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Design and Strength of Brazed Joints

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Design and gap clearance play a vital role in determining the strength of brazed joints. Many factors and variables can influence the physical properties of brazed joints and need to be considered in the design and construction of various components.

The design of a brazed joint has specific requirements that must be met in order to achieve the performance necessary during service. Important influencing variables are the selected base and filler materials, gap clearance and design, brazing cycle parameters and atmosphere.

Joint Design and Clearance

The joint clearance has a significant effect on the mechanical properties of a brazed joint. This applies to all types of loading, including static, fatigue, impact etc. There are several joint clearance related aspects which affect mechanical performance, including:

- the purely mechanical effect of restraint to plastic flow of the filler metal due to the greater strength of the base metal
- the possibility of flux entrapment and void formation
- the relationship between joint clearance and capillary force which account for filler metal distribution
- the degree of brittle intermetallic phases

Generally, small gaps and clearances are favourable because the capillary forces are greater promoting improved filler metal distribution throughout the joint area. This reduces potential for the formation of voids or shrinkage cavities as the brazing filler metal solidifies. Ideally, braze joints should be designed in such a way that they can withstand loading equal to or above the base material.

When high temperature nickel-based filler metals, such as **Nicrobraz®**, are utilized, high mechanical strength properties can be achieved.

The type of brazing process also has an influence on gap clearance potential and joint strength. Vacuum brazing using joint clearances of up to 0.08 mm (0.003 in.) will achieve the greatest capillary action and joint strength. Other brazing techniques can be adopted for larger gap clearances. Manual flux brazing for example can be used for gap clearances up to 0.5 mm (0.02 in.).

The brazing gap clearance should be calculated at the brazing temperature taking into account the thermal expansion coefficients of the materials.

To create a consistent gap for optimum flow into the joint, it may be necessary to use spacer wires, shims,

Joint Design Types

There are two main types of joints used for brazing, namely the lap joint and the butt joint.

Lap Joint

The braze joint should always comprise an overlap distance of at least 3 x t, where t is the substrate wall thickness, as shown in Fig. 1.

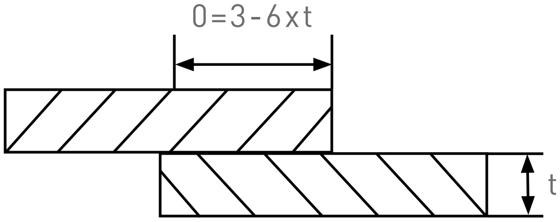

Fig. 1: Suitable ratio of overlap to thickness

Different material combinations may require different overlap to thickness ratios as presented in Table 1. It should be noted that too large an overlap can result in void formation and hence reduce joint strength.

Substrate material	Ratio of overlap to thickness
Copper / copper alloys	3 x t
Carbon steels	4 to 5 x t
High alloy / high strength steels	6 x t

Table 1: Ratio of overlap to thickness for different substrate materials

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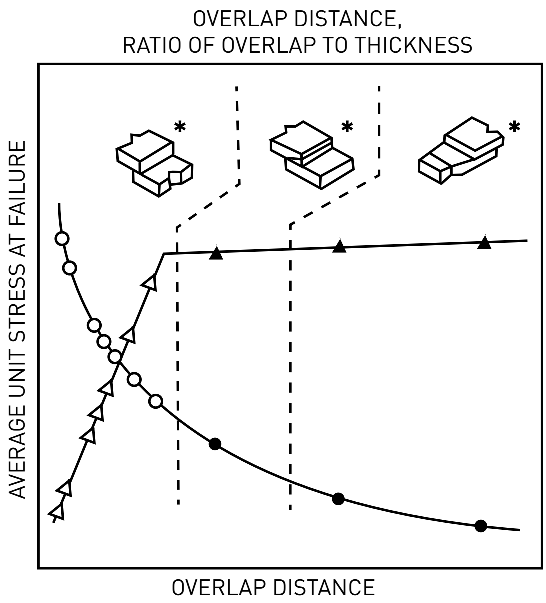

Fig. 2: with too small an overlap, failure can occur within the brazing filler metal. Large overlaps will result in failure in the base metal. Average unit stress at failure depending on overlap distance, ratio of overlap to thickness (from: American National Standard, AWS C3.2M/C3.2:2008)

Note: Average shear stress (circles) and average tensile stress (triangles) as functions of overlap distance. Open symbols represent failure in the brazing filler metal; filled symbols represent failure in the base metal. Starred(*) illustrations show types of failures.

The lap joint is easy to fabricate but increases the metal thickness and leads to stress concentrations at each end of the joint due to the abrupt change in cross section.

Modifications in the joint design can improve stress distribution, e.g. avoiding high stress concentrations at the edges of the braze joint.

Butt Joint

Butt joints are used where the thickness of lap joints would be impracticable. Laboratory butt-brazed sample tests often demonstrate higher tensile strengths compared to that observed under service conditions. As a result, butt joint strengths in service may fall below that of the base material. The strength of a butt joint depends on:

- the magnitude and type of stress encountered in service
- the filler metal strength compared to the base metal strength
- degree of brazing filler metal-base metal interaction during the braze cycle
- design requirements

To ensure adequate joint strength, the brazing filler metal strength should be comparable with that of the base material. Defects such as inclusions, voids, unbrazed areas, continuous brittle phases or porosity can adversely affect joint strength. Diffusion interactions at the filler metal and base metal interface leading to the formation of an alloyed layer can greatly enhance the joint strength properties.

Scarf Joints

Scarf joints are used to increase the cross-sectional area of the joint while maintaining the thickness of the joint equal to that of the base material, e.g. when joining thin wall structures care must be taken to ensure good fit up and alignment. The load carrying capacity of the scarf joint depends significantly on the scarf angle (a) illustrated in Fig 3.

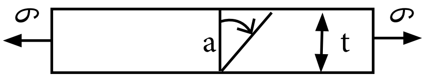

Fig. 3: Schematic of a typical scarf joint

Angles of < 30° can reduce the load bearing capacity in comparison to a butt joint. Angles of 45° can achieve superior joint strengths compared to a butt joint of identical wall thickness.

About Wall Colmonoy

Wall Colmonoy joins parts for high-temperature and corrosion applications using **Nicrobraz®**, **Cubraz®** and **Niferobraz®** brazing filler metals and brazing aids.

Wall Colmonoy is the pioneer of hi temperature brazing. In 1950, Wall Colmonoy's expert brazing engineer, Bob Peaslee, invented a new brazing technology involving nickel-based filler metals and hydrogen atmosphere furnaces. They named this new filler metal, **Nicrobraz®**.

Today, **Nicrobraz®** and the family of Nicrobraz (**Cubraz®** and **Niferobraz®**) brazing filler metals are seen in a variety of industries including aerospace, oil & gas, steel, energy, food, auto, rail and defense industries meeting AWS, AMS and G.E. specifications.

Available as powder, rods, paste, transfer tape and sheets, binders and pastes and in a full range of sizes and specifications.
Wall Colmonoy also custom formulates brazing filler metals to meet customer requirements.

Aerobraze Engineered Technologies, a division of Wall Colmonoy, provides complete solutions for brazing, surfacing, welding, thermal processing, fabricating, machining, and overhaul of engineering components, as well as, collaborating with customers to take concept from design to prototype to production. Specializing in aerospace, oil & gas, steel, energy, food, auto, rail and defense industries.

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