ABSTRACT

The properties of an alloy depend mainly on the alloying elements, method of production, mechanical and thermal treatments. The relationships between the process variables and final properties of the alloy are very much complex, non-linear in nature in many cases, which is the biggest hurdle in developing proper correlations between them by conventional methods and modeling tools. Regression analysis to model non-linear data necessitates the use of an equation in an attempt to transform the data into a linear form. This represents an approximation that inevitably introduces significant degree of error. Similarly, it is not easy to use statistical methods to relate multiple inputs to multiple process outputs.

An artificial neural network is an information processing and modeling system, which mimics the learning ability of biological systems in understanding an unknown process or its behavior. The knowledge about the unknown process, stored as neural network weights can be utilized to analyze and control the process. It not only takes decisions based on incomplete and disordered information, but can also generalize rules from those cases on which it is trained and then apply these rules to new patterns. The genetic algorithms are powerful probabilistic heuristic procedure for global search and robust optimization in multi-parameter search spaces based on the mechanics of natural genetics.

In the present investigation, efforts have been made to develop suitable models for some complex metallurgical systems using artificial neural networks and genetic algorithms. The analysis includes the prediction of outputs for given input parameters within and outside the range, evaluation of the sensitivity of the output variables on the input variables and design of hypothetical alloys in steels and Al-7Si alloy.

In case of Al-7Si alloy the influence of grain refiner (Al-Ti-B master alloys) addition level and holding time on the grain size has been modeled. The effect of composition on mechanical properties has been modeled in case of C-Mn cast steels. The influence of heat treatment parameters has been considered in addition to composition in case of EN100 steels. High-speed steels have also been studied in order to test the validity of the model over wide range of composition. The effects of process parameters such as finish rolling temperature and coil target temperature on mechanical properties has been considered in case of hot rolled steel strips. Finally, the technique has also been used to model the bainite plate thickness in low alloy steels and the results have been compared with the existing model.

The predicted results from a neural network model showed a good agreement with the experimental data, in spite of its nonlinear nature. Using the genetic algorithms, a model has been developed to design an alloy composition and/or thermal treatment cycles to get the desired properties. Finally, user-friendly computer software has been developed which is able to analyze the data with a high accuracy.