Kasetsart J. (Nat. Sci. Suppl.) Vol. 25, : 149-156 (1991)

High Moisture Content Corn Sheller

Akradet Artachinda [1] Prayouth Suwanchiwakorn [2] Anek Sukjaroen [2] Toshio Yamauchi [3]

ABSTRACT

The prototype of peg-tooth type corn sheller was designed and constructed based on the study of existing shellers locally manufactured. The purpose was to make it applicable to shelling ear corn with grain moisture content up to 28 precent, while the ordinary shellers were applicable to grain with moisture level of under 20 percent only. And at persent, the prototype had already been finished but the testing procedure was still undergo.

Spike tooth was used in the prototype after evaluation and analysis of the work done in the project and in the past. From the test and the study of its performace, the spike tooth gave rather low damage rate. In the test, it yielded under 6 percent grain damage at 27.8 percent grain moisture content, with unshelled rate lower than 1 percent. Suitable tip speeds of the drum that yielded lowest damage rate were about 5.5 to 6.0 meters per sec. for open-type and 5.0 to 5.5 meters per sec. for closed-type drum.

Similar results were expected for the prototype. However, the design was made so that, if the round peg tooth gave somewhat different result, the other designed square type would be immediately replaced.

INTRODUCTION

Corn is one of major crops of Thailand that brings much of the income to farmers. In cropping process, few mechanization is involved except land preparation which is normally done by tractor, and chemical application by small sprayer. Harvesting is completely done by hand when ear corn reaches the maturity with grain moisture content of approximately 28 percent or even higher as to avoid the comming heavy rain. Ear corn will be kept in barn untill the grain moisture content decreases to about 17-18 percent. This is the suitable condition for shelling. And that is considered a very long wait for farmers to earn some money. The reason that it takes a long time to dry is because, normally, corn cob contains more moisture than grain and this moisture will transfer from cob to grain. So the moisture level in grain will remain constant untill the moisture in cob is decreased to some level equal to the moisture remain in grain, then the grain moisture will start to decrease. This process takes quite a few days.

In shelling process, most of the shellers used are stationary type domestic made designed for shelling corn at grain moisture content below 20 percent to obtain the best result. And if higher moisture content corn is shelled then much of the damage will occur to grain. Most of domestic shellers produced low grain demage when apply to low moisture content corn only. The damage will incerase considerably as the grain moisture content increases beyond 20 percent.

Considering that the period of 30 to 40 days, which is the time spent in drying ear corn from harvesting to shelling conditions is a long time for the farmers who need to sell thier product as soon as possible. This period should be reduced to some shorter time just to help the farmers in selling corn. One possible way is to develope a sheller that can be used effectively on higher moisture content corn. So ear corn will be shelled immediately after picking. And, since corn kernel take less time to dry than the whole ear, then it will take about 5 to 7 days, under the warm climate of this country, to dry down to about 18

1 Department of agricultural Engineering, Faculty ofEngineering, Kasetsart University, Bangkok10900, Thailand
2 National agricultural Machinery Center, Kasetsart University Research and Development Institute, Kasetsart University, Nakhon Pathom 73140, Thailand
3 KU-Japan Expert. National Agriculture Research Center, Tsukuba.

percent moisture content. Then dried grain will be kept in bags and ready to be transported to market.

The main purpose of this research is to develope a sheller which can be efficiently applied to ear corn that contains moisture up to approximately 28 percent in grain. Benefits from this development will be, first, shorter time will be used in drying process as mentioned earlier. Second, time spent from havesting to storage will be greatly reduced. Third, the idea and concept used in designing of this sheller may be used as guideline to the design of a combined harvester for corn, as it is being requested by famers at present.

METERIALS AND METHODS

Three steps of work are incluede in this research:

1. Study of the existing sheller, both domestic made and imported. This study included field observation of real operation, testing of some domestic models in laboratory, and data collecting from other sources.

2. Design of some parts essential in causing damage to grain during operation, such as drum, shelling teeth, concave clearance and others. Several tests are run after the completion of the construction of these parts.

3. Results from the study and the tests are used as guidlines to design and construct a prototype of corn sheller that is applicable on high moisture content corn.

