RESULTS AND DISCUSSION

6- RESULT AND DISCUSSION

6-1 Belt Conveyor Evaluation:

A belt conveyor system was developed to transport a high material flow rate to the threshing section of the thresher. The speed of the crop was assumed to be the same of the slats and belt.[Schueller, et al., 1985]

Figure 15 shows the time required for the material to move on the conveyor. It is calculated as material velocity divided by the length to be transverse. Thus for the feeder conveyor:

$$\text{crop dwell time} = \frac{crop.velocity}{feeder.length}$$

The feeder unit was 2.55 m long and hydraulically operated at a speeds of 120, 125, 165 and 180 m/min (2 m/s, 2.08 m/s, 2.66 m/s and 3 m/s). Thus the value for crop velocity in m/s for the conveyor belt was (2, 2.08, 2.66 and 3 m/s). Therefore, crop time on conveyor belt was calculated using the above equation: at 0.7, 0.8, 1.05 and 1.15 seconds, at 2, 2.08, 2.66 and 3 m/s of conveyor belt speed respectively. Agricultural Engineering Research Institute (AENRI) in a 1988 report had no record of crop throughput. Therefore, the mechanical feeder was designed and established improved thresher capacity, besides improving eveness and controlled feed rates. During wheat field tests under normal working conditions three different feed rates (2400, 3000 and 3600 kg/h)were achieved by three different human operators.

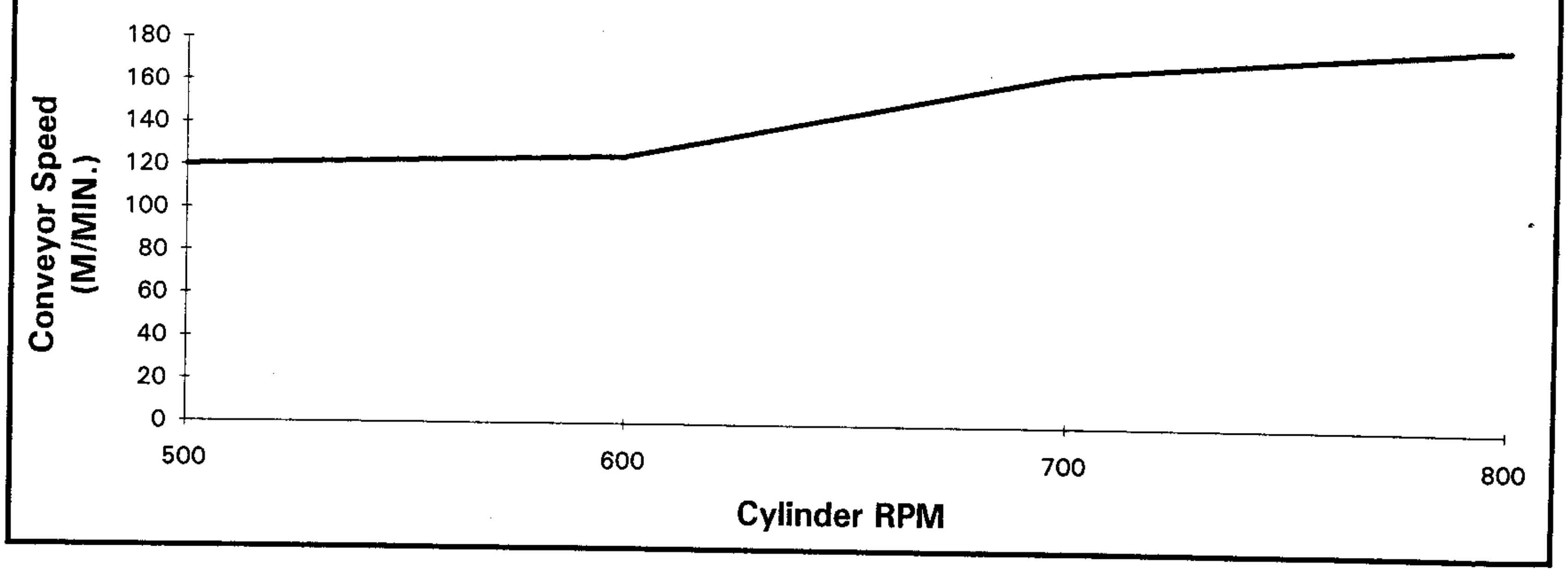


Figure 15:CONVEYOR BELT SPEED(M/MIN.)

6-2 Thresher Efficiency:

6-2-1 Wheat Crop Throughput, Grain output and Grain Loss:

Wheat crop throughput, grain output, grain loss, grain separation, grain straw ratio and straw break-up are used to calculate thresher efficiency.:

The thresher machine was tested, during 1988 under Egyptian conditions by the Agricultural Engineering Research Institute (AENRI) on paddy rice. Note the thresher efficiency on wheat test started after the modifications had been done at Purdue University Agricultural Engineering Department during the wheat season of 1993.

Figures 16 & 17 provide thresher machine efficiency for wheat tests at a cylinder speed of 800 rpm and a crop moisture content of 17.8 %, for three wheat crop feed rates of 40, 50 and 60 kg/min (2400, 3000 and 3600 kg/h). Grain output was 953.32, 1313.28 and 1323.84 kgs/h respectively. Due to machine modification several times wheat test have been delaied, this resulted to grain losses in storage field. At the same time soil firtility was the major factor of crop production from one spot to another. Therefor, machine performance was measured according to crop feed-rate. Also at the same time grain samples for grain losses determination were collected at the same feed rate. The values were 0.1716, 0.212 and 0.084 kg/h respectively. The grain losses were measured according to the crop throughput per hour [ASAE Standard]. Therefore, grain losses at 2400 kg/h feed rate was 0.171 kg/h. When the feed rate increased to 3000 kg/h, grain losses increased to 0.212 kg/h, but grain losses decreased to 0.084 kg/h at a feed rate of 3600 kg/h. At the high feed rate the thresher performed the best. This amount of grain loss was less than 1 %, which met ASAE standard # S343 T. Several trails of wheat threshing have been carried out at 400, 500, 600, and 700 cylinder rpm and at three different feed rates of 2400, 3000 and 3600 kg/h. Wheat straw accumulated inside the thresher due to a poor design of the straw thrower, and it was very difficult to collect grain output or grain losses at 500, 600 and 700 rpm. Random samples of wheat grain for the 800 rpm.tests were collected and examined for grain damage and grain purity. Grain damage was zero percent and grain purity was 99 % for the 800 rpm test and a 17.8 % crop moisture content.

Crop velocity was reported to be one-third that of the peripheral velocity of rotor [Depauw, 1977]. The average velocity of the straw in the threshing zone equation No (1) page (51) is assumed to be:

$$\overline{V_s} = \frac{k_f v_o + k_r v_T}{2}$$

From this equation the average crop velocity was determined as:

$$\overline{V_s} = \frac{0.47 + 3.424}{2} = 1.947 m/s$$

where $k_f = 0.4$ and $k_r = 0.4$, v_0 is belt feeder speed and v_T is peripheral speed of the rasp bars. The velocity will depend upon crop velocity as well as crop moisture content, the ratio of grain to MOG, and the threshing drum speed.

Under the assumption from Depauw of crop velocity being one-third that of the threshing rotor peripheral speed for 800 rpm, the crop dwell time test equation No (3) page (52) was computed to be:

$$t = \frac{L + 3 rotation * \pi * cyl.diam.}{1/3 * cyl.rpm * \frac{\pi}{60} * cyl.diam.}$$

substituting in the models gives dwell time as:

$$t = \frac{1.2 + 3 * 3.14 * 0.63}{(1/3 * 800 * 3.14)/60 * 0.63} = 0.822 \text{ sec.}$$

The actual time of crop movement along thresher cylinder was two seconds at 800 cylinder rpm and 60 kg/min feed rate. This time was measured from the moment colored crop reached the bottom edge of the thresher hopper until the colored straw came out of the cylinder straw outlet. The difference was between the theoretical time and actual time

