metal shavings. While dust can be easily removed by wiping, presence of oil needs more careful washing and degreasing followed by proper drying and storage. Parts that are insert molded, as is common in many automotive applications, may also have mold release compounds and sometimes even plastic residue on the surface. An adhesive or epoxy application on an adjacent area may inadvertently smear the welding location. Pinching a tube to form a hermetic seal may be affected by the liquid that was passed through the tube, especially if using ultrasonic welding.

If the prior step includes any type of edge preparation of sheets such as shearing, the faying surfaces may be embedded with contaminants and could also affect the edge quality. If the edge is cut by a plasma torch, the edges will be oxidized and may require chemical or mechanical cleaning. Waterjet cutting also has issues as the cutting media (fine abrasive particles) can easily get embedded in soft metals such as aluminum and copper. Presence of media can interfere with soldering/brazing and will also affect fusion welding, potentially causing internal defects such as inclusions which can only be detected by x-ray. Laser cutting produces a fairly clean cut and can often be used directly without any additional preparation. If the edge does need to be locally cleaned up to remove burrs or roughness, it can be done with a dremel tool or a draw file, followed by wire brushing and wiping with a lint-free cloth and alcohol. It is always a good habit to keep a separate set of cleaning tools specifically for a particular metal, and in some cases for a specific alloy, to avoid any chances of cross-contamination. Wire brushes should be made of stainless steel bristles and brushing should be done manually; using powered wire brushes is not recommended as they can end up smearing the surface rather than cleaning it. If making an x-ray quality weld, it may be a good idea to avoid any cloth for wiping; just use clean air to blow away the dust after wire brushing. If clean dry air is not available (shop air should not be used as it often contains moisture and organics), you can use Argon from the cylinder to blow away the dirt. Surface contamination can also come from surprising sources such as residue from any clamping fixtures made of another alloy such as copper on a steel component. Even an inadvertent rubbing against a copper fixture can leave enough residue on a weld location that can lead to cracking in steel welds. Such a phenomenon actually has a name to it, and is referred to as Copper Contamination Cracking, or CCC! (Weld Nugget - Fall 2010).

Another common source of contamination is the shielding gas (Weld Nugget – Spring 2017) used in fusion processes such as arc and laser welding. One of the issues can be purity of the gas itself, which is offered in many grade levels and selection should be based on quality requirements. Oftentimes, the gas itself is clean but can pick up contamination on the way to work; quite common when the gas is stored in large tanks and is piped everywhere in the plant. The gas can pick-up moisture contamination in the last few meters of the delivery tube in plant where temperature and humidity fluctuations are quite severe. When the machine is not operating at night and it gets cold, moisture can condense inside the last few meters of the tubes; when production starts in the morning, the moisture is picked up by the shielding gas and delivered to the weld. Perhaps the most common source of contamination from shielding gas is from improper usage; too little, too much, or misdirected. It is ironic that too high gas flow from a small diameter nozzle can actually draw air into the weld! The best option is to use a diffuser and a gentle flow, typically no stronger than flow required to blow a candle. As always, checking weld quality is the best judge of flow rate – ultimately, the proof is in the pudding.

Some of the contamination can come from poor process controls. For TIG welding, the common issue is transfer of tungsten into the weld which can occur when the electrode accidently dips into the melt; tungsten will show up on x-ray. For arc and laser welding processes, spatter generated during seam welding can fall forward and can adversely affect weld quality. In resistance welding, contamination can come from the electrode tips which can transfer material to the weld surface – especially likely if the tip is not cooled or maintained properly.

The materials including parts to be welded as well as fillers can also be a source of contamination. Processes that are sensitive to hydrogen can ingest moisture from welding rods, welding wire, or moisture on part surfaces. Processes that are potentially at risk of hydrogen embrittlement (Weld Nugget – Winter 2009) require careful handling and storage of weld rod/wire in heated cabinets. Contamination can also come directly from the base materials themselves, if they are not properly specified or of sub-standard quality. Welds are quite sensitive to even minor levels of impurities which may be within spec but not suitable for a particular welding process. For example, Al 3003 can crack with pulsed laser welding if amount of Fe (0.7% max) and Si (0.6% max) is at the high end; needs to be less than half those amounts to prevent cracking. Stainless steels such as 304 and 316 also become more crack sensitive if the combined amount of P and S exceeds 0.015%. Another problem often encountered is inadvertently specifying or procuring the wrong type of alloy. Even though the part drawing may call for a regular grade of steel, a vendor may choose to replace it with a machinable grade to reduce machining cost, not realizing that those machinable grades are not suitable for welding.

Removing contaminants is critical in ensuring weld quality and the user should use appropriate level of cleanliness as required or specified on the drawing to have a robust process.