Step 1

Studies were made on some properties of corn involving in shelling quality such as diameter and length of ear corn of several varieties, moisture content in cob and kernel at harvesting and shelling time, and time required for the whole ear corn to dry from harvesting to shelling stages compard with time needed to dry only kurnel of the same stages of moisture content. These studies included some field observation of the real operations of harvesting, storage condition, and shelling procedures. The studies also extended to the test of the existing domestic shellers for the performance characteristics and grain damage rates.

Step 2

Evaluation and analysis were done utilizing data and information collected. Results were used for design of some parts of the machine involved in causing damage to corn kernel. These parts included drum, shelling teeth, shelling cylinder and concave clearance. These new design parts were replaced in model sheller for performance test. Improvement was done to obtain better results. Test data was collected for analysis and evaluation.

Step 3

By using results analyzed from work done in step 1 and 2, the whole prototype sheller was designed. The expected highest kernel moisture content for this sheller was about 28 percent.

The domestic sheller selected for testing of performance was the modified peg-tooth stationary type sheller model LCS 300, made by Lim Chieng Seng Factory, Nakhonsawan. During the test process the driving power was supplied to the sheller through electric dynamometer which had following specification:

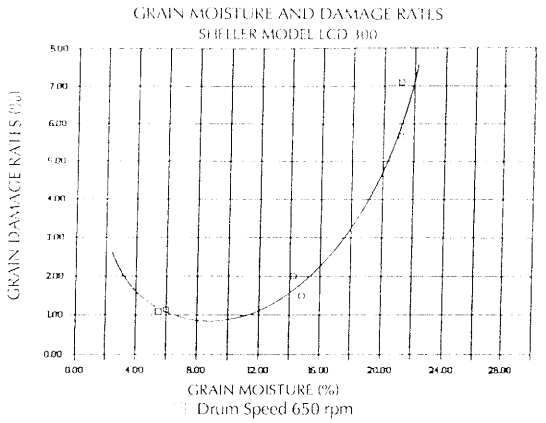

Figure 1 Grain dagame rates in typical domestic sheller.

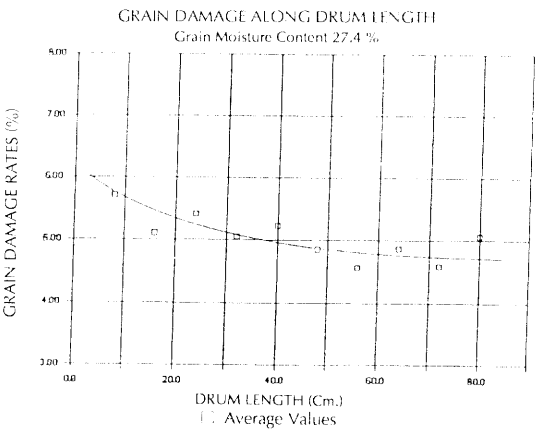

Figure 2 Damage of grain along the length of typical domestic sheller while shelling high moisture content corn.

Table 1 Details of corn varieties used in test.

Variety: Suwan 1

Corn variety	Suwan 1	Suwan 1	Suwan 1	Suwan 1	Average
Length of ear (cm.)	16.60	15.10	13.60	15.90	15.30
Ear diameter (cm.)	4.70	4.60	4.90	4.90	4.78
Number of row	14.30	15.70	14.50	14.90	14.85
Number of kernel/row	31.40	26.10	27.30	31.00	28.95
Weight (gm.)	169.00	162.00	188.00	210.00	182.25
Kurnel moisture (%)	27.40	28.00	28.20	27.60	27.80
Cob moisture (%)	36.20	37.10	36.60	32.70	35.65

Variety: Suwan 3

Corn variety	Suwan 3	Suwan 3	Suwan 3	Suwan 3	Average
Length of ear (cm.)	16.30	16.50	16.30	15.40	16.13
Ear diameter (cm.)	5.00	4.80	4.50	4.60	4.73
Number of row	15.00	14.10	14.60	15.40	14.78
Number of kernel/row	34.00	36.00	34.40	26.60	32.75
Weight (gm.)	192.00	211.00	152.00	176.00	182.75
KURnel moisture (%)	12.10	20.50	14.00	27.80	18.60
Cob moisture (%)	13.00	35.90	14.80	53.90	29.40

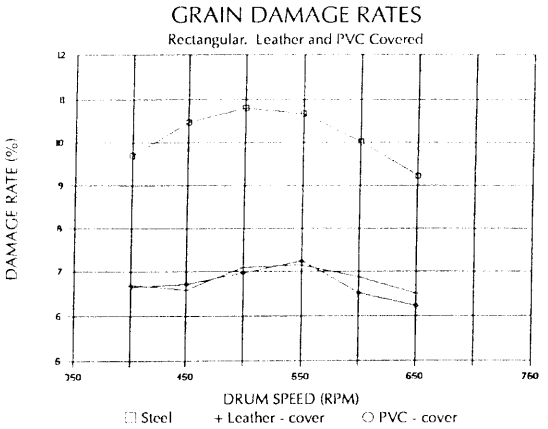

Figure 3 Grain damage caused by rectangular steel teeth attached with soft materials.

