American Journal of

Food Technology

ISSN 1557-4571

Academic
Journals Inc.

www.academicjournals.com

American Journal of Food Technology 6 (4): 314-321, 2011
ISSN 1557-4571 / DOI: 10.3923/ajft.2011.314.321
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Investigation on Grain Losses of the JD 1165 Combine Harvester Equipped with Variable Pulley and Belt for Forward Travel

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ABSTRACT

Grain losses due to harvesting with combine harvester is one of the main obsession in direction of wastes and losses control. For this purpose reduction of losses due to cutting platform of combine which comprises more than 50% of the entire harvesting losses, is one of the main and principle measures in decreasing the combine losses. The JD 1165 combine harvester manufactured by ICM. Company is equipped with variable pulley and belt mechanism for ground speed, which causes lots of vibration and increases the losses and depreciation of the machine. In this study the amount of losses of JD 1165 harvester combine equipped with variable pulley and belt mechanism has tested and investigated. For this purpose a typical JD 1165 combine was selected and adjusted for various functional specifications. Then in Markazi province a field with flat land was chosen, in which 307020 Shahriar and Bekras varieties planted in water farm and in seven repetitions so that the moisture of grains ranged between 8 to 12% the research was carried out. As consequences demonstrated, grain losses induced from platform of the investigated combine gained 1.29% and losses at the back of the combine was 0.96% on average in seven repetitions. In addition, the most amount of damaged grains achieved 10.8% at the speed of 850 rpm for the cylinder. Finally, suggestions were made in order to improve performance of the machine.

Key words: Combine harvester, grain losses, hydrostatic system, repetition, variable pulley

INTRODUCTION

Cereals especially wheat is one of the main substances in Iranian people's diets and poses as a strategic crop. Moreover, its consumption is increasing consistently attributed to sharp population rise, noticeable losses of agricultural crops and improvements in nutrition qualitatively and quantitatively. Therefore, any kind of effort for increasing its production through wastes and losses reduction is considered in order to reach self-sufficiency. An immense variety of crops from oilseeds, grass and clover seeds through to large fava beans are mechanically harvested with combines and mechanical threshers (Hanna and Quick, 2007). Since, a noticeable proportion of produced wheat losses occur during production and consumption steps, losses due to harvesting with combine harvester is one of the main obsession in direction of wastes and losses control (Tavasoli, 2002). The acceptable amount of harvest loss is 4-5% worldwide (Behroozi-Lar, 2000) while in Iran is somehow more than the global and acceptable level. Reduction of losses due to cutting platform of combine which comprises more than 50% of the entire harvesting losses, is one of the main and principle measures in decreasing the combine losses (Tavasoli, 2002).

Vibration and wobble are of the subjects which affect the combine losses. More importantly, their influence on the cutter bar of the platform causes vibration and stress on the plant stems and increases losses. The JD 1165 combine harvester manufactured by ICM. Co is equipped with variable pulley and belt mechanism for ground speed which causes lots of vibration and increases the losses and depreciation of the machine. The effect of vibration on the grain losses ascribed to the ground speed mechanism has not inspected on the above-mentioned combine harvester yet. Therefore, ICM Company due to reducing the losses in direction of meeting customers' needs and attracting their satisfaction, defined it as a research project with the cooperation of University of Tehran in order to convert the forward mechanism into hydrostatic one if necessary. In this paper the amount of losses of JD 1165 harvester combine equipped with variable pulley and belt mechanism has tested and investigated. Navid (2006) optimized the JD 1165 grain combine harvester in terms of reducing the loss of crop harvesting.

Overall losses without combine threshing and separation losses for Winter rape is around 11% in direct cutting and for the swathed crop, losses range from 10.7 to 24.8%. In addition, losses in spring rape 1.7 to 4.9% for direct cutting and 2.6 to 4.6% for the swathed crop (Price *et al.*, 1996). Oilseed rape harvesting losses, which occur during cutting, separation and cleaning and shaking, reach 5-10%, cutting and separation processes account for 80-90% of the total harvesting losses (Domeika *et al.*, 2008). Maertens *et al.* (2004) equipped a New Holland CX820 conventional combine harvester with extra sensors to measure the actual cutting width, crop throughput and separation. They performed Measurements on a field with varying crop conditions and carried out a feasibility study to estimate the instantaneous separation performance. Liu and Leonard (1993) described a system for the real-time monitoring of grain loss from the rotor of an axial-flow grain harvester. Domeika *et al.* (1999) analyzed interaction between rapeseed, a twin-blade active separator and a reel. Miu and Kutzbach (2008) presented the application of mathematical model for grain threshing and separation in an axial threshing unit with separation beginning in the tangential feeding zone. Craessaerts *et al.* (2007) equipped a combine harvester with extra sensors that could contain valuable information necessary to predict the performance of the cleaning section and presented a model which was important for the automation of the cleaning shoe. They also showed that the MOG content in the grain bin is influenced non-linearly by differences in the amount of biomass on the sieve section and the fan speed, which are also correlated with each other. Miu and Kutzbach (2008) presented the application of mathematical model for grain threshing and separation in an axial threshing unit with separation beginning in the tangential feeding zone. Klinner *et al.* (1987) following a feasibility study, designed and built an experimental header for a combine harvester to strip the seed off the crop in situ by means of a rotary combing mechanism. Junsiri and Chinsuwan (2009) predicted the header losses of a combine harvester when harvesting Thai Hom Mali rice attributed to grain moisture content, reel index, cutter bar speed, service life of cutter bar.