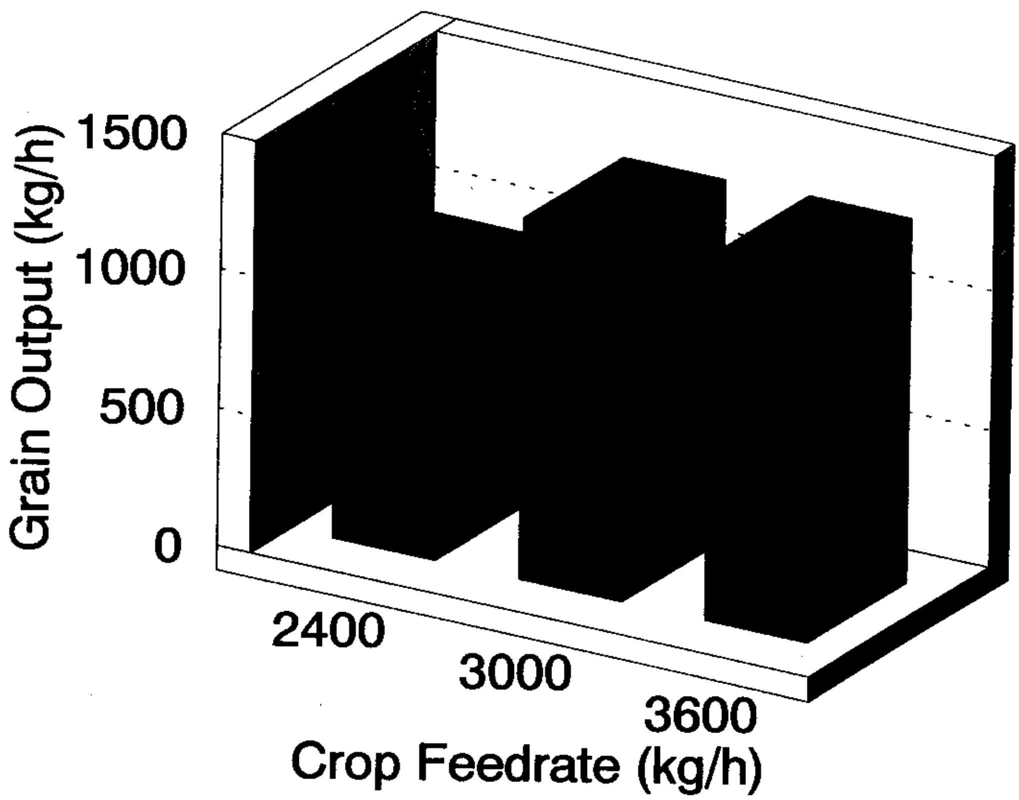


FIGURE 16 : MACHINE PERFORMANCE AT 800 CYLINDER RPM AND M.C. 17.8%

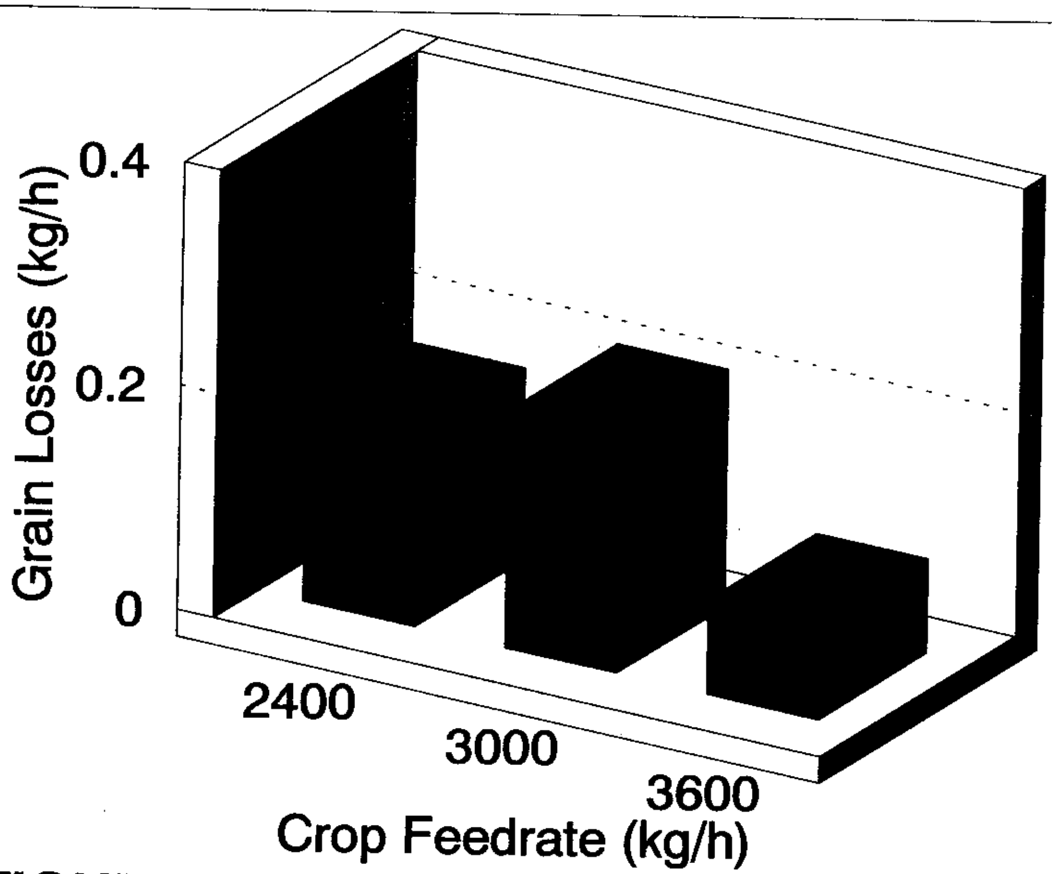


FIGURE 17 : THRESHER GRAIN LOSSES AT 800 CYLINDER RPM

in the threshing area, according to crop moisture content, concave and cylinder design and configuration. { El-Amin 1994} indicated threshing efficiency was increased by increasing the cylinder speed. Spike drum; hole/oval concave. This prove the results we obtained.

Figure 18 indicates grain separation at different distances along the threshing cylinder for the 800 cylinder rpm test and at a crop flow rate of 3600 kg/h, for 14.3 % moisture wheat. Three hundred and fifty-one grams were collected on the collection pan placed under thresher concave. The first section (0 - 30 cm.) had a separated grain percentage of 39.88 %. On the second section (30 - 60 cm.) of pan 426 grams of grain was collected for the separated grain percentage of 48.40 %. The amount of grain collected on the third section (60 - 90 cm.) was 103 grams and grain separated percentage was 11.70 %. Using Huynh et al. 1982 model for equation No:(8) page (53)

$$\overline{\delta_{max}} = \frac{Q}{\rho V_s w}$$

$$\overline{\delta \max} = \frac{1}{55 * 1.2 * 1.947} = 0.003 \text{ meter}$$

where $\overline{\delta_{max}}$ has thiknes unit in meters, Q is the mass feed rate kg/h, is free density kg/m,w width of the thresher,V is the peripheral speed of the rasp bars.

The mass flow analysis diagram for the thresher is shown in Annex IV.The numbers are assigned to the different working units, and the letters show the different flow of materials during processing in the machine. First unthreshed wheat is fed by conveyor belt to the crop hoppers, into the threshing unit (1). Then wheat kernels and chopped straw (b, c) drop onto the sieve separator (2). Eccentric action separates materials into three directions, dirt (i) moves toward to dirt collection pan, straw (d) is drawn by the suction fan (3) and blown onto the field (e) while wheat kernels (f) drop onto the grain pan underneath the sieve separator pan. Then wheat kernels (g) moved up to the cyclone separator (4, 5), and finally they are transports (h) going to a bagger (6) and stored in bags. The mass flow analysis of rice threshing. Unthreshed rice (a) is fed into the threshing unit (1) by a conveyor belt to a hopper. Rice straw (c) is ejected outside the

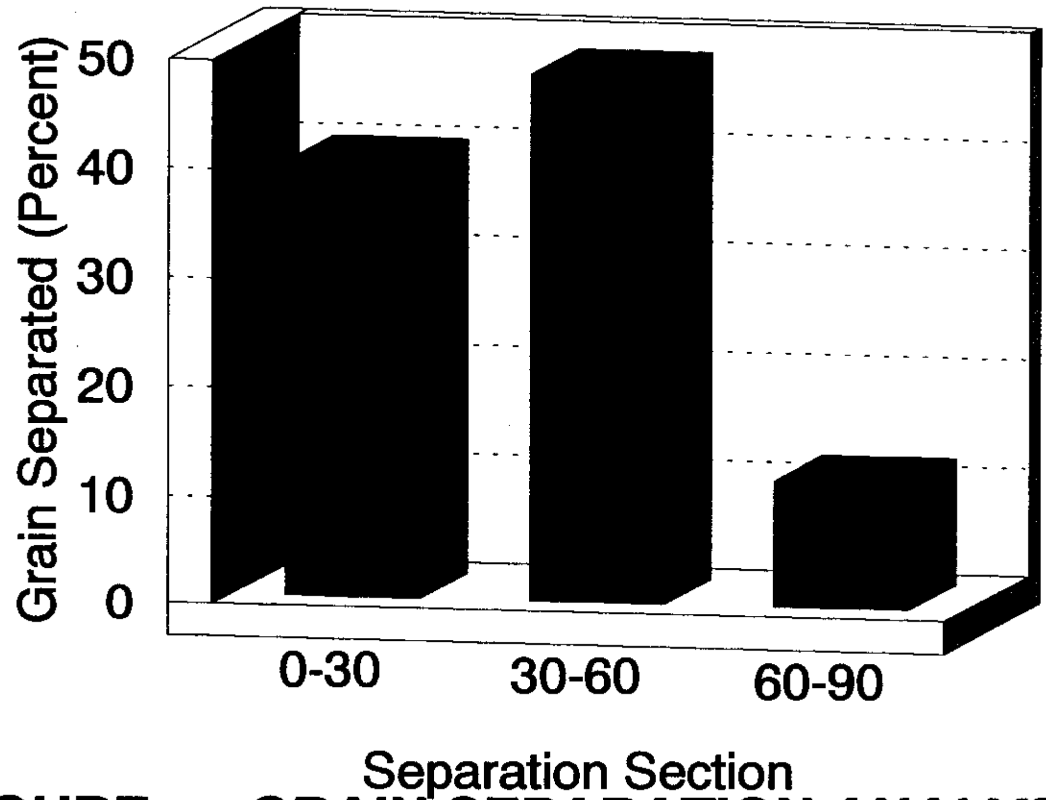


FIGURE 18 : GRAIN SEPARATION ANALYSIS ALONG THRESHER CYLINDER

was 1:1.66. This figure confirmed thresher machine efficiency at a feed rate of 3600 kg/h and a grain output of 1323.84 kg/h and a straw output of 2276.16 kg/h.

