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Instrumentation and Measuring of the Cutting Forces Presentation

In the paper the SUCTRONIC25 machine and the F_x , F_y , F_z cutting forces are described. A dynamometer capable of measuring forces in 3 directions can be used to measure cutting forces. In the example the composite has been turned at 100, 200 and 400 [m/min]. The numerical results are illustrated in table 1.

1. Introduction

The instrumentation used is a device called SURTRONIC25 for measuring the roughness and a dinamometre for measuring the cutting forces.

Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface:

- with the workpiece rotating;
- with a single-point cutting tool;
- with the cutting tool feeding parallel to the axis of the work piece and at a distance that will remove the outer surface of the work.

Taper turning is practically the same, except that the cutter path is at an angle to the work axis. Similarly, in contour turning, the distance of the cutter from the work axis is varied to produce the desired shape.

Even though a single-point tool is specified, this does not exclude multiple-tool setups, which are often employed in turning. In such setups, each tool operates independently as a single-point cutter.

SURTRONIC25 is part of the long standing Surtronic range manufactured by UK precision metrology company, Taylor Hobson, distributed by Rosebank Engineering in Australia. This portable roughness measurement instrument is battery powered and has a large display with simple menu structures as well as up-to-date parameters.

SURTRONIC25 is configured to calculate up to **10** parameters which have been carefully selected to cover the most common requirements to check surfaces for fractures or damage, oil retention characteristics, feed rates, friction and wear properties. Additional parameters can be calculated and in depth analysis of measurement profile can be carried out with the optional Talyprofile software.

The SURTRONIC25 incorporates new electronics for fast analysis. The results are calculated and displayed even before the traverse unit returns. Its mechanical rigidity and styli have a firm reputation for reliability, giving repeatable surface finish measurements across a wide range of applications.

The SURTRONIC25 can be used either freestanding (on horizontal, vertical or even inverted surfaces) or bench mounted with fixturing for batch measurement and laboratory applications. It offers extensive flexibility in terms of accessing component features such as steps, grooves, bores and lands.

The measurement stylus has a vertical adjustment of up to 50mm and can be rotated to various positions for right angled or even inverted measurements.

This feature, plus an extensive range of pick-up options, allows areas and features of a component to be easily measured without the need for additional fixturing at a minimum set up time.

2. Cutting forces

Forces in Orthogonal Cutting

A dynamometer capable of measuring forces in 3 directions (only 2 are needed in orthogonal cutting) can be used to measure cutting forces. In the diagram below the reactions to these forces, which are acting on the tool, are shown:

F_c acting in the direction of cutting

F_t thrust force needed to keep the tool in the work-piece (direction perpendicular to the work-piece surface). At high positive rake angles the thrust force is negative and the tool is pulled into the work-piece.

The resultant force on the tool, P_r, is made up of a normal force, P_n acting perpendicular to the tool face and F the friction force acting along the face and is presented in fig.2.1.

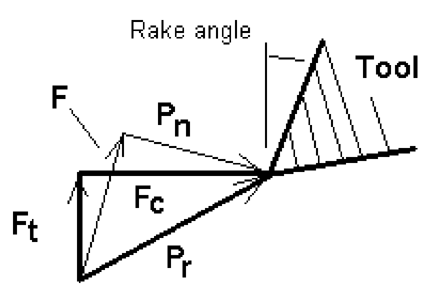

Fig.2.1. The forces reppresentation

$P_n = F_c \cos(alpha) - F_t \sin(alpha)$

$F = F_c \sin(alpha) + F_t \cos(alpha)$

where alpha is the rake angle.

Knowledge of the shear angle, phi, will allow the deformed chip thickness to be estimated.

Material removal described so far is known as orthogonal, producing only two cutting forces; when turning these are axial and tangential.

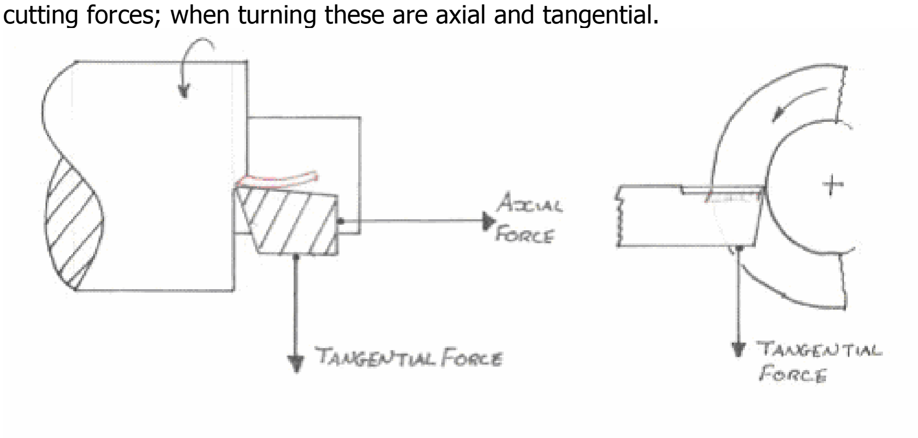

Fig.2.2. The tangential force and axial force representation

Tangential cutting force is by far the greater (if translated to the planer this is the force acting on the tool in the direction of the work-piece travel).
Axial cutting force is the force required to keep the cutting edge in contact with the work-piece (perpendicular to the surface of the work-piece on the planer).

