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PLC-HMI AND FUZZY BASED AUTOMATION INTWO AXIS PROFILE CUTTING MACHINE

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ABSTRACT

There are existing works based on CNC machines controlled by PLC. Most modern CNC machines use various programming methods such as implementation of GK-code, M-code, etc. In this paper, a novel design based on Fuzzy Inference System (FIS) is developed using B&R (Erwin Bernecker and Josef Rainer) Industrial Automation PLC (Programmable Logic Control) - HMI (Human Machine Interface) for enhancing the real time performance of a Profile Cutting Machine is proposed. Its Objective is to design and develop two axis Profile cutting machine using PLC with Fuzzyand to visualize the working status using HMI. In this work static FIS is developed and implemented in the PLC controller to achieve the coordinates of the Profile. Instead of training the FIS for the new set of data, two more parameters are added externally to the output of FIS in order to adapt for variation in the Profile. As outcome the Profile cutting machine will cut in desired angles at desired positions by simply adding two more inputs to the actual output of the FIS structure. PLC - HMI Input/Output Modules of the Proposed Profile cutting machine are X20 BR 9300, X20 DI 9371, X20 DO 9322, X20 AI 2622, X20 AO 2622, X20 AT 2402 and with Power Panel 4PP045.0571-062 are fabricated with an objective of attaining the coordinates of the profile.

Keywords: PLC - HMI, fuzzy inference system, profile cutting machine.

INTRODUCTION

Profile cutting [3] is a process that is used to cut steel and other metals of different thicknesses. Modern processes in industry are characterized by non-linear and time varying behaviour with large number of sensors, loops, and interactions among them. This makes the design of control system difficult and time consuming. B. Moharanaat *et al* [1] deals with a particular Delta, developed for high-speed laser cutting. Zhang, Dat *et al* [2] represented integrated Mechatronic system consisting of three subsystems such as sensorial, control and decision-making, and actuation subsystem. Shashi Sahuet *et al* [3] presented profile cutting machine by using PLC technique. Dr. Yalcin Ertekin *et al* [4] integrated strategic process optimization concepts and intelligent controls in high speed machining, creative thinking and solutions-based applications, machine tool calibration, onmachine quality control, precision metrology applications. Shubh kumar *et al* [5] presented the concept of special purpose mild steel sheet cutting machine using single point cutting tool and easily available low cost microcontrollers. Ajay M Patel *et al* [6] designed an automated Gas profile cutting machine for linear profile cutting of metallic sheets. It reduced the time to perform the repetitive operation, reduced human errors, increased accuracy and eliminated the need of skilled labour. Osamah *et al* [7] implemented the effect of cutting parameters on the surface quality by the experimental results obtained from cutting a non-Galvanized steel plate ASTM BN 1323 in different cutting parameters (cutting speed, preheat time, and plate thickness) followed by non-destructive (hardness and roughness of a cutting surface) tests to investigate the quality control on the cut specimens. Dound Pramod *et al* [8] made the design of various components required for gas cutting machine and calculations were interpreted.

To overcome the difficulties such as inherent time delay and nonlinearity of the profile in the existing profile cutting machines and thereby to enhance the performance of the profile cutting machine, the PLC-HMI and Fuzzy based automation is developed in it. In this work among the various techniques, Fuzzy Logic Control (FLC) is preferred along with PLC - HMI for more speediness in profile cutting machine and accurateness of the profile. This paper is structured as follows: Section 2 deals with the proposed profile cutting machine. Section 3 deals on the proposed PLC-HMI with FIS for profile cutting machine. Section 4 describes the PLC-HMI. Section 5 discusses on PLC-HMI visualization and Section 7 gives the conclusions.

PROPOSED PROFILE CUTTING MACHINE

The AUTOCAD designs of the proposed profile cutting machine are represented in Figures 1 and 2 forX axis and Y axis respectively.

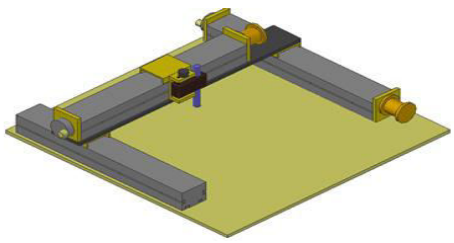

Figure-1. AUTOCAD design (X axis)of the proposedprofile cutting machine.