Figure 19 shows straw break up for two separate tests. First the straw is broken by threshing and second the straw is measured after straw chopper treatments. This figure indicate that the straw length fell into three groups and two treatments. In group one straw length after threshing was 25 cm., but straw length was reduced to 7.233 cm. after chopping. For the second group straw length was 13.066 cm. after threshing, but when treated by the chopper straw length reduced to 2.41cm. In the thired group straw length was 6.4 cm. after threshing, but when straw was treated by a straw chopper the straw length become 2.34 cm. Therefore, a chopper attachment might be needed if the farmer will not accept long straw after threshing.

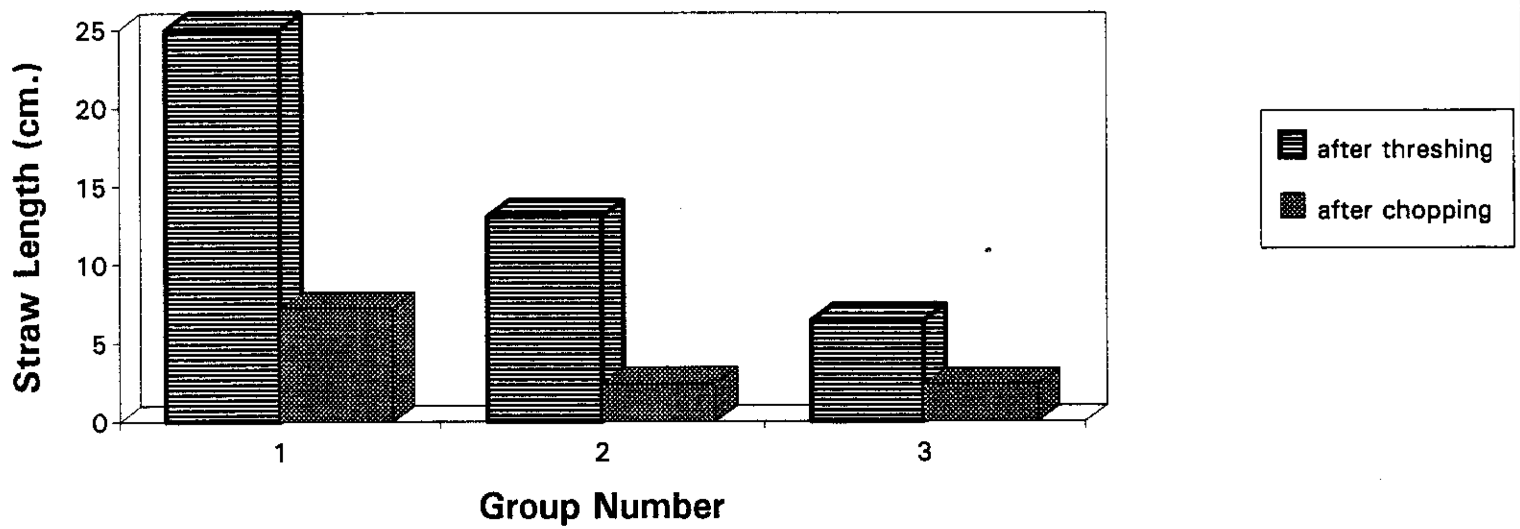
6-2-2Soybean Throughput, Seed Loss, and Seed Damage

Figure 20 & 21 provide thresher machine efficiency for threshing soybeans. Two thresher cylinder rpm's were used (300 and 400) , for a crop moisture content 13.8 % at 40 kg/min (2400 kg/h) crop feed rate. Results indicated that, seed losses were 0.19 % at 300 rpm, and increased to 0.25 % at 400 cylinder rpm. Also seed damage was 7.315 % for 9.15 % moisture content at 300 cylinder rpm and increased to 8.42 % for 13.8 % moisture content soybeans, at 400 cylinder rpm., Also, soybean seed damage was 15.458 % for 9.15 % moisture content and 300 cylinder rpm and increased to 16.915 % for 13.8 % moisture content and 400 cylinder rpm at a flow rate of 40 kg/min. This figure indicats that cylinder rpm and seed moisture content had a major effect on seed damage.

6-2-3Corn Throughput, Seed Loss, and Seed Damage

Figure 22 shows results of the corn shelling test at two different cylinder speeds (300 and 345 rpm) and two different ear shelling conditions of non-husked ears and husked

Figure 19 : WHEAT STRAW LENGTH VS. GROUP NUMBER.



