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Simulation and Loading Path Optimization of a Hydroform Part Using Response Surface Method

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ABSTRACT

Tube hydroforming is an interesting method to produce seamless parts. Hydroforming Process has many advantages over traditional methods, such as reducing tool and equipment requirements, eliminating blanking and trimming operations, and etc.

In tube hydroforming process, balancing between internal pressure and axial feed is necessary to produce defect-free parts. Various methods have been developed for load path optimization in this process.

In most forming processes the attainable strains are path-dependent[1]. Thus, the formability characteristics of the produced parts are a function of the loading path during forming process. Since the stress is a function of the strain path, in processes such as tube hydroforming where several loads are applied, the order and magnitude of each load would affect the final characteristics of the final product. Therefore, it would be of interest to form the material such that the desired characteristics is resulted in the final part, i.e. minimize part thickness variation, minimize the residual stresses, attain the maximum formability, etc.

Employing optimization methods along with 'design of experiments' methods and 'finite element' simulations have shown to be a powerful tool to overcome many of the above problems [2]. In recent years, researchers have concentrated on optimization of loadig trajectories for different tube hydroforming processes.

In this work, Response Surface algorithm and FE simulation used for optimization of the loading path of T shape part. The objective of the research is to achieve optimal loading path resulting in a part with minimum wall thickness variation and maximum forming.

To design a precise model for the problem, the simulation must be repeated for a certain number of iterations. In this optimization, minimum variation in wall thickness would be considered as objective function and the height of the T branch as the constraint.

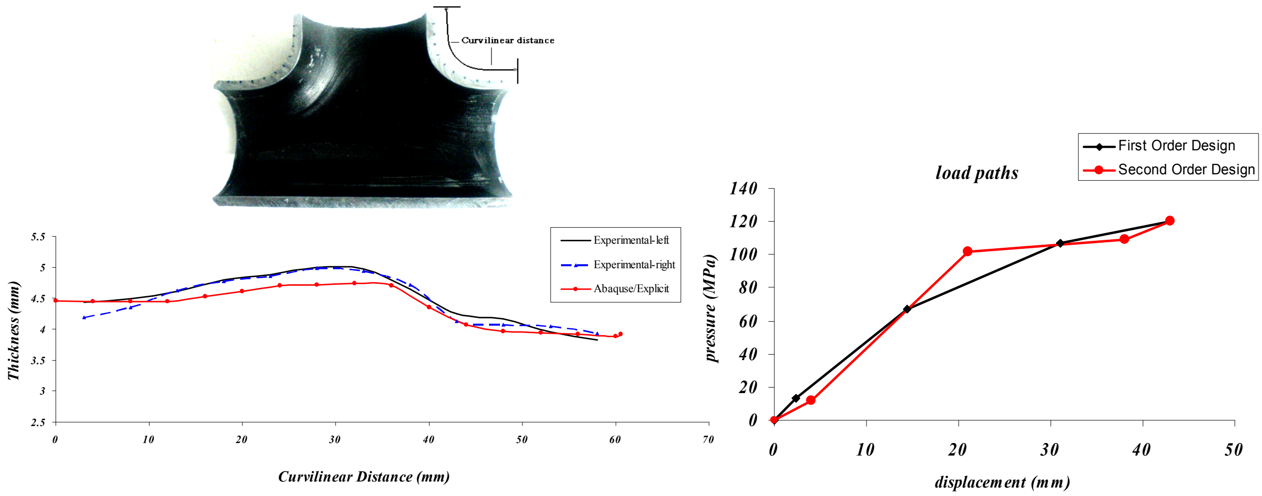
To analyze of the forming process, a numerical method such as FE simulation can be used. In this research, FE method using ABAQUSE/EXPLICIT 6.4 code was used to simulate the process. To verify simulation procedure, T shape part, had been cut on longitudinal symmetry plane, and its wall thickness was measured in 12 points.

Thickness of the produced part and the result of simulation have been compared as shown in Figure 1-a.

In designing of experiments, Response Surface Method (RSM) have been used. RSM is a collection of experimental strategies, mathematical methods, and statistical inference that enable an experimenter to make efficient empirical exploration of the system of interest.

The RSM have been used for two schemes: 2k & 3k Factorial Design .

For the design of experiment, data collection Matlab/mbc-Model tool box has been used. Then the Excel/Solver has been used for optimization.



1-a ***1-b***

Figure 1: *a) Wall thickness simulation and actual part*
b) Predicted optimum load paths by RSM techniques

In order to decrease the number of design variable, model was built based on pressure-displacement diagram, that is independent of the time.The pressure-displacement diagram has been modeled by 2 fixed end points and intermediate points. In the first attempt, two level factorial model has been built by using 8 experimental points. In the second attempt, second order RSM has been built using 27 experimental points. The resulting optimum load path attempt has been shown in **Figure 1-b**.

The optimum load path has resulted in a protrusion height of 82.5 mm. which is the minimum acceptable height. The wall thickness variation improved from 0.153 for actual part to 0.053 for predicted optimum load path by second order. The second order RSM seems to have a better results over the first order model.

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