G11.05

The study of the Joining Mechanism in Ultrasonic Welding of Injection Molded PS by the Observation and Image Processing

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Ultrasonic welding is widely used in the industrial field because of short processing time, good adhesion and the safety without toxic solvents. However, the joining mechanism in ultrasonic welding has not been clarified yet. In this study, the mechanism has been discussed by measurement of the roughness of the specimens and image processing of the welded spots in ultrasonic welding of injection molded PS. First, it was confirmed that the patterns of the welded spots were always quite similar under the same welding conditions. The non-contact measurement of the roughness of the specimens showed that the first points of the contact between two specimens led to the formation of the welded spots. Second, it was observed that the joining style changed before and after some welding time. At the early stage of the welding process, welding at many independent spots was predominant. Then, the melt flow occured and each spots combined to each other. Third, it was proved that the area of the welded spots were proportional not only to the pressure and the welding time but also the amplitude of vibration at the radiating face of the ultrasonic horn. Forth, it became clear that there was the molecular weight dependence in the welded spot area of PS. Low molecular weight PS showed better joining performance. Nevertheless, the temperature rise at the joints was more remarkable for high molecular weight type PS. From these results, it was concluded that ultrasonic welding causes not only frictional heating but also viscous heating, and the joining style changes from spot welding to melt flow. Furthermore, it was clarified that the total area of the welded spots shows dependence on both the welding pressure, the amplitude of vibration and the welding time. That is, equation $E=\int F \cdot V dT$ was proved to come into being, where E denotes the ultrasonic energy, F the vibration force, V the vibration velocity , and T the time.