JPRS: 22,023

OTS: 63-41233

25 November 1963

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BRAZING

by F. V. Kulikov and I. R. Lekhtsiyer

- USSR -

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/Following is the translation of the table of contents and one section from the Russian-language book Tverdaya Payka (Brazing) by F.V. Kulikov and I.R. Lekhtsiyer, State Power Press, Moscow-Leningrad, 1959. The section translated is on pages 33-39 of the Russian text./

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BRAZE FOR STAINLESS AND HIGH TEMPERATURE STEELS

The brazing of the high strength steels alloyed with special elements presents well known difficulties. When these steels are heated in furnaces there is oxidation of the surface of the steel resulting from the chemical reaction between the oxygen or the oxygen-containing gases and the iron and the alloying elements. These oxides create serious obstacles to the brazing and force the use of various types of fluxing materials in order to dissolve these oxides and to prevent further oxide formation. The oxides of such elements as aluminum, titanium, silicon, chromium, etc are particularly easily formed and difficult to remove.

Although the fluxes do provide the required strength of the brazed joint they still do not protect the portions of the parts which are not brazed from oxidation and this is reflected in the surface quality of the parts. As the result of chemical activity the flux residues cause corrosion of the metals. Therefore in order to avoid corrosion and provide a good commercial finish for the parts it is necessary to utilizé quite complicated and expensive methods for removing the scale and flux residues.

In order to avoid the use of the fluxes which are difficult to remove after brazing, the process is carried out in a vacuum. However, the highest quality brazed joints for the steels which contain chromium, silicon, aluminum, etc are obtained using a dry hydrogen atmosphere. Hydrogen is a reducing gas and purifies and cleans the scale from both the braze alloy and the parent metal.

The service operating conditions of parts fabricated from the stainless steels and high temperature alloys require that the brazed seams meet certain corrosion resistance and strength-at-high-temperature requirements. These demands may be met only by use of special brazing alloys and special brazing techniques.

For the brazing of the stainless steels of the 1Cr18Ni9T type and the high temperature alloys of the Cr20Ni80T types a brazing alloy has been developed which contains a copper-nickel-silver base and a series of additives, part of which are hardeners while the other part serve to reduce the melting point of the braze.

The foreign literature indicates the use for brazing of the stainless and high temperature steels and alloys of a braze having a base consisting of silver, nickel, manganese, and copper.

Table 23 presents data on the brazes used in foreign practice.

Table 23

High temperature and corrosion resistant brazes

Braze type	chemical composition, %						Melt. pt., °C
	silver	manganese	nickel	silicon	boron	other	
silver-copper-lithium	92.3	-	-	-	-	copper 7.5, lithium 0.2	890
silver-palladium	90	-	-	-	-	palladium 10	1065
manganese-nickel	-	80	20	-	-	-	
manganese-nickel	-	70	30	-	-	-	1024
nickel-chrom-boron-silicon	-	-	72.5	5.0	3.5	chrom 16, iron rest	1004
nickel-boron-silicon	-	-	rest	4.5	3.0	-	1010

These brazes [are described] ~~may be characterized as follows.~~

The Silver-Copper-Lithium Braze. The addition of a small amount of lithium to the silver braze makes a notable improvement in the fluidity and the wetting properties. Recent brazing of honeycomb chrome-nickel stainless steel panels has seen more frequent use of the silver-copper-lithium braze which at the maximum working temperature of this steel provides short-term strength of the joint of 24-28 kg/mm^2. In a vacuum, or in a dry hydrogen or inert gas atmosphere this braze wets the surfaces to be brazed well without a flux. One drawback is the formation of runs on large curved surfaces as the result of its high fluidity.

The Silver-Palladium Braze. Additions of palladium to the silver raise the melting point of the braze, increase the strength and the ability to wet the alloys based on iron and nickel. Further additions of manganese improve the wetting properties still more. These brazes do not dissolve the parent metal at all. The composition of the silver-palladium brazes alloyed with manganese and the mechanical strength of the joints are shown in Table 24.

Table 24

Mechanical strength of brazed joints using silver-palladium braze

Braze composition, %	Shear ultimate strength at 500°C, kg/mm²	
	Stainless steel	Nimonic 75
Silver 75, palladium 20, manganese 5	7.8	12.4
Silver 63, palladium 33, manganese 4	12.4	23.3

Bonds in the Nimonic 75 alloy made using braze No 2 sustain stresses of 1.55 kg/mm² at 800°C for a period of 500 hours.

The Manganese-Nickel Braze. These brazes are used for the brazing of the stainless steels alloyed with chromium (to 15%), titanium, aluminum, manganese, silicon, and other high temperature alloys. The resistance of the bonds to oxidation is higher than when using the silver-copper-lithium brazes. The manganese-nickel brazes dissolve the parent metal less than a braze with a high nickel content. It is believed that these brazes will find wide application in the brazing of heat exchangers, rocket engine components, turbine blades, sandwich materials, etc.

The Nickel-Chromium-Boron-Silicon Braze. In the brazes of this group the nickel serves as the base while the silicon and the boron are the alloying elements. Sometimes a portion of the nickel is replaced by chromium which increases the corrosion and oxidation resistance. The brazes with a high nickel content have outstandingly high strength at temperatures of 870-980°C.

The nickel-boron-silicon brazes are used for the brazing of chrome-moly steel, high temperature alloys of the Hastelloy type having a high content of nickel, molybdenum, chromium which are used for rocket nozzle parts, and also for the brazing of stainless steel heat exchangers. The melting point of these alloys is in the 1150-1185°C range. This braze is produced in powder, sintered and cast form.

For the brazing of the stainless steels use is also made of the silver brazes whose composition is shown in Table 25.

Table 25

Silver braze for stainless steels

Chemical composition, %					Melting temp., °C
silver	manganese	tin	nickel	copper	
85.0	15.0	-	-	-	960-976
72.0	-	-	-	28.0	780-(eutectic)
7.0	-	8.0	-	85.0	-
65.0	5.0	-	2.0	28.0	-
40	-	-	10	50	820-840

The production of a completely corrosion-proof brazed joint between the hard silver braze containing nickel and the stainless steel which does not contain nickel depends on the formation of a sufficiently uniform layer of the nickel-rich constituent of the hard braze over the entire portion of the surface of the stainless steel which is covered by the braze. This has led to the proposal of the nickel-bearing silver brazes whose compositions are shown in Table 26.

Table 26

Braze for ensuring corrosion-proof bonds in the brazing of the stainless steels which do not contain nickel

No	Chemical composition, %						Melting point, °C
	silver	tin	nickel	zinc	cadmium	copper	
1	63.0	6.0	2.5	-	-	remaining	802-821
2	60.0	10.0	2.0	-	-	"	759-777
3	40.0	-	5.0	25.0	-	"	849
4	50.0	-	3.0	15.5	16.0	"	688
5	40.0	-	2.0	28.0	-	"	779

Brazes Nos 1 and 2 evidence very little corrosion but they have poor fluidity so that to reduce the distance which they have to run the braze should be spread ahead of time over all the area where it is possible. The bonds, using these brazes, of the stainless steels which do not contain nickel have quite satisfactory corrosion resistance.

The joints made using brazes Nos 3, 4, and 5 are only slightly subject to corrosion and in contrast with brazes Nos 1 and 2 these brazes do have satisfactory fluidity. n'B, SS

It is recommended that chemical coatings of nickel and copper be used on the stainless steel surfaces to be brazed in order to improve the flow characteristics of the braze alloy.

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