Studies on the Pick Up Characteristics of the Spreading Chopped Straws (Part I)

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The straws which are discharged from the combine harvester are chopped and distributed over the field and the dried straws after chopping are gathered by the machine such as the hay baler. In this paper, we have examined the influence of the many factors on the chopped straws picking up with the flail knives type and obtained the basic data of the pick up of the chopped straws on the field. As the first step, the case of the fixed knives type was experimented. The pick up characteristics of the spreading chopped straws were investigated by the pick up ratio, the scatter ratio in front and the *sides* or the remainder ratio and the pick up height distribution ratio of each stage in the collecting box. The factors which gave a large influence on the pick up performance were the rotating speed, the length of the chopped straws, the clearance between knives and rotor housing. the clearance of knives and the knife width.

INTRODUCTION

During harvest time, the straws discharging from the combine harvester are chopped and distributed over the field or burned.

In recent years, the dried straws after chopping are gathered by the hay baler and the others for effective use as materials of the manure or the stock feed. Formerly, the pick up in the case of the unchopped hays was carried out by the fingers of the baler, the hay stacker, the forage harvester and the others (Dohne, 1967; Sato, 1976), but there are few studies on the flail type pick up of the chopped straws on the field (Miyamoto *et al.,* 1971; Kawasaki *et al..* 1976 ; Fujioka *et al.,* 1977). Recently, the manufactures of Takakita Noki Co. Ltd appeared in the market. However, the performance of the pick up with the chopped straws is not enough, there is some room for further improvement. In order to examine the performance of the pick up of the chopped straws with the flail knives type, all of the influenced factors and level were set up and studied on the effect of these factors on the chopped straws pick up.

EXPERIMENTAL APPARATUS

Fig. 1 shows the apparatus of the chopped straws pick up used in this experiment. The pick up knives and the rotor housing are set on the fixed
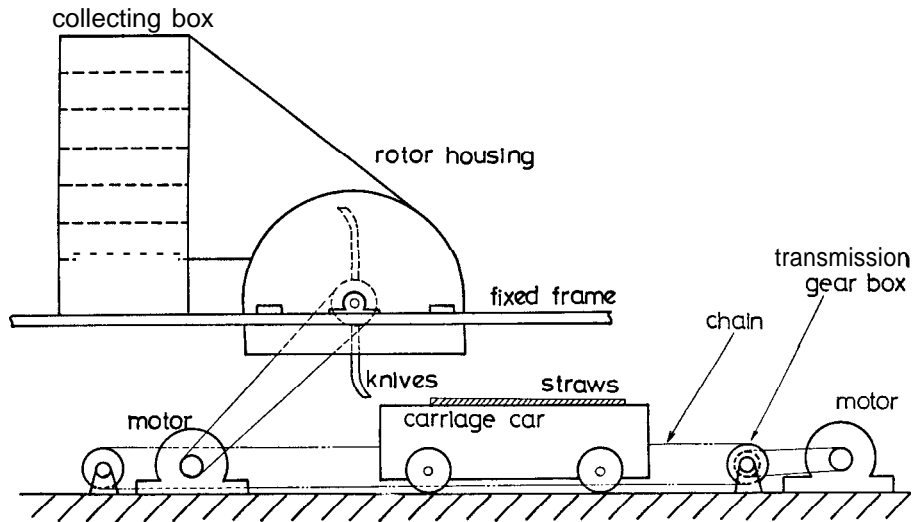
Fig. 1. Schematic diagram of experimental apparatus.

frame and the rotor is driven by a motor. The chopped straws with constant
certain weight per pick up width are uniformly spread on the horizontal board,
which is put on a carriage car running on the rails with the arbitrary velocity
by the other motor and a transmission gear box. The chopped straws picked
up with the revolution of the rotor passing through the chute are thrown
away into the collecting box that consists of six stages put vertically on the
fixed frame (Fig. 1). The knives were set symmetrically in two lines to keep
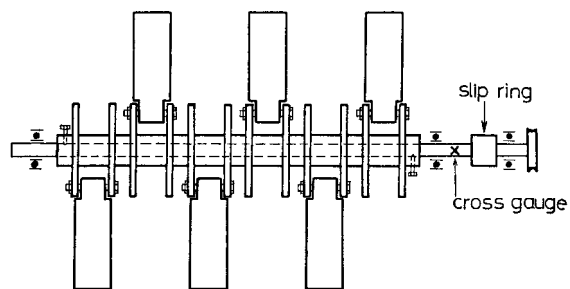the balance of their moment (Fig. 2).

Fig. 2. The experimental rotor assembly.