MATERIALS AND METHODS

In order to perform the investigation in the agricultural year of 2009, in Markazi province, Arak city a field with flat land was chosen, in which 307020 Shahriar and Bekras varieties planted in water farm. Harvesting operation was conducted over four sunny days and in seven repetitions

Table 1: Field and crop specifications for the wheat used for the test during each experiment

	Repetition						
Field specification	1	2	3	4	5	6	7
Experiment date	2009/6/21	2009/6/22	2009/6/22	2009/6/23	2009/6/23	2009/6/24	2009/6/24
Ear length (cm)	7.5	7	6.6	7.5	6.5	7	8
Crop height (cm)	92	82	78	79	79	74	86
Ear number per m^2	790	670	680	720	402	620	620
Ex-crop	Corn	Potato	Bean	Bean	Corn	Wheat	Wheat
Grain to straw proportion	0.6	0.7	0.7	0.7	0.6	0.8	0.8
Seed per ha in planting (kg)	200	180	200	190	200	200	200
Field yield	3854	4175	4181	3415	2793	4454	3983
Weight of 1000 grains	30.7	34.8	36.6	25.4	27.8	36.8	35.2
Grain moisture (%)	9	9	8	11	10	8	10
Field dimensions (m^2)	133×45	154×52	277×100	138×60	125×75	200×97	200×96

Table 2: Functional specifications of the utilized combine during each experiment

	Repetition						
Functional specification	1	2	3	4	5	6	7
Engine revolution (rpm)	2450	2450	2450	2450	2450	2450	2450
Movement gear	1	1	2	1	1	1	1
Threshing revolution (rpm)	600	800	750	900	900	850	850
Forward speed (km h^{-1})	1.6	2.8	3	2.5	2.7	2.1	2.2
Harvest duration (min)	60	42	120	46	53	131	110
Platform width (cm)	460	430	455	452	453	458	473

so that the moisture of grains ranged between 8 to 12%. Table 1 represents the field and crop specifications for the wheat planted for the test during each experiment.

A typical JD 1165 combine manufactured by ICM. Co was selected for undertaking the intended investigation. Moreover, the combine functional specifications such as forward speed, threshing unit revolution, platform width and so on, adjusted for each experiment as Table 2 presents. At the beginning with the purpose of preparing the field, its surround was harvested to provide enough space for moving while sampling. During harvesting the field surround, the initial adjustments were conducted, then within the field a plot with 10 m length in the line of combine harvest separated from the field. Afterwards for precise calculation of the combine losses, in three steps measurements were done as follows:

Preharvest measurement

Natural loss (L_1): For measuring natural loss as well as losses due to cutting platform, some containers with the dimensions of 50×50 cm were produced. Then with six repetitions, before entrance of the combine, sampling box was thrown throughout the field and grains and ears fell on the ground were collected and after drying, were weighed.

Measurements during harvesting

Grain loss measuring through the cutting platform: Collecting loss is associated with grain and ear losses from the cutting platform which have become out of access of the cutter bar and have fallen on the ground during harvesting and due to inaccurate adjustments of the cutter bar and the reel.

