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Concurrent Optimization of Springback and Failure in Stamping Processes

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In sheet metal stamping, first the deformation is elastic and reversible; then follows a plastic regime which ideally yields the desired workpiece geometry. Indeed, the sheet metal is normally deformed to conform to the shape of the tools, except that upon unloading, the sheet looks for finding its original geometry due to the elastic component of deformation work previously stored as potential energy. This phenomenon is called Springback and is always aimed to be reduced if not eliminated. Another problem which may occur during stamping is the failure of the deforming sheet. A reliable concept to study the failure is the Forming Limit Curve (FLC) determined by experimental tests which allow to determine the boundary space in the principal strain space that separate homogeneous and localized strains. These two phenomena are sensitive to several process parameters among which we select the blank thickness e and punch speed V_e as optimization variables. Actually, springback and failure are antagonistic criteria, so we are interested in efficient methods for the computation of the Pareto Front. Our contribution is as follows. We consider an elasto-plastic system with a yield function of Hill type, numerically solved with the FEA code LS-DYNA using Belytschko-Tsay shell elements. The FLC and springback criteria are post-processed for a uniform sampling of $(e; V_e)$ values, and are used to build a spline approximation (surrogate) of the criteria. We then implement a version of NNCM [1] and NBI [2] methods, dedicated to the computation of Pareto Fronts, which use a hybrid optimizer. This optimizer couples the Simulated Annealing (SA) with simultaneous perturbation stochastic approximation (SPSA) method [3] used as a local optimizer. We then use the NBI/NNCM formulation with SA+SPSA optimizer for the spline approximations of the two criteria to compute an approximate Pareto Front. This approach is validated against many mathematical well-known benchmarks, e.g. [5]. An industrial application of the described approach is presented. The sheet metal is made of high-strength low alloy steel (HSLA260), and is cross-punched. The approximate Pareto Front is successfully compared to the one obtained by NSGA-II[4]. The second step present the approximate Pareto Fronts obtained (using NBI and NNCM with SA+SPSA and compared to NSGA-II) for 4 design parameters, the sheet thickness, punch speed, friction coefficient and blank holder force (BHF). The results were motivating, we minimized more sprinback and failure.

References

[1] A. Messac, A. Ismail-Yahaya and C. A. Mattson, The Normalized Normal Constraint Method for Generating the Pareto Frontier, *Struc. Multidisc. Optim.*, 25(2), 86-98, 2003.

[2] I. Das and J. E. Dennis, Normal-Boundary Intersection, A new Method for Generating the Pareto Surface in Nonlinear Multicriteria Optimization Problems, *SIAM Journal on Optimization*, 8(3), 631, 1998.

[3] J. C. Spall, *Introduction to Stochastic Search and Optimization: Estimation, Simulation, and Control*, Jhon Wiley & Sons, Inc., Hoboken, New Jersey, 1998.

[4] K. Deb, Multiobjective genetic algorithms: Problem difficulties and construction of test problems, *Evol. Comput.*, vol.8, no.2, pp. 205-230, 1999.

[5] E. Zitzler and L. Thiele, Multiobjective optimization using evolutionary algorithms - A comparative case study, *in Parallel Problems Solving from Nature, V, A. E. Eiben, T. Bäck, M. Schoenauer and H,-P. Schwefel, Eds. Berlin, Germany: Springer-Verlag*, pp. 292-301, 1998.