PREFACE

Tube hydroforming is one of the new forming techniques for forming of tubular parts with variable diameter by applying internal hydrostatic pressure along with axial force on two end of straight or preformed tube. Tube hydroforming is relatively advanced technology than conventional forming processes, which has been technologically developed in recent years and is now became popular for forming of tubular components in various field such as automotive, aerospace and household applications. Few of typical applications include forming of tubes into ‘X’, ‘Y’ and ‘T’ shape components, engine cradles, stepped hollow shafts, exhaust manifolds etc. The tube hydroforming process having many distinct advantages over routine manufacturing process via deep drawing, stamping and welding process such as weight reduction of the part due to part consolidation, minimum tooling cost, low scrap rate, enhanced structural strength and improved stiffness, lesser secondary operations, better dimensional accuracy, significant reduction in spring back effects. Being such an important forming process in manufacturing industry, tube hydroforming is considered to study and explore the present research work. Due to complexity of the process, selection of process parameters is one of big challenge in tube hydroforming process. Modeling and optimization of tube hydroforming process using soft computing techniques has significant growth in the present scenario.

The present work focused on the detailed working principle of tube hydroforming process, various process parameters which are involved in tube hydroforming and their effects, and design of experiments with Taguchi designs are described. The influence of various process parameters such as internal pressure, axial movement and length of the tube on the various outputs such as maximum bulging in terms of bulge ratio and minimum thickness variation in terms of thinning ratio in tube hydroforming of annealed Inconel 600 super alloy using ANOVA are discussed.

Inconel 600 having numerous applications in various industries and having superior properties such as heat and corrosive resistance. Hence, in the present research, Inconel 600 is considered for the tube material. Various properties of Inconel 600 tube is tested before and after annealing and results are included in the
present work. Variation of the microstructure before and after annealing process is also investigated and reported.

Using DEFORM-3D explicit server, FEM simulation has been carried out and compared simulation observations with experimental observations. Solid modelling of the various components such as die, axial plungers and tube is explained. The details procedure of the simulation process using DEFORM-3D of tube hydroforming process is explored in the present research.

Response Surface Methodology (RSM) was applied for developing the empirical models in the form of multiple regression equations correlating the dependent parameters with the independent parameters (Internal pressure, axial movement and length of the tube) in tube hydroforming of annealed Inconel 600 tubes. Using the developed model equations, the response surfaces have been plotted to study the effects of process parameters on the output responses. Empirical models are developed for both simulation and experimental data using RSM. The confirmation experiments were performed to verify the developed empirical models, which were found within 95% confidence interval.

Genetic algorithm in combination with RSM has been used for optimization of response characteristics of conflicting nature. The optimal sets of process parameters for multi objective optimization with maximum bulge ratio of the selected performance measures were found as per the assumed models. The optimal values of process parameters for multi objective optimization using RSM and genetic algorithm are reported.

The investigation consists of simulation and experimentation on tube hydroforming, studies the effect of various process parameters on output responses, modeling and multi-objective optimization using response surface methodology (RSM) and genetic algorithm approach and related results and discussions, and finally conclusions are incorporated in seven chapters.