Microhardness Testing of Aluminum Alloy Welds

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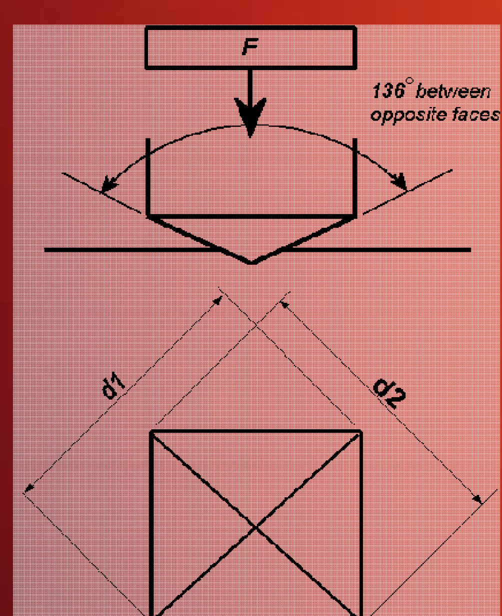
A weld is made when two pieces of metal are united or fused together using heat or pressure, and sometimes both. There are several different types of welds, each having their own unique properties and microstructure. Strength is a property normally used in deciding which kind of weld is suitable for a certain metal or joint. Depending on the weld process used and the heat required for that process, the weld and the heat-affected zone undergo microstructural changes resulting in stronger or weaker areas. The heat-affected zone (HAZ) is the region that has experienced enough heat to cause solid-state microstructural changes, but not enough to melt the material. This area is located between the parent material and the weld, with the grain structure growing as it progresses respectively. The optimal weld would have a short HAZ and a small fluctuation in strength from parent metal to weld. To determine the strength of the weld and decide whether it is suitable for the specific joint certain properties are looked at, among these are ultimate tensile strength, 0.2% offset yield strength and hardness. Ultimate tensile strength gives the maximum load the metal can stand while the offset yield strength gives the amount of stress the metal can take before it is 0.2% longer than it was originally. Both of these are good tests, but they both require breaking or deforming the sample in some way. Hardness testing, however, provides an objective evaluation of weld strengths, and also the difference or variation in strength across the weld and HAZ which is difficult to do with tensile testing. Hardness is the resistance to permanent or plastic deformation and can be taken at any desired point on the specimen. With hardness testing, it is possible to test from parent metal to weld and see the difference in strength as you progress from parent material to weld. Hardness around grain boundaries and flaws in the material will show how these affect the strength of the metal while still retaining the sample. This makes hardness testing a good test for identifying grain size and microstructure.

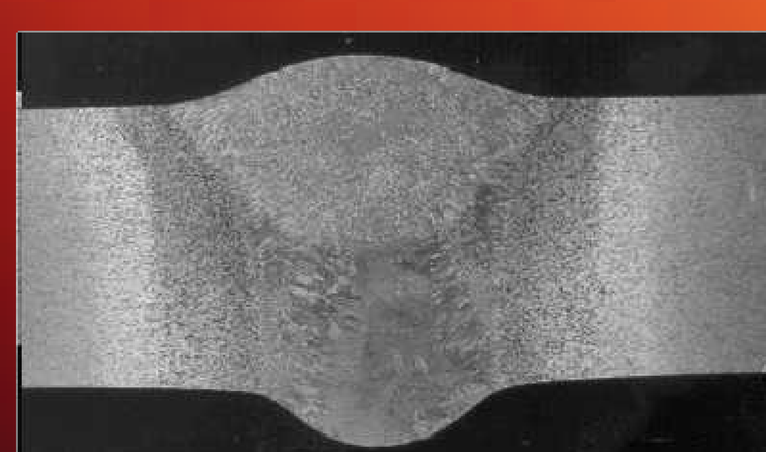
Microhardness



Microhardness testing is done by forcing a diamond shaped indenter with a fixed shape and size into the surface of specimen using a specific load. There are two methods used in finding microhardness: Knoop and Vickers. Knoop testing uses a rhombus indenter to leave an indention with a 7 to 1 ratio between long and short diagonals. The microhardness number (HK) is found by the ratio of load applied to unrecovered area of the indention. Vickers testing, which is the process used in this project, uses a square-based indenter with angles of 136˚ angles to leave an indention. The microhardness number (HV) is found by the ratio of the load to the surface area of the indention.

Two-Pass Fusion Weld

- Weld area is primarily a filler material.
- Filler materials used are similar to the parent material.
- Makes two trips or "passes" to fuse the parent material.

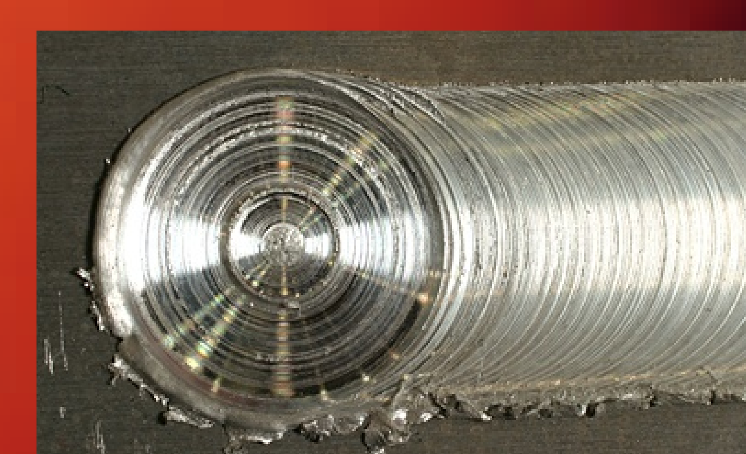


	Parent Material (?)	Heat-Affected Zone (HAZ)	Weld Area
QL095-0003 (AL-2219 alloy)	112-127 HV	122-141 HV	100-122 HV

Friction Stir Welding (FSW)

- Solid-state welding.
- Uses enough heat, while applying pressure, to soften metal but not enough to melt it.
- Maintains microstructure in material better than fusion welding.
- Aluminum and its alloys are generally used.
- Creates a stronger joint than Fusion Arc Welding.
- Uses a rotating tool to cause friction and deformation of the material.

Self Reacting (FSW)



- No filler material is added.
- The parent material from the retreating and advancing sides are mixed together to form the weld, causing a ripple looking weld.
- Used for cylindrical welds where the start point is also the end point.

	Parent Material	Heat-Affected Zone (HAZ)	Weld Area
M-2 (AL-2195)	182-197 HV	102-179 HV	87-97 HV
KS09MZ Advancing (AL-2219)	141-147 HV	96-139 HV	85-90 HV
KS09MZ Retreating (AL-2195)	182-190 HV	109-167 HV	100-106 HV

Conclusion

After testing each type of weld, I discovered that the Two-Pass Weld creates a stronger Heat-Affected Zone than the Self Reacting Weld. The weld area was also stronger in the Two-Pass weld. The two-pass weld has metal being added during welding letting the area around it the only be affected by heat, while the self-reacting weld has the material from the parent metal in it causing small changes in the surrounding material.