MICROWAVE WELDING OF THERMOPLASTIC RODS WITHOUT ANY CONDUCTIVE MATERIAL

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ABSTRACT

A thermoplastic polymer material is usually welded by using a hot air gun to raise its temperature to the melting point and some mechanical pressure is required to hold the parts together to achieve a good bond. This technique works in practice but it is not suitable for fast or large scale welding.

Microwave power has been investigated as an alternative possibility. There are many patents on microwave welding/bonding techniques. Patent GB565592 (1944) [1] demonstrates the welding of thermoplastic and thermosetting polymer materials by subjecting them to High Frequency at 40 MHz. Patent US5338611 (1994) [2] discloses the use of microwave frequencies in the range of 0.5 GHz to 10 GHz to weld thermoplastic substrates by interposing a carrier strip. The strip is formed of a polymer carrier that is miscible in the substrates. Electrically conductive submicron carbon black susceptor particles are chosen to absorb and generate heat confined to the weld zone. Patent EP0705682 (1996) [3] describes the thermally bonding of two polymeric substrates using microwave energy. At least one of the surfaces is coating with a microwave absorbing material. Patent DE4447521 (1996) [4] is identical to EP0705682 [3] even though the title is different. Patent DE19648526 (1998) [5] reveals a new method of welding plastic foam mouldings using microwaves. The foam is coated with a dry, active material that is susceptible to microwave heating. Patent WO0069230 (2000) [6] discloses a microwave device to generate high temperature plasma in a passing gas, which could be used for welding.

Microwave welding is inherently quicker because it can penetrate a polymer material more rapidly than conventional heat. In general it can be stated that there are few virgin polymer materials that absorb microwaves well. To absorb microwaves well, a polymer must consist of polar molecules, which are free to rotate in a microwave field. When a polymer does not absorb microwaves an additive is added or sometimes an absorbing layer or a conducting layer is used as revealed in some of the above patents. In the former case, the modified polymer becomes microwave absorbent. In the latter case, microwaves will only differentially heat the added layer, which in turn transfers heat to the cooler polymer material to be welded.

It is claimed in the above patents that it is also possible to weld thermoset polymer materials but they must be locally de-polymerised before they can be welded using heat. One method of de-polymerisation uses mechanical supersonic vibrations. Another method is to coat the area to be welded with a chemical or to pass an active gas over the area.

The present paper is concerned essentially with using electromagnetic energy, of which microwave is a part, at an appropriate frequency to generate a micro-plasma using an appropriate gas between two polymer objects to be welded. Hence the polymer object can be transparent to microwaves and no conductive polymer is required. The heat generated by the micro-plasma will cause local melting to weld the objects together under some mechanical pressure to bring the objects into contact to each other. Because the material is transparent to microwaves, a weld can be affected while the welding surfaces are shielded that is they are not optically visible. This is seen as a great advantage of the microwave technique.

The paper discusses the process of welding thermoplastic polymer and in particular the blind joining of two polypropylene rods having a diameter of 20mm without using any conductive polymer.

REFERENCES

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