In the step of the basical experiment, the knives were fixed on the shaft
by the metal fittings and bolts as shown in Fig. 3. Assuming that the fixed
angle of knives α is 0 deg. when the knives set in balance to the direction
of the rotor radius, it may be fixed before and behind to -10, -20 deg. and
+10, +20 deg. in five steps. The distance from the center of the bolt hole
to the tip of a knife and the thickness of a knife were constant with 156.5 mm
and 5mm respectively as shown in Fig. 3. The refracting angle of the knife

and the knife width were changed to 32, 46, 60 deg. and 15, 30 mm respectively and the knife thickness of the experimental knife as 5mm using in this study shown in Fig. 4.
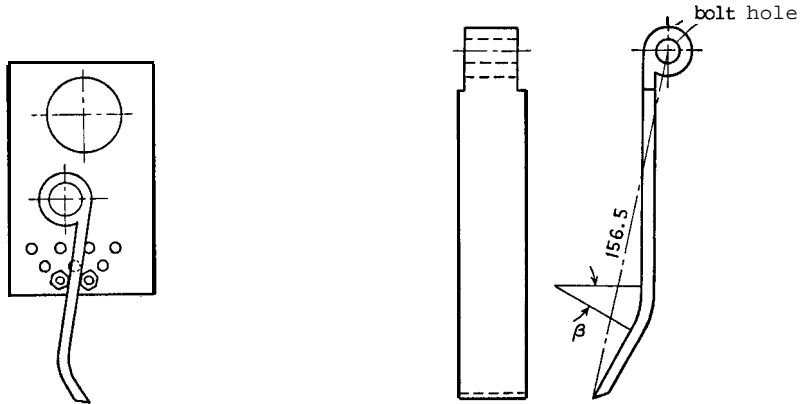

Fig. 3. Setting of knife and metal fitting.   **Fig. 4.** The experimental pick up knife.

MATERIALS AND METHODS

The torque of rotor shaft was determined with strain cross gauge at load and no load, the rotating velocity of the shaft was measured with a tachometer and the speed of the carriage car was calculated from the value by a stop-watch.

a) The influenced factors and level on the experiments:

Some of the factors which are supposed to have a large influence on this experiment were selected and examined by means of statistical analysis. Table 1 shows the allocation of these factors and level.

Table 1.   Allocation of influencing factors and level.

No.	Factors		Level		
I	Rotating speed	(rpm)	900	1100	**700**
	Length of chopped straws	(mm)	**50**	**80**	
	Clearance of knives	(mm)	**15**	0	**30**
	Speed of carriage car	(m/s)	**0.2**	0.4	
	Clearance between knives and rotor housing	(m/s)	**50**	**100'**	
II	Rotating speed	(rpm)	900	1100	
	Length of chopped straws	(mm)	50	80	
	Clearance of knives	(mm)	15	30	
	Speed of carriage car	(m/s)	0.2	0.4	
	Knife width	(mm)	15	30	
	Fixed angles of knife	(deg)	-20, -10, 0, 10, 20		

h) Measuring items and methods:

The knife width is one of the factors as well as the clearance of knives, the pick up width varies according to the set up condition. Some of the

spreading chopped straws are thrown away into the collecting box, the others are scattered to front and both sides.

Therefore, the following equations may be written as:

$$W = W_p + W_f + W_s$$
$$R_p = W_p / W$$
$$R_f = W_f / W$$
$$R_s = W_s / W$$

where W : Gross weight of the spreading chopped straws equal to the pick up width.

W_p : Gross weight of picked up straws.

W_f : Gross scattered straws in front.

W_s : Gross scattered straws on both sides or the remainder.

R_p : Pick up ratio.

R_f : Scatter ratio front.

R_s : Scatter ratio on both sides or the remainder ratio.

In order to know the basic performance of the pick up distribution of the chopped straws passing through the chute, the collecting box that consists of six stages as above mentioned, the respective heights of these stages were 0.34, 0. 54, 0.74, 0.94, 1.14 and 1. 34 m from the upper plate of the carriage car, then the pick up height distribution ratio of each stage is shown as a following typical equation.

$$R_h = W_t / W_p$$

where R_h : Pick up height distribution ratio of each stage.

W_t : Weight of picked up straws of each stage.

