A Fuzzy Logic Solution for Feed Drive Control

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Abstract— Because of high speed conditions of work and nonlinearities during machining the feed drive mechanism of vertical milling machine it becomes a very difficult model to be designed and controlled. In this paper we try to find a fast solution to overcome these problems and it is an attempt of finding alternative easiest ways of successful fuzzy logic control implementation. We propose an approach that offers some stability characteristics and very good computational performances efficiency. The controller gives fast loop response stability; reducing the steady state error, increasing the rising time and decreasing the settling time.

Index Terms— Fuzzy logic, feed drive, CNC, membership function, control, intelligent control, PID

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1 INTRODUCTION

Usually today's CNC machine tools have high speed spindle motors and high-power servomotors with high-lead ball-screws. [1] During high speed and high accelerations work conditions, the main issue is vibration, respectively machining accuracy losses in term of path tracking errors, positioning errors, wavy and spoiled surfaces of the parts, etc Generally these feed drives are designed using a rotary servomotor and a ballscrew. The most common motors used in the feed drive are dc motors since they allow a wide range of operating speed with a sufficiently large torque delivery required by machine tools. This torque produced by the motor is spent in acceleration of inertia reflected in the motor shaft, overcoming the friction in the motor contact surfaces, friction in the mechanical part of feed drive as guideways, bearings and resisting against feed cutting forces.[2] But when a high speed command is given, that causes problems with controlling the relative movement between work piece and the tool because of vibration and inertia in the mechanical system. To overcome all these nonlinearities and difficulties during the system control, over the years have been used various PID based controllers, in order to improve the dynamic characteristic of the feed drive control loop. By fuzzy logic we can model imprecise concepts and by different weights of defining conjunction and disjunction and fuzzy set negation, we can manage different nature of nonlinearity behaviors of the system.

Optimization is achieved by setting the dynamic range of the fuzzy sets according to tuning process results on MatLab. Considerable improvements are shown on the output response of the system by reducing overshoot, rising and settling time.

Simulated results made by using MATLAB/ SIMULING shows the relevant effectiveness of its applications by errors comparison between conventional and applied controller.

2 THE MODEL

The feed drive mechanism of a three-axis vertical milling machine consist of a DC motor and a lead-screw with recirculating balls. The DC servomotor which is directly connected to lead-screw shaft drives the table and work piece. [3] The motor, for a short period of time, have to deliver a high dynamic torque to accelerate the lead-screw assembly and the table with work-piece, which means a high peak torque delivery at the start, until the drive reaches the desired steady state speed, and a sufficiently high continuous torque delivery range to overcome the friction in the sideways and feed drive bearings and also the cutting force. [3]
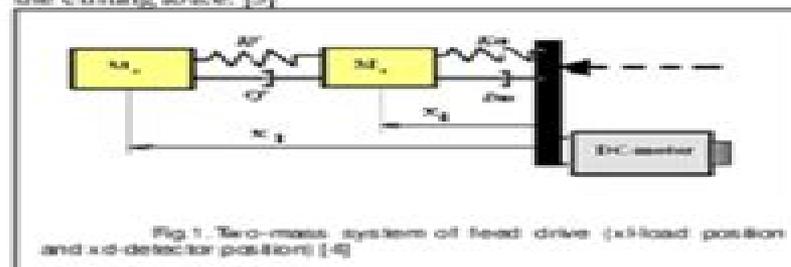

Fig.1. Two-mass system of feed drive (x=load position and x-d=detector position) [4]

This is a typical mechatronic system and can be divided into three parts: mechanical structure, drive mechanism and control system. For this servomechanism, the transfer functions of the individual system components are usually known or have to be calculated. The electrical part, it is presented by a transfer function (1) according to [3] and, gives a actuator force to the second part which is the model of mechanical system and which is simplified to a two-mass system with a spring and a damper element as shown in fig.1. [4]

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