

PROCESS OF CUTTING OFF MATERIAL WITH DISC ROTATING DIES FOR SANITARY ABSORBENTS

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Abstract: This is a virtual method of defining the cutting process for rotating dies with complicated shape. The virtual model represents the harmonious work of rotating die and a smooth cylinder which contact with inconstant area. Model area: SolidWorks

Keywords: MEASURING, CUTTING FORCES, VIRTUAL MODEL, EQUATIONS OF FORCES

1. Working principle of separation operations knives

With rotary die tools high performance and smoothness of operation could be achieved, thus they are more prevalent. Cutting the material with rotary tools is shown on the scheme in Figure 1, typical for punching soft materials (paper, rubber, etc.).

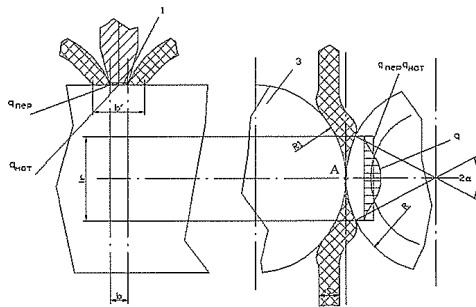


Fig. 1

The cutting edge of these tools is shaped like a wedge, which is not sharp and at its tip it has a cutting path of width b , which is along the entire length of the cutting edge. Rotary blade 2 has a radius R and works in tandem with the supporting smooth drum 3. R and $R1$ have similar sizes and kinematics of motion is preferred which to ensure rolling of one drum to another without slipping. Rotary cutting blade is pressed against the smooth drum with the appropriate power Fig.2, thus cutting out the piece of the tape material. This effort is regulated, as determined in function of the thickness of the material and its composition and condition of the cutting edge. With wear of, the cutting edge width of the path increases.

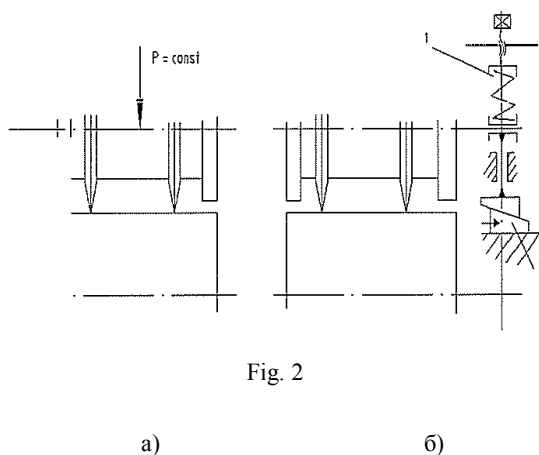


Fig. 2

a)

b)

Different circuit solutions of machines, mainly working with cutting blade and supporting drum with parallel axes. The most common schemes providing cutting force are shown in Figure 2, A

and B. In Figure 2 a) - the effort is provided by pneumatic cylinders, by regulating the pressure. In Figure 2 a) - the effort is provided by pneumatic cylinders by regulation pressure. In Figure 2 b) - with prisms 2 minimum distance between the axis of the rotary blade and supporting drum is adjusted but, with a spring 1 force of cutting edge.

In [1] methodology and dependencies defined for the cutting force are proposed.

2. Determination of cutting force

The contour of the cut parts can generally be divided into straight and curved sections. When cutting, belt material is deformed in a length lr and width b , where b is the width of the cutting strip located at the top of the tooth 1. R is the outer radius of the cutting blade 2, and $R1$ is the radius of supporting smooth drum 3. Geometric relationships shown in Figure 3 could be applied to determine the magnitude lr :

$$R^2 = \left(\frac{lr}{2}\right)^2 + (R-S)^2 \quad (1)$$

$$lr = 2\sqrt{S(2R-S)}$$

Due to change of the angle of the tangent of the edge to formation line of the main cylinder at the contact point, this value is variable, as in this case (1) this is the minimum value. Practically, lr affects the radius of curvature of the cut contour R'' in the present section Fig.3. If the cutting strip of the cutting knife was width $b = 0$, the theoretical contact between him and the smooth drum will be in point. If $R = I$ and $R1 = I$, then the cutting edge will be plane placed against the plate. In Figure 1 the thickness of the strip material is denoted by S . Tensions in the cutting zone [6], [7] are:

