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EXPERIMENTAL RESEARCH ON THE FLOW DIRECTION ANGLE AND ANGLE OF CHIP BURSTING IN THE CUTTING REGIME

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Abstract. *This paper offers results of experimental measuring of the flow direction angle and the angle of chip flow in the function of basic parameters in the cutting regime, namely v, s and a. The materials examined are duralumin, bronze, brass and gray iron. The method used is the direct method of measuring the angle of chip flow (photo-method). The results of measurements were processed by means of a personal computer and given on the diagrams with comparative commentaries.*

Key words: *angle, flow, chips, cutting.*

1. INTRODUCTION

The observation of the cutting process with a number of brittle materials in the conditions governing the production process, as well as a series of conducted experiments, shows that the angle and direction of chip flow are dependent upon a large number of factors. The basic factors are the following: type of processing (lathing, boring, abrading, milling, etc.), physical and mechanical characteristics of the working piece material, cutting regime, geometrical parameters of the tools, etc.

The experimenatal research of the author was conducted at traverse (longitudinal) lathe work on duralumin, brass, bronze and gary iron [2,3]. The cutting regime and geometrical parameters of the cutting tool during the process of brittle metal cutting, in production-type conditions have been adopted in accordance with recommendations and based on personal experience.

The objective of the experiments was to determine:

1. the chip flow direction,
2. the influence of cutting regime parameters (*v, s, a*) on the direction and angle of chip flow,

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The results of this research should serve as a basis for tracing the ways for the most efficient technical solution for incessant chip and dust removal from the cutting tool.

2. METHOD USED

For the research on the form of chip flow and direction of flowing at longitudinal processing of brittle materials by the lathe, the direct method of measuring the angle ρ_H, ρ_F and ρ_P by photographing (photo-method) was used. The chip flow was observed from three points. The cutting tool is fixed on the right-hand side of the holder, so that it enables free bursting of chips. Screens with measring scales are fixed for the holder of the cutting tool, i.e. its carriage and during the processing they move together (fig.1). Photo-cameras are fitted so that at the point of photographing they are perpendicular to the corresponding screen.

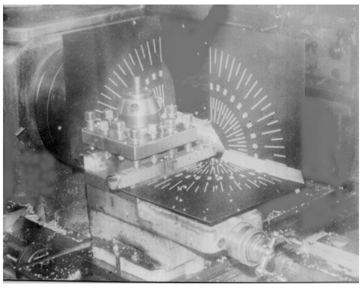
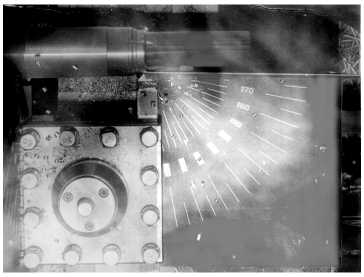
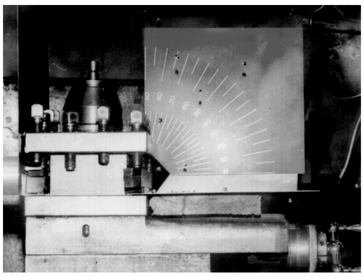


Fig. 1. Working place for flow direction angle registering and registering of the angle of chip flow in horizontal, frontal and profile plane

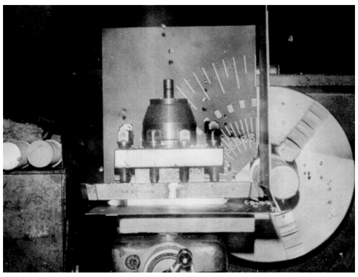
Photographic shots of the flow of chips together with measuring scales have enabled the determination of the geometrical shape of the chip flow with a greater precision, as well as the determination of its position in space during the process of brittle metal cutting. (fig. 2).



(a)



(b)



(c)

Fig. 2. Photographic shots of chip flow during duralumin D5 processing a) in horizontal plane, b) in frontal plane, c) in profile plane.

