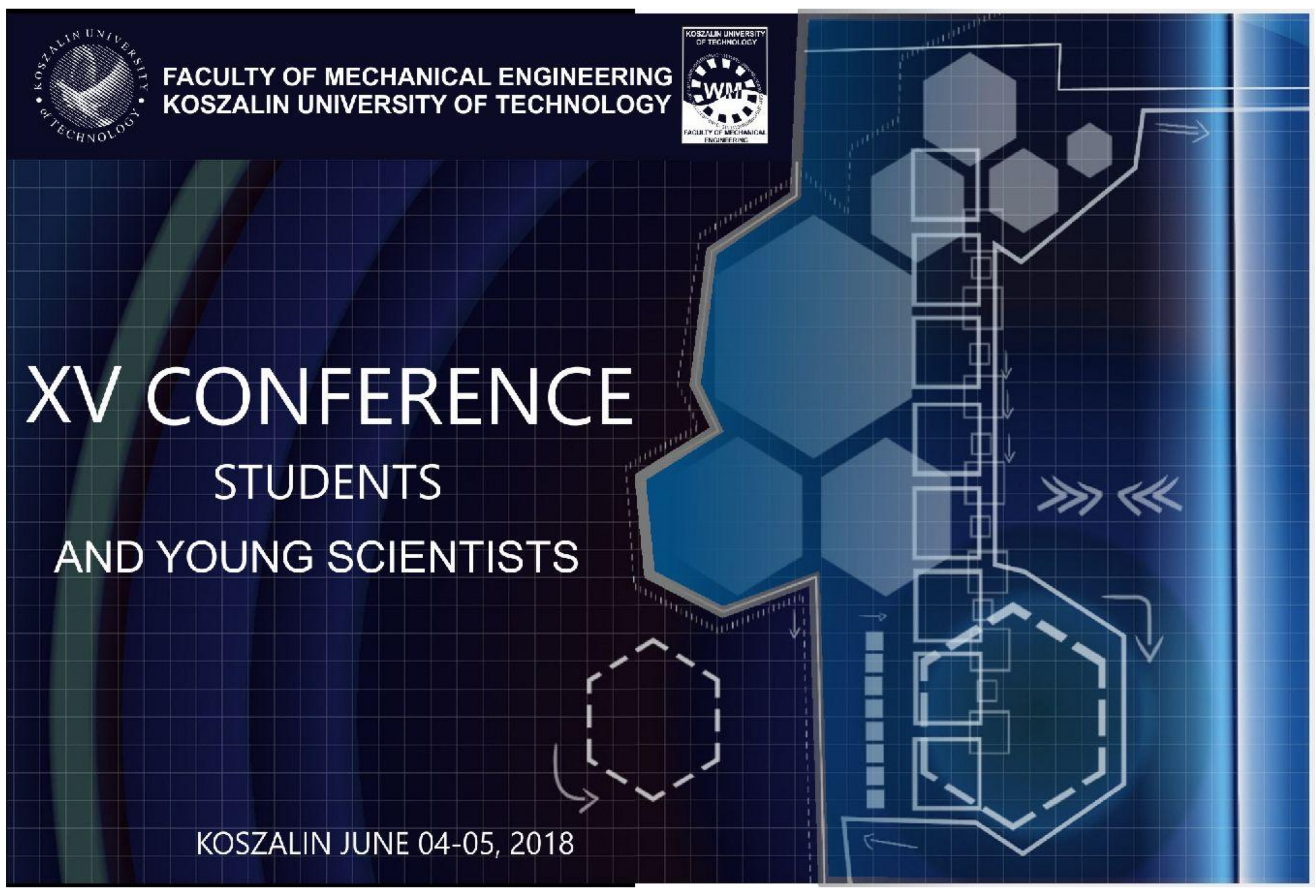

POLYOPTIMIZATION OF THE TURNING PROCESS

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SUMMARY

The necessity of constant progress means that the implementation of manufacturing processes, required to make the most favorable decisions, conditioning the achievement of the desired goals. One of the main means to achieve these goals is optymization. The optimization of manufacturing processes should be understood as optimization of the processing conditions (parametric optimization) as well as optimization of the structure of processes (structural optimization). The purpose of parametric optimization is to choose (from among the possible to use in actual conditions - in the area of acceptable solutions defined by restrictions) such values of cutting parameters that provide the extreme value of the assumed optimization criterion [1].