- those arising from cut contour – q_{per} ;
- occurring in the area where there is main pressure – q_{pres}

The power that arises in the cutting zone can be defined as:

$$P = P_{per} + P_{pres} = lr \cdot S (2 \cdot q_{per} + b \cdot q_{pres}) \quad (2)$$

Reduced values q_{per} q_{pres} are defined as load per unit length of the cutting edge, respectively, per unit area of the zone ($b \cdot lr$). As it can be noticed from Figure 1, in an almost ideal case load distribution in the area ($b \cdot lr$) will be uneven, so it should be averaged and treated as an aligned per unit length, respectively, per unit area. In practice, the calculation of power at punching, specific tensions q_{per} and q_{nat} can be determined experimentally for a given material. This can happen for a specified material thickness S and assuming a linear

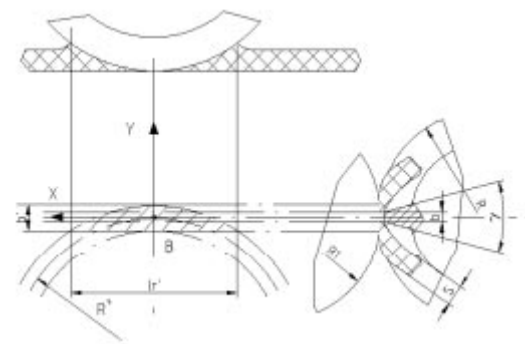


Fig. 3

connection with q , the determination can be performed according to the relationship (1). If linearization is inadmissible, then:
$$P = l r (2 \cdot q_{\text{per}} + b \cdot q_{\text{pres}}), \quad (3)$$

where q_{per} and q_{pres} are of certain thickness and material properties [6].

To determine the cutting force contact area is required between the working surface of the cutting blade and smooth surface of the cylindrical drum.

3. Method for determining the contact area between the working surfaces of two cylinders

Figure 4 shows a virtual packaging system for rotary die.

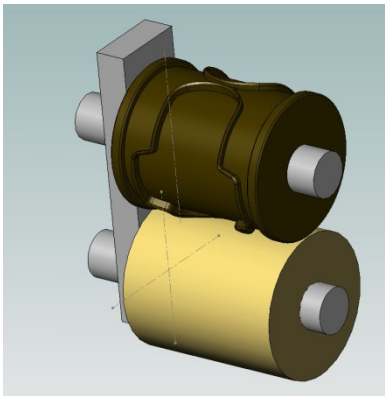


Fig. 4

To solve the task, in SolidWorks a virtually modeling teamwork is done, as it is simulated a joint operation of cutting knife and further the virtual contact patch of the two drums is investigated. At the characteristic zones with area increase, the number of measurements is increased. Very simple packaging system of attachment to both the drum is used, so as to fulfill the restrictive conditions in space - the two drums are only of 1 degree of freedom which is also partially limited by angle, to allow measurements to be committed. Measurement is done by simulating the penetration of the cutting tooth in the smooth drum of order of 0,01 mm. For this study, the tip of the tooth has a path of width 0,1 mm. Path of the tooth is located on the cylindrical surface with a diameter that is larger than the diameter of the drum with a 0,02 mm. In practice, penetration is impossible because of the very close hardness of the two drums.

55	60	65	70	72	73	74	75	76	77	78	Deg
0.24	0.24	0.24	0.24	0.26	0.30	0.52	0.70	0.76	0.72	0.58	mm ²