At the same time the angles of the beginning $\rho_i^{'}$ and ending of chip bursting $\rho_i^{''}$,and the mean values, i.e. angles ρ_H, ρ_F and ρ_P were calculated afterwards (fig. 3). On the basis of the measured values, diagrams were obtained for every variable. (fig. 4÷15)

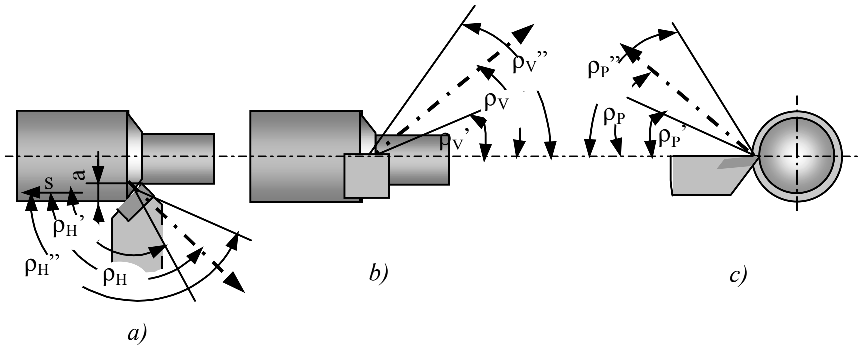


Fig. 3. Parameters which determine chip flow direction and angle of chip bursting a) in horizontal plane, b) in frontal plane, c) in profile plane

3. Experimental conditions

The experimental research was conducted at traverse (longitudinal) lathe work of aluminium alloy D5 (duralumin of HB > 100 hardness), brass CuZn39Pb2 (hardness HB > 120), centrifuged bronze CuSn14 (hardness HB = 100) and gray iron SL 18 (hardness HB = 200). Work piece diameter was D = 50 mm for each of the tests.*

During the experimental part of the research, lathe cutters with soldered hard metal plates (K10) were used. The cutters were whetted with diamond abrasive plate under the same conditions, with final fine abrading of the breast surface. The angle geometry was varied so that it encompasses real cutting regimes [2].

The control of angular geometry of tools was performed on the co-ordinate measuring device MITUTOYA. Maximal deviation from the desired geometry of the tool was ±0,3%.

In the course of testing, the following parameters of the cutting regime were varied:

1. -cutting speed v of 94 ÷ 314 [m/min] at ~ 50 [m/mm] each,
2. -cutting pitch s of 0,107 ÷ 0,325 [mm/o] at ~ 0,05 [mm/o] each,
3. -cutting depth a of 0,5 ÷ 4 [mm] at 1 [mm] i each

Certain experiments were repeated several times, and after each of the measurings the chips were collected for further elementary particle analysis.

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*Duralumin has an internal marking D5 which corresponds to the marking Al Cu Mg Pb. according to DIN.
Brass Cu Zn39Pb2 (JUS) DIN marking is MS 58
Bronze CuSn14 (JUS) DIN marking is G-Sn Bz14
Gray iron SL 18 DIN marking is GG-18.

After a number of preliminary research activities and adoption of the array of considered parameters, three independent measurements were carried out for each variable. The mean values were calculated afterwards and on this basis diagrams were obtained (fig. 4÷15).

The experiments were conducted by means of a universal lathe ADA POTISJE PA 631 P, in the Factory of non-ferrous metals NISSAL in Niš, FAM and "Jastrebac" MIN Niš. The additional conditions of experimenting have been supplied with each figure separately.

4. RESULTS OF MEASURING

The plotting on the diagrams were obtained on the basis of mean values from three independent measurements. The plottings were connected with a second-order polynomial of the type:

$$y = A + Bx + Cx^2$$

Key:

dependence of chip bursting angle:

$$\psi_i = \rho_i'' - \rho_i' = f(v, s, a, \lambda, \kappa, \gamma, r)$$

● ρ_H' - beginning of chip bursting in horizontal plane,

○ ρ_H'' - ending of chip bursting in horizontal plane,

● ρ_F' - beginning of chip bursting in frontal plane,

○ ρ_F'' - ending of chip bursting in frontal plane,

▲ ρ_P' - beginning of chip bursting in profile plane,

△ ρ_P'' - ending of chip bursting in profile plane,

dependence of chip flow direction angle:

$$\rho_i' = f(v, s, a, \lambda, \kappa, \gamma, r)$$

+ ρ_H - chip flow direction angle in horizontal plane,
+ ρ_F - chip flow direction angle in frontal plane,
x ρ_P - chip flow direction angle profile plane.

The results of measurements are given in the form of diagrams on the following pages.