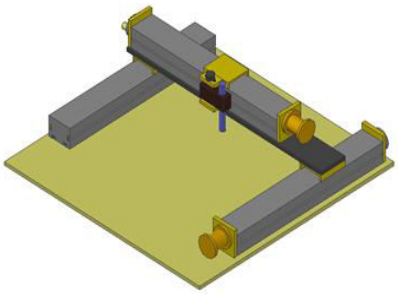

Figure-2. AUTOCAD design (Y axis)of the proposed profile cutting machine.

The mechanical set up of the proposed profile cutting machine is shown in Figure-3.

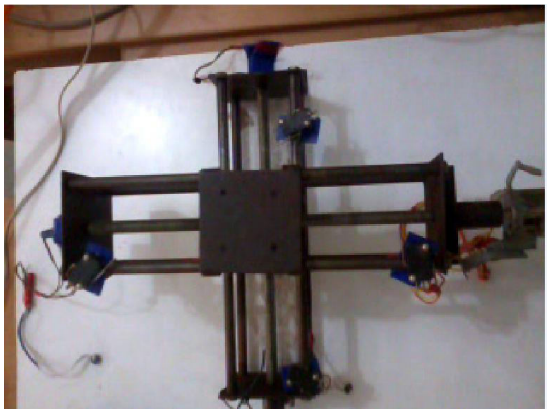

Figure-3. Proposed profile cutting machine mechanical set up.

In order to actuate the Profile cutting tool in X axis and Y axis, it is designed according to that. Moreover this proposed profile cutting machine interfaced with PLC-HMI and Fuzzy Inference System (FIS) in order to perform cutting of the profile in high speed and accuracy.

PROPOSED PLC- HMI WITH FIS FOR PROFILE CUTTING MACHINE

The Inputs and Outputs of the PLC - HMI are represented in Figure-4.

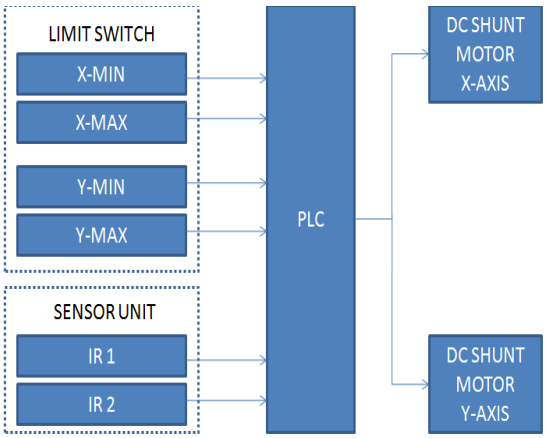

Figure-4. Inputs and outputs of the PLC – HMI.

FIS Outputs are one set of Inputs to the PLC which will fix the X axis and Y axis. Using Limit switch the minimum and maximum coordinates of the X and Y axis are controlled by the PLC. Another set of Inputs are taken from IR sensor 1 and IR sensor 2 which will sense the cutting profile in X axis and Y axis and it will send those electrical signal to the PLC - HMI so as to control the coordinates of the X axis and Y axis.

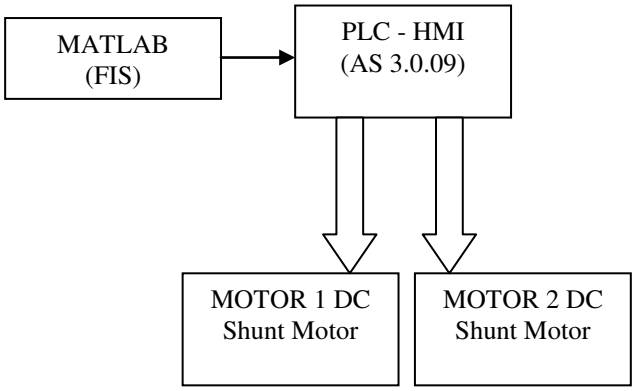

Figure-5. PLC-HMI and FIS in profile cutting machine.

The control signal from the PLC - HMI are given to DC Shunt Motor 1 for X axis and DC Shunt Motor 2 for Y axis as shown in Figure-5 which will actuate the profile cutting tool. As shown in block diagram representation of Figure-6the Image - square is converted into binary coordinates. And the output of the FIS that is Recreated Binary Image Coordinates are given as Input to the PLC - HMI.