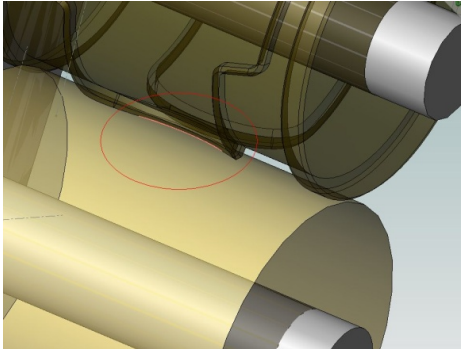


Fig. 5

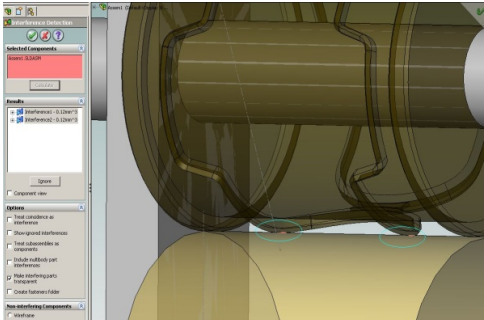


Fig. 6

In the virtual environment research when drawing it is necessary to prevent physical intrusion (interference) between the two drums to be able to calculate this by the software product. Otherwise, it is not possible to locate the contact zone between the edge and smooth drum. The results of measured penetration of one tooth of the drum are shown in Figure 7.

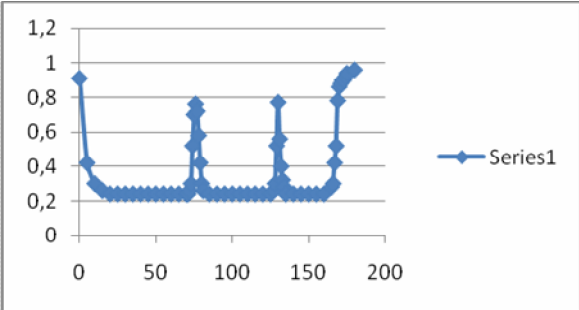


Fig. 7

The results suggest that the ability of the cutting tool depends on the specific area along the contour of the knife, i.e. angle of the tangent with the formation line of the cylinder.

0	5	10	15	20	25	30	35	40	45	50	Deg
0.91	0.42	0.42	0.3	0.26	0.24	0.24	0.24	0.24	0.24	0.24	mm ²

79	80	81	85	90	95	100	105	110	115	120	Deg
0.42	0.30	0.26	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	mm ²

125	127	128	129	130	131	132	133	134	135	140	Deg
0.24	0.26	0.3	0.52	0.77	0.56	0.40	0.32	0.28	0.24	0.24	mm ²

145	150	155	160	165	166	167	168	169	170	171	Deg
0.24	0.24	0.24	0.24	0.28	0.30	0.42	0.52	0.78	0.86	0.88	mm ²

172	173	174	175	180							Deg
0.9	0.9	0.92	0.94	0							mm

Table 1

As a result of the described above method for measuring contact patch between the cutting tooth and smooth drum resulting a precise value can be measured as volume mm³. To talk about the contact patch and its size, planar measure of the value must be obtained. Therefore one of the dimensions of volume must be ignored and this is depth H, because in fact it is negligible - order of 0,01 mm. In this way we allow to accept the values obtained from CAD-product of the area indicated. For more accurate indication, we could describe the present volume as a simple 3D object with a trapezoidal section and length, which could be described by rights, arc, ellipse, etc. Thus defined, the area makes it possible to determine the strength of the cutting, as being aware of the specific pressure. According to this method the formula of the classic punching [6.7] is not entirely applicable, since the cutting edge in cross-section is triangular, i.e. sharp, with a trapeze platform at the top. Thus, cutting is the result of the rupture in crushing, which leads to separation of the tape material.

In [1] and [2] it is not considered another important factor influencing the variation of cutting force, which is linked to tools cutting power variation and their geometry.

4. Process of cutting the material, taking into account the variation of cutting ability and tools geometry

Figure 8 shows three basic conditions of variation of tools geometry in different phases of work after re-sharpening:

- Figure 8 a) describes the initial state of the cutting knife. The cutting contour is set at a value b over boards to provide resources to work. The difference in height " b " cannot be a great value ($0,01 \div 0,03$ mm), as it will lead to a rapid increase in the width of the path of the cutting edge of the area. This can reach the unacceptable increase in stress and breaking of the cutting edge. During this phase for the same reason, cutting force is also changed, as it increases.

- Figure 8 b) shows the depleted resource " b ", when a process of cutting the material in which cutting edge is gradually "hiding" behind the boards i.e. $b = 0$ is established. At the next stage the boards of the cutting drum come in contact with the smooth (supporting) drum. The cutting is performed by cutting edge penetration into the material at a depth less than the thickness " c ". This range of work of the sword is the longest and it is associated with very slowly increasing the width of the cutting path.