Dependence of the angle of chip bursting and angle of chip flow direction on the **cutting speed** at traverse (longitudinal) processing ($\kappa = 45^o$; $\gamma = 4^o$; $\lambda = 0^o$; $\alpha = 8^o$; r = 0.5 mm; s = 0.16 mm/o and a = 2 mm):

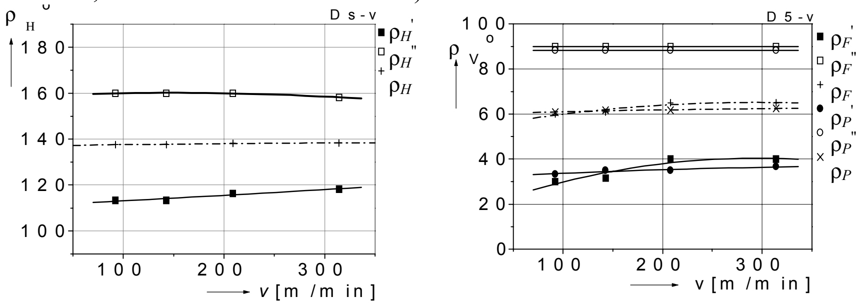

Fig. 4. Duralumin D5

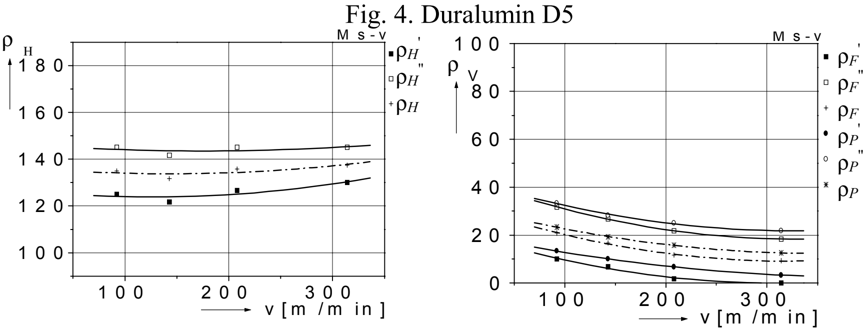

Fig. 5. Brass CuZn39Pb2

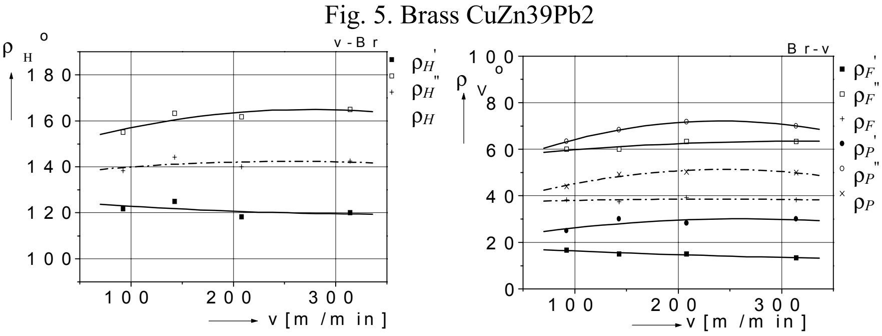

Fig. 6. Bronze CuSn14

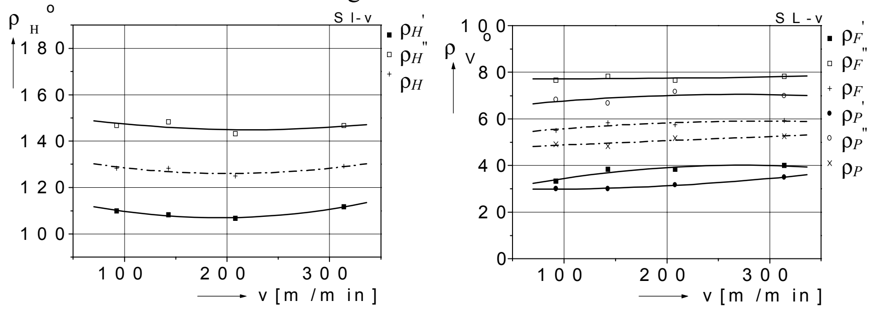

Fig 7. Gry iron SL 18

Dependence of the angle of chip bursting and angle of chip flow direction on the **cutting pitch** at traverse (longitudinal) processing ($\kappa = 45^o$; $\gamma = 4^o$; $\lambda = 0^o$; $\alpha = 8^o$; $r = 0.5$ mm; $v = 208$ m/min and $a = 2$ mm):

