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Effect of types of cutter bar drivers of a Thai combine harvester on vibration and header loss

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Abstract

The objective of this study was to compare the vibration and header losses of a Thai combine harvester due to different types of cutter bar drivers. 4 types of cutter bar drivers were tested: reciprocating type, stir type, perpendicular axis type driven by chain, and perpendicular axis type driven by a belt. Comparative vibration and header loss of the 4 types were tested. Results of the test indicated that the 4 types tested similarly in the header loss. The vibration of the header tended to be lowest when using the perpendicular axis type driven by a chain.

Keywords: Combine harvester, Cutter bar driver, Vibration, Header loss

1. Introduction

Thai combine harvesters play an important role in rice harvesting in Thailand, where there were more than 40,000 rice combine harvesters operated [1]. They are machines with reaping and threshing systems in one, which have been developed to be suitable for harvesting conditions in Thailand.

A Thai combine harvester consists of different sets of equipment, one of the most important is the header which involves cutting, combining, and conveying rice to be screened and separated from straws in the threshing chamber. In the cutting process, a cutter bar driver is shown in Figure. 1, is an equipment driving cutter bars to cut rice stems. It consists of the header's drive axial transmit power via a connecting rod which drives the cutter bar to move in a swaying motion. Cutter bar drivers in rice combine harvesters are currently designed to move perpendicular to the rice combine harvester's moving direction. This caused great vibration in the combined head and threshing drum, whereas more vibration was also caused when operating with a reel and auger. The component, in a rice combine harvester, that creates the strongest vibration is the cutter bar driver. On the other hand, the reel, the auger, and the chain conveyor are moving along the rice combine harvester's moving direction, causing relatively low vibration compared to that caused by the cutter bar driver [2].

Vibration in rice combine harvester causes the components and parts in it to wear out earlier than they should, especially in the frame under the conveyor and header, which bear the machine weight. The machine manufacturer was, thus, required to increase the size of metals in such machine structures to reduce damages caused by vibration. Consequently, there is an increase in manufacturing cost as well as the machine weight. Vibration can also increase harvesting loss especially when harvesting local rice varieties, whose rice paddies fall easily [3], since the vibration in the header might shake the rice stem during harvesting. Therefore, this study aims to compare study on vibration and header losses of a Thai combine harvester due to different types of cutter bar drivers.

2. Materials and methods

This study was conducted using the axial flow rice combine harvester, provided by the Agricultural Machinery and Postharvest Technology Research Center. The harvester cutting width was 3 m, the engine power was 194 kw (260 hp), the diameter of the auger was 600 mm, 6 pickup bars with 26 pickup teethes/bar.

Four types of cutter bar drivers were tested: reciprocating type or original type (Figure 1), stir type (Figure 2), perpendicular axis type driven by chain (Figure 3), and perpendicular axis type driven by belt (Figure 4). The study was done in 2 steps as follows:

2.1 Comparative analysis of vibration in cutter bar drivers

Vibration in the cutter bar driver was measured in the study at the header's drive axial speed between 250 to 400 rpm. The experimental speed was divided into 7 levels with 25 rpm intervals. There were 9 replications for each level. The revolution speeds used in the study were commonly used because speeds lower than 250 rpm could be too slow leading to a jam in the cutter bar, reel, and the front auger. On the contrary, 400 rpm would be too fast, leading to too much vibration on the header, causing the reel index to be too high which could increase header loss [4].

A vibration meter, VM-120, was used to measure vibration in 2 directions: horizontal and vertical, as shown in Figure 5. The measured location was done where the arm extended farthest from the header. Vibration measurement was done by measuring the amplitude or the swaying distance of the header from the balancing line, measured in Root Mean Square (RMS).

Figure 1 Reciprocating type

Figure 2 Stir type

Figure 3 Perpendicular axis type driven by chain

Figure 4 Perpendicular axis type driven by the belt

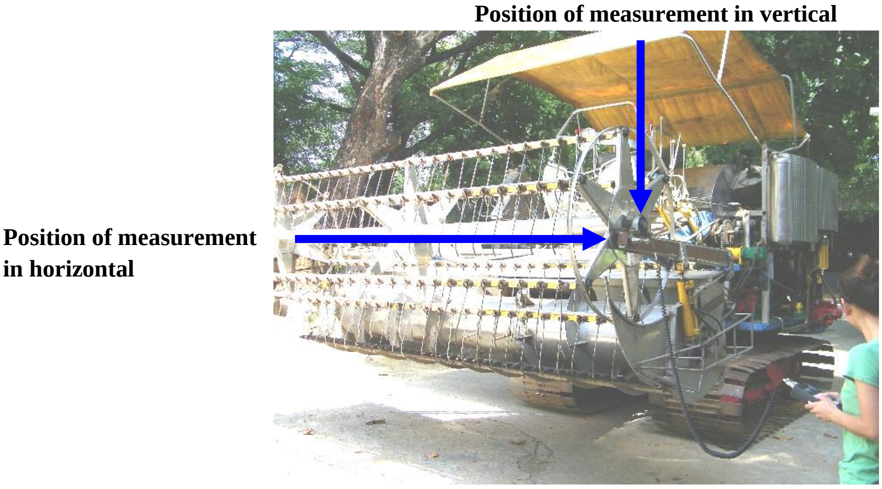

Figure 5 Area where horizontal and vertical vibration were measured.

