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Rice (Wheat) Combine Harvester With Cutting and Windrowing Straw Immediately After Stripping

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Abstract: Stripper header invented by AFRC UK, mounted on grain combine harvester showed its two deficiencies in China: Leaving the stripped straw standing without windrowing and relatively high free grain loss especially working at lower ground speed. This paper reports the invention of a stripping rotor with air suction for pneumatic conveying the materials, eliminating the previous auger and conveying belt on the stripper header. For processing the large amount of threshed materials author invented a vertically positioned "4 in 1" apparatus, performing 4 functions: the elevation, separation, cleaning, and recycling of the materials. Its field trial showed that the free grain loss is reduced and specially invented windrowing device closely behind the stripping rotor located justified itself by the clear cutting with shorter stubble and being center2delivered windrow of the straw.

Key words: pneumatic conveying; stripping harvesting; windrower
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1 Introduction

The stripper header invented by AFRC UK mounted on grain combine harvester in place of the conventional one features with its simplicity of construction, higher ground speed of machine, and in addition it uses the thresher2separator of the existing combine harvester. But it also showed its deficiency in China as follows:

First, leaving the stripped straw standing without windrowing that poses an additional operation in sequence for harvesting the straw, because in multicropping area the planting of succeeding crop needs timely cleaning out the field;

Secondly, the free grain loss is higher than desired at lower ground speed of machine which is unavoidable in paddy field with its limited size in China.

An attempt (Neale, 1991) was made towards fitting a hydraulically powered cutterbar behind the stripper header. The straw was fed on to two draper belts and swathed into a single windrow suitable for a baler to deal with. "The set doesn't work well yet"[1], admitted by the author. Since 1989 in Russia a conception of systematic method and means for harvesting the MOG after stripping were put forward, there hasn't been found any successful ways in literature.

As to harvesting the straw immediately after stripping in China some attempts were made with straightly putting the commercially available side2 delivery windrower behind the stripper header. It makes the machine extremely long relative to its narrow swath and necessitates a bigger head land for turning the machine at the end of each run and cutting off the plants by hand labor on the boundary of the paddy field for windrows side2 delivered by machine in its first round operation.

The objective of research reported in this paper is to develop a new combine rice (wheat) harvester with cutting and windrowing the straw immediately after stripping. In view of that the prolonged longitudinal dimension of stripper header causes the putting of a cutterbar and windrower behind it very difficult, the pneumatic

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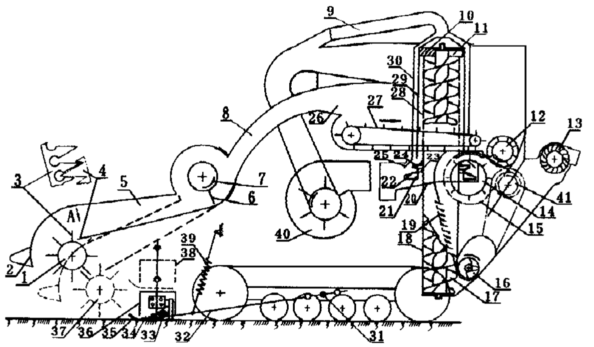
conveying system is introduced into the patented design of the new machine so that the auger and intermediate conveying means (belt, roller or shaker etc.) as in stripper header can be omitted. Consequently, a spacious room for the cutterbar and windrower is obtained. At the same time the free grain loss expected to be reduced owing to the air suction enhanced by the airflow produced from the pneumatic system.



