Synopsis of the Thesis

Flow forming, comparatively a late comer in the field of sheetmetal working, is a volumetric rotary forming process for manufacturing the rotationally symmetric hollow metallic parts of various shapes - conical, tubular, ogival or curvilinear - to a high degree of accuracy and surface finish with improved mechanical properties. In this process, the work-metal is plastically deformed to the shape of rotating mandrel by applying considerable force through one or more power assisted rollers.

Theoretical study and analytical work hitherto carried out in the field of flow forming technology employed only approximate methods based on certain assumptions because of the difficulty of applying exact mathematical models to the problems of interest. In fact, the work done in the field of assessment of various important controlling factors (independent variables) influencing the performance characteristics (end results) in flow forming is too inadequate to draw definite inferences. Therefore, successful solutions to the flow-forming problems would be a function of the experience gained through the practical experimental work which is the main objective of the present thesis.

Content of the Thesis :

The thesis consists of six chapters. The Chapter 1 **"Introduction"**, gives a preamble to the present work on flow forming process. The reasons for choosing the present work and as well as the scope of the present work, have been explained and highlighted in this introductory chapter.

The Chapter 2 entitled **"Fundamentals of flow forming"** is based primarily on the literature survey. It reviews the history of evolution, physical concepts and description of process, process characteristics, process parameters (controlling factors affecting the process performance characteristics), advantages and limitations as well as applications of flow forming process alongwith different types of available flow forming machines in the world. This chapter also embodies the review of the theoretical work on the analysis and mechanics of flow forming carried out by earlier researchers.

The Chapter 3 is entitled **"Flow-formability of materials".** An overview of formability in general, definition and measure of flow formability, identification of the factors influencing the flow formability of the sheet metals have been described in the first part of the chapter followed by the experimental work carried out by the author. Actual experimental work carried out for assessment of the factors (variables) affecting the flow formability of sheetmetal have been recorded. The statistical design of experiment, namely, 2^3 *factorial design* and proper *analysis of variance* have been used to assess the degree of significance of the different controlling factors on the flow formability of the sheetmetals of different materials, namely, aluminium (Al), copper (Cu) and deep drawn grade steel (DDS).

Further, this chapter deals with a suitable composite design of experiment conducted while flow forming three different sheetmetals (Al, Cu, DDS) employing various combinations of controlling factors like sheetmetal thickness (T), mandrel rotational speed (N), and forming roller feed rate (f) in order to arrive at a functional relationship between the flow formability and the controlling variables. The established functional relationship has also been tested for its adequacy by proper analysis of variance (ANOVA). Three-dimensional *response surfaces* for different flow formability have also been constructed.

The Chapter 4 titled **"Assessment of Obtainable Accuracy & Surface Finish in flow forming of sheetmetal cones"** deals with actual experimentation carried out for the purpose. First, the general nature of deviation/variation in wall thickness as well as surface finish of the flow formed cones have been studied with the help of preliminary experiments.

Then a 3^3 *factorial design and response surface methodology* were used to evaluate the dimensional accuracy in terms of the deviation of cone wall thickness and surface finish with the change in three controlling variables such as percentage reduction in wall thickness (R), mandrel rotational speed (N) and roller feed (f) for two different sheetmetals (Al & Cu).

Functional mathematical models for dimensional accuracy and surface finish of flow formed cones were evolved based on the experimental results and their adequacies have been tested and the significance of the factors (variables) has been quantified by suitable statistical tests, (F-test & t-test). *3-D Response surface contours* for given accuracy or surface finish based on the evolved equations have been illustrated for both aluminium and copper flow formed cones.

The Chapter 5, titled as **"Parametric optimisation in flow forming of sheetmetal cones"**, reports on the optimisation of the objective functions for accuracy and surface finish. Suitable programs have been created using 'MATLAB' software for the optimisation technique, namely, *direct search method* with a view to arrive at the optimum values of the controlling factors - R, N & T - at which the dimensional deviation of the cone-wall thickness and the surface roughness on the external surface of the flow-formed cones attain minimal or optimal values.

In the final chapter, i.e. in Chapter 6 titled **"Conclusions"**, all the results and findings from the experiments have been consolidated and summarised. Definite inferences have been drawn with regards to the obtainable flow formability, dimensional accuracy and surface finish; and how these objective performance parameters are influenced by the input controlling parameters (factors) in flow forming of sheet metal cones within the regime of the experiments. Further scope of work has also been suggested in this important area of flow forming.

At the end, a comprehensive list of References has been provided.