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SOIL CUTTING OF TWO-SIDED WEDGE IN HIGH SPEED CURVE MOVEMENT

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ABSTRACT

This paper discusses the action on soil of two-sided wedge in high speed curve movement, with the emplasis on the deformation of soil and its cutting resistance.

Key Word: soil cutting, high speed, deformation, cutting resistance

INTRODUCTION

In the 1930s В.П.Горячкин(USSR) analyzed the deformation and force of soil under the action of two-sided wedge. Soon afterwards, the scholars in U.S., Japen, German and USSR conducted a series of experiments, But the conclusions were all based on the two-sided wedge in straight movement and a maximum cutting velocity at 3.9 m / s (14km / h)[1]. What will happen when the two-sided wedge are in a curre movement with its velocitg more then 14 km / h. In recent years, rotary tillers and rotary diggers are getting repidly development. It is necessary that to research the action on soil of two-sided wedge at high-speed curve movement. It is generally accepted that when the velocity of a tool is increased, the resistance to motion increases. However, some phenomena indicate that when the velocity of a tool increases, the area of plastic deformation decreases. [2] The cutting resistance may be decrease if the the cutting velocity is up to plastic propagation velocity. The authors try to seek the relationship between the cutting power and its structure parameters as well as its kinematic parameters as theoretical basis for the design of working parts of rotary tillage machine.

High speed cutting discussed in this paper is soil cutting that cutting velocity approaches or equlizes the plastic propagation velocity of testing soil. Measuring method of stress propagation velocity of soil sees also references

[3]. The plastic shear wave velocity of testing soil is about 13.4–18.9m / s.

METHOD OF RESEARCH AND TESTING APPARATUS

1. Experimental equipment

All experiments are carried out in testing equipment of in–door soil trough, which is 1.5 meters wide and 30 meters long. The constructions of testing equipment are shown in Fig.1. Longitude × width × highness of testing soil strip equals to 3000 × 45 × 75mm.

The testing blade (seen also Fig.2) is set on the rotary arms.The arms not only rotate also move forward together with carriage. The curve trajectory of the tool is a cosine–pendulum curve (same as the working parts of rotary tiller and rotary digger).

2. Experimental and controlling parameters.

Cutting power consumption has concern with the water content and solidality of soil, cutting depth, cutting width, cutting velocity. velocity ratio (the ratio of circumference velocity to forward velocity),the thickness and angle of blade. This paper study emphatically the relations between cutting velocity, cutting resistance and soil deformation. The water content and solidality of soil, cutting depth and cutting width are all control parameters. Water content of soil is 18% ± 1%, soil solidality is 58.8N / cm^2 ± 4.9N / cm^2. The width of soil strip is 45mm, and its cutting depth is 70mm. There are two speed regulation engines which control forward speed and rotary speed respectively, thus alternating cutting speed and cutting pitch. Cutting velocity are chosen to 4,6,8,11,13.5m / s. Four kinds of two–sided wedges are made with different thicknesses and edge angles. their structure parameters are shown in Fig.2.

3. Measurement of soil deformetion

In order to observe the regulation of soil deformation, 10 × 10 nets are drawn on one side of the soil strip (see also Fig.3). The photoes of deformation process are taken with high speed photograph, and the photoes are dealt with one by one. The method dealt with the photo of deformation net see also reference [4]. The results see also Fig.4–5. Strain values in Figture are the sum of strain values of all deformation units in a cutting cycle. Deformation area is the total square in a cutting cycle. Distance of deformatiion lead is defined as the distance between the tool and the centre of unit which is the farest deformation unit from the tool.

4. Measurement of cutting power consumsption

The work consumption W is obtained by measuring the torque of rotary shaft M and revolutions n

$$W = \pi / 30 \cdot M \cdot n \cdot t$$

Where t--time completed one cutting.

Measurement of torque is by means of strain gages which are stuck to the rotating shaft. Revolution is directly taken from the revolation sensor of slip ring. A / D transformation and sampling are carry out with MS-1213JD sampling plate for measured signals of torque and revolution.The date is processed with softwara CRAS (Chinese Random Signal Analysis System).

