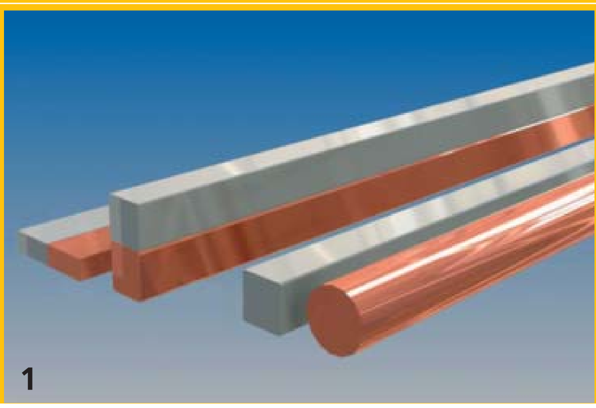

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WIRE-SHAPED LASER ROLL PLATED BIMETALS

THE TASK

Several fields of engineering would have been unthinkable for decades without bimetals. They can be made by cold or hot roll bonding, extrusion of composites or centrifugal composite casting, and are used as contact or connecting elements, fasteners, or as bearing materials. With suitable material compounds, properties can be combined in a semi-finished product, which could not be achieved with a single material, on the one hand. On the other hand, high quality materials can be used more efficiently and thus more economically. Both aspects currently play important roles.

Most bimetal semi-finished products are produced as strips or sheets. This results in labor-intensive machining and is thus costly for applications that demand very slim geometries and thus comprehensive subsequent machining, such as for semi-finished products for electrical contact or connection elements or transition joints. Thin, wire-shaped bimetals are commercially available only as fully coated round wire (for instance Cu/St). Rectangularly shaped wires and profiles for small final sizes would be much more favorable, both in terms of manufacturing engineering and economy.

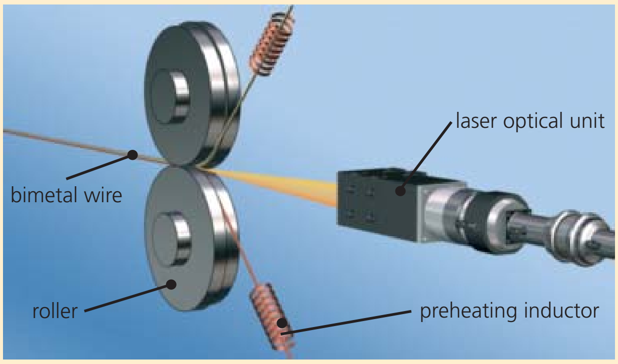
OUR SOLUTION

Manufacturing rectangularly profiled bimetal wires by means of laser roll bonding, a process developed by the Fraunhofer IWS and subsequently patented, is a low-cost alternative to produce thin bimetal semi-finished products. The basic principle of this technique is shown in Figure 2.

In contrast to conventional plating technologies, in laser roll bonding, both semi-finished products (square or rectangular wires with an edge length of up to 5 mm) are guided to the pass at an angle of 45 ° (Fig. 2). In this procedure, the internal wire surfaces can be heated to process temperature immediately before going through the pass by means of a linear or rectangular laser beam. Laser power values of maximally 3 to 4 kW are sufficient for the most wire geometries. The highly concentrated and localized heat input means that forming occurs only in these areas.

If necessary, both initial wires can be individually tempered by preliminary inductive heating. The conditions in the pass can thus be optimally adapted to the specific material combination and geometric requirements. The heated regions and the laser contact zone situated directly in front of the pass are protected against oxidation by a shielding gas enclosure.

Basic principle: inductively supported laser roll bonding of wire-shaped semi-finished products



