Cutting forces during ball end milling of hardened steel

mgr inż. Szymon WOJCIECHOWSKI

dr hab. inż. Paweł TWARDOWSKI

dr inż. Damian PRZESTACKI

ABSTRACT

The main objective of the dissertation was the development of cutting force model for the ball-end milling of hardened steel process, in the range of variable milling parameters. Subsequently, the model was validated during its experimental verification.

In the first part of the work, the literature survey of cutting force models – applied mainly during ball-end milling was carried out. The selected factors influencing cutting forces were analyzed.

As part of preliminary studies, the influence of cutting parameters: cutting speed – v_c, feed per tooth – f_z, surface inclination angle – α on the cutting forces was investigated. On the basis of the research results, the specific cutting force coefficients (K_{ic}, K_{ie}), which are essential for cutting force model's formulation were determined. Furthermore, the static radial run-out was also measured.

The obtained results of preliminary studies were the starting point to the primary studies, which were focused on the cutting force model's formulation.

The research revealed, that formulated model enables cutting force estimation in the wide range of cutting parameters (v_c, f_z, α), assuring relative error's values below 16%. Furthermore, the consideration of cutter's radial run-out phenomenon in the developed model enables the reduction of model's relative error by the 7% in relation to the model excluding radial run-out phenomenon.

The quantitative and qualitative influence of surface inclination angle on cutting forces (F_x, F_y, F_z) generated during ball-end milling was also observed. This observation confirms the validity of α angle's consideration in the developed model.

In the last part of the dissertation, the cognitive and utilitarian conclusions, as well as conclusions related to the further research were formulated.