DEVELOPMENT AND INTRODUCTION
OF A TECHNOLOGY FOR MAKING STRIP
USED FOR THE SUPPORT PLATES OF
COPPER-BRASS HEAT EXCHANGERS

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The production of Kuprobreiz heat exchangers has been made more efficient by the introduction of a new technology at the Kirov Nonferrous Metals Plant for the production of 0.8–1.0 mm strip composed of new brass LN64-3.

In 2003, the Shadrinsk Automobile and Machine Plant (ShAAZ) – which is part of the Ural Mining-Metallurgical Company (UGMK) – introduced a new technology for making Kuprobreiz heat exchangers used in motor vehicles. The technology was invented by the International Copper Association to produce copper-brass automotive heat exchangers – radiators for gasoline engines and air superchargers for diesel engines (DAS). The goal was to make the radiators competitive with aluminum radiators. The main difference between this technology and the conventional technology is that soldering of the core of Kuprobreiz radiators (soldering of the cooling plates to the tubes and soldering of the tubes to the support plates) is done with a hard self-fluxing solder of the system Cu–Ni–Sn–P (the solder is a low-temperature paste based on copper) rather than a liquid solder based on lead. As a result, Kuprobreiz radiators of the same size as traditional copper-brass radiators cool with 10–30% more efficiency.

Soldering with a hard solder provides for much greater mechanical strength in Kuprobreiz radiators at the junctures between fins, tubes, and support plates compared to copper-brass radiators soldered with a soft solder.

The overall strength and durability of Kuprobreiz radiators is obtained by making them both with hard solders and with new materials that are now being used for tubes, cooling plates, and support plates. The Finnish company Outokumpu has developed alloys and a technology which uses these materials to make brass strip (for tubes and support plates) and copper foil (for cooling plates). These alloys can be readily shaped and retain the necessary strength after soldering. The soldering temperature with hard solder is 550–620°, which is 350° higher than the soldering temperature with liquid solder. The materials normally used to produce traditionally-made automobile radiators soften at 650°.

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When the ShAAZ was beginning the commercial production of Kuprobreiz heat exchangers, the plant made their support plates out of imported SM2464 strip 0.8 and 1.0 mm thick. The strip is delivered in accordance with TU No. 3-2004, which stipulates a grain size within the range 55–100 µm and nominal hardness values of 60–80 HV. For informational purposes, the TU standard also includes values of tensile strength ($\sigma_u = 350$ MPa), yield point ($\sigma_{0.2} = 115$ MPa), and elongation ($A_{10} = 70\%$).

The literature does not contain any reliable data on the foreign manufacture of heat-resistant radiator strip made of brass. However, it is known that Outokumpu has a technology for making Kuprobreiz radiator strip on pieces of equipment which Russian nonferrous metals plants do not have: continuous casters that make it possible to obtain a brass semifinished product (coil) with dimensions of $30 \times 680$ mm and a weight of 50 tons; furnaces with a protective atmosphere for annealing both the semifinished strip and the finished strip of the final thickness.

Russian nonferrous metals plants cannot use this technology to make brass strip for Kuprobreiz radiators either because they lack equipment of the necessary type or because the equipment that they do have does not have the necessary specifications.

In the course of this study, we determined the optimum chemical composition of the strip and found efficient methods of making it and heat-treating the semifinished product at different stages of the production process.

At present, the main problem is developing a technology for making 0.8- and 1.0-mm strip for the support plates of Kuprobreiz heat exchangers. In addition to having good formability, the strip should provide the plates with the necessary strength after sintering (soldering) of the body of the radiator.

We studied five different compositions of dispersion-hardening alloys based on brass L75 and containing Ni, Si, Al, P, and Mn as additional alloying components. The concentrations of these elements range from hundredths of a percent to one percent. We also examined an alloy of the system Cu–Zn–Ni. These investigations made it possible to choose the following two alloys for commercial trials: LNK75-2.5-0.5 ($Cu = 75\%, Ni = 2.5\%, Si = 0.5\%, Zn$ and impurities – remainder); LN64-3 ($Cu = 64\%, Zn = 33\%, Ni = 3\%, impurities = 0.3\%)$. It was determined that strip LNK75-2.5-0.5 takes more time to make than strip LN64-3. We therefore chose alloy LN64-3 to master a technology that was developed to make commercial batches of strip for support plates. The following results were obtained:

- regimes (the temperature of the melt, coolant-water temperature, and casting speed) were developed and introduced to cast flat ingots made of new grades of brass in an ILK furnace;
- temperature-time regimes were developed and introduced for heating $180 \times 600 \times (1700–1800)$-mm ingots before hot rolling, and a scheme was devised for hot-rolling $850 \times 1500$-mm strip to a thickness of 8 mm in order to obtain finished strip of high quality (free of cracks or oxide films);
- regimes were found for welding different strips together in order to form larger coils;
- regimes were established for cutting coils of strip with a thickness of up to 7.4 mm, and a method was developed for rolling the cut coils to a thickness of 2.2 mm on a three-high continuous 1000 mill;
- it was determined necessary to rebuild the existing batch annealing furnaces in order to ensure attainment of the required structure and properties in both the 2.2-mm-thick semifinished strip and the finished strip of the final thickness.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>$\sigma_u$, MPa</th>
<th>$\sigma_{0.2}$, MPa</th>
<th>$A_{10}$, $%$</th>
<th>HV$_{25/10}$</th>
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<tbody>
<tr>
<td>SM2464</td>
<td>355</td>
<td>125</td>
<td>68</td>
<td>73</td>
</tr>
<tr>
<td>LN64-3</td>
<td>360</td>
<td>120</td>
<td>67</td>
<td>69</td>
</tr>
</tbody>
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**Table 1. Results of Tests of Brass Strip 1 mm Thick for the Support Plates of Heat Exchangers**