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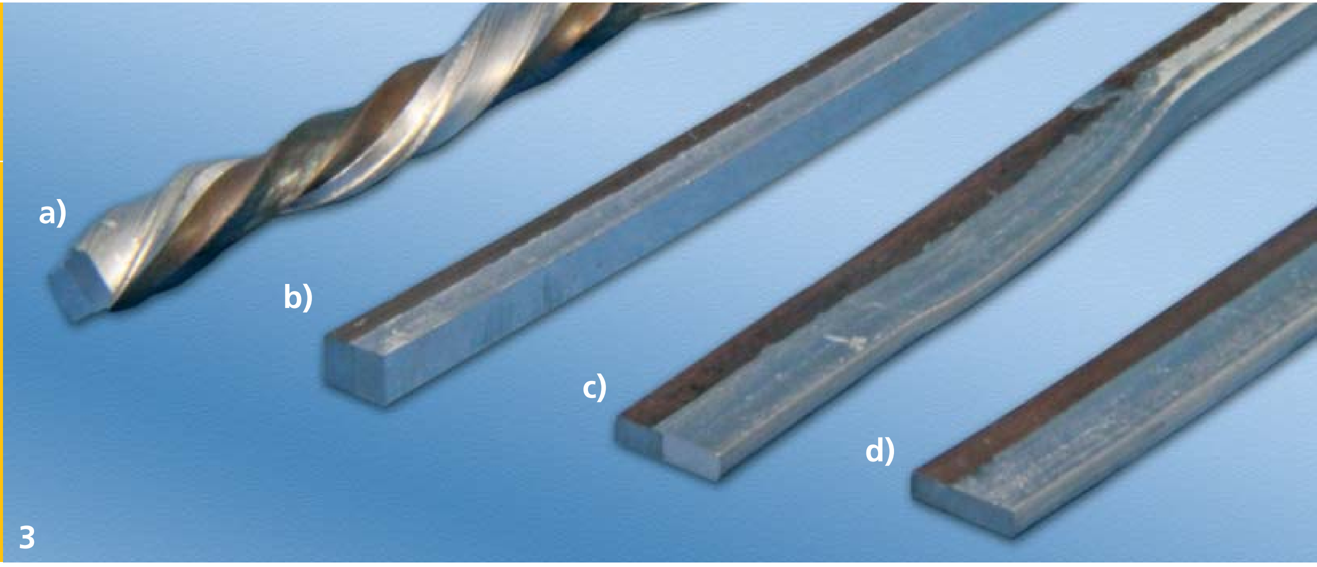

RESULTS

The conditions of the technology (local energy input and local deformation) allow for very small total deformation ratios in order to generate highly loadable bimetal wires. Thus, near-net-shape plating is possible. Greater degrees of freedom arise in the thickness combination of the semi-finished products being joined in comparison with conventional roll plating methods. To guarantee a homogeneous deformation across the entire cross section for wires with narrow rectangular cross sections as well, a roller couple designed as a "closed gauge" is used. The rolls form the desired bimetal contour in the pass.

When the materials are available as wires, many material compounds can be made by laser roll bonding. In addition to several combinations of steels and copper or copper alloys with aluminum or its alloys, steels can also be combined with copper alloys, or bimetals can be made of several steels and contact materials.

Depending on the deformability of the bimetal compound, narrow butt joints of approximately 1 mm thickness are also feasible (Fig. 3). They can be used as transition joints in car assembly or for several electrical engineering/electronics applications.

The combination of laser roll bonding and subsequent cold or semi-hot rolling (see Fig. 3) expands the range of application. A preliminary contour is made by laser roll bonding; then it is swiveled by 90 ° to the rolling plane and rolled to the final contour afterwards. At the IWS, the second roll mill of the laser roll bonding equipment is applied for this step. In this roll mill, the required pass is shaped by 4 mutually offset rollers enabling various rectangular cross sections without tool change.

In principle, suitable initial semi-finished products of square or rectangular contour can also be manufactured from commercially available round wires in the calibration mill in a preliminary operation.

In laser roll bonding, brittle phases are either non-existent or only partially formed which is quite advantageous and provides high-strength material composites with good cold formability – even for material combinations which traditionally strongly tend to form intermetallic phase borders at material transitions such as combinations of steel or copper with Al materials. In laser roll bonding, the deformation of the materials to be combined immediately at the joining zone generates a material flow contrary to the feed direction. Thus the diffusion-controlled formation of intermetallic phase seams at material transitions is prevented.

1 Representation of the initial and final products (simulation), from right: round initial wire, rolled to four-edged wire, rectangular bimetal wire, flat rolled

3 Laser roll plated Cu/Al bimetals a) laser roll bonded and twisted, b) laser induction roll plated, c) transition of laser induction roll plated and rolled, d) rolled to final contour

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