ScienceDirect

Materials Today: Proceedings

Available online 25 March 2023

In Press, Corrected Proof What's this?

Optimal cutting speed selection for milling with multi-criteria decision using ANFIS based reasoning

Phatchani Srikhumsuk [a], Siridech Kunhirunbawon [b], Suthep Butdee [c]

Show more

https://doi.org/10.1016/j.matpr.2023.03.298

Get rights and content

Abstract

The milling process is widely used in the most industrial sectors for machined parts because it is more flexible than forming and molding process. However, selection parameters are still inconsistent depending on human experiences which causes inefficiency and less competitiveness particularly in the age of industry 4.0 which manufacturing processes should deal with uncertainty and respond to engineering changes rapidly and timely. The complexity of the selection is caused by multi-criteria decision making in order to obtain the optimal solutions. This paper proposes ANFIS-based reasoning to deal with

multi-criteria decision making on the optimal cutting speed based on three critical factors: workpiece material, tools material, and design constraints. The model is developed by using the MATLAB toolbox. Fuzzy rules are captured and collected experts and machine text books. The case study is illustrated by modelling and experiment.

Introduction

Optimal cutting parameters are critical and impact on productivity and quality of machined parts in a machining process. Machining is a manufacturing process which is designed to remove unwanted material in the forms of chips. A milling process is one of the commonly machining which is used in various industries that the parts are fixed on the machined table and the tool is rotated by high speed to cut work-piece material based on the tool path planning. The part design is created by CAD (Computer-Aided Design) under the solid modeling as a part model. The model is then prepared for machining using CAM (Computer-Aided Manufacturing) as a process planning which is human interaction process. This method is tedious, expensive, and time consuming as well as needs a machinist expert. Presently, computer simulation is more advanced in order to assist human for analysis and making decision intelligently and efficiently. Fuzzy logic and Neural network are widely the mathematical simulation tool which is used to design, plan control even predict the machining parameters. ANFIS reasoning is combination of a neural network and fuzzy logic which is sometime called neuro-fuzzy system. It is a knowledge-based reasoning system used to create a new model for selection optimal parameters for milling process under constraints. Simulation and modeling approach are currently used to support decision making procedure and reduced human errors, cost, and process planning time as well as testing and reworking time. CNC machines are used to make rotational parts and prismatic parts. The prismatic parts are mostly used to machine on milling such as the standard mold plates for injection molding, stamping, metal molding and so on. Process planning is created before the machining process starts. One of the difficult tasks for the process planning is to select the suitable, optimize cutting parameters for the CNC machine control. The main milling parameters consist of cutting speed, feed rate, depth of cut which are depended on the machining constraints like work piece material types, cutting tool material, coolant types and so on. ANFIS reasoning is a kind of expert system that represents human intelligent and experiences inside the computer system the forms of rules. Crips data is collected and translated to the format of fuzzification. The fizziness data is converted back in the form of defuzzification and become the crisp data for human insight. This paper proposes the ANFIS reasoning to select the optimal

cutting speed for milling which is the critical factor for machining efficiency. This contribution helps naive engineering to choose parameters for milling correctly and short time.

Section snippets

Fuzzy logic-based reasoning

Fuzzy logic reasoning is widely applied in various domains of applications such as robotics, computers, component design, production control, medicine, military, etc. Unlike traditional logic, the fuzzy logic deals with the fact that can occur as uncertainty and approximately. Fuzzy defines things that are inexact, imprecise, and incomplete. Definitions are varied on region, geographic and community. Therefore, the fuzzy logic is done by the way of human decision making. Zedeh [1] introduced…

Research methodology

There are various stages for the research study. Firstly, milling process is studied under the cutting parameters constraints. Then, milling parameters are gathered from documented papers and experiments, as well as expert discussion. Next, ANFIS model is created and tested by modeling to obtain optimal parameters based on the manufacturing constraints and multiple criteria decision making. The case study is on the aluminum workpiece material under the ANFIS parameter selection. The constraints …

