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Power Electronics for - and Modelling of - Resistance Welding Equipment

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Abstract:

Resistance spot welding is an inexpensive and efficient way of joining metals. It has extensive applications in household appliances and in automotive industries. In traditional spot welding machines 50 Hz welding transformers are commonly used. The drawback associated with these transformers is that they are both heavy and bulky.

With the development of high power semiconductor switches and DC-DC converter topologies, it is now possible to develop inverter drive resistance spot welding equipment (RSE) which can be operated at frequencies higher than the 50 Hz frequency. The advantage of using high frequencies is the reduction in the size of the transformer.

In many industrial applications long welding arms are required between the transformer and the weld spot, which increases the inductance. The parasitic inductance in welding arms limits the maximum rate of change of the current. In order to achieve a higher power the current has to be rectified. To rectify a current of the order of a tenth of kA is a challenging task and is one of the major sources of loss.

The full bridge converter topology is used for the inverter drive RSE. The power switches used in the converter are IGBT. In RSE, the DC link capacitors are used to store high energy. In the case of circuit failure, the stored energy can cause the IGBT device to rupture and in order to avoid this, a protection scheme is discussed in this work.

A controller circuit, using a DSPIC33FJ16GS502 controller, is developed in order to drive a high frequency full bridge converter, which can also be used to drive the IGBTs in the RSE.

The secondary side welding current is of the order of kilo amperes. A requirement for the welding control is that the current must be sensed precisely and in order to fulfill this, a Hall sensor system has been developed. This developed circuit is used in the feed-back control of the RSE. The presence of metallic objects and tools in the vicinity of the Hall sensor system can affect its precision. The exclusion distance for the metal objects from the sensor by means of a model developed in COMSOL Multi-physics software has been estimated.

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COMSOL Multi-physics software has been used to model the resistance welding process:

A model for spot welding steel sheets has been developed. The timed temperature distribution of the developed model can predict the amount of welding current, force, and time required to join steel sheets of different thicknesses.

Both two and three dimensional models of seam welding process are discussed in the thesis. Two dimensional models concerning the seam welding process do have some limitations. The longitudinal two dimensional models cannot be used to examine the effects of the electrode shape and thickness regarding heat generation during the seam welding process. The transversal two dimensional models are not helpful for examining the nugget growth during the seam welding process. The three dimensional model developed is a step towards selecting the appropriate welding parameters so as to produce a good welding nugget.

Spot welding aluminium alloys require less welding time but higher electric power as compared to steel, which is the most common material used in the automobile industry. FEM simulations are performed to investigate the advantage of preheating prior to spot welding. Both spot welding and preheating processes have been modeled using COMSOL multi-physics software. The simulation results show that when spot welding Al 6082 after preheating up to 200 oC, the output current requirements to make the spot weld are reduced.