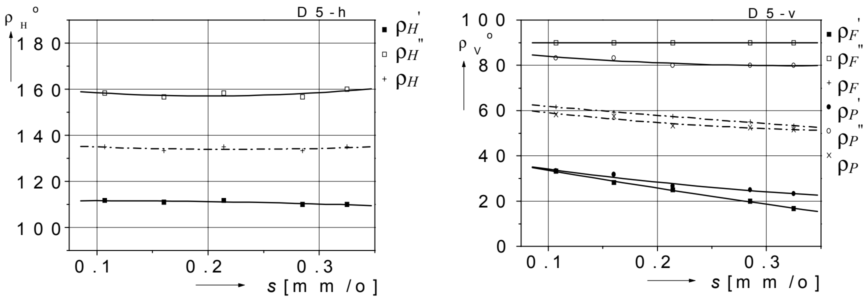

Fig. 8. Duralumin D5

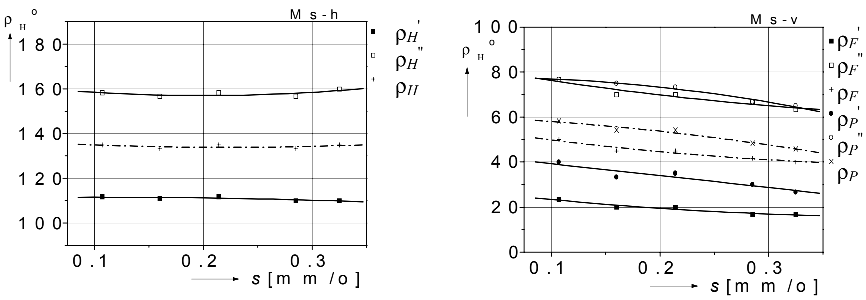

Fig. 9. Brass CuZn39Pb2

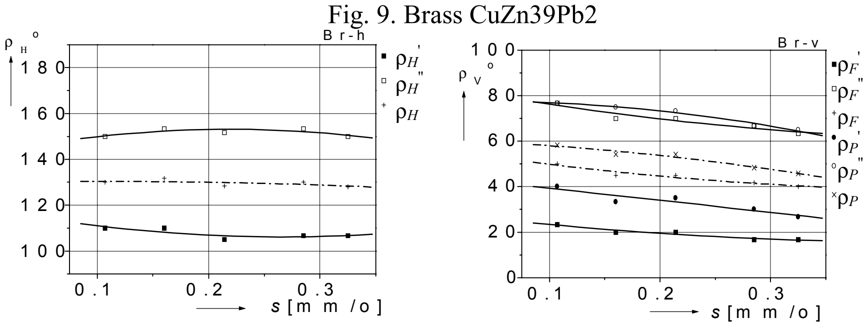

Fig. 10. Bronze CuSn14

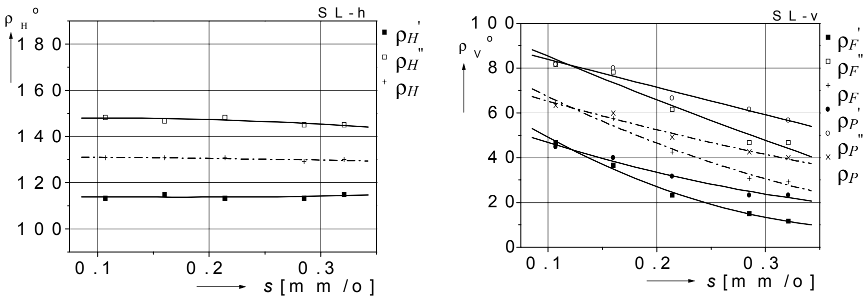

Fig 11. Gry iron SL 18

Dependence of the angle of chip bursting and angle of chip flow direction on the **cutting depth** at traverse (longitudinal) processing ($\kappa = 45^o$; $\gamma = 4^o$; $\lambda = 0^o$; $\alpha = 8^o$; $r = 0.5$ mm; $s = 0.16$ mm/o and $v = 208$m/min):