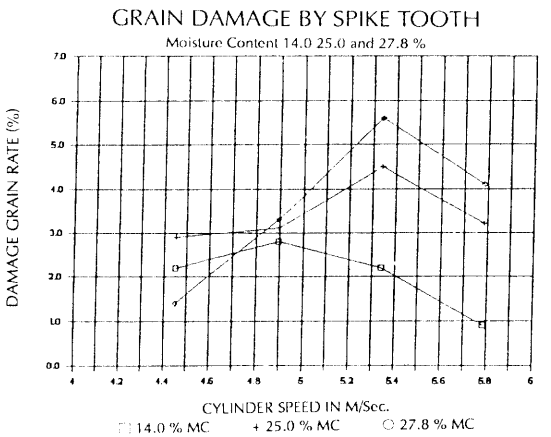

Figure 4 Grain damage caused by spike tooth.

Revolution Range: 400-2600 rpm.
Maximum Power: 30 ps
Output Power: 2.92-19.0 kw. (when used as motor)

Drum speeds used in the test ranged from 400 to 900 rpm. This was based on the values used in nornal operation by farmers. Corn varieties used were local varieties; Suwan 1 and Suwan 3. Details of these ear corn were shown in Table 1. Grain moisture level in the test ranged from 19 to about 28 percent.

RESULTS AND DISCUSSION

Two types of corn sheller manufactured commercially in Thailand, the rasp bar and the peg tooth. But the peg tooth sheller was more popular because it was simple in construction and fabrication.

It was found that drum speeds of about 4.5 to 5.5 metres per second (mps) were the best range that yielded lowest grain damage for almost every type of shelling teeth used in the test. The original type which

