

Chapter 7

Models and Optimization Techniques of Machining Parameters in Turning Operations

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ABSTRACT

Machining parameters optimization is one of the most essential and interesting problems in manufacturing world. Efficient optimization of machining parameters can produce high-quality products with low cost and high productivity. Thus, many process optimization models of the turning operations with one or two tools are established in order to realize various machining aims. Due to the complexity of optimization models, many new optimization techniques are proposed to solve them. Major optimization techniques include genetic algorithms, simulated annealing, ant colony optimization, particle swarm optimization, et cetera. In this chapter, a comprehensive discussion on various soft computing techniques are presented, especially meta-heuristic algorithms concerning optimization of machining parameters in both single-tool and multi-tools turning operations. In addition, some future challenges and research trends are also discussed in this chapter.

INTRODUCTION

The application of computer numerical control (CNC) machining has brought enormous changes to manufacturing industry. CNC machines can achieve sizable savings in time and money if

automated process planning performs efficiently. The automated process planning of CNC machining reduce the routine work of manufacturing engineers, meanwhile offer an opportunity to generate optimal and consistent machining conditions. Process plans are developed through rational selection of machines, tools, determination of

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machining parameters, etc. for each operation of a given machined part. Computer Aided Process Planning (CAPP) is considered as the solution that can provide a great assistance in this aspect and could even replace completely the human planners in the planning procedure.

A CAPP system usually involves selection of machine tools and operations, selected operations planning, various parameters generation required in each operation, and so on. While there has been some success in some problematic areas, such as systematization of feature recognition and operation sequencing, the process of selecting cutting tool and parameters has been less successful since it depends largely on human experience. As machining parameters strongly affect the cost, productivity and quality of the machined parts, optimization of machining parameters is an important step in process planning of machining operations, which is referred to as machining economics problem. This problem has been extensively researched over the last 50 years (Gilbert, 1950).

In manufacturing world, optimization for machining parameters in turning operations is one of the most important and popular problems. Efficient optimization of machining parameters can reduce production cost, promoting machining productivity, and increasing machining precision as well (Mukherjee & Ray, 2006; Raja & Baskar, 2010b). Concerning machining parameter optimization, the primary objective is to determine optimal machining parameters (cutting speed, feed rate, depth of cut, number of cuts) that realize certain machining goals as follows: (1) minimum unit production cost; (2) minimum production time, i.e. maximum production rate; (3) maximum profit rate; (4) weighted combination of (1) and (2); while satisfying certain machining conditions (Chen & Tsai, 1996).

However, to determine the optimal machining parameters, complex mathematical models have been formulated to associate the machining parameters with the machining performance. The complexity is augmented if one considers that the

machining parameters are subjected to many machining condition constraints, such as permissible limit of power, cutting force, tool-life constraint, and surface roughness. Main difficulties arise because of the coexistence of parameters that interact in non linear modes (Mukherjee & Ray, 2006). Thus, optimization of machining parameters has been shown to be a critical and difficult task for conventional mathematic methods, such as geometric programming (Ermer, 1971), non-linear programming, dynamic programming (Agapiou, 1992a; Agapiou, 1992b), and sequential unconstrained minimization techniques (Duffuaa et al., 1993) etc. Therefore, soft computing techniques were devised to tackle those (Quiza et al., 2010). Soft computing is a computing approach which is similar to the remarkable ability of the human to reason and learn in an environment of imprecision. With the knowledge of imprecision and uncertainty present in machining, soft computing-based methods can find out reasonably useful solutions. Soft computing techniques include fuzzy logic, neural networks (NN), meta-heuristics, etc.

Genetic algorithm (GA) is stochastic meta-heuristic method of search and optimization based on the computational models of the biological evolutionary process (Goldberg, 1989). In GA, a solution is encoded into individuals (or chromosomes) which are represented by binary or decimal numbers. Each individual is assigned a fitness value that decides its suitability to survive. A set of them, called population, evolves under the control of genetic operators such as crossover and mutation with selection processes favoring the fittest individuals. The individual that is survived as the fittest in the final generation is usually considered the optimal solution to the problem. The genetic algorithms have been found very powerful in searching the global optimum. Further, in designing a GA to the practical problems, it is beneficial to embed a good local improvement method into GA, which can leads to good global solutions (Michalewicz, 1996).

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