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A probabilistic approach for optimising hydroformed structures using local surrogate models to control failures

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Abstract

A probabilistic approach is proposed to optimise hydroformed structures by taking into account the potential variabilities. An efficient implementation requires an appropriate strategy for uncertainty representation and propagation. Moreover, the probability of failure associated to each failure mode must be accurately estimated. To this end, the failure modes are controlled locally only at the highly strained regions which reduces the problem complexity and increases the precision of the generated surrogate models. In this study, finite element simulations with material formability diagrams are used to predict the critical zones in which failure modes may initiate. The predicted zones agree well with the experimental and numerical simulations. By this simplification, the optimisation problem is formulated differently while retaining the relevant physical features of the process. To illustrate this strategy, tee-shaped tube hydroforming process is proposed due to its complexity to demonstrate the benefits of the probabilistic approach. The optimisation problem is formulated within deterministic and probabilistic frameworks to determine the optimal loading paths. It will be shown that probabilistic optimum allows better process mechanics and improved thickness distribution in the hydroformed tube. This approach can be extended to other metal forming processes and easily implemented for industrial products within reasonable computational time.

Keywords:
Probabilistic approach, Hydroformed structures, Uncertainty propagation, Surrogate models, Optimisation

1. Introduction

During the last decade, hydroforming process has become one of the most important advanced manufacturing technology used for producing a large variety of components and structures. The process finds various applications in the aerospace industry, such as panels, fuselage parts and in the appliance industry, such as fitting, joints, knobs and handles. The process offers significantly improved component stifnesses in addition to lower cost compared to traditional techniques such as stamping, forging or welding. Since the application of the hydroforming process is relatively new (compared to other metal forming processes such as stamping and forging), a know-how with many trial efforts and numerical simulations such as optimisation strategies coupled with finite element analyses (FEA) is requested to achieve a good performance of the process. More precisely, it appears that monitoring and controlling the process is necessary in order to obtain parts that satisfied the desired specifications. Indeed, final shapes obtained by hydroforming process are highly dependent on the applied loads, material properties,

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