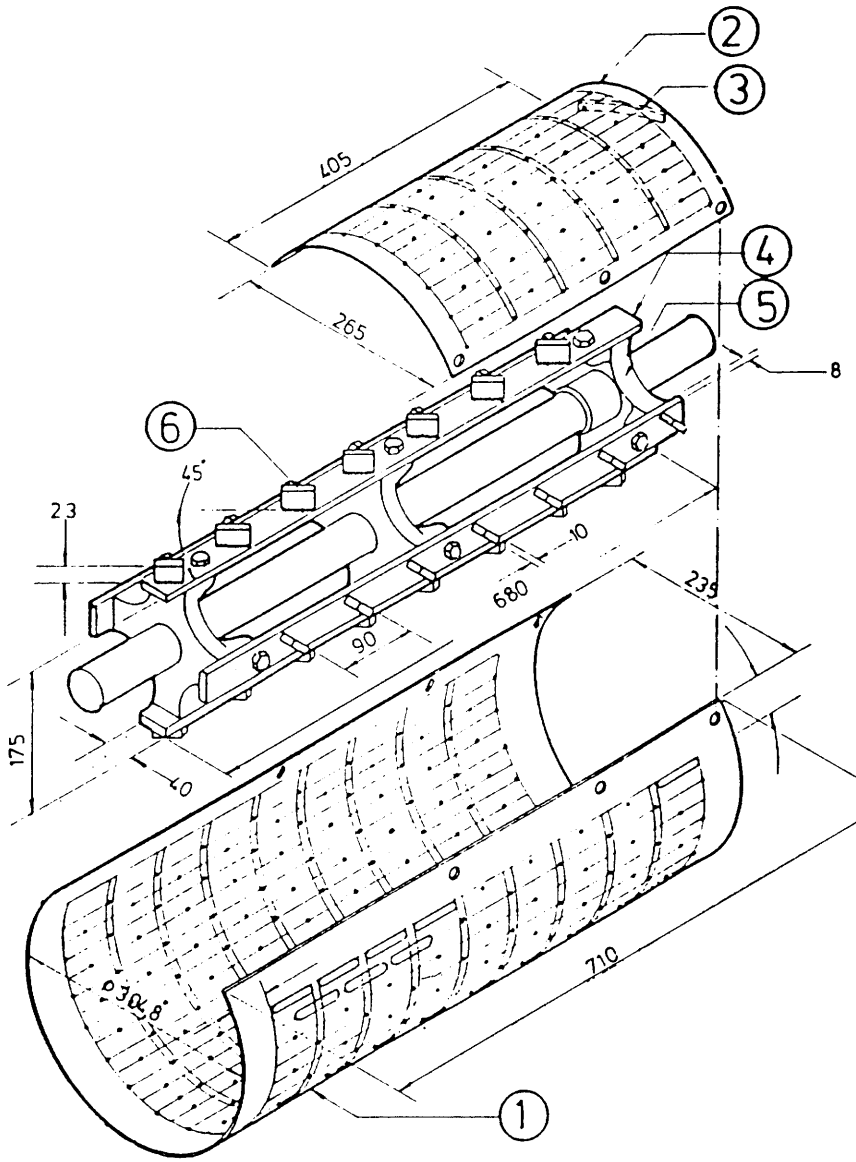

Figure 5 Conventional shelling mechanism of existing corn sheller.

