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THE ANALYSIS OF THE ZONE FOR INITIATING THE CUTTING PROCESS OF X37CrMoV51 STEEL

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Abstract: *This article has presented the results of the research based on the analysis concerning the zone for initiating the process of longitudinal turning and face milling of X37CrMoV51 steel. The research was conducted in two stages at the laboratories of the Kielce University of Technology. The first stage included performance of cutting attempts that were to gradually initiate the process of cutting thanks to a flowing change of depth of the cutting by tilting the working surface of samples at a slight angle. The second stage was about performing measurements of the cuboidal and conical working surface of samples on a non-sliding contact profilometer TOPO 01P. As a result, the measurements acquired 2D profiles of the sample presenting the zone for initiating the cutting process. Profiles of the surface were analyzed in order to identify and compare the characteristic contact areas of the tool on the cut item. The results of the conducted analysis of 2D profiles of the working surface have been presented graphically.*

Keywords: initiating the cutting process, the minimum thickness of the cut layer, turning, milling.

1. Introduction

When analyzing the stereometry of the cutting plate, we notice that it is not sharp enough, but it has a rounded edge with radius r_n and stereometry errors that result from the technology of its manufacture. During a precision treatment of the precise parts of machines and prototypes (Adamczak, Bochnia, & Kaczmarska, 2014; Adamczak, Kaczmarska, & Bochnia, 2015), i.e. contactless face seals (Błasiak, 2015, Błasiak, 2015), parts of gyroscopes (Krzysztofik & Koruba, 2012, Koruba et al., 2010) and cylindrical elements (Adamczak, Zmarzły, & Janecki, 2015), it is particularly significant to determine vibration in the process of cutting (M. Blasiak & Kotowski, 2009; Miko & Nowakowski, 2012a) and the real geometry of the cutter, which has an important influence on the minimum thickness of the cut layer (h_{min}) and the roughness of created surfaces (Miko & Nowakowski, 2012b) ensuring their high reliability of machine parts (S. Blasiak, Takosoglu, & Laski, 2014) and low manufacturing costs (Takosoglu, Dindorf, & Laski, 2009). The parameter h_{min} determines the beginning when the layer of the material is divided in form of shavings during cutting, so it determines the smallest layer of material that can be possibly removed in particular conditions.

When observing the zone of initiating the cutting process, one may distinguish three vivid stages of the effect of the cutter on the treated material, depending on the depth of cutting (a_p) (Cgae, Park, Freiheit, 2006; Grzesik, 2010):

I - when $a_p < h_{min}$: there are elastic deflections and malleable pressure of the treated material,

II - when $a_p = h_{min}$: there are elastic and malleable deflections with partial cutting of the treated material (chasing of the treated material),

III - when $a_p > h_{min}$: beginning of removing the material in form of shavings.

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There is a lot of theoretical research conducted in the world that is to determine the minimum thickness of the cut layer.

The aim of the scientific research is to experimentally determine the parameter of the minimum thickness of the cut layer for the process of longitudinal turning and face milling of X37CrMoV51 steel. The analysis concerned the zone of initiation of the process of rolling and milling in order to identify and compare the characteristic contact areas of the tool on the cut item.

2. Methods

The process of the practical determination of the parameter h_{min} meant gradual initiation of the cutting process through a flowing change of the depth of cutting. The flowing change of depth of cutting was achieved thanks to special preparing of the specimen geometry (Graba, 2011; Graba, 2012). The sample for rolling was of conical shape with an angle forming 0°19', while the milling sample was of a cuboid fixed on a wedge with an angle of 0°18'. The working surface of the samples was exposed to the process of precise grinding.

The cutting attempts were planned in such a way that they were to be as similar to each other as possible; the rolling and milling processes were performed with the feed of 0.12 mm/rev at the cutting speed of 300 m/min. Lathe works were conducted at DMG ALFA500 lathe centre. The attempts used a DCMT150408 cutting plate with a corner radius of 0.8 mm, while the milling works were conducted at an AVIA VMC800 vertical milling centre, where the cutter body (Adamczak, Janusiewicz, Makieła, Stępień, 2011) was facilitated with one 490-08T308M-PL plate with a corner radius of 0.8 mm in order to avoid axial run-out (Janusiewicz, Adamczak, Makieła, Stepień, 2011). The plan of cutting attempts has been presented in figure 1a.

