Chapter 3
Metaheuristic Approaches for Extrusion Manufacturing Process:
Utilization of Flower Pollination Algorithm and Particle Swarm Optimization

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ABSTRACT

Optimization, basically, is a method used to find solutions for a particular problem without neglecting the existing boundaries or limitations. Flower Pollination Algorithm (FPA) is one of the recently developed nature inspired algorithms, based on the intriguing process of flower pollination in the world of nature. The main aim of this study is to utilize FPA in optimizing cold forward extrusion process in order to obtain optimal parameters to produce workpiece with the minimum force load. It is very important to find the most optimal parameters for an extrusion process in order to prevent waste from happening due to trial and error method in determining the optimal parameters and thus, FPA is used to replace the traditional trial and error method to optimize the cold forward extrusion process. The optimization performance of the FPA is then compared with the particle swarm optimization (PSO), in which the FPA shows comparable performance in this regard.

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INTRODUCTION

Forming or better known as metal forming is a metalworking process to form or shape a raw material into desired geometry and shape. Metal working is also can be categorized as a process of forming a metal parts and objects through a mechanical deformation process whereby the workpiece will be reshaped without adding or removing of material. Various process parameters such as the shape of the workpiece, shape of the product, forming sequence, shapes of tools, shapes of the dies, coefficient of friction, and metal forming speed, working temperature and properties of the material as well as the properties of the tools used can be used to characterize a particular metal forming process. In order to improve the quality of the output product and contributes in reducing the production cost, it is very important and significant to determine and figure out the optimum forming parameters beforehand by utilizing optimization techniques (Byon & Hwang, 2003; Kuzman, 2001).

Currently, due to the development of applied mathematics, operational researches, informational computational methods, simulations and design of experiment (DOE) contributed in the improvement of forming technologies by employing the knowledge from the area such as modelling, optimizations, computer techniques and artificial intelligence previously. Today, there is plenty more different approach in optimization methods.

For this particular study, different optimization approaches, particularly, the classical mathematical approach, flower pollination algorithm (FPA) and particle swarm optimization (PSO) algorithm, are used to determine the optimum values of logarithmic strain, die angle as well as the friction factor of cold extrusion process. Experiment plans based on factorial design of experiment (DOE) and orthogonal array has been used to minimize the force required for cold extrusion process and then classical mathematical approach, FPA and PSO optimization have been performed, based on the response model of forming force for the cold extrusion process. By minimizing the extrusion force required, longer tool life, improve formability of workpiece and increment of product quality can be achieved.

The objectives of this study can be summarized as follows:

- To optimize the process parameters of cold forward extrusion, *viz* logarithmic strain, half-die angle and friction factor, such that the extrusion force is minimized.
- To compare the effectiveness of classical mathematical approach, FPA and PSO in optimization of the cold forward extrusion process.

BACKGROUND

Extrusion is a plastic deformation process in which a block of metal, called the billet, is forced to flow or pass through the die opening of a smaller cross-sectional area than that of the original billet. Extrusion can be classified as hot and cold extrusion. However, for this particular study, only cold extrusion process will be considered. Selection of the optimal process parameters, including the shape of billet, extrude sequence, shapes of dies, friction, extrusion speed, temperature and material properties plays a determinant role to the success of the extrusion process. In this regard, different types of optimization techniques are continuously explored and applied in the process in order to reduce the production cost and to improve the quality of a product (Sadollah & Bahreininejad, 2012). The optimization techniques are used based on the required degree of accuracy for object modeling, and type of processes.