1. Stripping rotor 2. Hood 3. Teeth on rotor 4. Stagger positioned teeth on conduit bottom 5. conduit 6. Tines of raking booster 7. Drum of booster 8, 9. Conduit 10. Exit for recycling 11. Blade 12. Discharge rotor 13. Cross flow fan 14. Axial flow rethresher 15. Concave 16. Horizontal auger 17. Vertical auger 18. Auger case 19. Shutter 20. Container 21. Discharge blade 22. Sheave 23. Ball bearing 24. Blade on ring distributor 25. Conic reflector 26. Depositing chamber 27. Belt conveyor 28. Cylindrical sieve 29. Intermediate cylinder 30. Outer cylinder 31. Hinge 32. Pushing rod 33. Crank roller 34. Knife 35. Guard with upward point 36. Rod of revolving rake 37. Stripping rotor in lowest attitude 38. Cutterbar in transportation attitude 39. Suspension spring 40. Fan 41. Detachable axial flow rethresher

Fig. 1 Schematic arrangement of rice (wheat) Combine Stripper Harvester "4ZTL21800"

2 Combine Description and Its Working Principle

Fig. 1 is a schematic arrangement of that new developed combine stripper harvester "4ZTL21800". It shows the grain and chaff are stripped at the entrance of stripping rotor (1) under the hood (2) are sucked and conveyed through the conduit (5), the raking booster (7), upper conduit (8) into the depositing chamber (26) and down to the discharge rotor (12), while airflow along with debris goes through fan (40) to the atmosphere. The mixture of grain and chaff are then conveyed to axial flow rethresher2separator (14) in which the broken straw of small amount moves axially and to be expelled outside of machine. The light chaff falling from concave (15) is cleaned out from the grain by a cross airflow produced by cross flow fan (13). The preliminarily cleaned grain is then transferred from the horizontal auger (16) to vertical one (17). The unthoroughly threshed ears undergo a further threshing in the clearance between the auger flight and its case (18) in the course of elevation. The upper half of the case is a perforated cylindrical sieve. By virtue of the centrifugal force the grain and debris along pass through the sieve hole effectively and then drop down through the annular channel onto the ring distributor (24), the blades (24) of which throw the mass horizontally forming a very thin layer and strike against the conic reflector (25) at the bottom end of the outer cylinder. The upward air flow produced by the fan (40) penetrates that thin layer of mass bringing the debris to go through the annular channel between outer (30) and intermediate cylinder (29) and finally through the fan to atmosphere. The reflector imparts the grain a higher reflective vertically downward speed, producing a good potential to increase the upward speed of airflow for raising the cleaning efficiency. The grain and unthreshed ear, if there is, in the chaff at the upper end of the vertical auger is discharged by the blade (11) through the exit (10) and cross connecting tube into the depositing chamber for recycling in the system. The clean grain deposits in container (20) and is discharged by the blade (21) attached on lower half of the sheave (22) running on three ball bearings (23). The grain flows through the outlet of container into the sack. On the upper half of the sheave are fixed the blades (24) forming a ring distributor.

The floating cutterbar is put closely behind the stripping rotor so that as the top part of the plant just leaves the stripping rotor the straw comes to be cut.

The knife assembly is driven by the vertical crankshaft (33), doing a harmonic motion. On crankshaft is fixed the revolving rod (36) for raking the cut straw at front of the crawler centrally, forming a windrow between two crawlers. The revolving rake on the other side rotates counter wise to that one. The suspension spring (39) facilitates the flotation of cutterbar. The cut straw on the central portion of the swath moves over the cutterbar by its inertia and the stiffness of the foregoing uncut stem.

3 Performance and Discussion

Because that the crop harvested before or after hoarfrost coming to be its conditions like moisture content, mechanical properties etc. are quite different, the field trials were arranged on foregoing two different harvesting periods respectively. Its results for harvesting rice are shown in Tab. 1, for harvesting wheat in Tab. 2. The data for Shelbourne stripper header RX224 are cited aside for reference.

In course of 42year field testing in production conditions the prototype of full size harvested 40 hm^2 of rice and small area of wheat.

The data in Tab. 1 acquired from early harvesting on Sept. 26, 1996 showed that as ground speed of machine raised to 1.43 mÖs the separation loss was unacceptable high value of 1.98%. A new small detachable axial2flow rethresher (41) was developed in this connection. It is attached to major rethresher (14) as an adjunct one. The separated materials through the concave are conducted to horizontal auger.

The data of Sept. 26, 1998 revealed that the separation loss has substantially decreased as harvesting the wet, high yield rice.