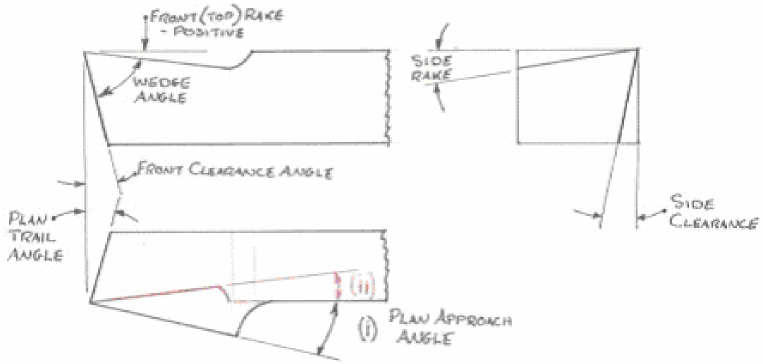

Fig.2.3. A typical turning tool with nomenclature

Oblique cutting introduces a third cutting force, radial. Fig.2.3. shows a typical turning tool with nomenclature. It can be seen from the plan view that the cutting edge will not now be perpendicular to the axis of rotation Fig.2.4. illustrates radial cutting force.

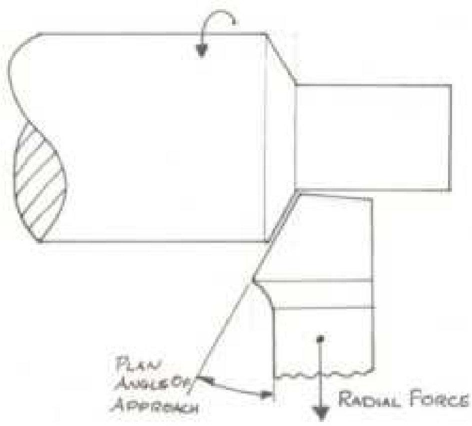

Fig.2.4. The radial cutting force representation.

Tangential cutting force resists the rotation of the work, as relatively high speeds are used the bulk of power consumption lies here.
Axial cutting force resists the travel of the tool, however this is a relatively low speed compared with rotation of the work, so for all practical purposes power consumption may be ignored.

Radial cutting force produces no movement therefore consumes no power, however, the effect can improve stability during cutting as it ensures the cross slide nut and screw are kept in contact, thus improving accuracy. The plan approach angle ii) in Fig 2.3. is likely to be found on a facing and turning tool, if heavy longitudinal cuts are to be taken with this configuration of tool a backlash eliminator (see sec. 5.3.) would be required because the direction of radial cutting force would be reversed and the tool would tend to be pulled into the work producing a tapered turn.

3. Results and Discussion

The composite has been turned at 100, 200 and 400 [m/min].
The depth of cut is a=1[mm].The piece has been turned having the next feeds rate: 0,05; 0,10; 0,16; 0,20 and 0,32[mm/rev].

The data base for the cutting forces is presented in the next label:

Table 1

Feed rate	**V**	**Fz**	**Fx**	**Fy**
0,05	100	10,51	5,97	2,52
0,10	100	13,16	10,91	5,15
0,16	100	13,82	12,72	6,19
0,20	100	14,65	13,32	6,55
0,32	100	14,96	14,88	7,5
0,05	200	15,08	14,96	7,92
0,10	200	15,12	15,2	8,05
0,16	200	15,22	16,11	8,17
0,20	200	15,33	16,41	8,38
0,32	200	15,4	16,6	8,6
0,05	400	15,75	17,8	9,08
0,10	400	15,84	18,62	9,5
0,16	400	15,92	19,15	10,24
0,20	400	16,00	20,00	11,37
0,32	400	16,22	21,33	11,9

The correlation between the cutting forces and Ra will be presented in the next paper.

4. Conclusions

SURTRONIC is configured to calculate up to 10 parameters which have been carefully selected to cover the most common requirements to check surfaces for fractures or damage, oil retention characteristics, feed rates, friction and wear properties. The SURTRONIC25 machine contains new electronics components for fast analysis of parameters. The results are calculated and displayed even before the traverse unit returns. Its mechanical rigidity and styli have a firm reputation for reliability, giving repeatable surface finish measurements across a wide range of applications.

The figures and the table1 contents the numerical results of this study.

The correlation between the cutting forces and Ra will be presented in the next paper.

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