In order to compare power consumption of the tool in different cutting pitch, working width and depth, we adopt ratio power consumption (power consumstion in cutting a unit volume soil) which is more rational.This paper, hence, takes ratio power consumsption as a symbel to study the influence of struture parameters (thichness, edge angle) and kinematic parameters (cutting velocity, velocity ratio) on cutting power consumption. Ratio power consumption Pr

$$Pr = W / (s \cdot a \cdot b)$$

Where s--cutting pitch; a--cutting depth; b--cutting width.

RESULTS OF RESEARCH

1.Relationship between strain and cutting velocity

From Fig.4, it is easy to see that in all velocities, shear strain is biggest, the strain in y direction next, and the strain x direction least. With the increase of cutting velocity, shear strain and the strain in y direction decrease, while the strain x direction varies a little.

2.Relationship between deformation area and cutting velocity

From Fig.5, it is easy to see that value of deformation lead and deformation area all decrease with the increase of cutting velocity.

3. Relationship between ratio power consumption and structure parameters

Shown in Fig.6 is ratio power consumption of four kinds of two-sided wedge with different thicknesses and angles (refer to Fig.2) at various cutting velocities when the velocity ratio λ is 50.3. From Fig.6, it is easy to see: At slow speed ($v = 4m / s$), there are no apparent difference with ratio power consumption of various two-sided wedges, it indicates that the thickness and angle of the tool have little effect on ratio power consumption; At high speed ($v = 13.5m / s$), the blade with thichness 5mm and edge angle 32° is about doule of that of the blade with thickness 2mm and edge angle 14°. It is apparent that the structural parameters of blade has a significant effect on ratio power consumption when high speed.

4. Relationship between ratio power consumption and kinematic parameters

Research results show that cutting velocity of two–sided wedge v and velocity ratio λ have a significant effect on ratio power consumption. Ratio power consumption increases as cutting velocity increases, and decreases as cutting velocity decreases. Shown in Fig.7 is relationships between ratio power consumption and kinematic parameters of the blade which has 4mm thickness and 26.5° edge angle.

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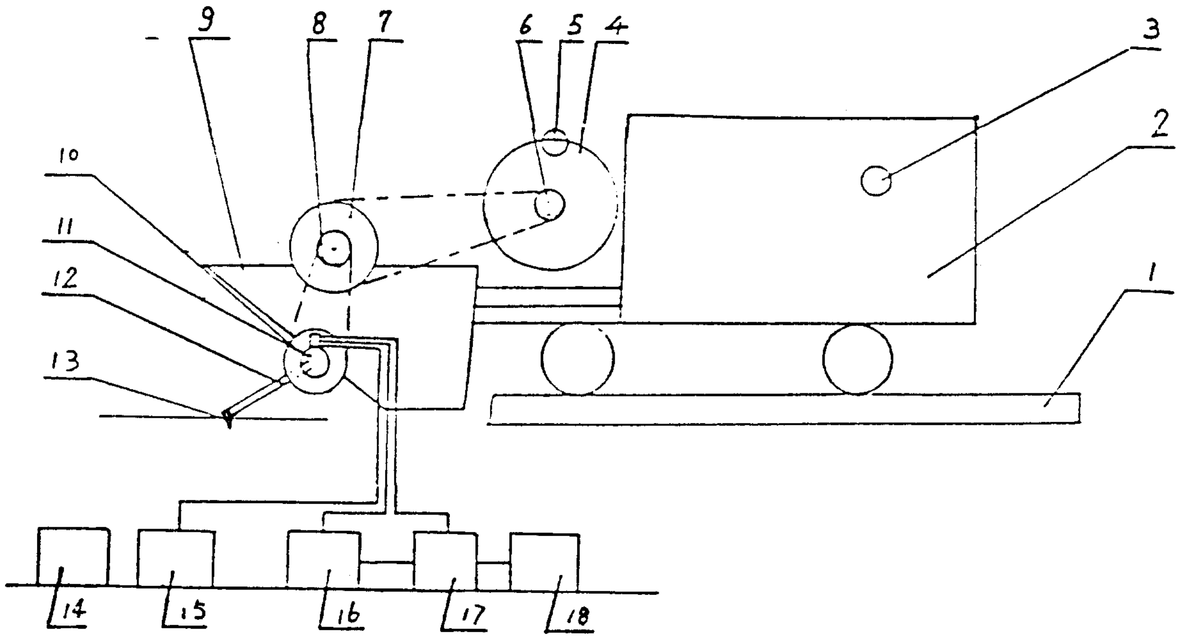