INTRODUCTION

1. **Description of the analyzed object –** the tested object is the turning process (Fig. 1).

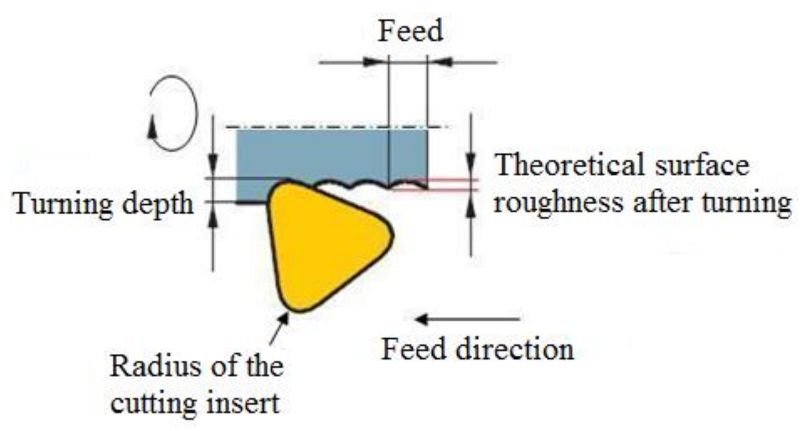

Fig. 1. The scheme of the optimized process

2. **The aim of polyoptimization**

The aim of polyoptimization is to find the best solution due to two criteria at the same time:

- the highest specific efficiency of the turning process $Q \rightarrow$ MAX,
- the lonest theoretical roughness height $R_t \rightarrow$ MIN.

Due to the fact that the criteria are conflicting (contradictory), the task of polyoptimization will be to find a subset of polyoptimal (*Pareto-optimal*) variants in the set of permissible options (compromise solution).

3. **Mathematical model**

3.1. Decision variables

- *cutting feed* f_n, mm/rev,
- radius of the cutting insert r_e, mm.

3.2. Fixed parameters

- cutting speed peripheral [4], v_s = 0,56 m/s,
- the thickness of the cutting layer [4], a_p = 0,2 mm.

3.3. Restrictions

- feed limit [4]:

$$0{,}2 \le f_n \le 0{,}6 \text{ mm/rev},$$

- restrictions of the radius of the cutting insert [4]:

$$0{,}4 \le r_e \le 1{,}2 \text{ mm}.$$

3.4. Assessment criteria

- turning performance Q described by a formula [4]:

$$Q = f_n \cdot a_p \cdot v_s \quad \text{mm/rev}$$

where:
f_n – feed, mm/rev,
a_p – the thickness of the cutting layer, mm,
v_s – cutting speed, mm/s.

- Surface roughness height R_t described by a formula [4]:

$$R_t = \frac{{f_n}^2}{8 r_e} \quad \text{mm},$$

where:
f_n – feed, mm/rev,
r_e – radius of the cutting insert, mm.

R_t – total height of the profile: the sum of the heights of the highest elevation of the profile Z_p and the deepest depth of the profile cavity Z_v inside the measuring section l_n.

4. **Criteria for optimization**

k(1) = Q →max (maximizing the proper turning performance)
k(2) = R_t →min (minimization of the surface roughness height)

Because the maximization of the proper turning performance is carried out, the objective function has the following form :

F = (1 – weight) · k(1) – weight · k(2) ← *objective function*
w = [0.1:0.1:0.95] ← *weight vector*

5. **Computer model**

The task of polyoptimization was realized by the use of Matlab software. The *fmincon* function has been used. This function is the basic tool for solving non-linear tasks with continuous decision variables with constraints with one objective function [2, 3].

The figure 2 illustrates the set of compromise solutions (*Pareto-optimal*). The set was presented graphically to make the solution easier to choose (the decision-maker arbitrarily has the option of making a choice).