2.2 Comparative analysis of header loss in cutter bar drivers

The study was conducted on the Kao Dok Mali rice variety in the Khon Kaen irrigation area, at grain and straw moisture content of 21.01% and 61.37% wet basis, respectively. The average rice density was 38,707 plants per ha, the average stem length was 0.88 m, and the average inclined angle of the crop plant was 40.2 degrees. The cutter bar speed was at 0.45 m/s, while the reel index was at 3 and the driving speed was 2.5 km/h. The clearance between the finger and cutter bar was 50 mm and the header's drive axial speed was 325 rpm.

For each type of cutter bar driver tested, three replications were done. In each replication, the rice combine harvester to run at least 15 m to ensure steady operating conditions before collecting header loss data and the test follow as RNAM [5]. Fallen grains were collected from the area where header loss data was to be measured. Afterward, the rice combine harvester was run through the designated area and then stopped without stepping into the area. The loss was collected by operating cutting width.

3. Results and Discussion

3.1 Comparative analysis of vibration in cutter bar driver

The resulting RMS of horizontal vibration amplitudes in the header, while using different cutter bar driver at various speed, were compared, and displayed in Table 1, while the vertical vibration amplitudes were displayed in Table 2.

Figure 6 shows correlations between header's drive axial speed and RMS of horizontal vibration in the header, according to data in Table 1. It was found that as the header's drive axial speed was increased from 250 to 350 rpm, all 4 types of cutter bar drivers yielded linearly increasing RMS of horizontal vibration. Once the speed exceeded 350 rpm, RMS dramatically increased. At speed lower than 300 rpm, all 4 types of cutter bar drivers yielded similar RMS. However, when the speed was increased to be more than 300 rpm, RMS of the existing cutter bar driver tended to be increased the most, followed by the stir type, while the chain and belt type yielded similar RMS.

Table 1 RMS of horizontal vibration amplitude in the header when using different types of cutter bar driver at various header's drive axial speed (mm)

Header's drive axial speed (rpm)	Types of cutter bar driver			
	Reciprocating	Stir	Perpendicular Axle	
			Driven by chain	Driven by belt
250	2.05	2.45	2.14	3.19
275	2.78	2.88	2.27	3.40
300	4.06	3.18	3.01	4.04
325	5.05	3.72	3.42	4.12
350	6.19	5.01	3.78	4.51
375	10.07	9.47	5.40	5.46
400	13.44	12.01	8.04	6.70

Table 2 RMS of vertical vibration amplitude in the header when using different types of cutter bar driver at various header's drive axial speed (mm)

Header's drive axial speed (rpm)	Types of cutter bar driver			
	Reciprocating	Stir	Perpendicular Axle	
			Driven by chain	Driven by belt
250	3.77	3.14	3.28	4.09
275	4.30	3.44	3.59	4.37
300	5.88	3.78	3.95	4.49
325	7.54	4.38	4.12	5.20
350	12.03	6.39	4.60	6.23
375	15.62	11.35	7.03	7.03
400	18.65	15.65	10.69	9.01

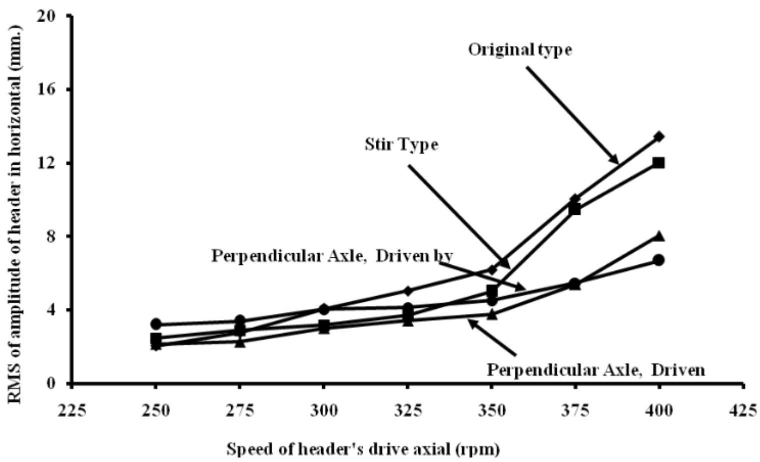

Figure 6 Correlations between header's drive axial speed and RMS of horizontal vibration, when using different cutter bar driver

