INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	Biplab Das
Roll Number	:	11610310
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Name of Thesis Supervisor(s)	:	Prof. Pankaj Biswas
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In this study, a detailed strategy for sheet forming by laser line heating has been presented. The work presented in this thesis is concerned with the evaluation of the effect of process parameters on thermal history, residual deformation, residual stresses, and strains associated with the process of laser line heating. Residual deformation is induced on the metallic sheet due to the heating effect of a laser beam when irradiated over a suitable heating path. The deformation generally takes place due to the combined effect of yielding and temperature distribution across the thickness of the metallic sheet. Both numerical and experimental analyses on laser line heating were carried out to investigate the thermal history and residual deformation.

Numerous experiments were conducted using a CNC-operated CO_2 laser heating machine. The mild steel sheet was used as a substrate material for the process. The effect of each operating parameter was taken into consideration for finding the optimum parameter. The design of the experiment was applied with the help of the Taguchi method and the results were obtained and analysed with the help of Taguchi analysis (signal-to-noise ratio), for the determination of the optimized operating parameters with their effect towards residual deformation in the process. A regression analysis was also performed to obtain a suitable co-relationship between operating parameters and residual deformation.

Initially, a 3-D FE model was developed and was validated with experimentally obtained temperature distribution at various locations of the sheet material. The temperature distributions and residual deformations were evaluated by changing the process parameters of the sheet material. The sheet surface temperature was maintained within the recrystallization temperature of the sheet material. The results obtained from the temperature distribution were further utilized in structural analysis to predict the residual deformation stresses and strain pattern for the line-heated sheets. Here the non-linear elastoplastic transient thermo-mechanical analysis was carried out using temperature-dependent thermal and mechanical properties. The results of residual deformation obtained numerically were again validated with the experimental ones. The 3-D FE model was further utilized for the determination of the magnitude and distribution of the residual stresses and strains by changing the heating parameters.

The second part of the work was concerned with the development of a 3-D compound curved surface by the process of laser line heating. Two different compound curved surfaces i.e. a pillow and a saddle shape were considered. A large deformation elastic FEM technique was applied for the generation of blank. The principal stresses, strains, and bending strains distribution over the top and bottom surface for the individual curved shape were evaluated. Based on the results obtained from FE analysis, the position of the heating path was determined. The heating parameters for the individual heating path were decided based on the magnitude of the strain associated with the heating path for the individual curved surface. The laser operating parameters for the individual heating path were obtained from the results of the thermal strain from the heated zone obtained from different operating parameters from the 3-D FE model. Since, finite element calculations are enormously time-consuming, in this work Artificial Neural Network (ANN) is used for the estimation of the heating parameters for the unknown strain values. Based on the stresses and strains field distribution pattern the experimental process parameters were decided and experiments were conducted to develop the compound curved surfaces by using the laser line heating processes. The experimentally obtained doubly curved shape matched fairly well with that of the actual shape.