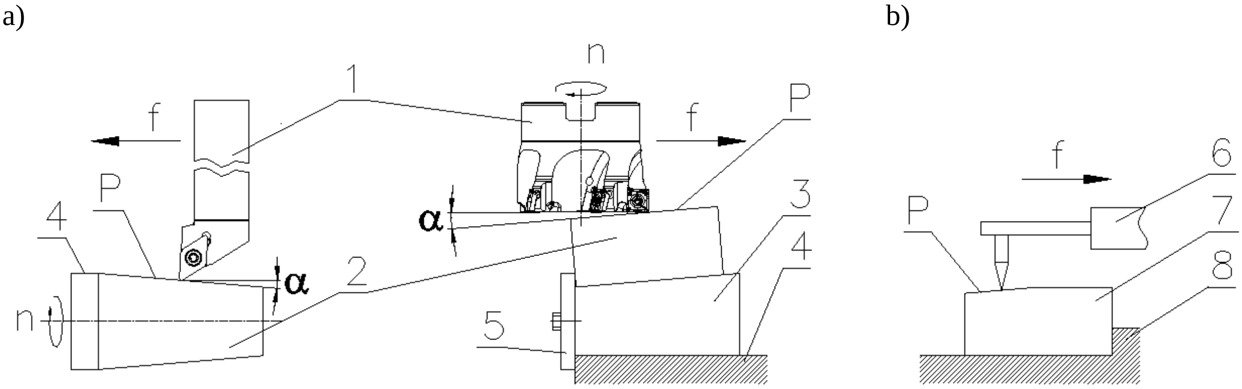

Fig. 1. View of: a) cutting attempts, b) measurement of samples in order to determine the minimum thickness of the cut layer. 1– tool, 2 – sample, 3 – wedge, 4 – handle, 5- stopper, 6 – head of the profilometer, 7 – measured sample, 8 – handle of the profilometer, f – feed, n – rotation, P – working surface of the sample, α – angle of the working surface

Another stage of the experiment was the performance of measurements of the cuboidal and conical working surface (Fig. 1b) on the contact profilometer TOPO 01P that was facilitated with a non-sliding measuring head. As a result, the measurements acquired 2D profiles of the working surface of the sample presenting the zone for initiating the cutting process. The profiles of the surface were analyzed with software TOPOGRAFIA and MATHEMATICA in order to identify the characteristic contact areas of the tool on the cut item.

3. Results

The results of the conducted analysis of 2D profiles of the working surface have been graphically presented in Figure 2. In order to compare the profiles, they were superimposed on each other in the software MATHEMATICA, so that the points of the first contact of the tool with the treated material were the same. Then, the identification of characteristic zones was conducted, their length was measured and the angles of working surfaces of samples were determined. Another step was to directly measure the h_{min} parameter, which is defined as the distance of the highest point of the profile from the middle line of the processed profile.