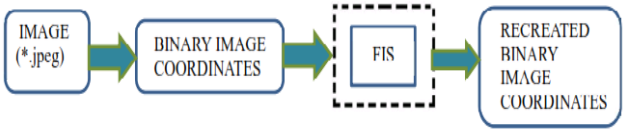

Figure-6. Block diagram representation of image to recreated Image coordinates.

Based on the condition either True or False the shape of the profile is confirmed and thereby the control signal from the PLC is given to DC shunt Motors 1 and 2 (Final Control Elements) that actuate the cutting tool.

PROGRAMMABLE LOGIC CONTROLLER - HUMAN MACHINE INTERFACE

The Hardware details of B&R PLC system is shown in Figure.7. It has Input/output sections, Power supply unit, Processor unit (CPU), Memory section, Programming device and System buses.

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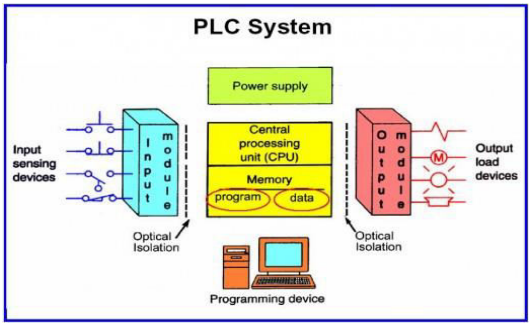

Figure-7. PLC System.

On the whole B&R PLC-HMI Hardware set upis shown in Figure-8. It comprises of PLC, HMI, Input/ Output modules and Power supply.

Figure-8. B&R PLC hardware set up.

It's Hardware specifications are represented in Table-1.

Table-1. Hardware configuration.

Digital Input	X20 DI 9373
Digital Output	X20 DO 9322
Analog Input	X20 AI 2622
Analog Output	X20 AO 2622
Analog Transmitter	X20 AT 2400
Power Supply	PS 1050
Servo Motor	8MS A2L R0-67
Servo Drives	8V1016-50-2
Bus Receiver	X20 BR 9300
Analog Transmitter	X20 AT 2400

In this proposed Profile cutting Machine based on PLC-HMI and FIS, the profile's shape (Square) is fed into Matlab in jpeg format. The Image shape, Square is imported to Matlab and it is shown in Figure-9.

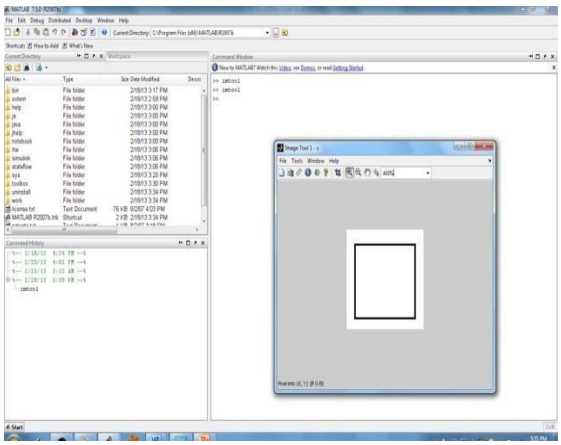

Figure-9. Imported image to Matlab.

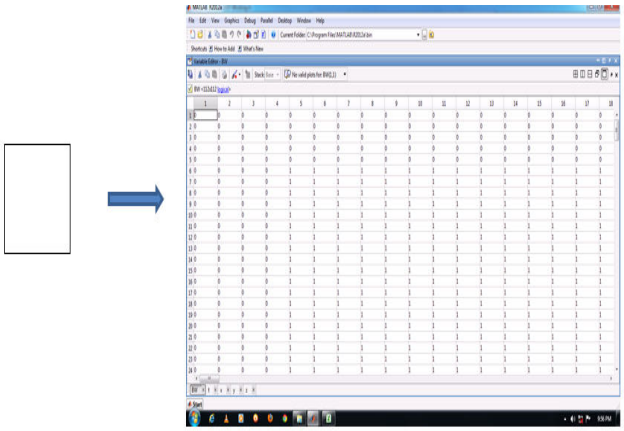

Figure-10. Conversion of the image - square into binary format.

Then the shape of the Image, Square is converted into binary format and it is shown in Figure-10. Those Binary coordinates are taken as Input to the Fuzzy Inference System (FIS). Recreated Binary Image coordinates are the outputs from the FIS. Instead of training the FIS for the new set of data, two more parameters are added externally to the output of FIS with the intention of adapt for variation in the Profile.