RESULTS AND DISCUSSION

The results obtained from the above equations were shown in Fig. 5. It was clarified that the chopped straws were collecting in the lower boxes at 700rpm and contrary they scattered highly and spread in the higher boxes at 1100 rpm. Fig. 6 shows the significant factors and level, also the arrow marks in the figure show the confidence interval. The pick up ratio with the chopped straws of about 80 mm rose more than the 50mm length, the more the clearance between the knives and the rotor housing became narrow, the more pick up ratio became large, while there is the most suitable value on the clearance between the knives. As shown in Fig. 6, a good pick up performance is obtained at the revolution of 900 rpm for picking up the chopped straws. The difference due to the influence of the fixed angle of knives α on the pick up ratio did not recognize significantly. It is conceivable that there is no significant difference between the fixed knives type and the flail knives type on the pick up ratio. Fig. 7 shows the characteristics of the pick up ratio and the scatter ratio or the remainder ratio for moisture content. There is no large influence of moisture content on the pick up ratio
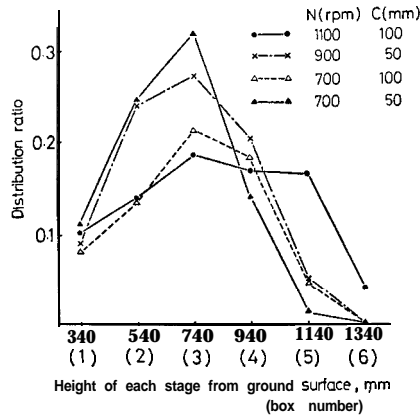
Fig. 5. The characteristic of pick up height distribution in the case of the forward speed of 0.4 m/s, the clearance of knives of 0 mm and the length of chopped straws of 80mm. N: Rotative velocity, C: Clearance between knives and rotor housing.
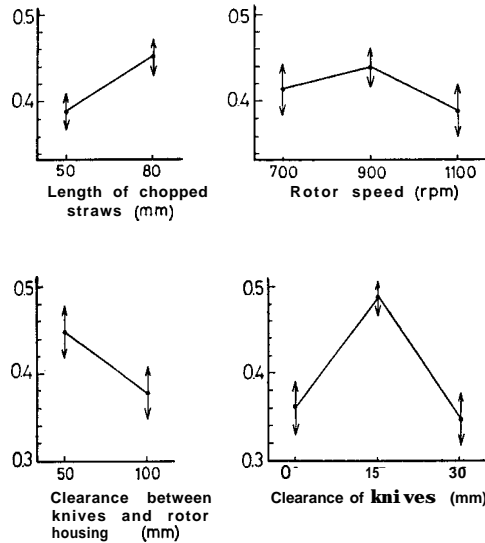
Fig. 6. The effects of four factors on the pick up ratio

although in the case of the 80 mm length of straws as the moisture content is higher the pick up ratio tends to be lower. The dried straws scatter easily in front while the moist ones are difficult to scatter and to be picked up, so that the scatter ratio on both sides or the remainder ratio showed a tendency to be higher. However, there is no influence of the moisture content in the case of the 50mm length. Generally, the straws remainder were scarcely different in the moistrure content under 50per cent.

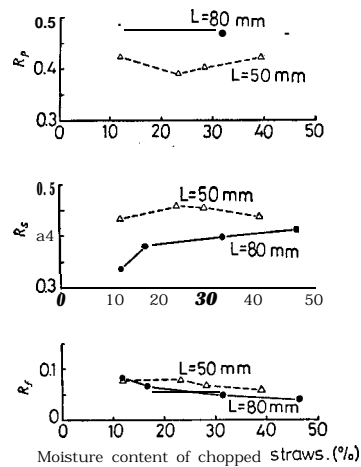The above mentioned experimental results showed that the width of the pick

Fig. 7. The effects of the moisture content of straws on each ratio. In the case of the rotative velocity of 900 rpm, the knife width of 30mm. the clearance of knives of 15 mm, the forward speed of 0.4 m/s and the clearance between knives and rotor housing of 50mm.

up knives are equal with that of the straws distribution and the pick up ratio would show about 50per cent, but in the case of the width of the distribution spreading on one side showed the highest ratio of 70~80 per cent. Moreover in the case of expanding spread on both sides, the pick up ratio was over 100 per cent in 80 mm chopped straws length and about 80 per cent in 50mm length. About the fact which showed over 100 per cent, this may be explained by the fact that the gross weight of the chopped straws pick up is much more than that of the spreading chopped straws inside the pick up width due to the mixing together with the outside straws.

CONCLUSION

In order to examine the influence of the many factors on the chopped straws pick up with the flail knives type and to obtain the basic data of the chopped straws pick up on the field, as the first step, the case of the fixed knives type was experimented and the results were shown as follows:

1. Among many kinds of factors, the factors which gave a large influence on the pick up performance were the following four factors: The rotative velocity, the length of chopped straws, the clearance between knives and rotor housing and the clearance of knives. In addition to these, the knife width is also a main factor.

2. The chopped straws of the 80mm length showed a higher pick up ratio than the other one.

3. It is conceivable that the suitable rotative velocity for picking up the chopped straws is about 900 rpm because the chopped straws are scattered widely and abundantly in front by the growing strong wind at the higher

rotative velocity.

4. The moisture content of under about 50per cent has little influence on the pick up performance.

5. The resistance of the chopped straws working on the pick up knives showed only a few value and the torque at no load indicated about from 70 to **80** per cent of that at full load.

ACKNOWLEDGMENT

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