In order to sample collecting losses the 50×50 cm box was thrown in the vacant place behind the cutter bar on where output material from the back of the combine has not poured. Then grains and ears in it were gathered, weighed and recorded.

$$L_2 = (B\text{-}A)\times 10 \tag{1}$$

$$L_2\% = \frac{(L_2\times 100)}{P} \tag{2}$$

Where:

L_2 = Platform loss amount (kg ha^{-1})
P = The gross yield of the field
A = Weight of both collected grains and clusters due to natural loss in four repetition
B = Weight of both collected grains and clusters at the back of cutting platform in four repetition

Loss measuring at the back of the machine: Processing loss in combine consists of threshing loss and separation loss as well as cleaning loss. After preparing the field, during the first path, combine adjustments were done presicely to reduce the loss amount and measure the real amount of it. Then the grain tank was emptied and the combine was driven at the beginning of the harvest place. Along the harvest path, a length of 10 m was specified with index and at the same time, the distance of the first crop row was measured by the index and wrote down. Then the combine operator drove the machine with a constant speed and harvested the segregated 20 m. While harvesting the three 50×80 boxes which had cloth at their bottom to prevent from losing the grains, were thrown between the combine rear wheels, along the combine direction so that material come out of the straw walkers and cleaning shoes pour into them. After the combine passed, grains and unthreshed ears (tailings) were separated and weighed.

$$L_3 = \left(\frac{M\times 10}{F\times 1.2}\right) \tag{3}$$

$$L_3\% = \frac{(L_3\times 100)}{P} \tag{4}$$

Where:

L_3 = Grain loss at the back of the combine (kg ha^{-1})
M = Weight of both collected grains and ears in the three sampling boxes (g)
F = Correlation coefficient between cutting width and the left swath width of straws at the back of the combine. This amount for JD 1165 combine harvester is 4.3

In order to calculate the speed of the combine a revolution-counter was used and time elapsed for harvesting the designated 10 m was measured. Afterwards the harvested crop in the grain tank was emptied and the percentage of the intact grains, tailings, damaged grains and impurities were calculated individually.

Postharvest measurement: In order to measure yield of the field, the amount of harvested crop through 20 m was weighed precisely and the field yield was achieved as follows:

$$E = \left(\frac{W}{L}\right) \times 500 \tag{5}$$

$$P = E + L_1 + L_2 + L_3 \tag{6}$$

Where:
E = The yield of the field (kg ha^{-1})
P = The gross yield of the field
W = Weight of harvested crop along 20 m
L = Average width of cutting platform

RESULTS AND DISCUSSION

The flat planting method has high yield and the main reason is more even distribution of bushes and less competition on the planting rows (Pak *et al.*, 2007). The results indicated that in flat planting, average yield equals 3836.43 kg ha^{-1}. Fanaee *et al.* (2006) announced effect of planting method on the yield is not significant. In addition to more proper distribution of bushes and receiving resources like sunlight better and regularly. It seems that high yield of the field in flat planting method was due to increase of bushes in the area. The ear density in one square meter was gained 634 ears. Existence of such high density of ears in flat planting can be induced from regular distribution through the field as well as little competition on accessible resources with each other.

Through modifications and optimization of settings it is possible to reduce header losses to minimum of about 80 kg ha^{-1} in winter wheat (Klinner *et al.*, 1987). As achieved results, show in Fig. 1, the least amount of losses at the platform was 0.3% with yield of 4181 kg ha^{-1} and the most amount was 2.8% with yield of 2793 kg ha^{-1} and the number of ears in the experiment which resulted in the least yield and ear density gained 402. Such low amount of ears can be attributed to stresses on the crop stalk due to cutter bar and platform encountering low density. Non-adjustment of various sections of the combine as well as inappropriate moisture of grains while harvesting are also among the effective parameters in the amount of losses at the platform of the combine (Anonymous, 2003).

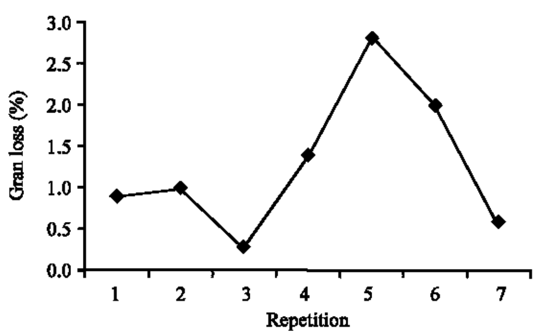

Fig. 1: Grain losses at the platform of the investigated combine in various experiments

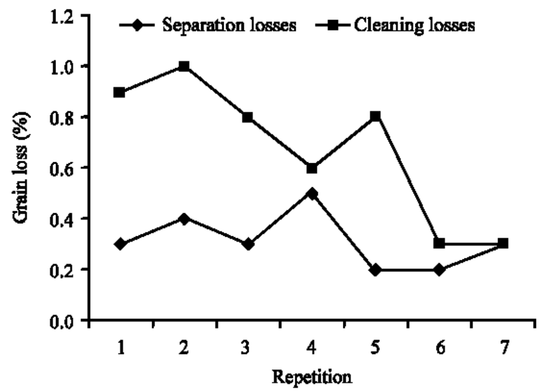

Fig. 2: Grain losses in relation to separating and cleaning units in each experiment