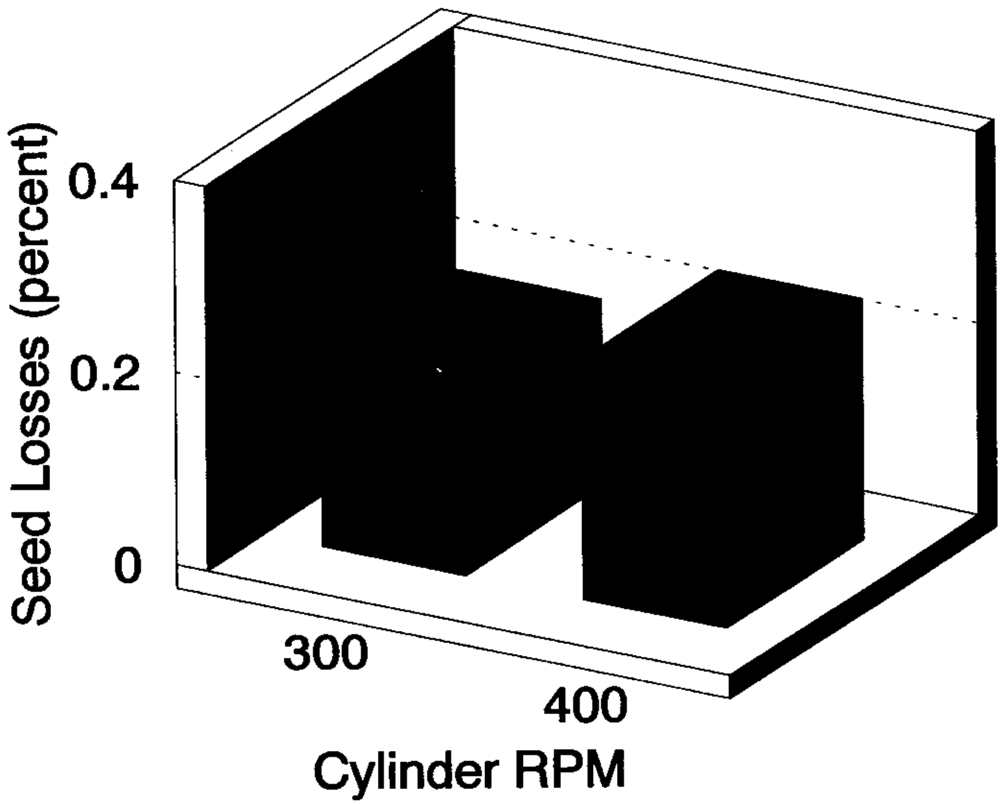


FIGURE 20 : SOYBEAN SEED LOSSES AT 40 KG/MIN FEEDRATE AND M.C. 13.8%

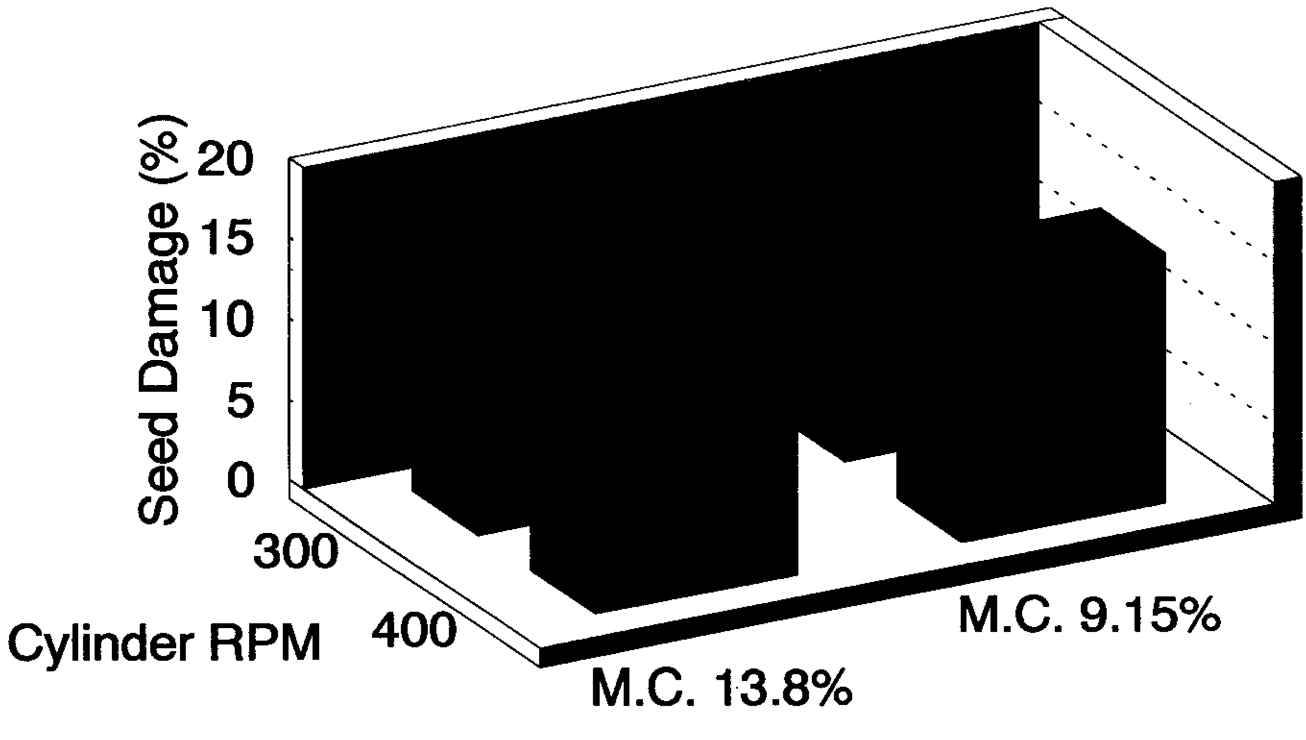


FIGURE 21 : SOYBEAN SEED DAMAGE IN PERCENT

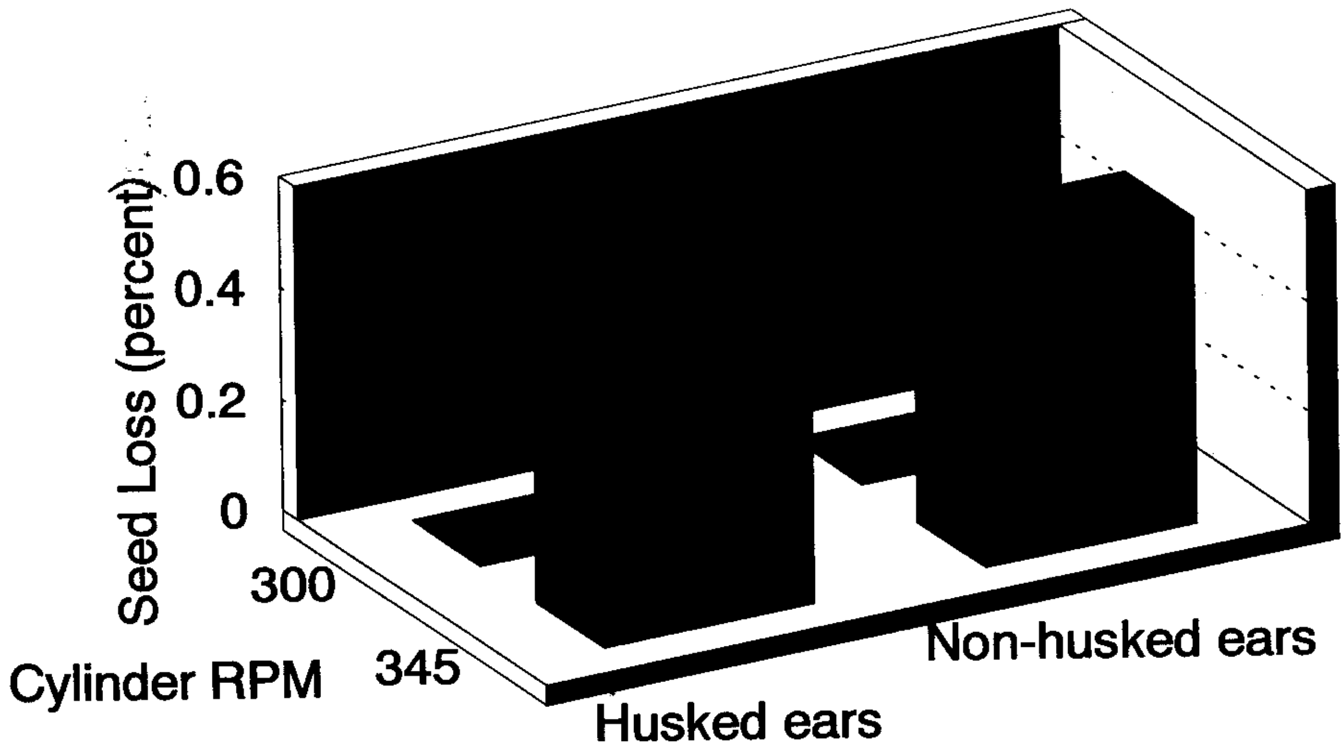


FIGURE 22 : CORN SEED LOSS AT 100 KG/MIN FEEDRATE AND M.C. 15.8%

ears. Seed losses were measured at 300 and 345 cylinder rpm for a feed rate of 100 kg/m/min. and a moisture content of 15.8 %. During corn shelling at 300 cylinder rpm the tractor engine stopped because the tractor fuel pump governor setting was at the maximum of the rated and avaliable power was exceeded. Therefore, the corn shelling test was conducted at a 345 cylinder rpm at the same feed rate and crop moisture content. Kernel losses for non- husked ears was 0.55 % and kernel losses for husked ears was 0.475%. Corn losses was higher when the thresher was fed with non-husked ears. I observed that ear husks hold some kernels at the thresher outlet but kernel losses were less when husked ears were shelled.

Figure 23 provides the percentage of corn kernel damage at 345 cylinder rpm and a feed rate of 100 kg /min for corn ears of 15.8 % moisture content. Corn kernel damage was 8.092 % for non- husked ears and 12.29 % for corn husked ears. Kernel breakage was less on non-husked ears than husked ears. This was due to the fact that husk's protect the kernel from cylinder impact. Random corn samples were collected for a corn kernel breakage test, and the percentage of kernel breakage were determined by two methods. The first method was mechanical kernel sieving and the second method was light bulb visual inspection.