The correlations between header's drive axial speed and RMS of vertical vibration in the header are shown in Figure. 7. When the speed was increased from 250 to 275 rpm, the 4 types of cutter bar drivers yielded no significant differences in RMS of vertical vibration. However, once the speed exceeded 275 rpm, the existing cutter bar driver tended to yield the highest RMS, followed by the stir type whose RMS increase dramatically when the speed exceeded 325 rpm. Those from the chain type and belt type increased linearly and were identical.

From analyzing the vibration in the header caused by the cutter bar drivers, both vertically and horizontally, it was found that cutter bar driver caused more vertical vibration then horizontal vibration. In fact, the cutter bar driver causing highest vibration, both vertically and horizontally, was the existing one, followed by the stir type. The perpendicular-axis, driven by chain, caused less vibration than the perpendicular-axis, driven by belt, when the speed was lower than 375 rpm. However, when exceeding 375 rpm, the belt type tended to cause less vibration than the chain type, both vertically and horizontally.

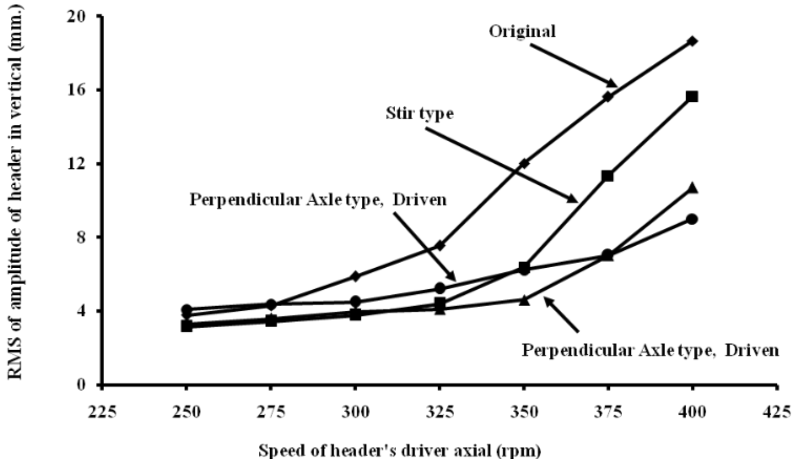

Figure 7 Correlations between header's drive axial speed and RMS of vertical vibration, when using different cutter bar driver

3.2 Comparative analysis of header loss in cutter bar driver

The header loss caused by each type of cutter bar driver when harvesting the Kao Dok Mali 105 rice variety is shown in Table 3. The results showed no statistical differences in header loss, indicating that the performance of the type of cutter bar driver did not influence header loss.

Table 3 Header loss caused by different types of cutter bar drivers

Types of cutter bar driver	Header loss (%)
Reciprocating	1.37 a
Stir	1.10 a
Perpendicular axle driven by chain	1.37 a
Perpendicular axle driven by belt	1.57 a

(Note: the same letter in the same column means an insignificant difference, compared to using LSD at a 5% significant level)

4. Conclusions

This study tested the 4 types of cutter bar drivers in terms of vibration and header loss. The results indicated that the 4 types of cutter bar drivers had no influence on header loss. However, when vibration in the header was considered, the chain type tended to yield the least vibration. Thus, the chain type is suggested to be developed and modified to fit the manufacturing process of manufacturers in Thailand.

5. Acknowledgements

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6. References

[1] Chinsuwan, W. Evaluating losses from rice combine harvesters to formulate policy-oriented recommendations for management and enhancing production efficiency. Final report, The Agricultural Research Development Agency (Public Organization). 2019.
[2] Chuan-Udom S, Srison W, Wiangwisad T. Comparative study on vibration of a combine harvester due to operation of cutter bar driver, reel, and auger. Thai Society of Agricultural Engineering Journal. 2009;15(1):3-6.
[3] Chinsuwan W, Pongjan N, Chuan-Udom S, Phayom W. Effects of reel index on gathering loss of rice combine harvester. Thai Society of Agricultural Engineering Journal. 2003;11(1):7-9.
[4] Chinsuwan W, Pongjan N, Chuan-Udom S, Phayom W. 2004. Effects of feedrate and threshing speed on performance of axial flow rice thresher. Thai Society of Agricultural Engineering Journal. 2004;10(1):9-14.
[5] Regional Network for Agricultural Machinery (United Nations) (RNAM). RNAM test codes and procedures for farm machinery. 2nd ed. RNAM; 1995.