Fuzzy Logic Controller Design for Intelligent Drilling System

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***Abstract*— An intelligent drilling system can be commercially very profitable in terms of reduction in crude material and labor involvement. The use of fuzzy logic based controller in the intelligent cutting and drilling operations has become a popular practice in the ever growing manufacturing industry. In this paper, a fuzzy logic controller has been designed to select the cutting parameter more precisely for the drilling operation. Specifically, different input criterion of machining parameters are considered such as the tool and material hardness, the diameter of drilling hole and the flow rate of cutting fluid. Unlike the existing fuzzy logic based methods, which use only two input parameters, the proposed system utilizes more input parameters to provide spindle speed and feed rate information more precisely for the intelligent drilling operation.**

Keywords—fuzzy logic controller; intelligent system; drilling operaion system.

I. INTRODUCTION

Over the decades of revolution, manufacturing field is stepping into a new era of integration of intelligent control and automation with the manufacturing processes. This advancement leads to reduction in crude material and labor. The integration of fuzzy logic controller with the drilling process allows the machining parameters such as spindle speed, feed rate to be automatically and correctly selected under different machining conditions. This can certainly reduce the risk of spoiling the drill bit and increase the productivity. Furthermore, the system will become more intelligent and may result reduction of man power in great amount.

So far, few research works on the application of fuzzy logic in drilling operation is available. Among those, a model was developed in [1] to select cutting speeds for three different materials in drilling operation. The relationship between a given material hardness and drilling speed was evaluated by fuzzy relation for different cutting tool materials, hole diameters and feed rates. Fuzzy logic models to select machining parameters such as, cutting speed and feed rate, was proposed by [2] for computer aided process planning (CAPP) systems. Each model utilizes two-input and two-output variables which are partitioned into several fuzzy sets according to their minimum and maximum values allowed to control the model.

In the consequence, to determine the minimum quantity of lubricant (MQL) according to feed rate and cutting speed a fuzzy logic model was developed in [3]. This study used two main inputs to determine the proper minimum quantity of lubricant by using two inputs, feed rate and cutting speed. In [4] the development stages of a fuzzy logic model were described for metal cutting. The model is based on the assumption that the relationship between the hardness of a given material and the recommended cutting speed is an imprecise relationship, and can be described and evaluated by the theory of fuzzy sets. Almost similar investigation was conducted by [5] where the proper cutting speed according to the hardness of the work piece and the material in turning operation was determined by using fuzzy logic model. In addition to the above, a fuzzy-logic controller (FLC) is designed in [6] to automatically adjust feed rate in order to regulate the cutting force of milling processes in a vertical machining center. The controller utilizes the cutting force, difference between cutting force and reference cutting force to calculate and compute the feed rate. In the sequel fuzzy inference system for intelligent air-conditioning system was developed in [7].

A parameter optimization method for machining glass-fiber reinforced plastic (GFRP) composites with multiple characteristics using fuzzy logic was proposed in [8]. A multi-response performance index (MRPI) was used for optimization. The machining parameters, namely, work piece fiber specially applied to the GFRP composites, cutting speed, feed rate, depth of cut, and machining time were optimized with considerations of multiple response characteristics, including material removal rate, tool wear, and surface roughness. The drilling parameter optimization for Carbon Fiber Reinforced Plastic (CFRP) was described in [9]. The fuzzy optimization of drilling parameters is based on five different input performance characteristics, namely, thrust force, torque, entry delamination, exit delamination and eccentricity of the holes. The fuzzy logic controller then selects the best drilling parameters such as spindle speed and feed rate for the operation of machining the CFRP. Also, in [10], the fuzzy logic model has been developed for the drilling operation. The model is used to select drilling speed for the workpieces for two different materials, mild steel