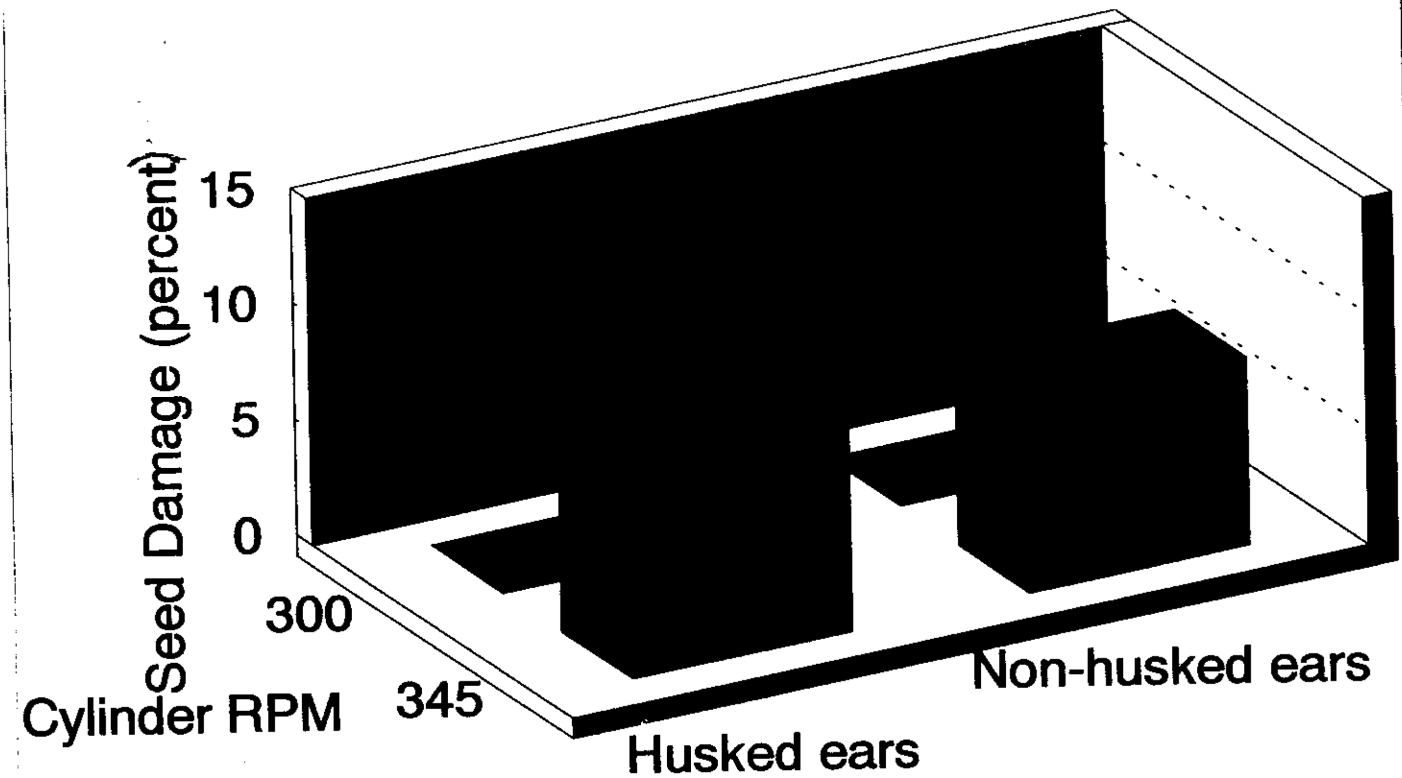


FIGURE 23 : CORN SEED DAMAGE AT 100 KG/MIN FEEDRATE AND M.C. 15.8%

6-3 Straw Fan Air-Flow

The thresher machine has two different types of fans. The straw fan mounted on the same threshing drum shaft has the main function to eject MOG outside the threshing system. The chaff fan is located on top of the grain screen and is mounted on an independent shaft and driven by a V-belt. The chaff fan separates chaff and light material from the grain.

Test results of the thresher fans air-velocity lab test at different thresher cylinder rpm's (500, 600, 700 and 800) for both the straw and chaff fans are shown in figure 24. For 500 rpm cylinder speed the air-velocity of the straw fan was 353.4 m/min and it increased incrementally to 365.8, 460.3 and 493.9 m/min. at 600, 700, and 800 rpm respectively. Also, the air-velocity of the chaff fan was measured at 500, 600, 700 and 800 rpm, and was 341.4, 346, 417.6 and 530.4 m/min respectively. [R. A. Kepner 1972], reported that a blower fan could handle agriculture materials at an air-velocity of 1000 - 1500 m/min.. Therefore, several modifications were conducted to increase the straw fan air-velocity. First, the straw fan outlet and chaff fan outlet were combined together, air-velocity was measured at 500, 600, 700 and 800 cylinder rpm and was 292.6, 362.8,417.6 and 551.5 m/min respectively. In the second modification the straw fan was disconnected from the chaff fan and connected to the grain loading fan and air-velocity was measured at 500, 600, 700 and 800 rpm with the air-velocity increasing to 295.7, 364.3, 423.7 and 603.3 m/min. Both modifications did not reach air-velocities recommended by Kepener et al. 1973. It was decided to conduct research on redesigning the thresher straw fan according to standard engineering designs at some future test.

Limited modifications were done on the straw fan. Straw fan blades were increased by 3 cm. in length, which reduced the gap between the straw fan blades and straw fan housing to 3 mm. as recommended by Kepner et al. 1973.

Figure 24 : THRESHER FANS-AIR VELOCITY VS. CYLINDER RPM

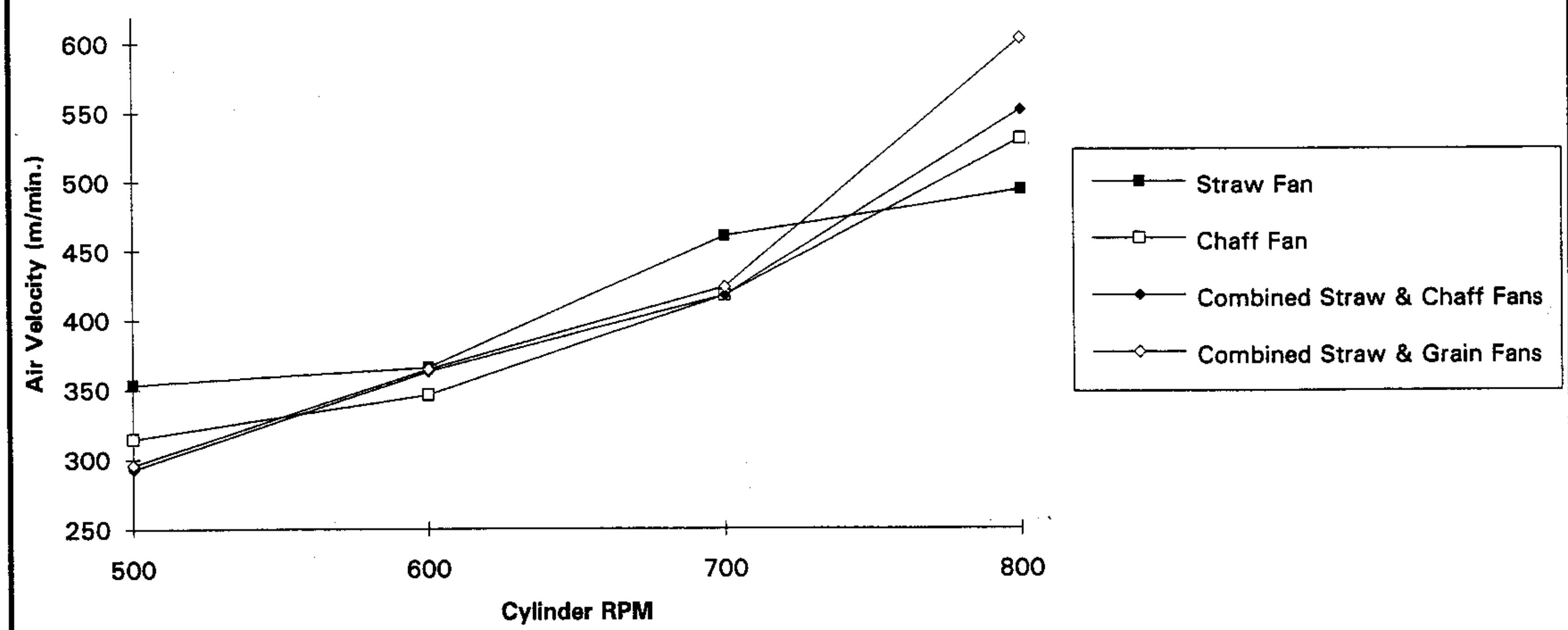
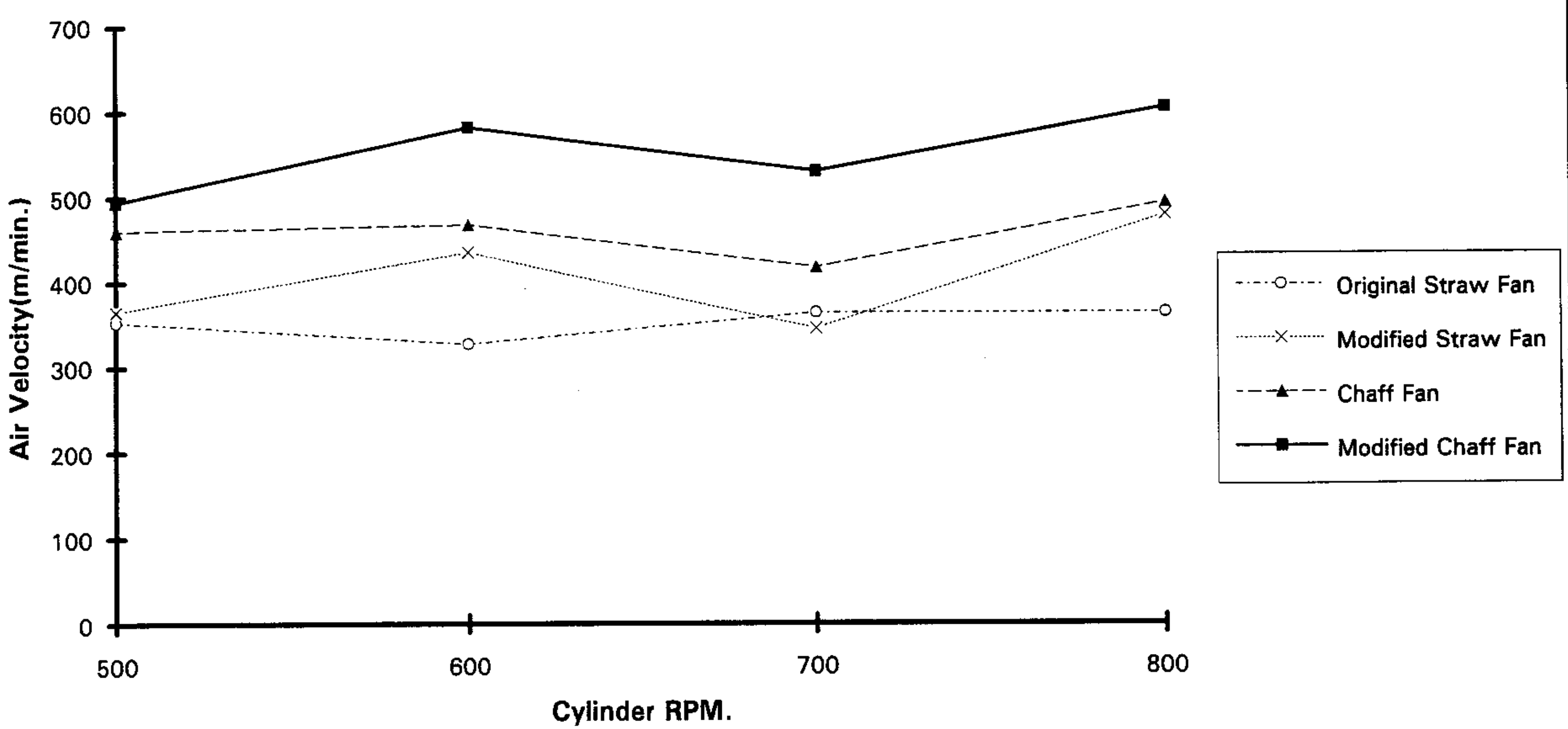


