A new Approach for Optimization of Sheet Metal Components

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Abstract. Beads are a widespread technology for reinforcing sheet metal structures, because they can be applied without any additional manufacturing effort and without significant weight increase. The two main applications of bead technology are to increase the stiffness for static loading conditions and to reduce the noise and vibrations for dynamic loadings. However, it is difficult to design the bead patterns of sheet metal structures due to the direction-controlled reinforcement effect of the beads. A wrong bead pattern layout can even weaken the properties of the structure. In the past, the designs were predominantly determined empirically or by the use of so called bead catalogues.

Recently, different optimization approaches for bead patterns were developed, which are based upon classical mathematical programming optimization algorithms together with automatically generated shape basis vectors. However, these approaches usually provide only vague suggestions for the designs. One of the most severe difficulty with these approaches is to transfer the optimized results into manufacturable designs. Furthermore, another severe difficulty is that the optimization problem is non-convex, which frequently leads the mathematical programming algorithms into a local optima and thus to sub-optimal solutions.

The investigations in this article show an optimization method, which within a few iterations leads to bead structures with excellent reinforcement effects using optimality criteria based approach. Generally, the results can be transferred without large effort into a final design.

The new optimization method calculates the distribution of the bending stress tensor and the principal bending stresses based upon the results of a finite element analysis. The bead orientations are calculated by the trajectories of the principal bending stress with the largest magnitude. The beads are projected on to the mesh of the component using geometric form functions of the desired bead cross section. A local bead ratio of 50% (defined as average area of the beads in relation to total area of the sheet) is used by the algorithm to determine the maximum moment of inertia.

The proposed algorithm is numerical implemented in the optimization system TOSCA and available for being applied with the following finite element solvers: ABAQUS, ANSYS, I-DEAS, NX Nastran, MSC.Nastran, MSC.Marc and PERMAS. The optimization algorithm is successfully applied to static and dynamic real world problems like car body parts, oil pans and exhaust mufflers. In the present work several academic and industrial examples are presented.