Background

Resistance Welding utilizes a power supply and a weld head to deliver electricity to a specific point as shown in Figure 1. The weld head holds two electrodes; work pieces are placed between the electrodes and a force is applied by the electrodes to squeeze the parts together. While resistance welding is capable of melting the work pieces, it is possible to use less current and more force to create a solid state weld.

Various electrodes can be created and used for different tasks, making resistance welding a versatile process; for instance, our early electrode design is in Figure 2.

In the medical field, titanium is commonly used due to its high corrosion resistance, with a high strength to weight ratio. It is ideal for implants and replacement parts inside the human body since it is bio-compatible. Cases can be made of titanium for batteries and capacitors, much like the ones used in pacemakers (Fig.3).

Motivation

Previously, welding a case to a pin for batteries and capacitors as seen in Figure 4 was done electrically, but the welding but there were issues with excessive contamination through mixing of the electrolyte with the melted metal. Micro resistance welding can make a solid state weld, which would be free of contamination by the electrolyte since no metal is melted.

Objectives & Approach

• Goal: Discover if it is possible to use micro resistance welding to create a solid state weld of Grade 2 Titanium.
  • No expulsion of any kind
  • May have minimal visible melting
  • Able to withstand 20 lbf in a tensile test
• Path to success:
  • Design electrodes and clamps
  • Use Solidworks to create pieces
  • Design an experiment
  • Force change to limits of pin
  • Pulse length from short time to long
  • Current from minimal for weld to expulsion
  • Polarity- positive to plate or to pin
  • Develop lobe curves
  • Tensile test samples
  • Perform metallography

Conclusions

Metallography shows that the weld is successfully sealed. The tensile data displays that greater electrode force is a key variable when creating these welds; a significant number of the welds with a tensile strength greater than 20 lbf were at 6 lbf of electrode force. Four sets of variables produce a weld with a 99% degree of certainty that the strength is above 20 lbf. Using a bottom electrode that is one piece provides more symmetrical heating, lowering the possibility that one side will not seal while the other side does. While it is possible to weld Grade 2 Titanium with resistance spot welding, the size of these pieces put a severe limit on the range of force for acceptable welds before buckling.

Future Work

This study proved that the process does work and that an increased time for process refinement would have the potential to eliminate the majority of melting, enough to possibly not interact with the electrolyte. While the metallography does show sealing of the weld, it does not show a hermetic sealing throughout the entire circumferencence of the weld. A helium leak test would confirm a complete seal. The new bottom electrode made of one piece of copper created a more symmetrical weld; the electrode should be optimized and further tests should be made with the new electrode.

Results & Discussion

Figure 7a on left, 7b on right: Lobe curves made with differing weld head forces. Note that the 6 lbf curve has all the proper tensile strength for all parameters.

• Each sample on the lobe curve was repeated 3 times for tensile testing and the averages were added to the lobe curves.
• There were 9 welds that had average tensile strengths above 20 lbf.
• The size of the pin led to buckling under higher electrode force. This sideways movement further led to modifications in the setup.
• Optical microscopy of the strongest welds showed that there was limited melting. On all of the welds made with the electrode seen in Fig. 8, there was a larger weld on one side compared to the other, or no weld at all in addition to uneven deformation of the pin. This imbalance occurs because only one side of the bottom electrode is conducting the current.

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Figure 9: This sample was made with the new electrode shown that had conduction on both sides. This weld resulted with even heating and deformation and there was more even bonding on both sides.