Figure 25 shows straw fan air-velocity m/min. before and after modifying the fan blades and narrowing the clearance between the blades and straw fan housing to 3 mm. The data for tests run before modifications at 500, 600, 700 and 800 rpm had a straw fan air-velocity 353.4, 365.8, 460 and 493.9 m/min respectively. After that fan blades were modified and clearance between fan blades and fan housing reduced to the recommend gap of 3 mm.. Air-velocity was measured at 500, 600, 700 and 800 rpm and the results were 328.2, 435.6, 468.5 and 582.5 m/min. Therefore, the straw fan air velocity improved by 19 %,1 %, and 17 %, at 600, 700 and 800 rpm. Addition work was recommended for a 2 years project. Also the chaff fan (separating fan) air-velocity was measured before and after straw fan modification to determine the effect on chaff fan efficiency. Before the straw fan modification for 500 rpm the air-velocity of the chaff fan was 364.6m/min and it increased to 346, 417.6 and 530.4 m/min. respectively for wheat. Also, the chaff fan air-velocity was measured after the straw fan was modified and at 500 rpm the air-velocity was 364.6 m/min. and increased incrementally to 479.5, 493.9 and 605 m/min. for 600, 700 and 800 cylinder rpm, Because the air turbulence was less after straw fan modification, the chaff fan air-velocity improved by 6 %, 38 % and 18 %, at 600, 700, and 800 cylinder rpm.

Figure 25: THRESHER FANS-AIR VELOCITY,AIR VELOCITY VS. CYLINDER RPM



6-4 Energy Requirements and Efficiencies

The thresher has a simple power transmission system. Power from the tractor is fed to the thresher counter shaft through a connecting PTO shaft. The counter shaft drives the threshing drum shaft with three V-Belts. The pulleys on the counter shaft and threshing drum can be integrated to provide the 300- 1000 rpm threshing drum speeds needed for threshing different crops. After reading all test reports on this thresher machine published by June, 1990, [AERI annual reports] it was found that power requirements were not included for the thresher under normal operating conditions in Egypt. Therefore, a thresher power test has been carried out at the AGEN workshop and wheat field at the Purdue Throckmorton farm.

6-4-1 Laboratory Tesr:

Figures 26-30 provided the results of the power required in kW at different tractor PTO rpms (280, 300, 350, 380 and 410) for different components of the system. The first run measured the power required to operate components at a no- load condition. The thresher cylinder, bagger fan, cleaning sieve and separating fan (chaff fan) at 280 P.T.O rpm required 2.798 kW (torque 95.5 N/m) and increased to 7.509 kW (torque 175 N/m.) The second run measured power to operate the system at No- load except the bagging fan was disconnected. For 280 P.T.O rpm power measured was 2.161 kW (73.75 N/m.) and increased to 7.18 kW (167.6 M/m). The third run measured power required in the lab at different P.T.O rpms (280, 300, 350, 380 and 410). At 280 P.T.O rpm the fans (bagging and separating) were disconnected and average power measured was 1.49 kW (51 N/m) and it increased to 3.604 kW (84 N/m) at 410 P.T.O rpm. Finally, the bagging fan, separating fan and grain sieve were disconnected and power measured was 0.73 kW (25 N/m) at 280 P.T.O rpm and increased to 2.338 kW (54.5 N/m) at 410 P.T.O rpm., This

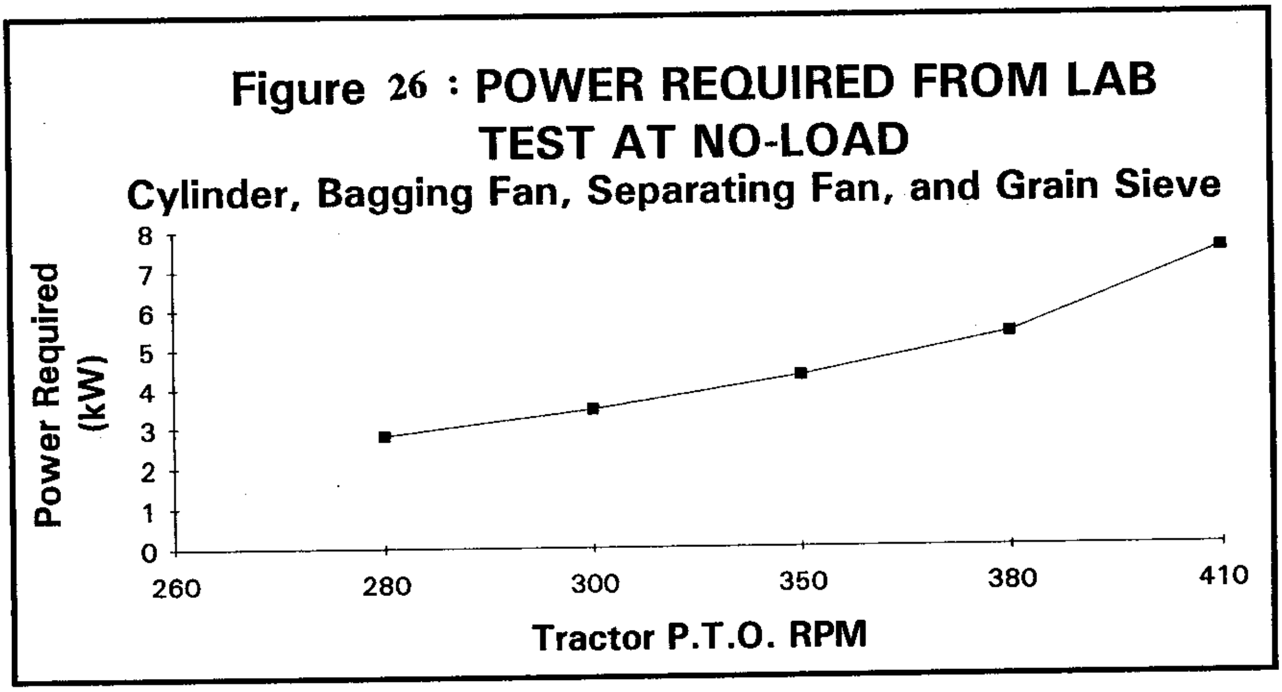


Figure 26 : POWER REQUIRED FROM LAB TEST AT NO-LOAD
Cylinder, Bagging Fan, Separating Fan, and Grain Sieve
Power Required (kW)
0
1
2
3
4
5
6
7
8
260
280
300
350
380
410
Tractor P.T.O. RPM