Experimental study

This study employed ANFIS-based reasoning to obtain the optimal cutting speed based on three critical factors consisting of workpiece material, tools material, and design constraints.…

Results and discussion

The results of the experiment are compared with the ANFIS modelling as shown in Table 6. The results of the ANFIS have computed by training 1000 epochs in the MATLAB toolbox program. The experiment shows 12 trials, in order to obtain cutting speeds under the workpiece material, and tools material conditions. The result shows each experiment, for instance in the trial number 6 employed workpiece material hardness of 77 HB, tools material is 2 (cemented carbide), the cutting speed is 630m/min,…

Conclusion

The paper has presented a multi-criteria decision using ANFIS-based reasoning to obtain the optimal cutting speed based on three critical factors. They are workpiece material, tools material, and design constraints. The process of study consists of three steps as the following.

- The first step defined a model for ideal design constraints in production drawing.…
- The second step experiment was to find surface roughness in each of hardness material.…
- The third step established the model ANFIS for…

…

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Siridech Kunhirunbawon reports administrative support, equipment, drugs, or supplies, and statistical analysis were provided by Pibulsongkram Rajabhat University.…

Acknowledgements

The authors are also thankful to the Department of Production Engineering Technology, Faculty of Industrial Technology, Pibulsongkram Rajabhat University for supporting necessary resources in this research.…

References (21)

L.A. Zadeh

Fuzzy sets

Inf. Control (1965)

T.L. Tseng *et al.*

A novel approach to predict surface roughness in machining operations using fuzzy set theory

J. Comput. Des. Eng. (2016)

X. Wu *et al.*

Investigation on the surface formation mechanism in micro milling of cemented carbide

Int. J. Refract Metal Hard Mater. (2019)

R.S. Babu *et al.*

Fuzzy logic model to evaluate the surface roughness in the drilling of oil hardened non-shrinking die steel

Int. J. Eng. Res. Technol (IJERT) (2018)

X. Lu *et al.*

Cutting parameters optimization for MRR under the constraints of surface roughness and cutter breakage in micro-milling process

J. Mech. Sci. Technol. (2018)

K. Danesh Narooei *et al.*

Optimal selection of cutting parameters for surface roughness in milling machining of AA6061-T6

Int. J. Eng. (2022)

M. Jebaraj *et al.*

Experimental study of the influence of the process parameters in the milling of Al6082-T6 alloy

Mater. Manuf. Process. (2019)

H. Gokce *et al.*

Cutting parameter optimization in shoulder milling of commercially pure molybdenum

J. Braz. Soc. Mech. Sci. Eng. (2018)

K. Kalita *et al.*

Experimental investigation and parametric optimization of a milling process using multi-criteria decision-making methods: a comparative analysis

Int. J. Interact. Des. Manuf. (IJIDeM) (2022)

P.P. Monka *et al.*

Optimal cutting parameter specification of newly designed milling tools based on the frequency monitoring

Int. J. Adv. Manuf. Technol. (2021)

There are more references available in the full text version of this article.

Cited by (0)

Recommended articles (6)

Research article

Higher-order cell-centered finite volume scheme for the simulation of elastic-plastic flows in 3D

Materials Today: Proceedings, 2023

Show abstract

Research article

Numerical prediction of influence of chain length on contact pressure distribution on polymer composite sprocket

Materials Today: Proceedings, 2023

Show abstract

Research article

Multi-linear optimization of machining parameters of CNC turning of AA6061alloy using GRA method

Materials Today: Proceedings, 2023

Show abstract

Research article

Investigation on turning process performance during machining of 15-5PH stainless steel material with eco-friendly machining technique

Materials Today: Proceedings, 2023

Show abstract

Research article

Polar effective plastic strain - forming limit diagram of DP 440 steel sheet with application to two-step forming test

Materials Today: Proceedings, Volume 77, Part 4, 2023, pp. 1039-1044

Show abstract

Research article

Exploring the effects of vibration on surface roughness during CNC face milling on aluminum 6061-T6 using sound chatter

Materials Today: Proceedings, 2023

Show abstract

View full text