Fig.1 Test equipment

1.Soil trough rail 2.Soil trough carriage 3.Adjusting wheel of carriage forward velocity 4.Governing engine used by working parts 5.Governor 6.The first stage driving wheel 7.The first stage driven wheel 8.The second stage driving wheel 9.Frame of working parts 10.The second stage driven wheel 11.JD-24 slip ring 12.Rotary arms 13.Two-sided wedge 14.CKC-1 high-speed photograph 15.D.C.power 16.DPM-6H self-balance dynamic strainometer 17.MR-30C recorder 18.SZ-4 oscillograph

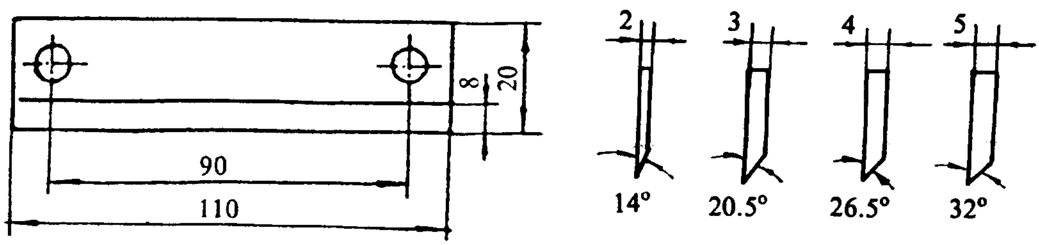

Fig. 2 Blade form

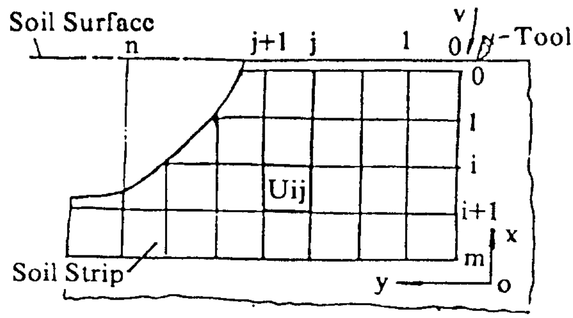

Fig. 3 Deformation unit of soil

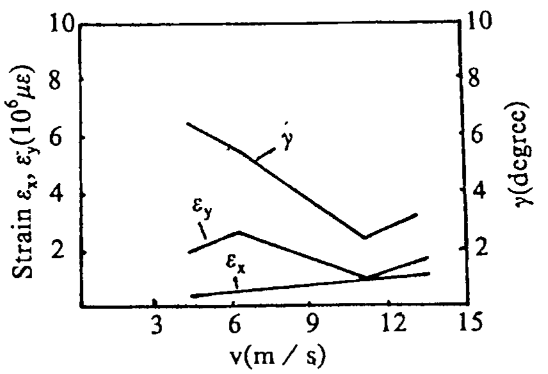

Fig.4 Strains against cutting velocities

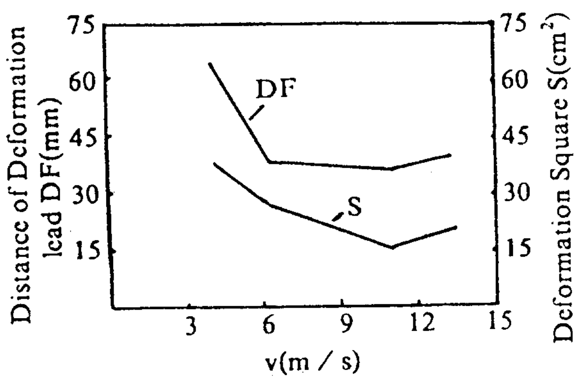

Fig.5 Deformed ranges against cutting velocities

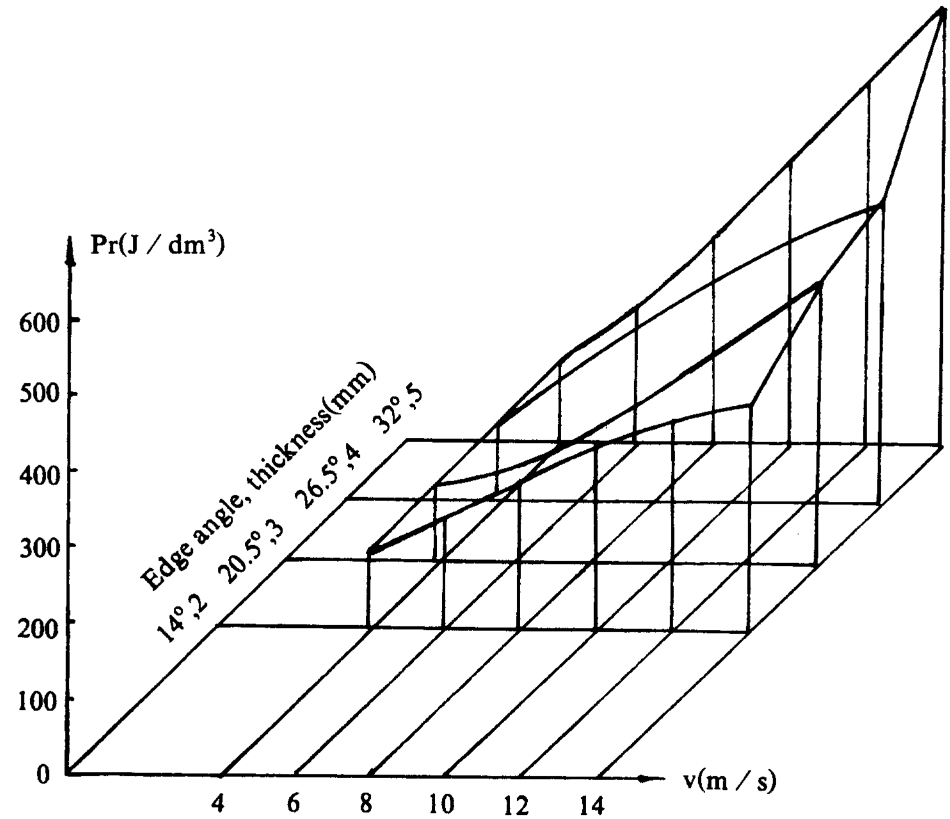

Fig.6 Ratio power consumption against cutting velocity

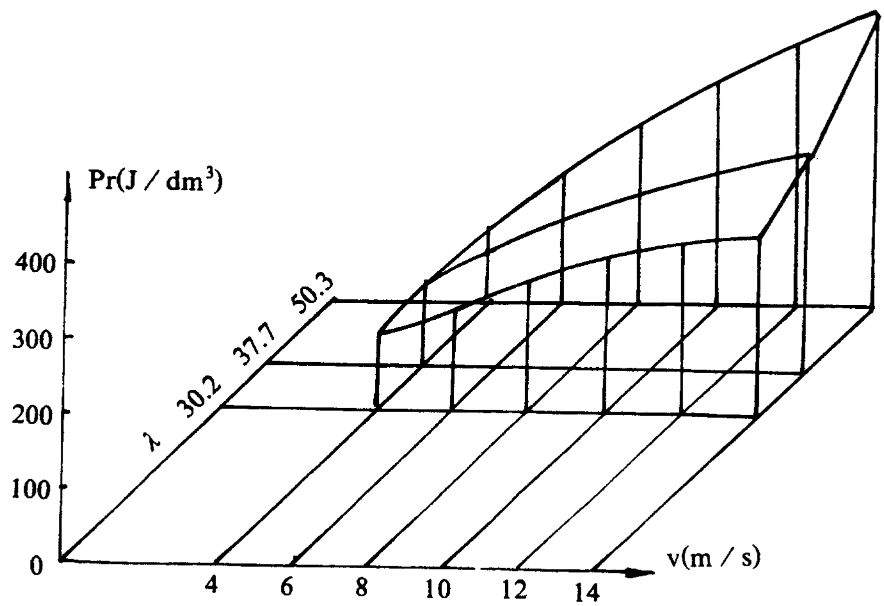

Fig.7 Ratio power consumption against kinematic parameters