ABSTRACT

The present work introduces a new methodology for designing machine element shapes. The element is represented using non-uniform rational B-Spline (NURBS) in order to give it a form of shape flexibility. A special form of genetic algorithms known as real-coded genetic algorithms is used to conduct the search for the design objectives. Shape optimization of C-frames are used as an application of the proposed methodology. C-frames constitute a large portion of machine tools that are currently used in industry. Examples of these frames include drilling machines, presses, punching and stamping machines, clamps, hooks, etc. The design parameters of these frames include the dimensions of their cross-sections, which should be chosen to withstand the applied loads and minimize the element's overall weight. The results showed that the optimal shape was a semi I-section.

In a further development, the hybridization of different optimization methods has been used to find the optimum shape of the element. While random search techniques, such as genetic algorithms has a high probability of achieving global optimality, they usually arrive at a near optimal solution due to their random nature. On the other hand direct search methods are efficient optimization techniques but linger in local minima if the objective function is multi-modal. The optimization of C-frame cross-section using a hybrid optimization algorithm is used. Real coded genetic algorithm is used as a random search method, while Nelder-Mead is used as a direct search method, where the result of the genetic algorithm search is used as the starting point of direct search. The results showed that the use of Nelder-Mead with Real coded Genetic Algorithms has been very significant in improving the optimum shape of a solid C-frame cross-section subjected to a combined tension and bending stresses. The hybrid optimization method could be extended to more complex shape optimization problems.

The 3D frame of the C-frames is also optimized using the same optimization techniques, and its shape is represented using 3D NURBS representations. For the purpose of analysis, curved beam theory is applied on local cross-sections on the

NURBS surface. A finite elements analysis was conducted on SDRC-IDEAS for verifying the results obtained using the curved beam theory.