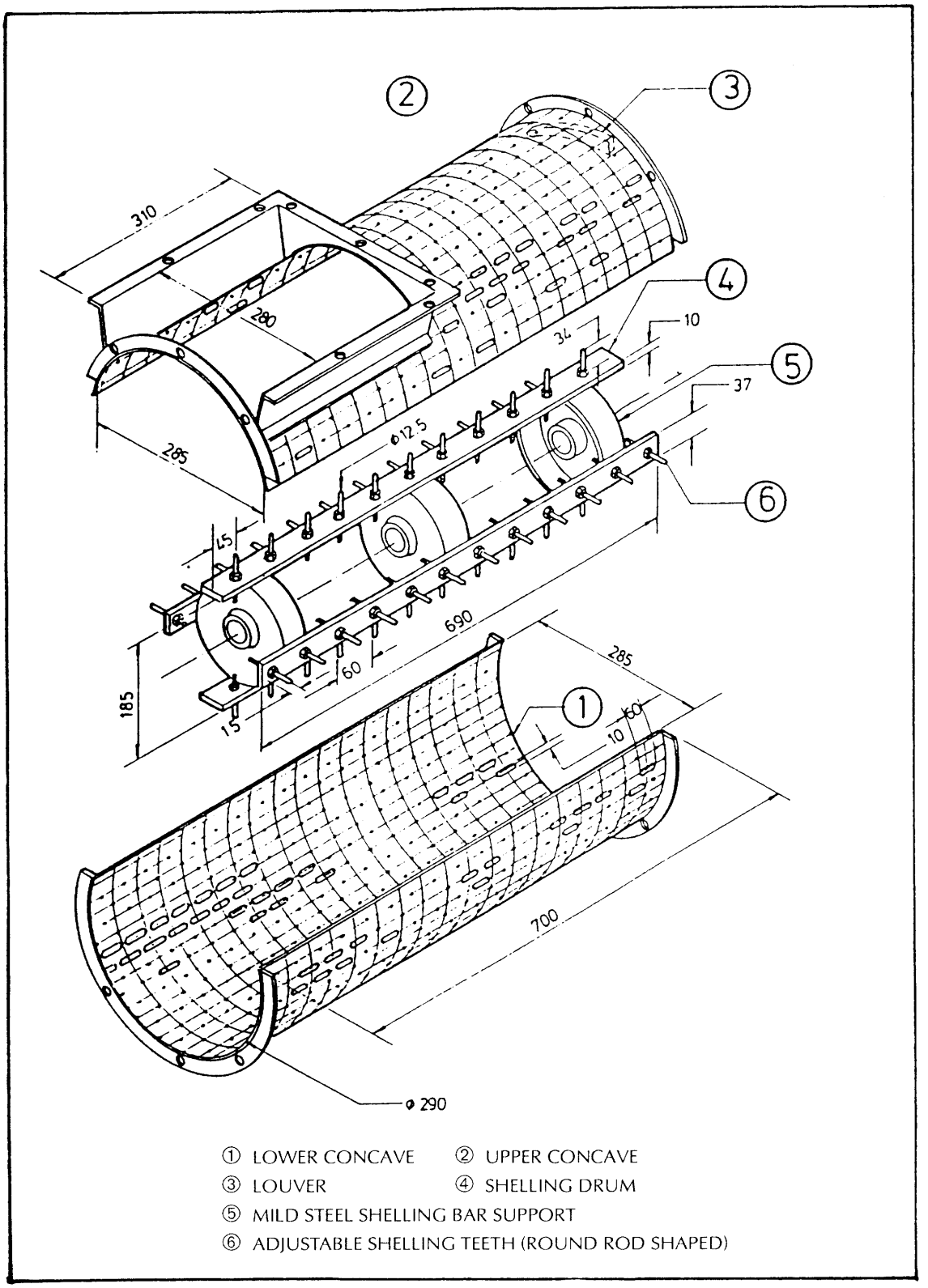

Figure 6 Design of shelling mechanism and concave for high moisture content corn.

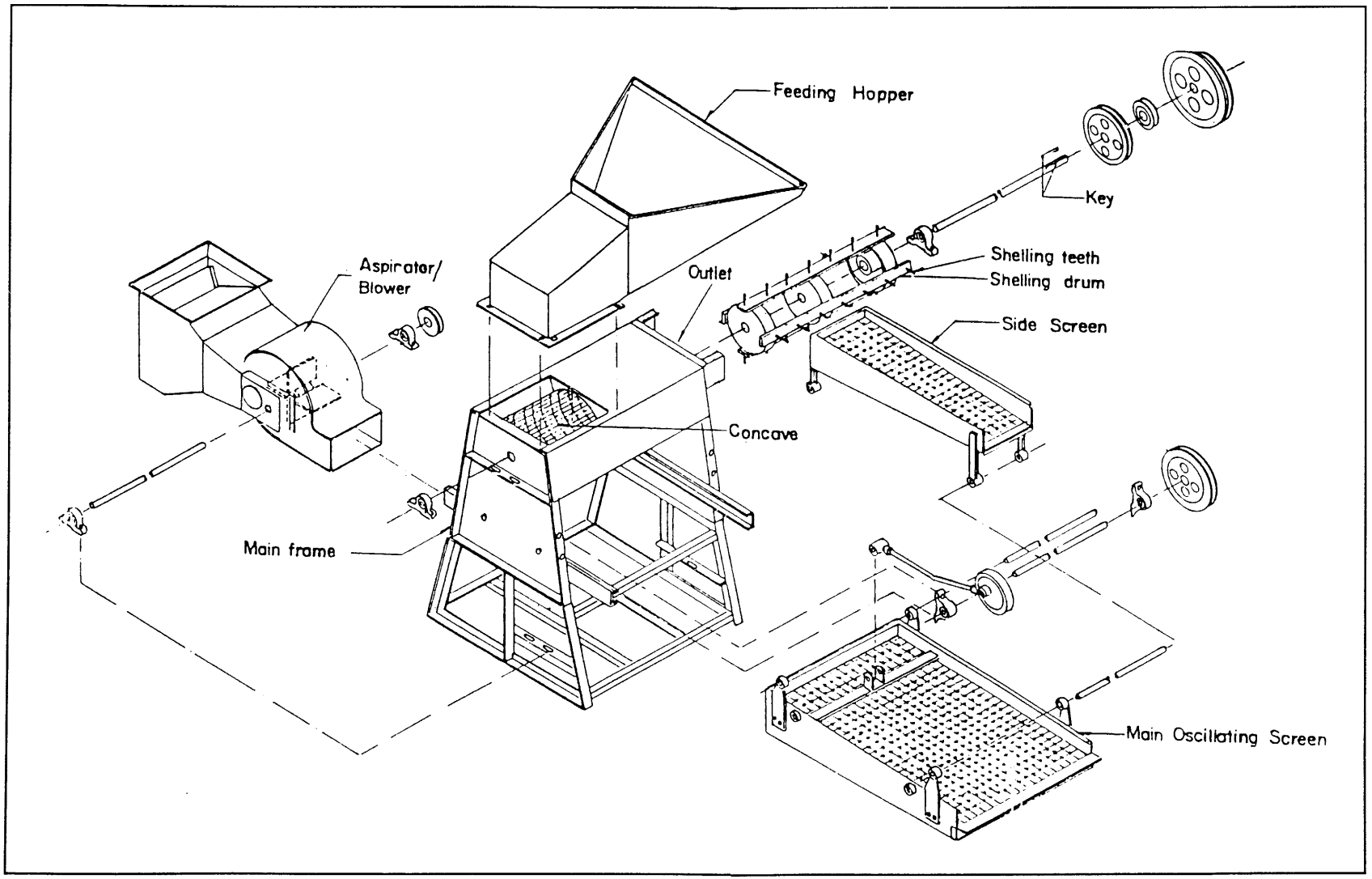

Figure 7 Details of high moisture content corn sheller.