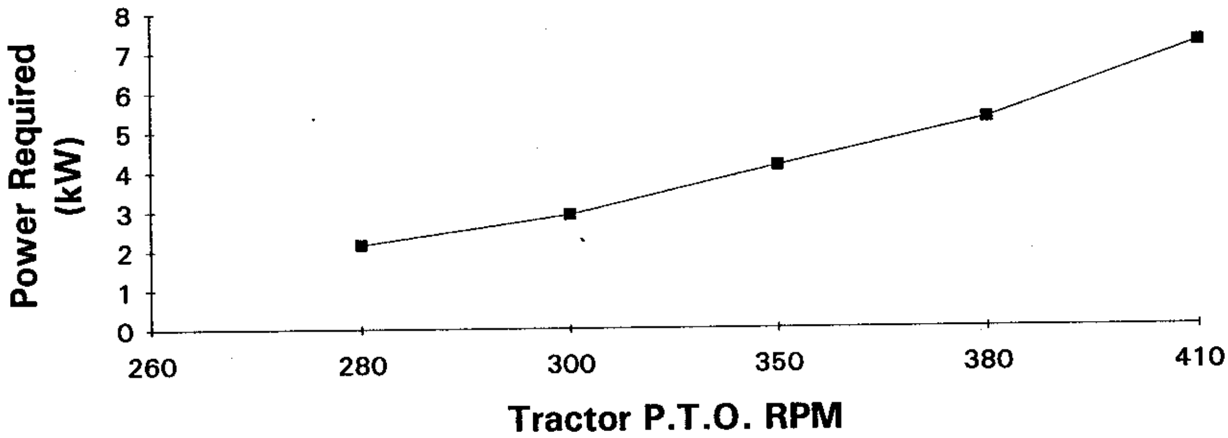


Figure 27 : POWER REQUIRED FROM LAB TEST AT NO-LOAD

Cylinder, Separating Fan, and Grain Sieve

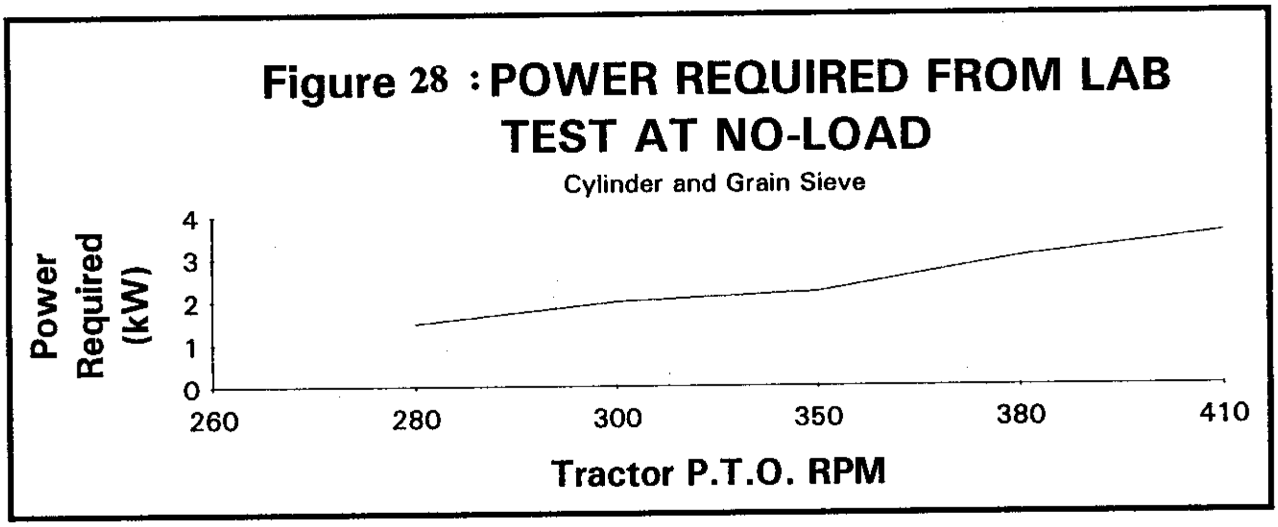


Figure 28 : POWER REQUIRED FROM LAB TEST AT NO-LOAD
Cylinder and Grain Sieve
Power Required (kW)
0
1
2
3
4
260
280
300
350
380
410
Tractor P.T.O. RPM

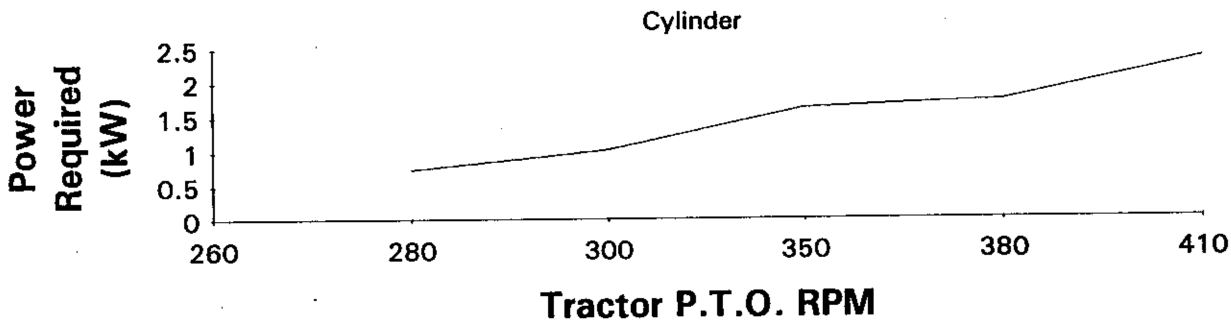
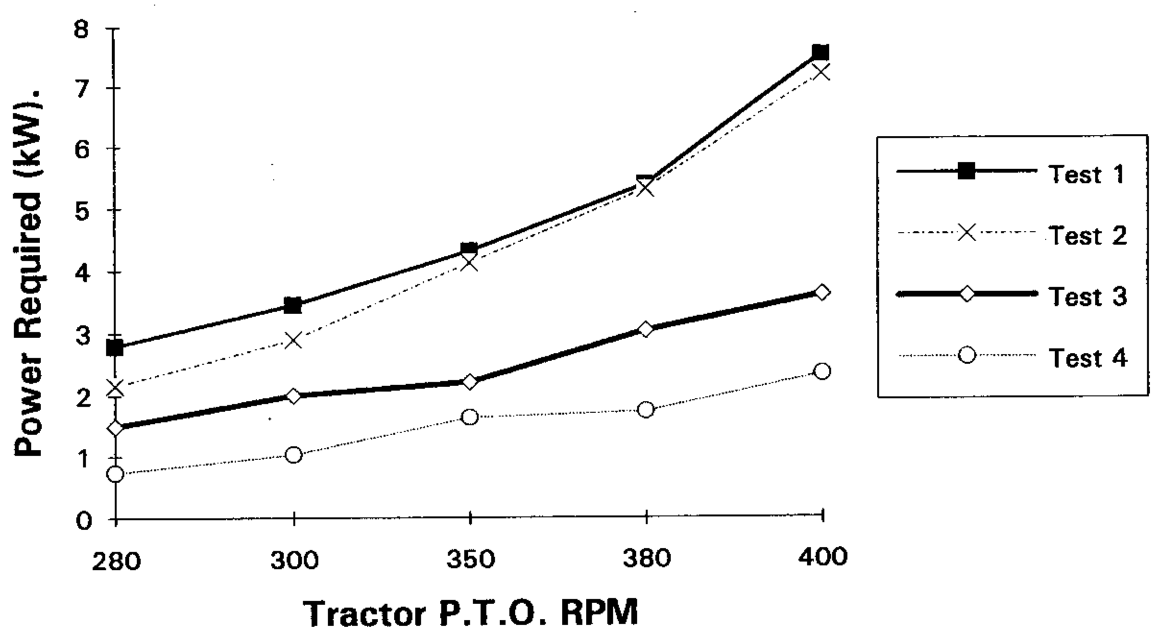


Figure 29 : POWER REQUIRED FROM LAB TEST AT NO-LOAD

Figure 30 : POWER REQUIRED FROM LAB TEST AT NO-LOAD.



Test1 : Cylinder + Bagging Fan + Separating Fan + Grain Sieve
Test2 : Cylinder + Separating Fan + Grain Sieve
Test3 : Cylinder + Grain Sieve
Test4 : Cylinder

test allowed us to measur no-load power required in kW and torque (N/m) for each system component.

Figures 31 shows the results of power required (kW) at the different tractor P.T.O rpm's 280, 300, 350, 280 and 410 for each component of the system. The power required to operate a no- load bagging fan at 280 P.T.O rpm was 0.637 kW and 0.329 kW at 410 P.T.O rpm. Also the power measured to operate a no-load separating fan (Chaff Fan) was 0.671 kW at 280 P.T.O rpm and 3.570 kW at 410 P.T.O rpm. The grain sieve power at non- load at 280 P.T.O rpm was measured as 0.757 kW and 1.266 kW at 410 P.T.O rpm. Finally, the power measured to operate a no- load threshing cylinder was 0.732 kW at 280 P.T.O rpm and increased to 2.338 kW at 410 P.T.O rpm. The power required per cm to operate a no- load thresher cylinder was 0.00006 kW at 280 P.T.O rpm and 0.019 kW for the thresher at 410 P.T.O rpm.