- Figure 8 c) illustrates the phase in which the cutting tooth is lower than the boards supporting the drum i.e. value b is negative. It is analogous to the classical stamping [5], where cutting is achieved before the punch has sunk to a depth greater than the thickness of the material. Additional beneficial effect appears when there is a path always at the top of the cutting edge that leads to the division of detail and waste.

From the examination is can be concluded that the determination of the cutting force (2) must be corrected by an additional factor $k = f(t)$, where t is the number of cycles (Figure 9).

$$P = P_{\text{per}} + P_{\text{pres}} = l r . S . K . (2 . q_{\text{per}} + b . q_{\text{pres}}) \quad (4)$$

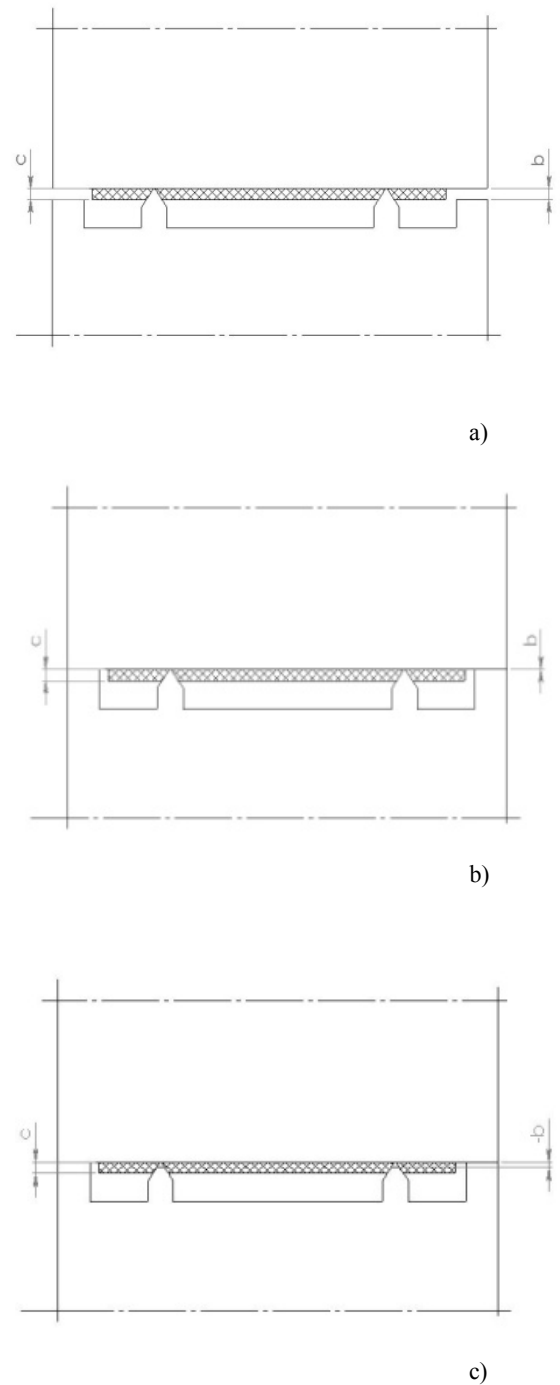


Fig. 8

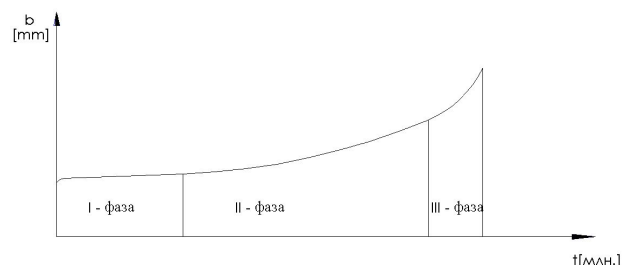


Fig. 9

5. Conclusions

- Approach for determining the cutting force as of the contact area, specific tension in the cutting zone and the degree of wear of the rotary knife is developed.
- Theoretical study is conducted, which was confirmed in experimental observations for process variation of cutting absorbent sanitary - there is a cut of the material, even after the cutting edge as a result of wear became a diameter smaller than the diameter of the boards.
- Correction factor depending on the number of cycles, respectively, the width of the path in the formula for determining the cutting strength is proposed.

6. References

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