was peg-tooth type modified to be rectangular steel plate gave lowest grain damge rate of under 3 percent when applied to corn contained moisture lower than 20 percent only. The damage increased remarkably as grain moisture increased.

The study indicated that there were many points in sneller that affected shelling performance especially the damge that occured to kernel. These were:

- type , shape and arrangement of teeth on drum,
- spacing between teeth and cylinder wall (concave clearance),
- drum speed or revolution,
- length of drum,
- size and shape of seed separating sieve.

First thing to be considered was type and shape of shelling teeth, with its arrangement on the drum as well. Many trials were done to the improvement of shelling teeth, in order to reduce grain loss by damage and unshell. First, soft materials such as a piece of leather and PVC plate were attached to the front of rectangular shape steel teeth. Second, several arrangement was made to the rows of teeth on drum bar. Third, by using spike-shape teeth instead of the rectangular ones. And the last was the design of closed-type drum with spike teeth lining 30 degrees to drum axis.

Rectangular steel tooth attached with piece of thick leather on the front yielded lowest percentage of damage among all at the same speed. Even at 27.8 percent grain moisture content. At this moisture level this type of tooth gave as low as 6.2 percent at 5.8 mps drum speed, while the PVC covered teeth took the second place of 6.8 percent at the same speed. But both materials worn off very easily and the cost of PVC plastic was somewhat high.

Spike tooth was the next to be considered. It yieled 1.3 percent damage at 19.3 percent grain moisture content, and 9.8 percent damage at 27.8 percent moisture level. Drium speed was about 5.0 mps. Kurnel damage seemed a little high. But if the concave clearance and the size of separating sieve were adjusted this damage rate was experted to be lower.

Power consumed by sheller was not so high. Between 550 to 650 rpm. shaft speed and 27.8 percent grain moisture level, rectangular steel teeth with soft material attached used less than 4 ps., while spike tooth consumed less than 2 ps. since it had less area of contact on tooth surface than rectangular one.

In the design of the whole sheller, spike tooth was selected to be used in the prototype. The following criteria was set for a design consideration:

a. Simple, with minimal change in shelling mechanism.

b. Simple fabrication techinque.

c. Easy in operation.

d. Adjustable for low moisture content corn.

Details on essential parts of prototype sheller are as followed:

Overall Dimemsion : 80 *93 *135 cm (W *L *H)

Shelling Drum : Open type, 680 mm. in total length. Outer diameter of 175 mm. bolted with four shelling bars. 12 rounded spike teeth, 12,5 mm. diameter and 34 mm. height are set 90 mm. apart on each bar and perform a line of 45 degress to drum axis. The height of teeth is adjustable for proper clearance with concave wall.

Concave : Concave has a circular shape of 305 mm. diameter, and 710 mm. in length. It made of perforated iron sheet. Inlet opening is 235 mm. Wide and 305 mm. long. Grain outlet is at the end of drum. Cob is forced to move through outlet by louver (cob guide vane) installed on the upper part of concave.

Separating System : Consists of two oscillating screens. The main screen has dimension of 63 mm. wide, 90 mm. long with slotted opening of 9 * 15 mm. positioned under the concave. It is oscillated by eccentric roller. The other screen of 240 * 720 mm. with the same size of opening is connected directly to the main screen and located next to the cob outlet to catch grain that is carried through cob outlet and send back to main screen through the path installed under this screen.

Cleaning System : The system consists of a dust disperser and an aspirator/blower. Dispersing box is 35*26*39 mm. and consists of 7 pieces of 35 degree inclined flaps. Foreign matterial that falls in to this box will be sucked out through blower outlet. Blower has 25 cm. wheel diameter with four 18*10 cm. blades. Its revolution depends on main shaft speed. volume of air flow is adjusted by changing size of inlet opening.