6-4-2 **Field Test:**

Figure 32 provide the power required in (kW) to operate the thresher in wheat at different tractor P.T.O rpm's (280, 300, 350, 380) and at a 3600 kg/h crop feed rate for a crop moisture content of 15.5 %. The power required to operate the loaded thresher was 3.8 kW at 280 P.T.O rpm and it increased incrementally up to 5.33, 6.96 and 7.9 kW at 300, 350 and 380 P.T.O rpm respectively. This figure also indicates that the power required to operate the thresher at a no - load at the same P.T.O rpm of 280 rpm was 2.798 kW and increased gradually to 3.454, 4.304 and 5.369 kW at 380 P.T.O rpm., Therefore, power required for only threshing (no friction) at 280 P.T.O rpm was 1.002 kW and increased to 1.876, 2.656 and 2.531 kW at 300, 350 and 380 rpm. Several wheat threshing tests were carried out at different P.T.O. rpms. At 280 P.T.O crop performance was not museard, also we realosed power consumed at 280 P.T.O was 0.9 Kw for wheat threshing increased to 1.3 Kw at 380 P.T.O rpm (800 cylinder rpm) which recomended speed of wheat threshing for high crop threshing performanceto suite ASAE standared and farmer

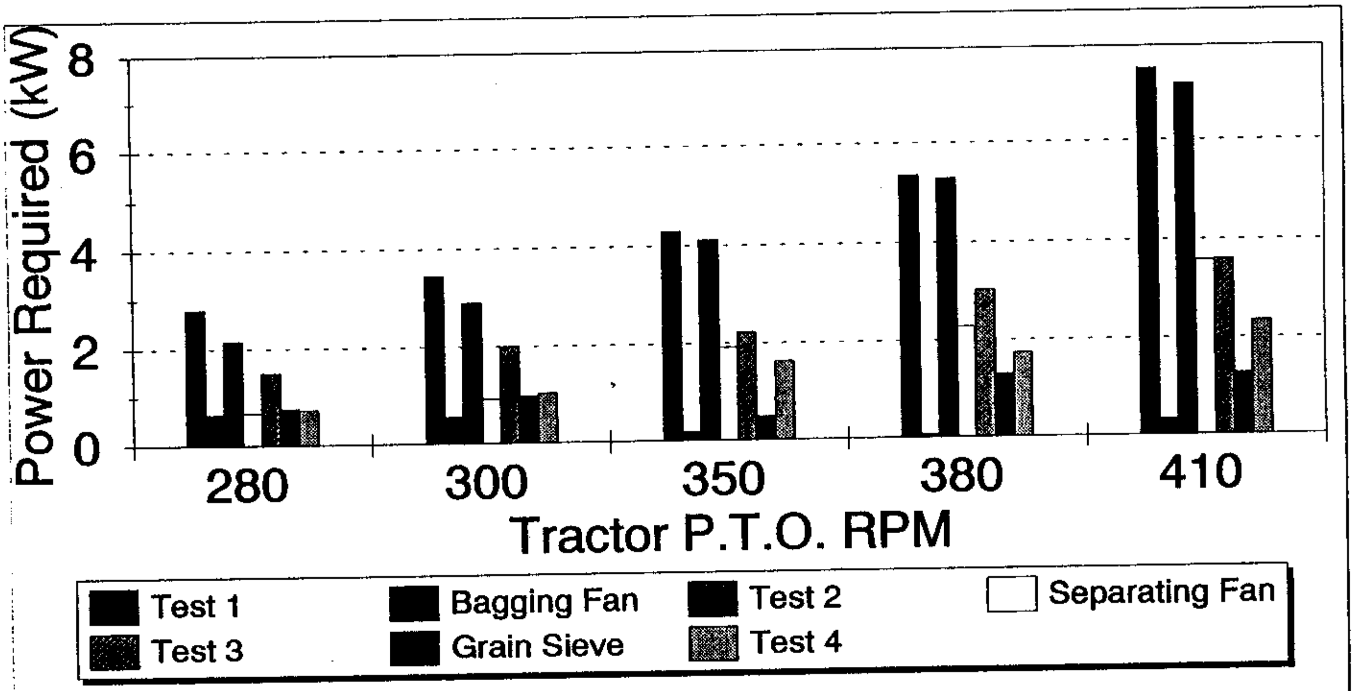


FIGURE 31 : POWER REQUIRED FROM LAB TEST OF EACH COMPONENT AT NO-LOAD

[redacted]

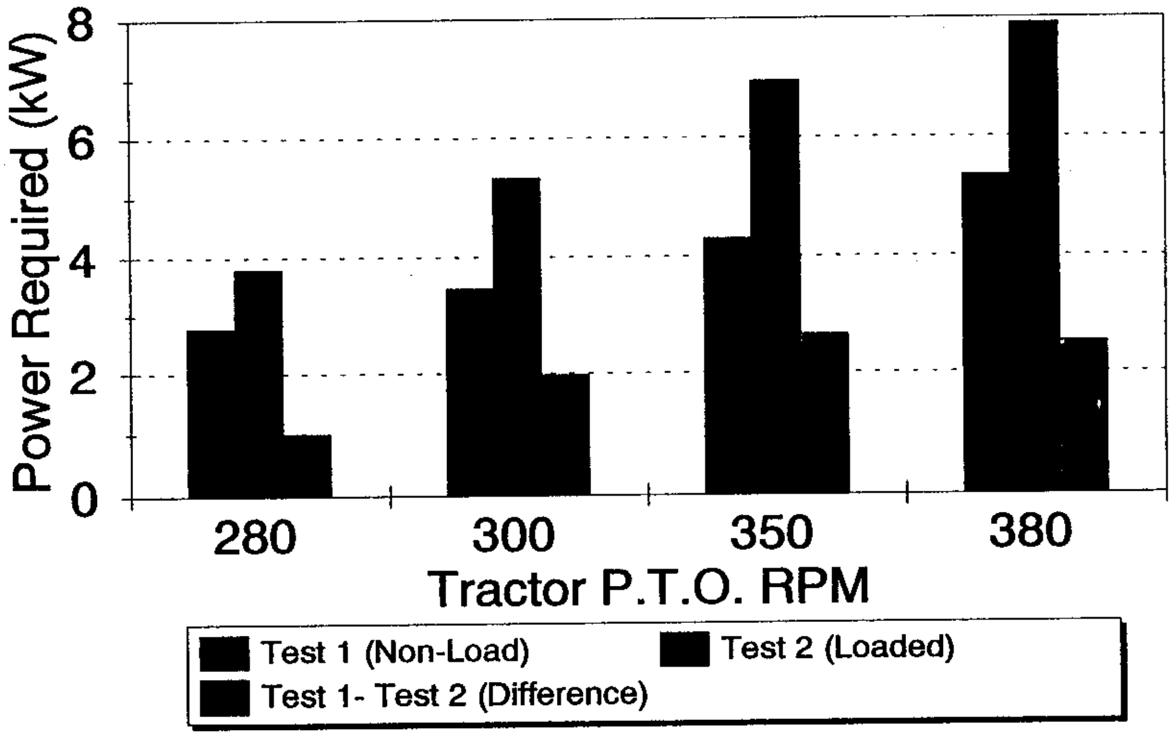


FIGURE 32 : POWER REQUIRED FOR WHEAT THRESHING AT 3600 KG/H FEEDRATE

M.C. 15.3%

requirements of fine straw to be used as cattle feed, purity and less grain loss.When the power required at 280, 300, 350 P.T.O rpm was measured no crop threshing perfprmance was recorded. Kepner et al. (1973) reported that the total power required was 2.1 to 2.7 hp/hr (1.565 to 2.01 kW/hr) per 1000 lb. (444.4 kg) of non- grain material feed rate. Using his relationships for this thresher at 3600 kg/h the thresher power required should be was 12.677 Kw or 21.87 kW. Rotz et al. (1993) reported a simplified method for estimating rotary power for agricultural machinery by the following equation:

$P_r = a + cF$

P_r = rotary power required (kW)

F = material throughput rate (t/h)

a,c = machine specific parameters

Parameter a & c are for a PTO driven machine. The value "a" 10 Kw/h and "c" was 3.6 Kw/h. The power equation for our system computed by Rotz's his equations:

P_r = 10 +3.6*3.6 = 22.96 kW/h

This calculation includes short peak power requirements. If this result is compared with our wheat field test on 8/27/93 (when the power recorded was 7.6 kW/h) and if short peak power two times normal is considered, the power required for the thresher would be 15.2 kW/h. But, if short peak loading of three times normal is considered the thresher power required would be 22.96 kW/h. Therefore, in order to size an engine to operate this type of a thresher the power should be within a range of 15.2 - 22.96 kW/h.

Also, the data obtained during lab test for a no - load system was compared to the data obtained by [Phan Hieu Hien, 1991] in the following Table for the AFT thresher.

A comparison can be made between the data established by Phan and this El Shames thresher data. Both thresher drum lengths were 1.2 m., but the El Shames thresher grain output was 993 - 1323 kg/h, matching categories 1 & 2. Also, both threshers are PTO powered. The El shames thresher power value was close to that obtained under the assumption of Phan.

V.M. Huynh, et al, 1982, derived the thresher power demand equations:

$P_o = NT + P_n$

N is the thresher rpm

T is thresher torque

Pn is the no-load power for the thresher

Thus, the thresher power demand using Huynh equation is:

Po = 380*135+5.369= 10.738 kW/h.

This value is close to the power value (15.2 kW/h) which was calculated for the thresher including peak loading. Also, Alaa Mohamed 1994, stated that, the relation between the drum speed and power was inversibly proportionate with increasing drum speed from 750 to 900 rpm the power increased from 7.552 to 9.748 hp respectively under Egyptian condition. This results prove results which we obtained under U.S condition for wheat crop.