INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Among different metal forming processes, the high strain rate forming is very challenging as it involves the application of high energy for a short duration of time, which enables to deform large size parts easily. In case of electromagnetic shearing it has advantage of reduced burrs and slivers. High strain rate deformation improves formability of the material. Electromagnetic forming (EMF) is a high strain rate forming process which utilizes electromagnetic forces to deform the metal workpieces such as sheets and tubes. Some of the researchers have found that the forces generated in the electromagnetic forming are higher enough to shear the material easily. Here in this work, a feasibility study on Electromagnetic forming and perforation (EMFP) of the tube technique has been carried out. In the conventional manufacturing of perforated tubes, the metal sheet is first perforated by blanking, then rolled and welded into the tube. This process is time-consuming as it involves multiple operations, and also it leads to some weld defects. To overcome this problem, a novel EMFP technique is developed where simultaneous expansion and perforation of the tube can be possible. This will result in near net shape product with faster rate of production. The optimum discharge energy is determined with experimental trials that lead to successful forming and perforation of the tube. Experimental results show that the concave punches are more suitable for perforation as complete removal of slug took place, which results in clear perforation.

For the comparison of conventional (low strain rate) and electromagnetic (high strain rate) shearing, a setup for quasi-static die-less perforation is developed, and experiments are carried out. Here, we have studied different sheared edge zones for EM as well as Quasistatic forming with both pointed and concave punches. The results obtained during this study show the capability of electromagnetic perforation to obtain perforated holes with better edge surface finish and material properties over the quasi-static perforation process.

Further, the experimental and numerical study on the electromagnetic forming of muffler tube with a die has been carried out. In traditional manufacturing techniques of muffler tubes, the metal sheet is formed by conventional practices, then it is rolled and welded into desired shape. The welded zone in the muffler tube is more brittle, and it has less fatigue strength, which may result in failure. In this part of work, experiments are carried out on Al6061 tubes, which results in a single piece of component of the desired shape (muffler), hence it eliminates the weld zone

and the working life of muffler may extend. In conventional muffler the tube used is steel and it adds to the weight of automobile. Use of aluminium is difficult due to poorer formability at low strain rate. EM forming being high strain rate can form Al muffler tube and reduce the weight of the automobile. The FE analysis is carried out for both EM forming of muffler tube and EMFP process. The coupled and non-coupled simulation algorithms are developed and used for the FE analysis. Advanced techniques and meshing methods available in non-coupled simulation software's are used for more accuracy. In the case of FEA of EM forming of muffler tube, a coupled simulation method is used, and a good agreement with deformation obtained experimental results is observed. Optimum discharge energy is determined for maximum die filling for EM forming of the muffler tubes.

On the other hand, in the FEA of EMFP, both simulation methods are used. At lower discharge energy, the coupled model results are found in 96% agreement with diameter of perforated hole obtained in experimental results. While on the other side, at the same discharge energy, although the non-coupled simulation shows a 94% agreement, it has succeeded in better capturing of the initiation of perforation. Stress variations along the tube during forming and perforation are thoroughly studied for both type of punches. Also, the shearing mechanism and slug separation for punchless EM perforation is studied with FE simulations.

In general, the good agreement of FEA results with findings in the experiment shows the prediction capability of developed numerical models. Overall, the presented study concluded that the EM techniques are advantageous over conventional processes. Finally, by modifying the parameters as per requirement in this study, one can commercialize these applications of EM forming processes.