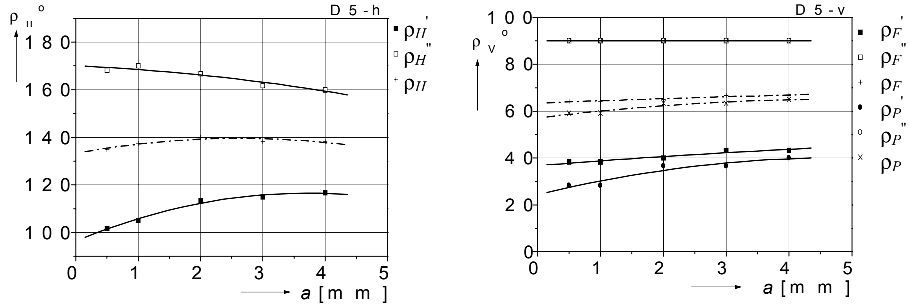

Fig. 12. Duralumin D5

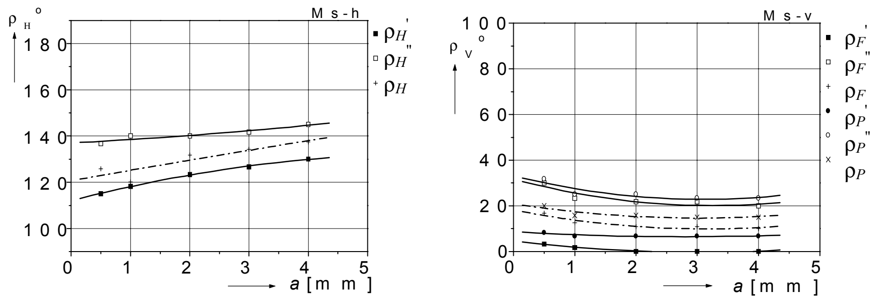

Fig. 13. Brass CuZn39Pb2

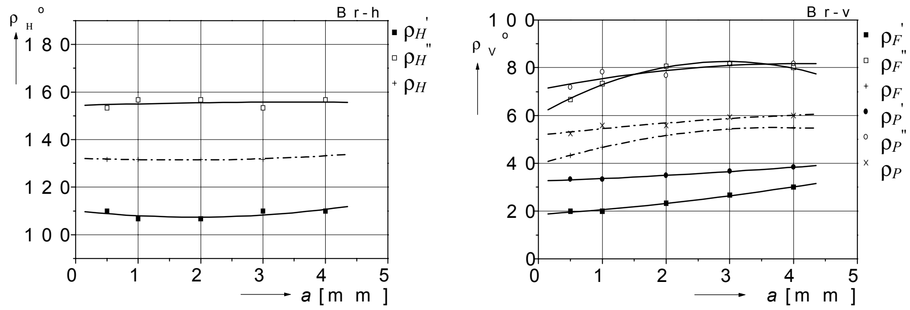

Fig. 14. Bronze CuSn14

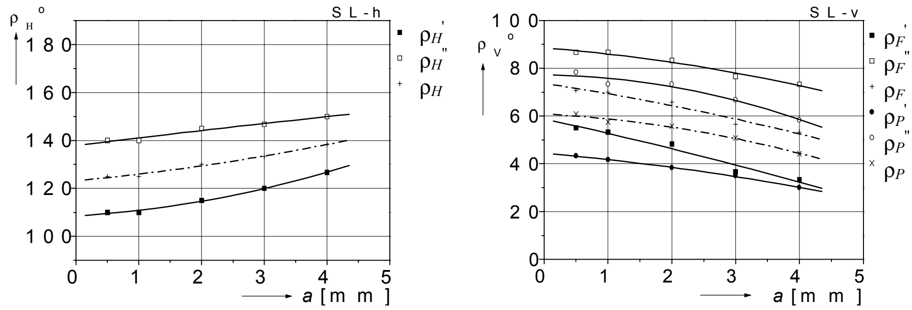

Fig 15. Gry iron SL 18

5. CONCLUSION

1) The influence of certain parameters of the cutting regime on the chip flow direction and angle of bursting can be noticed in the area close to the cutting tool.

2) The character of changes in the chip flow direction and angle of bursting in the function of certain parameters in the cutting regime is the same for the majority of examined materials.

3) At brass processing, the chip flow direction can be tracked at a larger distance from the cutting edge of the tool, even more than a meter from the cutting edge. However, at duralumin processing, and to a certain degree bronze and gray iron processing, the chip flow direction examining has effect only in the immediate proximity to the cutting tool (maximally 10-15 cm from the cutter).

4) External factor effect is far more explicit on duralumin chips.

5) Duralumin and bronze mainly preserve the same shape of the elementary chip particles with all the tests (tubular-spiral shape) while the dimensions, and the mass accordingly, changed for different testing conditions. For brass and bronze, it changed from needle-like and laminar to tubular-spiral shape [2] .

6) The absolute value of the angle of chip bursting is primarily a characteristic of work piece material.

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EKSPERIMENTALNA ISPITIVANJA UGLA PRAVCA TOKA I UGLA RAZLETANJA STRUGOTINE U FUNKCIJI REŽIMA REZANJA

Miodrag Jovanović

U radu se daju sopstveni rezultati eksperimentalnih merenja ugla pravca toka i ugla razletanja strugotine u funkciji osnovnih parametara režima rezanja v, s i a. Ispitivani materijali su duraluminijum, bronza, mesing i sivi liv. Primenjen je direktni metod merenja ugla pravca toka strugotine (foto-metod).

Rezultati merenja su obrađeni na računaru i dati na dijagramima sa uporednim komentarom.

Ključne reči: *ugao, tok, strugotina, rezanje.*