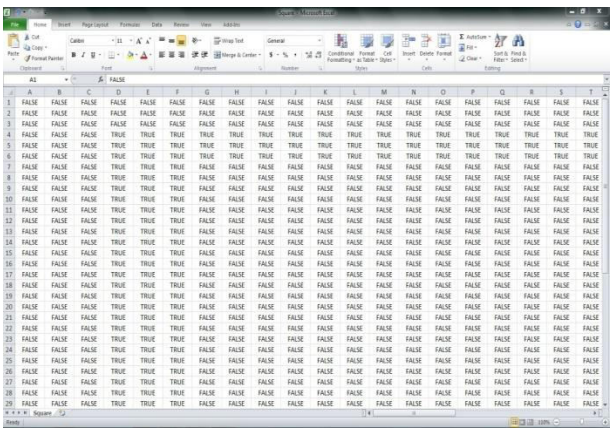

Figure-11. FIS Output.

FIS outputs are shown in Figure-11. According to the FIS outputs (Recreated Binary Image Coordinates) based on either True or False, the PLC will control the Final Control Elements, DC shunt motor 1 and DC shunt motor 2 of the profile cutting machine. The PLC will give control signal based on the following conditions mentioned below.

FALSE - 0 Image areas in black
TRUE - 1 Background in white

PLC-HMI VISUALIZATION

In PLC - HMI, Visualization is made to design the process that will be easy to monitor and also handy to follow the ongoing process by monitoring in the HMI screen. With the evolution in touch screen, the inputs can be fed in the PLC and if there any changes in the data can also be updated online. Figure-12 represents the HMI which exhibits the X axis and Y axis parameters of the

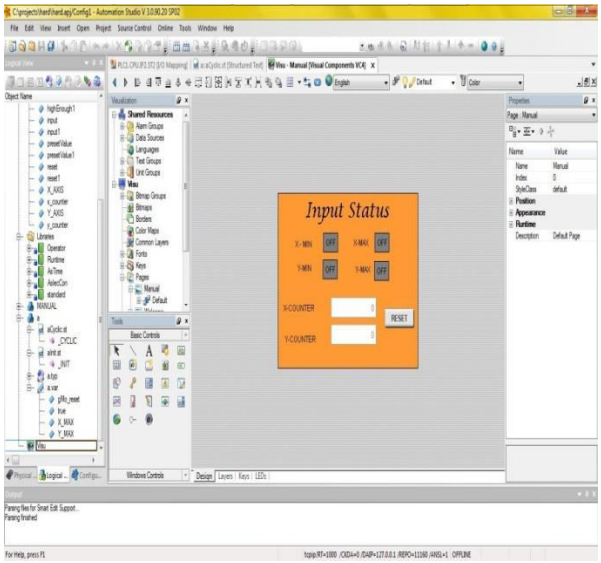

Figure-12. HMI Screen.

profile cutting machine so that it is ease to monitor and control the profile cutting machine.

EXPERIMENTAL RESULTS

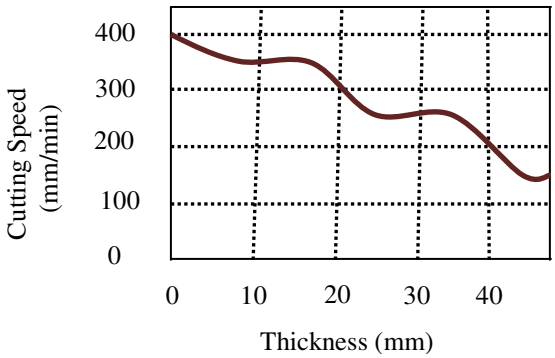

Figure-13. Cutting speed vs. thickness.

Figure-13 represents the Experimental Results of the proposed Profile cutting machine in Cutting Speed Vs Thickness of the material. On analysis, it is refined that the performance of the proposed profile cutting machine is with more speed and accurate in cutting the profiles even though increase in thickness of the material.

CONCLUSIONS

In this manuscript, PLC - HMI and Fuzzy based Profile cutting machine was designed for Industry utilization. This two axis Profile cutting machine working status monitored by using HMI as user friendly.Static FIS is developed and implemented in the PLC controller to achieve the coordinates of the Profile.

As consequence the Profile cutting machine cut the profile in desired angles at desired positions by simply adding two more inputs to the actual output of the FIS structure. It cut the preferred profile with speed at accurate shape in various sizes of the material by automatically controlling the system.

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