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ON SELECTION OF OPERATING PARAMETERS IN MECHANICAL MANUFACTURING PROCESSES USING THE EXTENSION PRINCIPLE

Streszczenie. W pracy zaproponowano metodę wyboru parametrów pracy dla mechanicznych procesów wytwarzania, takich jak toczenie, szlifowanie, frezowanie i inne. Metoda ta oparta jest na zasadzie rozszerzania, stosowanej w teorii zbiorów rozmytych. Ilustracją poniższych rozważań jest przykład numeryczny.

Резюме. В работе предлагается метод выбора параметров работы для механических прозводственных процессов, таких как, обточка, шлифовка, фрезерование и др. Этот метод основан на принципе расширения, применяемом в теории размытых множеств. Рассуждения проиллюстрированы числовым примером.

Summary. A method of selection of operating parameters in mechanical manufacturing processes, like turning, grinding, milling, etc., is proposed in this paper. It is based on the extension principle, aapplied in the fuzzy set theory. The considerations are illustrated by a numerical example.

1. INTRODUCTION

In numerous mechanical manufacturing processes, as grinding, turning, milling and other machining processes, an important task is to determine optimal, or almost optimal, operating parameters [2,3]. If a mathematical model describing, the relationship between parameters, is known, the task mentioned above is relatively easy. For instance, the relationship between surface finish and other grinding parameters, obtained experimentally, may be given as follows [1]:

$$R_a = 317.5\ f^{0.52}\ v_W^{0.65} v_S^{-0.80}\ K \tag{1}$$

where R_a - Center Line Average (CLA) value of surface finish (output of the grinding process)

f - feed rate (input of the process)

v_W - work speed

v_S - wheel speed

K - coefficient of dressing condition.

Most often, however, obtaining such a model is difficult or even impossible. An alternative approach for finding optimal or almost optimal parameters of mechanical manufacturing processes, particularly in machining processes [5], based on using the extension principle [4] for finding fuzzy set analogs of respective crisp procedures, is proposed in this paper.

2. THE EXTENSION PRINCIPLE

In this section we will formulate the general extension principle for finding fuzzy set analogs of respective crisp procedures [4].

Let X be a Cartesian product of universes $X_1, \ldots, X_r$, i.e. $X = X_1 \times \ldots \times X_r$ and let $\bar{A}_1, \ldots, \bar{A}_r$ be r fuzzy sets in $X_1, \ldots, X_r$, respectively. The function f is a mapping from the universe X to a universe Y, $y = f(x_1, \ldots, x_r)$. The a fuzzy set $\bar{B}$ in universe Y is defined by

$$\bar{B} = \{(\bar{B}(y), y) : y = f(x_1, \ldots, x_r),\ (x_1, \ldots, x_r) \in X\} \tag{2}$$

where

$$\bar{B}(y) = \begin{cases} \sup \min \{\bar{A}_1(x_1), \ldots, \bar{A}_r(x_r)\} & \text{if } f^{-1}(y) \neq 0 \\ & \{(x_1, \ldots x_r) \in f^{-1}(y) \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

The physical meaning of $f^{-1}(y)$ is that it is that set of values of $(x_1, \ldots, x_r)$ for which $f(x_1, \ldots, x_r)$ would be y. There may be more than one such set for any value of y.

3. EXAMPLE

Let us consider a simple operation on two fuzzy sets, namely that of forming a product. Let $\bar{A}_1 = \bar{D}$ be a fuzzy set defined in the domain X_1 and let $\bar{A}_2 = \bar{C}$ be a fuzzy set defined in the domain X_2. Let us define $\bar{B}(y)$ to represent the concept of product of two fuzzy sets. The question is, what is $\bar{B}(y)$?

Let

$$\bar{A}_1 = \bar{D} = \{(0.5;0.15),(1.0;0.20),(0.25;0.25)\}$$

and

$$\bar{A}_2 = \bar{C} = \{(1.0;0.9),(0.95;1.1)\}$$

Then, for $y = f(x_1, x_2) = x_1x_2$, we have by the extension principle that

$$\bar{B}(y) = R_1(y) = \{(0.5;0.135),(0.5;0.165),(1.0;0.18),(0.95;0.22),(0.25;0.225),(0.25;0.275)\}$$

The result gotten is a fuzzy set. In our application, however, we have to determine a nonfuzzy value of a parameter. There are many methods of defuzzifying the set as given above. For this purpose we may use:

a value where the maximum of membership function appears,

the mean of maxima when a fuzzy set has more than one peak value,

center of gravity of the membership function,

and others.

4. CONCLUSIONS

The fuzzy set theory allows us to operate using linguistic terms. These terms, representing different criteria, can be aggregated by means of the extension principle, which results in a final fuzzy decision set. Using one of the defuzzification methods for this set we can get the optimal, or nearly optimal, value of a required parameter.

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WYBÓR PARAMETRÓW PRACY DLA MECHANICZNYCH PROCESÓW WYTWARZANIA Z WYKORZYSTANIEM ZASADY ROZSZERZANIA

W niniejszej pracy zaproponowano metodę wyboru parametrów pracy dla mechanicznych procesów wytwarzania, takich jak toczenie, szlifowanie, frezowanie i inne. Wykorzystano zasadę rozszerzania, sformułowaną i stosowaną w teorii zbiorów rozmytych. Zasada ta pozwala na agregację zbiorów rozmytych reprezentujących kryteria w celu uzyskania końcowego zbioru decyzyjnego. Wymaganą wartość parametru uzyskuje się opierając się na maksimum funkcji przynależności zbioru decyzyjnego, średniej z maksimów, jeżeli zbiór ten posiada skończoną ich liczbę, lub też wykorzystując środek ciężkości funkcji przynależności. Metodę zilustrowano prostym przykładem numerycznym.