The performance of machine shown in tables has following features:

1) Free grain loss is lower as the machine working both at higher and lower speed.

2) The working speed of machine reached 1.55mÖs for wheat, 1.39~1.43mÖs for rice and even higher in the later days of harvesting period.

3) The shoe loss (here referring to grain loss from two fans) is much lower than that in ordinary flat sieve 2 blast cleaning system by virtue of the

Tab 1 Field trial results3 of stripper combine harvester "4ZTL-1800" in harvesting rice

Period of trial	After hoar frost		Before hoar frost					
Date	Oct. 5, 1995		Sept. 23, 1996		Sept. 26, 1996		Sept. 26, 1998	
Height of panicles from ground Öcm	67.9		78		74		77	
Range of panicle height variation Öcm	26.2		34		42		31.8	
Moisture content of Grain(MOG) Ö%	15.7; (52.2)		26.5; (70.2)		25.4; (66.6)		22.2; (67.5)	
Crop yield Ökg · hm^{-2}	8300		6688		7240		11466	
Thousand2grain2weight Ög	26.1		28.3		27.5		28.7	
Ground speed of machine Öm · s^{-1}	1.17	1.28	0.70	1.33	0.73	1.43	1.18	1.39
Swath Öm	1.80		1.80		1.80		1.80	
Stabble height Öcm	6.14	7.71	5.10	5.40	—	—	7.9	5.1
Total grain loss Ö%	0.78	1.09	2.25	2.56	1.78	3.06	1.43	1.54
Free grain Ökg · hm^{-2}	23.5	34.2	19.8	19.1	50	49.5	48.3	34.1
Ö%	0.28	0.41	0.30	0.29	0.69	0.68	0.42	0.30
Unthreshed grain Ö%	0.08	0.20	0.07	0.16	0.36	0.35	0.41	0.51
Separation loss Ö%	0.40	0.47	1.67	2.05	0.68	1.98	0.60	0.73
Shoe loss Ö%	0.01	0	0.21	0.06	0.05	0.05	0	0
Hulled broken grain Ö%	0.94		0.37	0.47	0.66	0.52	2.0[3 3]	
Cleanliness of grain Ö%	96.6		99.12	98.82	99.04	99.26	98.6	99.4
Theoretical out put Öhm^2 · h^{-1}	0.76	0.83	0.45	0.86	0.48	0.93	0.76	0.90

3 Field trial and measurement performed by the state authorized Agricultural Machinery Testing and Evaluation Station affiliated to Heilongjiang General Bureau of Reclamation (Report No. S95XJ227, S96KJ29, S98KJ225)

3 3 High perentage of Hulled and broken grain is caused by "extraordinary small clearance in the grain auger due to improper assembly work" (see report S98KJ225)

Tab 2　Field trail results of 4ZTL-1800 in harvesting wheat

Machine		4ZTL 21800[3]			RX24 Schelbone2Haima stripper2header[3 3]	
Place		Yilane county Heilongjiang province			Nenjiang county Heilongjiang Province	
Date		July 14, 1998			Aug, 4, 1998	
Height of panicles from ground Öcm		103			87～90	
Range of panicle height variation Öcm		47. 3			—	
Crop yield Ökg · hm^{-2}		4197			4050～4327	
Moisture content Ö% Grain, MOG		21. 9; 44. 5			21～36; 25～42	
Thousand Grain Weight Ög		36. 6			—	
Ground speed of machine Öm · s^{-1}	0. 83	1. 30	1. 55	0. 78	1. 85	1. 76
Swath Öm		1. 80			2. 40	
Stubble height Öcm	10. 2	8. 0	8. 3		No report	
Total grain loss Ö%	1. 86	1. 83	1. 67	2. 56	2. 85	3. 32
Free grain Ökg · hm^{-2}	54. 4	52. 0	50. 5	86. 7	93	113
Ö%	1. 29	1. 24	1. 20	1. 97	2. 28	2. 74
Unthreshed grain Ö%	0. 26	0. 42	0. 17	0	0	0
Separation loss Ö%	0. 07	0. 04	0. 03		—	
Shoeloss Ö%	0. 24	0. 13	0. 27	0. 59	0. 57	0. 58
Broken grain Ö%	0	0. 2	0. 2	0. 36	0. 36	0. 34
Cleanliness of grain Ö%	98. 7	98. 5	98. 7	99. 41	99. 41	99. 0
Theoretical output Öhm^{2} · h^{-1}	0. 54	0. 84	1. 01	0. 67	1. 60	1. 52

