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Motion mechanism of rotating transverse paper cutting machine and its parameter optimization

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Abstract

The power of the rotating transverse paper cutting machine is huge because of unreasonable motion. The paper researched the motion mechanism of the structure, transformed the 3D trajectory of rotating blade and paper cutting marks into the same plane space. Ultimately the motion mechanism of the parameters of cutter and paper cutting are established and the reasonable cutting conditions are founded. At last the parameters are optimized according to the relationship of the planning and useless power consumption, achieve the goal of the roller rotate smoothly and the useless power consumption is zero in theory.

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1. Introduction

Rotating transverse paper cutting machine are widely used in printing and packaging industry, although its structure is not complicated, yet the parameters of it affect the normal work are more, and the coupling relationship between each parameter, which the motion mechanism exist in the actual production process is not clear, resulting in structural design and parameters debug in blind groping state; This is not only affects the reliability of the machine running, at the same time, it has a significant effect on the efficiency of the actual production and the rationality of the structure and the control.

At present, the enterprises lack systematic research of the motion mechanism of the rotating transverse paper cutting machine, they grope relying on the experience in the structural design under the condition of multi parameters coupling, it is difficult to determine the parameters values. In this situation it only fix a dynamic parameter then to try other parameters, once encounter appropriate parameters, it can only be fixed all down and can't be easily changed, so it cause the machine structure and motion are not reasonable. Because of this reason, the roller of constant acceleration and deceleration make useless maximum power to 70 kilowatt in actual production, large inertia force and vibration often cause cutter mismatch and force the machine to be repaired.

Now, with the rapid expansion of electronic commerce demand for the corrugated paper packaging, this kind of situation will cause great waste; I'm afraid there are few other mechanical like paper cutter into the research of less, huge economic benefit [1]; therefore, it's necessary that the motion mechanism of rotating transverse paper cutting machine is studied. This paper based on the research the motion mechanism of the rotating transverse paper cutting machine. After this it has been clear about the theory of motion between structure parameters and paper feed parameters. On the premise of a certain roller speed planning, through the influence of various parameters on the roller speed planning, ultimately ideal useless power consumption reach zero in theory by parameter optimization.

2. The structure and motion mechanism of the rotating transverse paper cutting machine

Nomenclature

a	acceleration of paper cutting
a_1	coefficient of triangle curve planning
b_1	coefficient of triangle curve planning
B	width of paper cutting

c_1	coefficient of triangle curve planning
J	moment of inertia of rollers
L	length of paper cutting
P	power of motor
R	radius of rotating blade
t	time
t_i	the i th point of time in planning
t_v	time used by paper from start cutting point to end of it
t_ω	time used by roller from start cutting point to end of it
Δt_1	time delay following cut
Δt_2	time delay before cut
T	torque of rollers
V	velocity of paper cutting
V_0	paper velocity of start point of cutting
x	distance of start point to end point of cutting along velocity of paper
y	arc length of start point to end point of cutting of blade along circumferential direction
α	deflection angle of roller in horizontal
β	helix angle of the blade
ε	acceleration of roller
ω	velocity of roller
$\dot{\omega}$	differential of velocity of roller
ω_0	roller velocity of start point of cutting

2.1. The structure

Rotating transverse paper cutting machine main structure includes two rollers, gears and frame, on each roller along the length direction is equipped with spiral cutting blade, two helix angles of the blades equal and toward contrary, the paper through the horizontal middle of the two rollers, as shown in Fig 1.

When the paper uniformly move forward while the roller rotate at the same time, the spiral cutter cut a certain length of paper after the roller rotate one cycle. When the paper movement direction is perpendicular to the axis of the roller, because of the cutting tool spiral angle, it cause the paper cutting line is not perpendicular to the paper side, as shown in Fig 2a. However, it requires paper cutting line must be perpendicular to the side of the paper in the actual production. In order to meet the conditions, it need to adjust the position of the cut machine, the method is to make the axis of the roller in horizontal have a deflection angle; in this way, there is a certain angle that between the roller axis and paper movement velocity, as shown in Fig 2b.



Fig. 1. Rotating transverse paper cutting machine simple structure.

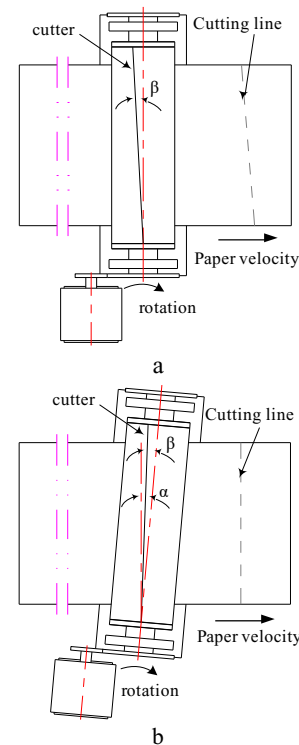


Fig. 2. Position relationship of roller and paper;(a) roller axis is perpendicular to paper velocity; (b) roller axis isn't perpendicular to paper velocity.

As the length, width, and speed of paper cutting need to be adjusted according to the production requirements, so they are variables. On the other hand, the structure parameters of cutter of the paper cutting machine are variables too, it main have blade rotation radius, blade helix angle and the roller deflection angle which above mentioned in horizontal direction. When these variables changed, the paper cutting roller velocity need adjusted to match the paper movement, to meet the requirements of paper cutting length, shape, and its accuracy. However, there are coupling relationship when these parameters changed, it's not separate parameter adjustment can meet the requirements. To achieve the correct cutting, it needs to research the mechanism of relationship between these parameters and movement.

2.2. The motion mechanism

The rotating transverse paper cutting machine is similar to scissors in paper cutting, they all work through two blades in a bit of mesh movement of paper cutting. But there are also differences, that when the rotating transverse paper cutting machine cut papers, the paper moves and roller itself rotates at the same time. The problem is how the change of the mesh point of rollers should be to cooperate the movement of the paper to meet the needs of the paper cutting. At this moment we need to consider the movement relationship between the cutter rollers and the paper. But one is rotate motion and the other one is the translation, how to analysis is a problem.

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