Q: We are brazing honeycomb rings onto the inside diameter of some metal ring housings for aero applications, but we’ve occasionally seen some of the honeycomb pull away from the substrate during the furnace brazing process. We thought we were tack welding the honeycomb to the substrate correctly, but wonder why some of those honeycomb rings fail to remain fastened to the substrate and pull away instead. What might cause this to happen?

A: The photos that you sent seem to indicate that your tack welding may not be sufficient to hold the honeycomb in place on the inside diameter (ID) surface of the substrate during the full heating and cooling cycle of the brazing process. Another issue may relate to your application of brazing filler metal (BFM) in the honeycomb. A third issue may relate to the furnace brazing cycle that you used. Let’s look briefly at each of these three possibilities.

Expansion/Contraction

First of all, a major factor in this entire honeycomb brazing process relates to the expansion and contraction of the metals themselves. All metals expand when heated, and then shrink (contract) when cooled, the amount of which depends not only on the so-called coefficient of thermal expansion (CTE) rate of each of the two base metals, but will also depend a lot on the mass/weight of those metals. More massive structures (such as the substrate on which the honeycomb is placed) will take more time to absorb...
heat and grow (expand), whereas very thin sheet metal structures (the honeycomb itself) can rapidly absorb heat and expand quickly compared to the heavy substrate, even if their COE rates were very similar. This is important.

Let’s assume for a moment that the honeycomb and the substrate were made from almost identical materials that had almost identical COEs. It can be easy for some people to believe that since the COEs were essentially identical, that just a few light tack welds should hold the honeycomb in place until brazing is completed, since the honeycomb and substrate will grow and contract at the same rate. Unfortu-

nately, that just doesn’t happen because you must take the relative mass of the two metals into account also.

As shown in Fig. 1, the thin honeycomb will grow rapidly during heating, faster than the substrate — so much so that the honeycomb can actually buckle slightly, pulling away from the substrate during heating, perhaps even breaking some tack welds (if the welds were very weakly made). This results in portions of honeycomb that will not braze, since they are no longer intimately in contact with the substrate.

Proper Tack Welding of Honeycomb to Substrate

It is your job to be sure that when the metals are heated and want to grow, the thinner honeycomb and the heavier substrate will expand and contract together, as much as possible. The only way for this to happen, realistically, is for the lightweight honeycomb to be strongly fastened to the heavy substrate along their complete interface, so much so, that the honeycomb will be “forced to conform” to the heavier substrate, and expand/contract along with that heavier substrate. This can be achieved through tack welding the honeycomb to the substrate in many places along the length of the honeycomb.

Figures 2 and 3 show typical setups used for tack welding the honeycomb to the substrate. This kind of tack welding setup uses a capacitive discharge spot welding machine that sends high energy through the honeycomb and melts a tiny bit of the honeycomb and the substrate metal below it to form a continuous path between the two that allows the electrical energy to flow through the grounded substrate.

The size of the weld bead that is formed by this instantaneous discharge of electricity depends on the amount of power sent between the two spot welding machine heads, the conductivity of the metals, and the pressure being used. Thus, the higher the conductivity of the metals involved, the greater the power that will be needed to generate a sufficient tack weld to hold the honeycomb in place throughout the subsequent brazing cycle.

Please be aware that, as shown in Fig. 3, the flexible copper sheet on the top electrode is pressed against the...
honeycomb and the discharge of electricity will seek the quickest path through the honeycomb and substrate, thus forming a light tack weld along that shortest, low-resistance, electrical flow path. As such, only one tack weld will be generated along the width of that honeycomb to hold it to the substrate. If you want to have the complete width of that honeycomb bonded to the substrate, then you’ll need to shift the honeycomb slightly between those two heads to get a tack weld in a slightly different spot.

To have the honeycomb properly fixtured to the substrate via tack welds, it will be necessary to create a myriad of tacks along the width and length of the honeycomb. Otherwise the honeycomb may not remain firmly attached to the substrate during heating/cooling in the brazing process.

It is important to note the amount of discharged electrical energy must be sufficient to hold the honeycomb in place to the substrate throughout the brazing cycle, but should not be so intense as to cause arcing/sparking/oxidation at that weld location, since the molten BFM will not braze to oxidized surfaces.

It is also important to note the amount of pressure used between the two weld heads at the time of electrical discharge is important, but must not be so high as to crush the honeycomb, or so weak that it does not adequately close the gap between the honeycomb and the substrate to which it is being tack welded.

**BFM in Honeycomb Cells**

The BFM is typically applied as a tape, and rolled into the honeycomb structure — Figs. 4, 5. It can also be applied as powder into the honeycomb cells after the honeycomb has been properly and fully tacked to the substrate. You indicated that you used brazing tape in your application. It is very important to remember the BFM must be thoroughly scraped off the bottom ends of the honeycomb cells before attempting to tack weld the honeycomb.
to the substrate, so there is a clean metal-to-metal contact between the bottom of the honeycomb and substrate when they are pressed together for tack welding. The "taped" honeycomb cells on the right side of Fig. 4 show the presence of BFM on the honeycomb cell surfaces that need to be removed prior to tack welding to the substrate.

**Brazing Cycle**

Many companies heat their assemblies too fast for brazing, thus necessitating built-in "holds" to be instituted during the heating of the parts to allow for temperature equalization on the way up to brazing. This is very poor practice and can be especially dangerous during honeycomb brazing. As shown in Fig. 5, you should find the heating rate will allow you to go up to brazing temperature without the need for built-in holds. By so doing, the honeycomb and substrate can remain in much better contact throughout the brazing cycle, and some of the problems, such as that you are asking about, could be eliminated.

**Conclusion**

Figure 6 shows what can happen when tack welding is not done properly, and/or the brazing cycle is much too fast. In this particular case, because there were only a few tack welds made along the length of the honeycomb, the buckling of the honeycomb during heating prevented it from bonding to the substrate in a number of spots along its length when it reached brazing temperature and then, during cooling, the very lightweight honeycomb structure shrank (contracted) much faster than the substrate below it, pulling away from the surface.

Take the proper amount of time to be sure the honeycomb is properly and thoroughly tacked to the substrate, the BFM application was done correctly in each honeycomb cell, and the brazing cycle allows everything to come up to brazing temperature together. When that happens, beautiful honeycomb brazing will result.

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