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Development of mathematical model for identifying bead geometry of arc welding for fabrication of farm machines

K.P. KOLHE*, P.P. KOLHE[1] AND R.M. DHARASKAR[2]
Department of Mechanical Engineering, College of Agricultural Engineering and Technology, Dapoli, RATNAGIRI (M.S.) INDIA

ABSTRACT

This study was conducted to predict the weld geometry, mechanical properties and HAZ dimensions by developing mathematical models following statistical methods. The important process control variables of welding *viz.*, voltage, current and travel speed were regressed with bead characteristics like quality, penetration, reinforcement, bead width etc. and the mechanical properties such as bead hardness, HAZ hardness etc. The purpose of such development of equation is to find the mathematical relation between the weld bead characteristics and mechanical properties with the welding parameters, as the dimensions and shape of the weld bead largely determine the strength of welded joint. For using automatic Submerged Arc Welding effectively, it is essential to develop equations that express mathematically the weld bead parameters in terms of process variables, the variation in HAZ dimensions and microstructure. The relationship between welding variables and weld feature like hardness, bead geometry and HAZ width also reduces the cost of weld procedure development by decreasing the number of trial runs. In order to ensure adequate weld bead quality, it is necessary that various welding variables should be in proper balance. Therefore, it is essential to know the effect of the process variables individually and in combination on the resulting weld bead dimensions. These dimensions not only control the type of microstructure but also determine the stress carrying capacity of a welded joint. The developed mathematical models in which the data is represented can be programmed, fed to a computer and used to develop an expert welding system. Statistical Analysis Software and MS Excel were used for the complete analysis.

Key words : Submerged arc welding, Statistical package for social science, Regression analysis, Mathematical models

INTRODUCTION

The important process control variables of welding *viz.*, voltage, current and travel speed were related with bead characteristics like reinforcement, bead width, penetration, quality etc. and the mechanical properties such as bead hardness, HAZ hardness etc. The purpose of such development of equation is to find the mathematical relation between the weld bead characteristics and the welding parameters. For using automatic submerged arc welding, it is essential to develop equations that express mathematically the weld bead parameters to the process variables and the variation in HAZ dimensions and microstructure. The relationship between welding variables and weld features also reduce the cost of weld procedure development by decreasing the number of trial runs. In order to ensure adequate weld quality it is necessary that various welding variables should be in proper balance. Therefore, it is essential to know the combined effect of the process variables on the resulting weld bead dimensions and shape relationship, as these dimensions control mechanical properties of a welded joint. The developed mathematical models or equation can be programmed and feed to a computer and so as to develop a expert system. Statistical analysis software (SPSS) and MS Excel were used for the complete analysis. As this technique is reported to result in improved properties as a result of refined microstructure as a consequence of effective weld pool stirring (Agarwal, 1994; Connel and Pherson, 1997; Ravussanka *et al*., 2005; Reddy *et al*., 2001). The mechanical properties of a welded joint largely depend on the weld bead dimensions and shape relationships which in turn are influenced by welding variables like welding current, arc voltage and welding speed. The bead geometry is specified by depth of penetration (P), weld bead width (W), reinforcement height (R), the ratio of weld width to penetration (W/P), known as weld penetration shape factor (WPSF), dilution (D) *i.e.* ratio of the area and contact angle (θ). A large number of research papers have been published for the final mathematical models by deleting insignificant regression coefficients were used to show graphical relationships between the welding variable and weld bead dimension. Refined microstructure as a consequence of effective weld pool stirring for the welding of steels using conventional TIG, MIG and submerged arc welding processes resulted improved properties (Mohandas and Reddy, 1996; Chandel *et al.*, 1997; Kolhe and Dutta, 2004;

*** Author for correspondence.**
[1] ARIS cell, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, AKOLA (M.S.) INDIA
[2] Department of Computer Science, College of Agricultural Engineering and Technology, Dapoli, RATNAGIRI (M.S.) INDIA