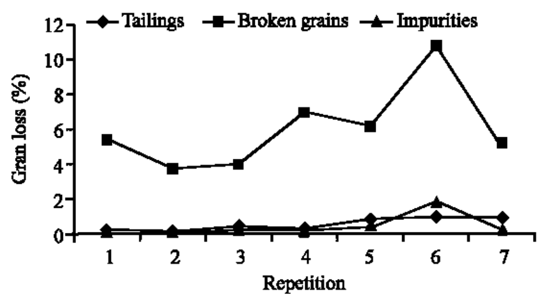

Fig. 3: Percentage of broken grains, tailings and impurities inside the grain tank of the combine after harvesting during each experiment

In Fig. 2 losses associated with separating and cleaning units have been demonstrated, of which losses at the back of the combine will be achieved. The least amount of losses at the back of the combine equaled 0.5% and the most gained 1.4% at yield of 4454 and 4175 kg ha^{-1}, respectively for the field. As the results represent, there is not a great deal of difference between the least and most amount of losses at the back of the combine which constitutes 0.9%. Although, the same amount for losses from the combine platform reaches to the considerable amount of 2.5%. Mehdinia *et al.* (2008) reported the total amount of losses in 955 JD combine and in Sahand S68 about 4.08 and 3.01%, respectively.

Inspecting the harvested crops inside the grain tank, as presented in Fig. 3, it became clear that the percentage of broken grains were drastically more in respect to tailings and impurities which is caused by imprecise adjustment of some sections such as the space between cylinder and concave, high speed of cylinder and adjustments related to the separating unit. Generally, 0.5 to 2% grain damage is achievable, but it can be much higher (Schrock and Taylor, 1995). The grain damage causes should be related to fed crop flow, technological parameters, grain separation through the concave, drum rasp bars speed and the clearance between the drum and the concave (Kutzbach and Schreiber, 2003; Shpokas, 2007). Grain damage also depends on the crop species characteristics and harvest time (Wacker and Schneider, 2000; Wacker, 2003). Grain damage was by 3% higher when the wheat species 'Oretes' was harvested if compared with 'Toronto' species. Grain damage was by 2% higher at noon than in the morning or in the evening. There is an exponential relationship between the grain damage and their moisture content (Waelti and

Table. 3: Comparison of grain losses inside the grain tank of JD and sahand combines

Combine Model	Field yield (kg ha^{-1})	Damaged grains (%)	Weeds (%)	Straw (%)	Tailings (%)
JD 955	3960	0.91	0.97	0.23	0.16
Sahand S68	3994	0.66	0.66	0.55	0.67

Buchele, 1969). Mehdinia *et al.* (2008) reported in a research over some combines the amount of straw, damaged grains and impurities as shown in Table 3.

The most amount of damaged grains achieved 10.8% at the speed of 850 rpm for cylinder and the least amount was 4% at 750 rpm.

CONCLUSION

The amount of acceptable losses for small grains when harvesting with combine is 3 to 5% so that 0.5 to 2% is attributed to the platform of the combine and 0.9 to 1.8% is ascribed to the back of the combine (Rad, 2004). Grain losses induced from platform in JD1165 combine gained 1.29% and losses at the back of the combine was 0.96% on average in seven repetitions. As the results showed, the achieved amounts are in the range of acceptable ones. Therefore, losses due to the investigated combine are permitted. On the other hand, since reduction in the platform losses follow considerable decrease in losses cost, converting the forward mechanism into hydrostatic one would cause less vibration and provide more control on forward speed and as a consequence would decrease the amount of losses ascribed to the platform.

The amount of broken grains in the JD 1165 combine as demonstrated, gained a remarkable amount. This is mainly attributed to the imprecise adjustments of the threshing unit such as the cylinder speed and the space between the cylinder and concave. Since these adjustments in the intended combine are done mechanically, precise control of them is to some extent impossible. Therefore, utilizing electrical mechanism for performing the adjustments of the threshing unit, it would make it possible to reach accurate and precise amounts of adjustments.

ACKNOWLEDGMENT

This study is derived due to an applied research in the frame of applied research proposals defined between University of Tehran and Mine and Industry Ministry with contract No. 450/51027041. Hereby I really appreciate all the contribution and cooperation made by R and D Department of ICM Company, particularly Eng. Khodabakhsi and Anajafi in order to this research is done.

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