The design and construction of the prototype sheller has already been finished and ready for the test and further improvement.

Test Plan

Unfortunately that the prototype was finished in dry season where no ear corn was available tor

testting. Harveting season for corn is from September to December. However, the test will be carried on as soon as the first corn area starts harvesting.

Testing will be undertake in comparison with the selected sheller at several grain miosture levels with highest value of 28 percent. The test will be based on the standard testing procedure notified in the "Corn Sheller Standard Document 1989" issued by Thailand Industrial Standard Institute, with the exception on the grain moisture content which will be higher than 20 percent.

Testing procedures will be carried out for the following items:

1) Shelling drum speed.

2) Cleanrance between drum and concave wall (concave clearance).

3) Rate of air flow through blower.

4) Shape and size of concave sieve.

5) Rocking speed and inclined angle of separating tray.

The following data will be collected for evaluntion and analysis:

1) Shelling capacity.

2) Grain damage and unshelled rates.

3) Grain loss through blower.

4) Grain cleanliness.

5) Vibration.

Corn varieties used in this test will be selected from the varieties widely accepted by corn growers. And the test is expected to be carried out promptly whenever the required material is available.

ACKNOWLEDGEMENT

The author would like to express sincere appreciation to the KU - JAPAN Phase II project for kindly providing of equipment, machines and experts, and to KURDI for the provision of budget which makes this project possible. Deeply thank is also expressed to the Agricultural Engineering Division, Ministry of Agriculture and Cooperatives for the help in provision of some valuable data and designing of the prototype.

LITERATURE CITED

จารุวัฒน์ มงคลธนทรรศ และ คณะ การใช้เครื่องกะเทาะข้าวโพด เอกสารการสัมนาพิเศษ เรื่อง การป้องกันกำจัดสารพิษแอฟลาท็อกซินในข้าวโพด มหาวิทยาลัยเกษตรศาสตร์ 1 เมษายน 2529

ภรต กุญชร ณ อยุธยา และคณะ การทดสอบและประเมินผลเครื่องกะเทาะข้าวโพด รายงานวิจัยเสนอ Asean Crops Post Harvest Programme ภาควิชาวิศวกรรมเกษตร คณะวิศวกรรมศาสตร์ มหาวิทยาลัยเกษตรศาสตร์ เมษายน 2530

ศูนย์สถิติการเกษตร สถิติการเกษตรของประเทศไทย ปีเพาะปลูก 2529/2530 เอกสารสถิติการเกษตร สำนักงานเศรษฐกิจการเกษตร พ.ศ.2531

Amano, Kensuke. The thresher - modified corn sheller. Final Report of Agricultural Extension and Agricultural Mechanzation Project. Part II: Agricultural Mechanization Project. KU Agricultural Extension and Agricultural Mechanization Project, JICA. June,1986. p.133-142.

Burkhardt, T.H. and Stout, B.A. Laboratory investigation of corn shelling utilizing high-velocity impact loading. ASAE Transaction Vol. 17, No. 1, January - February, 1974.

Byg, D.M. and Hall, G.E. Corn losses and kurnel damage in field shelling of corn. ASAE Transaction, Vol.11, No.2, March - April, 1968.

FMO Fundamentals of Machine Operation; "Combine Harvestion". John Deere Service Publication, 1973.

Hall, G.E. and Johnson, W.H. Corn kernel crackage induced by mechanical shelling. ASAE Transcation, Vol.13 No.1, January - Frbruary, 1970.

Hathaway, L. (Editor),. Combine harvesting. Fundamentals of machine opration, John Deere Service Publications. Deere & Company, 1973.

Keller, D.L. et.al, Corn kernel dagame due to high velocity impact. ASAE Transaction Vol. 15 No. 2, March - April, 1972.

Ronald, B.W. and Marley, S.J. Roller sheller low damage corn shelling. ASAE Transaction Vol. 16, No. 1, January - February, 1973.

Yamauchi, T., Artachinda, A. The improvement of corn sheller for high moisture content corn. Technical Report, Strengthening Research Activities in Kasetsart University (Phase II) Project, September, 1990.

Yoshihara, Tooru. Performance test of corn sheller. Final Report of Agricultural Extension and Agricultural Mechanzation Project. Part II: Agricultural Mechanzation Project. KU Agricultural Extension and Agricultural Mechanization Project, JICA. June, 1986. p.202-217.