Deforming Fibrous Insulating Tiles To Fit Curved Surfaces

Flat billets are heated and pressed gently against curved mold surfaces.

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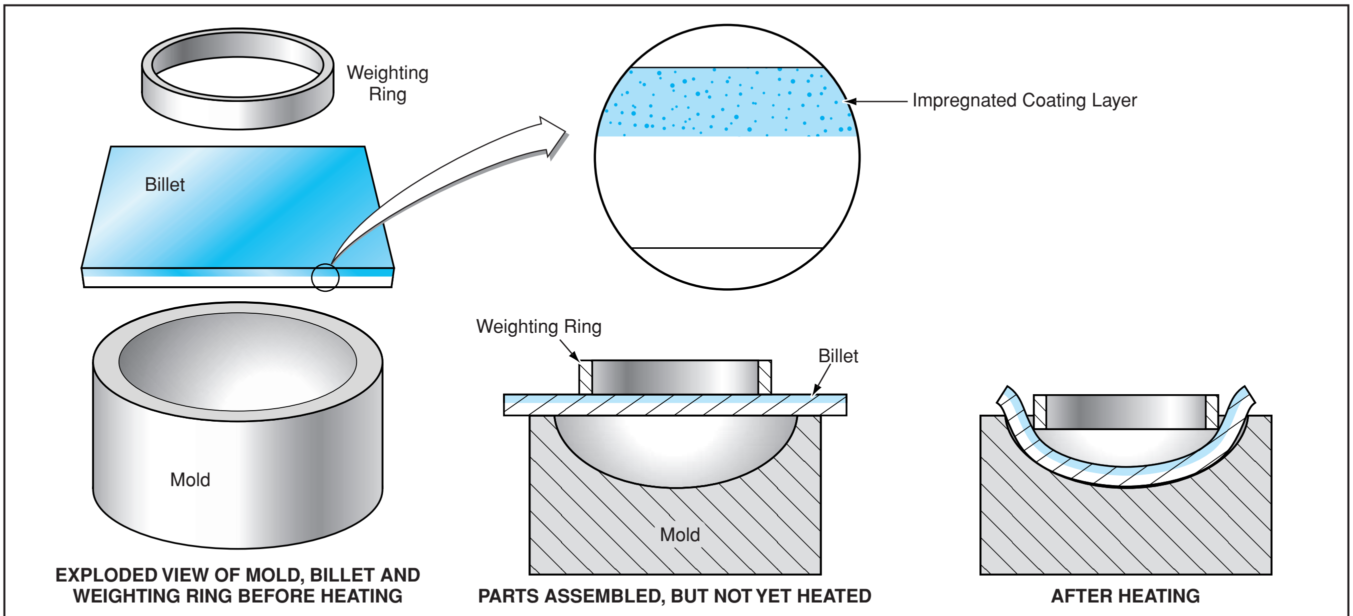

The **Billet Sags to the Mold Surface** under the weight of the ring when the assembly is heated for about 1 hour at 2,400 °F (≈1,300 °C).

A curved tile of refractory silica-fiber-based or alumina-fiber-based thermal-insulation material can be formed from an initially flat billet in a process that includes pressing against a curved mold surface during heating. The mold or tile curvature can be concave or convex. Curved tiles are needed for thermal protection of curved surfaces of spacecraft reentering the terrestrial atmosphere; curved thermal-protection tiles may also be useful on Earth in some industrial applications.

The present process was invented as an alternative to the conventional practice of fabricating curved tiles by computer-controlled machining of flat billets, and to facilitate the fabrication of tile areas with dimensions that exceed the customary ≈6 × 6 in. (≈15 × 15 cm). One disadvantage of machining large tiles with curved surfaces is that one must start with relatively thick flat billets and then waste considerable amounts of material. In addition, machining operations become difficult and cumbersome on a large scale, and the computer-controlled milling machines needed to machine large curved surfaces are expensive. Another consequence of machining is that not all the fibers are oriented parallel to the curved surface; this is disadvantageous in that the degree of thermal protection decreases with increasing departure from parallelarity.

The present process makes it possible to manufacture larger curved tiles starting from thinner billets [typical approximate dimensions 10 × 10 ×1/4 in. (≈25 × 25 × 0.6 cm)] with little or no machining of tile material. Unlike in the conventional approach, there is no particular great difficulty associated with fabrication of larger tiles. In addition, the process inherently causes the fibers in a curved tile to lie locally parallel to the curved surface to be protected by the tile.

The figure illustrates an example of the process as applied to forming a tile with a spherical curvature. In this case, a flat billet is placed over the opening in a concave mold. The width of the billet slightly exceeds the diameter of the opening in the mold, so that the billet covers the opening and there is some margin. A weighting ring is placed over the billet, concentrically with the mold. The outer diameter of the ring is slightly less than the diameter of the opening, so that the weight of the ring urges the billet downward into the mold.

The mold is made of a rigid, hard refractory material that can be similar to that of the billet. The weighting-ring material can also be similar to that of the billet and/or the mold. In any event, the mold and weighting-ring materials must be selected so that their coefficients of thermal expansion closely approximate that of the billet.

The assembly of the mold, billet, and weighting ring is placed in a furnace that has been preheated to a temperature of 2,000 °F (≈1,100 °C). Next, the temperature is raised at a steady rate for one hour to a maximum of 2,400 °F (≈1,300 °C), then held at this maximum level for one hour. During the residence at the maximum temperature, the weight of the ring deforms the billet until the lower surface of the billet conforms to the surface of the mold. At the completion of exposure to the maximum temperature, the furnace is cooled steadily for one hour to 2,000 °F (≈1,100 °C), then the assembly is removed from the furnace.

Optionally, before pressing and heating, the outer surface of the billet can be impregnated with a coating material. During the heating, the coating becomes sintered into the billet, forming an outer layer with high surface emissivity.

After the assembly has cooled, a graphite or fiberglass cloth impregnated with an epoxy, polyimide, or other suitable adhesive is placed on the inner surface of the billet and cured in place to form a support structure.

This work was done by Paul Kolodziej, Joe A. Carroll, and Dane Smith of **Ames Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the category.*

This invention has been patented by NASA (U.S. Patent No. 5,705,012). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14051.