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Optimization of Variable Blank Holder Force Trajectory via Sequential Approximate Optimization with Radial Basis Function network

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Abstract
In sheet forming, there are many factors that affect the quality of products, such as the Blank Holder Force (BHF), the friction and lubrication conditions of the interface, and the die geometry. Among these factors, BHF plays a key role in sheet forming. A lower BHF will cause wrinkling due to excessive material flow into the die, while a higher BHF will lead to tearing due to the thinning. Therefore, it is important to determine an appropriate constant BHF over the punch stroke in advance. In order to avoid these defects, the Variable Blank Holder Force (VBHF), in which the BHF varies throughout the stroke, is an important approach. In general, sheet forming simulation is so costly and time-consuming task that sequential approximate optimization (SAO) approach should be used for optimization. In this paper, the radial basis function (RBF) network is employed in the SAO procedure. In the proposed SAO with the RBF network, the optimal solution of response surface is taken as the new sampling point for improving the local accuracy. In addition, for global approximation, new function called the density function is constructed with the RBF network, in order to find the unexplored region. This density function generates local minima in the sparse region, so that the minimum point of this function can be taken as a new sampling point. The density function with the RBF network is easy to construct. In the proposed SAO algorithm, the density function is constructed repeatedly until the terminal criterion is satisfied. In this paper, the VBHF trajectory is optimized so as to minimize the thickness deviation through deep drawing. Thus, the thickness deviation is considered as the objective function. The forming limit diagram (FLD) is used to evaluate the risks of both the tearing and the wrinkling. These are separately handled as the design constraints. In order to obtain the VBHF trajectory, the total stroke is partitioned into the n sub-strokes and they are taken as the design variables. Numerical simulation shows that no tearing and wrinkling can be observed through the deep drawing process. It is found from numerical simulation that the tearing is more active than the wrinkling. This implies that tearing is more important constraint than wrinkling at the optimal VBHF trajectory. In industries, tearing directly leads to defective piece, and then tearing is more undesirable issue than wrinkling. Therefore, tearing is more important than wrinkling. This optimization result is consistent with the comments of experts in industries.