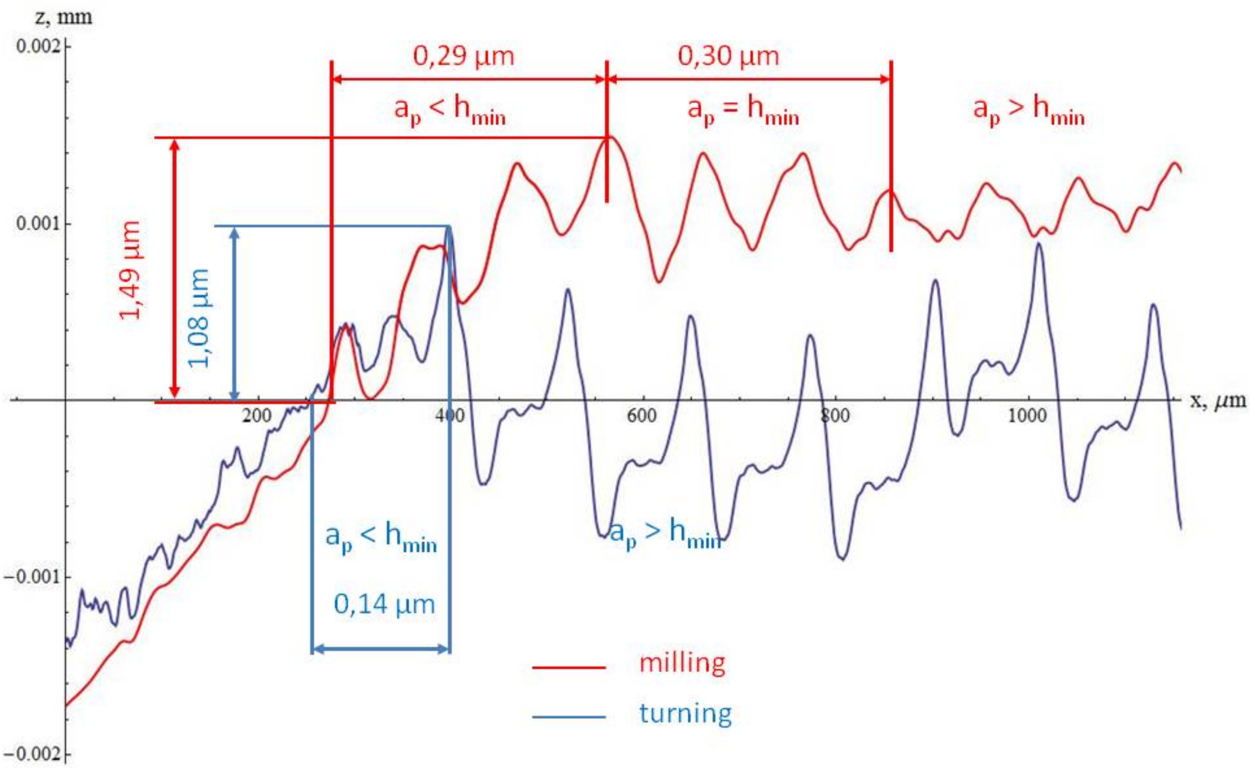

Fig. 2. View of the measured 2D profiles of the working surface of the rolled sample and milled sample

When analyzing Figure 2, it was noticed that there was a difference in the initiating zone of the process during rolling and milling. The profile acquired as a result of initiating the rolling process helped to identify only two characteristic zones I and III. Zone I of elastic deflections and malleable pressure of the treated material was 0.14 mm long, while the measured value of the parameter h_{min} was 1.08 µm. There was no zone II observed in case of rolling that would be responsible for elastic and malleable deflections of the treated material.

During the analysis of the milled profile, all characteristic areas of contact of the tool with the treated material were found. Zone I was 0.29 mm long, the second zone was 0.3 mm long. The parameter h_{min} during the head milling process was 1.49 µm.

During the comparison of the results of analyses, it was noticed that during milling the material or the machine worked within the area of elastic deflections, since the medium line of profile III of the zone is 11.4 µm higher than the medium line of zone III of the milled profile. The noticed different results arise from the elastic deflection of the spindle of the machine (which have been presented in one of the previous works of the Authors (Miko & Nowakowski, 2012b)) and this may significantly influence the dimension and form accuracy of milled objects.

4. Conclusions

The conducted research on initiating the process of longitudinal turning and face milling of X37CrMoV51 steel made it possible to measure, compare and analyze the characteristic contact zones of the tool on the treated item when initiating the cutting process. When analyzing the research results, a difference was noticed between the initiation process of rolling and milling. The profile acquired as a result of initiating the rolling process helped to identify only two characteristic zones I and III, there was no observation of zone II of elastic and malleable deflections with partial cutting of the treated material.

In the case of the milling process, all three characteristic areas of contact of the tool with the treated material were found.

During the comparison of the results of analyses, it was noticed that during milling the material or the machine worked within the area of elastic deflections, since the medium line of profile III of the zone is 11.4 µm higher than the medium line of the milled profile. The observed difference may have a considerable influence on the dimension and form accuracy of milled objects.

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