3　Field tiral & measurement perfomed by state2authorized Agricultural Machinery Testing and Evaluation Station affiliated to Heilongjiang General Bureau of Reclamation (Report No. S98JK219)

3 3　Results provided by Assembly- selling company of RX224 in China.

cylindrical sieve in which there isn't any grain loss slipped from sieve surface like on the ordinary flat sieve does.

4) The machine saves the tailings auger and tailings elevator thanks to the cylindrical sieve system that is capable to raise and feed tailings back to depositing chamber doing an endless recycling till all the grain is sieved out.

5) In rear of stripping rotor spacious room is available for putting the cutting and windrowing device while not making the machine too long. Floating cutterbar ensures the stubble of a short cut. But ground speed of machine should be slightly decreased to 1. 0m Ös or so while harvesting the wet and tall rice.

6) The attachment of a small axial flow rethresher enhanced the functions of machine in terms of adapting to various crop conditions. In Northeast China and the like most of the rice is harvested in dry condition then only the major rethresher is adequate to deal with.

7) Field trials revealed vertical cylindrical sieve with inside auger has some major advantages over the flat sieve:

①High capacity or flow rate per unit area of sieve surface is several times that of flat sieve owing to subjecting the grain to a radial acceleration which is much greater than gravity acceleration.

②The rotating auger inside the cylinder cleans the sieve surface and gets rid of clogging with trashes.

③ The performance of vertical cylindrical cleaning system is not appreciably affected by tilting as the harvester is operated on slopes.

④ The materials move over the cylindrical sieve more uniformly than on the flat sieve do. Thus the distributor isn't needed.

⑤Simpler construction.

8) Center delivered windrow has some advantages over the side delivered:

① Saving the hand labor for cutting off the crop on boundaries of paddy plot for laying the windrow side delivered by machine in its first round operation.

② Providing operator freedom to select any suitable route such as making a detour to prevent machine from bogging down in very soft field.

③Facilitating the machine in field to run in a shuttle pattern for increasing the efficiency instead of ordinary round pattern.

9) The deficiencies of machine are:

①The pneumatic conveying system is energy consuming in comparison with the stripper header with mechanical conveyer, but the specific power consumption rivals the conventional combine.

②The depositing chamber looks bulky but not heavy.

4 Conclusions

Four2year field testing in production conditions the full size prototype showed the objectives of this exploratory study have been gained, the machine harvested the rice before and after the hoarfrost and the wheat in principle well. That is the free grain loss is reduced owing to air suction; cutting and windrowing the straw is accomplished immediately after the stripping; the machine is capable to work with comparatively high ground speed; vertical cylindrical cleaning system justified itself with higher capacity, higher cleanliness and simplified construction in normal condition.

The further improvement should be focused on smoothly windrowing the wet, tall rice straw at higher ground speed (e. g. 1. 4 mös).

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摘脱后切割搂集茎秆成条铺的稻(麦)联收机

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摘 要: 英国发明的悬挂在联收机上的摘脱台在中国使用中有两个缺点: 摘脱后的基秆未能切割搂集成条铺和落粒损失, 尤其在低速时较大。此文报导了用气流吸运脱出物的摘脱滚筒, 从而省去了原摘脱台上的输送螺旋推运器和输送带 3 类的输送装置, 为了处理大量的脱出物, 作者发明了立式的"4 合 1"处理装置。它具有升运、分离、清选和自循环 4 个功能。田间试验表明落粒损失减少, 作者发明的设置于摘脱流通筒后面的切割搂集装置工作性能良好: 割茬低条铺放在两履带之间。

关键词: 气流输送; 割前摘脱; 条铺装置