

Friction Riveting

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Friction Riveting, hence the name Fricriveting, is an innovative joining technique for polymer-metal hybrid structures, developed and patented by the Helmholtz Zentrum Geesthacht in Germany. In this process, polymeric parts are joined by a metallic rivet; the joining is achieved by mechanical interference and adhesion between the metallic and polymeric joining partners.

Principles of the technique

The basic configuration of the process (Figure 1) consists in rotating a cylindrical metallic rivet and inserting it in a polymeric base plate. Heat is generated by the high rotational speed and the axial pressure. Due to the local increase of temperature, a molten polymeric layer is formed around the tip of the rotating rivet. By the end of the heating phase, the heat input rate increases to a higher level than the heat outflow, due to the low thermal conductivity of the polymer. The local temperature increases leading to the plasticizing of the tip of the rivet. While the rotation is being decelerated, the axial pressure is increased, the so called forging pressure is applied and the plasticized tip of the rivet is being deformed. As a result there will be an increase of the original rivet diameter, whereby the deformed rivet tip will assume a parabolic pattern due to the opposite reactive forces related to the colder polymeric volumes.

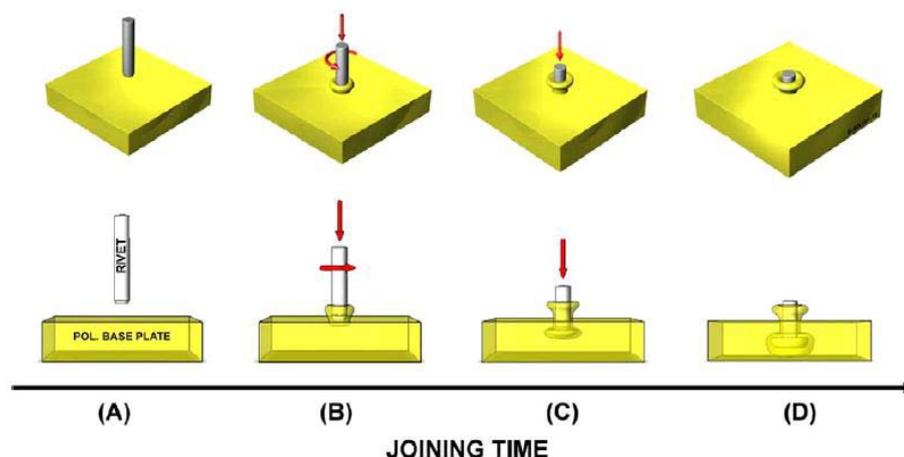


Figure 1: Schematic view of the Fricriveting process. (A) Positioning of the joining partners, (B) Feeding of the rivet into the polymer (Friction), (C) Rivet forging, (D) Joint consolidation

After the consolidation under pressure, the joint is held by the anchoring forces related to the deformed tip of the rivet, as well as by adhesive forces in the polymer/metal interface.

Process parameters

- **Rotational Speed (RS):** is the angular velocity of the rotating rivet. It is important in the heat generation and associated phenomena.
- **Joining Time (JT):** is the sum of the Friction Time (FT) and the Forging Time (FOT). Both are set by the operator. The Joining Time controls the joining speed, as well as the amount of heat energy supplied to the molten polymeric film, influencing the level of volumetric defects related to thermo-mechanical processing.
- **Joining Pressure (JP):** is the addition of the Friction Pressure (FP) and the Forging Pressure (FOP). Its main role is the controlling of the rivet forging and consolidation phases, but it is also related to the normal pressure distribution and heating of the rubbing surfaces.

Process variables

- **Heating Time (HT):** is the interval related to the initial contact between the rivet and the base element, and the moment when the rotational speed becomes null. This variable provides an estimate of the material plasticizing level and the amount of the thermal induced structural changes (polymer degradation, physical ageing etc.)
- **Burn-Off (BO):** is a variable associated with the insertion level of the rivet into the polymeric base plate and its deformed length.
- **Burn-Off Rate:** is the quotient between Burn-Off and Heating Time and provides an average approximation of the real joining speed.
- **Average Process Temperature:** provides an estimation of the changes in viscosity softened / molten polymer and is a key-variable when explaining the microstructural and properties changes within the joint area.
- **Frictional Torque:** is a tool for estimating the rheological behavior of molten polymer and plasticizing rivet material, and also a way of identifying process anomalies and defects regarding equipment malfunction and poor surface finishing.