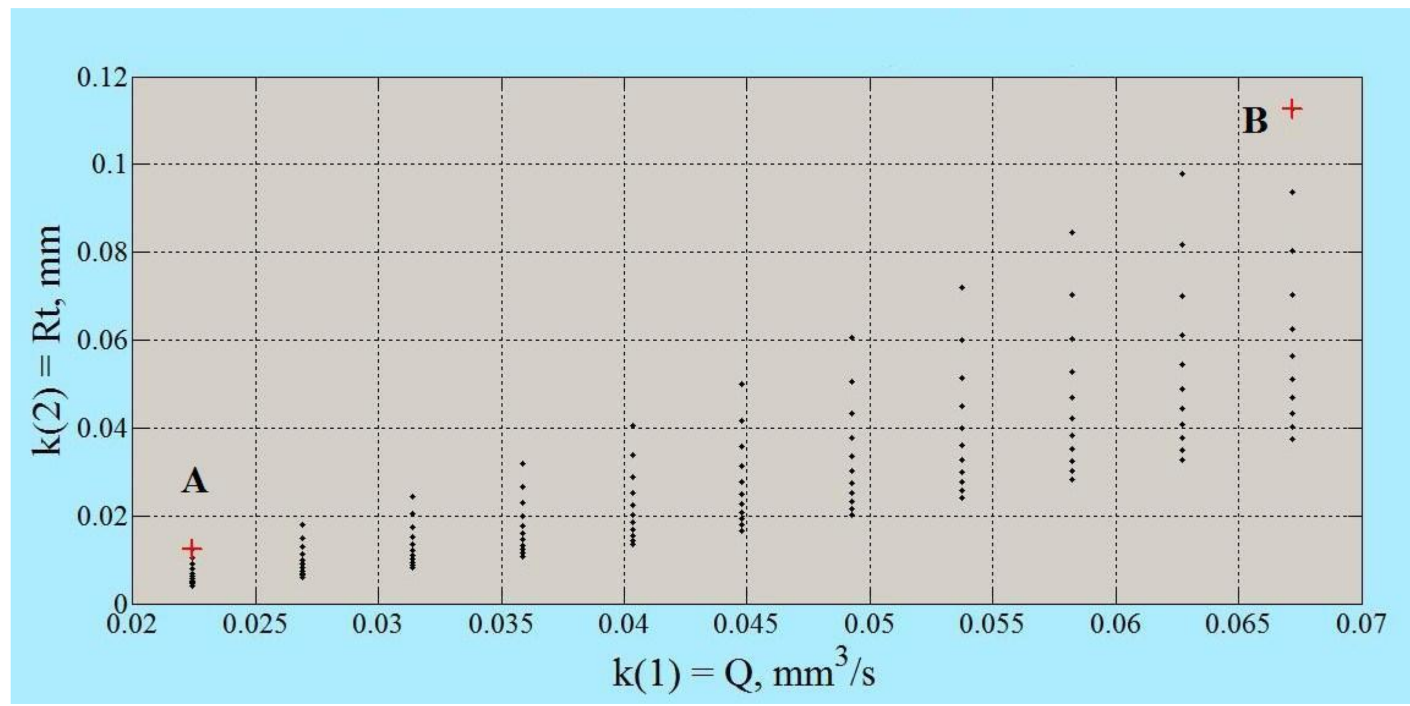

Fig. 2. Image of the obtained optimal poly solutions (points A and B) in the target space

Tab. 1. Polyoptimization results for different values of the weight coefficient

Value of the weight coefficient, *w*	Cutting feed f_n, mm/rev	Radius of the cutting insert r_e, mm	Turning performance Q - k(1), mm^3/s	Surface roughness height R_t - k(2), mm	The value of the objective function
0.1	0.2	0.4	0.0224	0.0125	0.0189
0.2	0.2	0.4	0.0224	0.0125	0.0154
0.3	0.2	0.4	0.0224	0.0125	0.0119
0.4	0.2	0.4	0.0224	0.0125	0.0084
0.5	0.6	0.4	0.0672	0.1125	-0.0226
0.6	0.6	0.4	0.0672	0.1125	-0.0406
0.7	0.6	0.4	0.0672	0.1125	-0.0586
0.8	0.6	0.4	0.0672	0.1125	-0.0766
0.9	0.6	0.4	0.0672	0.1125	-0.0945

CONCLUSION

Polyoptimum solutions lie on the edge of the acceptable area. By changing the value of the weight coefficient (Tab. 1) in the range of [0, 1] we receive polyoptimization solutions. For values w from 0 to 0.4 is optimization solution at F = k(1) = min!, and for values w from 0.5 to 1 is the solution of the optimization task at F = k(2) = max!. Point A (Fig. 2) is the optimal solution due to the minimization of the roughness height, and point B (Fig. 2) is the optimal solution for maximizing turning efficiency.

The results of polyoptimization are in line with intuitive predictions. They constitute a set of information enabling the selection of a polyoptimal solution, depending on which criteria the user accepts as more important for a balancing state.

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