Laboratory performance analysis of Rice Combine Harvester Daedong DSF75GT

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Abstract. Combine harvester is one of the most needed agricultural machinery by farmers as it is increasingly difficult to find harvest worker. To develop the machine, Department of Agriculture and Biosystem Engineering collaborated with AGM Systems & Engineering to test the DSF75GT type combine harvester machine. The preliminary test shows that the machine performance is not optimal, especially when it is viewed from the grain damage percentage during the harvesting process. Based on the process, the harvesting principle of the machine includes the stages of cutting, feeding, threshing, and moving the grain from the threshing unit to the grain tank, and finally with unloading stage. Process to grain transfer with screw conveyor system is suspected to be the cause of grain damage. For this reason, this study aims to determine the machine parts which potentially contribute to the grain damage. The test was carried out in laboratory with two sample, i.e. harvested grain samples (GKP) and milled dry grain (GKG). The sample was inserted in to the threshing chamber which is then transferred by screw conveyor to the grain tank before being removed. Observation of the grain damage is carried out at 5 points on the screw conveyors. The results showed that there were 3 screws which contribute significantly to grain damage. From the result, the next step focuses on modification of the parts.

1. Introduction

Indonesian Bureau of Statistics (BPS) stated that rice consumption per Indonesian people is about 114 kg per year. With more than 250 million of Indonesia’s population, needs almost 28 million tonnes per year of rice stock. On of the most important process of rice production is the harvestment process. Almost all of the harvestment process in Indonesia is still in manual way with cutting and threshing the crop by traditional tools. The low amount of field capacity causes the increase of labour needs to harvest the crop in a expansive area [4].

In all of the aspect that related to agricultural production, especially in harvestment and post-harvestment has improved on its technology which means the process of rice harvestment can be minimized in only just for one way process with the appearance of combine harvester. Combine harvester can also improves the effectivity, efficiency, and cutback the production cost that can reduced
the risk of agricultural operation which categorized as a one of the most high-risks operation in the world [5].

The preliminary test shows that the machine performance is not optimal, especially when it is viewed from the grain damage percentage during the harvesting process [1]. Based on the process, the harvesting principle of the machine includes the stages of cutting, feeding, threshing, screening, and conveying the grain from the threshing unit to the grain tank, and finally with unloading stage [7]. Process to grain transfer with screw conveyor system is suspected to be the cause of grain damage. For this reason, this study aims to determine the machine parts which potentially contribute to the grain damage.

2. Methodology
This research is conducted at Energy and Agricultural Machinery Laboratory of Agricultural and Biosystems Engineering Department, Faculty of Agricultural Technology Universitas Gadjah Mada and Dompyongan Village, Jogonalan Sub-District, Klaten Regency, Province of Central Java on the month of November 2018-March 2019. Data is collected by inserting the grain into the threshing unit of the combine harvester. To determine the results, this research uses 3 various of engine speed that set to 2300 RPM, 2500 RPM, and 2700 RPM. Before collecting the data, combine needs to be drained by inserting the grain then unload it with 2500 RPM of engine speed to reach homogeneous condition [2]. Data is collected on some of the conveying parts checkpoints for about 100 gr per sample that can viewed at Figure 1 i.e: Null Checkpoint (Control), 1st Checkpoint (Screw A), 2nd Checkpoint (Screw B), 3rd Checkpoint (Grain Tank), 4th Checkpoint (Bottom Unload), 5th Checkpoint (Top Unload), and 6th Checkpoint (Final Unload). Those checkpoint are arranged by each screw conveyor position.

3. Results and Discussion
This research attempts to find the grain damage percentage that caused by threshing operation inside combine harvester. The amount of grain damage percentage for each conveying parts (checkpoint) are determined the engine speed that suitable for harvesting operation [5].

3.1 Result analysis
This research has resulted three kind of data such as whole grain percentage, grain damage percentage, and side things of grain percentage [3].

3.1.1 Whole grain of harvested grain samples. Grain damage percentage has analyzed in a laboratory scale using Daedong Combine Harvester that results total amount of grain damage for each engine speed variance [6].
Table 1. Result analysis of whole grain (GKP) percentage

| Engine Speed (RPM) | Sample Checkpoint | Whole Grain (%) | Δ Whole Grain (%) |
|--------------------|------------------|----------------|------------------|
| 2300               | 0                | 98,02          |                  |
|                    | 1                | 98,14          | 0,13             |
|                    | 2                | 96,93          | 1,21             |
|                    | 3                | 96,91          | 0,02             |
|                    | 4                | 96,89          | 0,02             |
|                    | 5                | 96,86          | 0,02             |
|                    | 6                | 96,82          | 0,04             |
| 2500               | 0                | 98,02          |                  |
|                    | 1                | 97,77          | 0,25             |
|                    | 2                | 96,62          | 1,15             |
|                    | 3                | 96,60          | 0,02             |
|                    | 4                | 96,59          | 0,01             |
|                    | 5                | 96,49          | 0,09             |
|                    | 6                | 96,44          | 0,05             |
| 2700               | 0                | 98,02          |                  |
|                    | 1                | 97,57          | 0,45             |
|                    | 2                | 96,43          | 1,14             |
|                    | 3                | 96,40          | 0,03             |
|                    | 4                | 95,74          | 0,67             |
|                    | 5                | 95,72          | 0,01             |
|                    | 6                | 95,70          | 0,02             |

Figure 2. The relation between whole grain percentage and engine speed for each sample checkpoint (GKP)

Figure 2 shows that the highest amount of whole grain percentage in 2300RPM engine speed is about 1.21% on 1st checkpoint to 2nd checkpoint. But, there’s an anomaly data on null checkpoint to 1st checkpoint because a miscommunication between combine operator and researcher that can’t stop the engine at the right time. The highest amount of 2500RPM engine speed happens on 1st checkpoint to 2nd checkpoint for about 1.15%. On 2700RPM engine speed resulted that the highest amount of whole damage percentage is about 1.14% occurs at the same checkpoint with 2500RPM engine speed.
3.1.2 Broken grain of harvested grain samples. Conveying part of combine harvester has been suspected as a major cause of grain damage during the harvesting operation [8]. With those assumption, grain damage has analyzed in every checkpoint data that prejudice as a major causes of grain damage. Then, the result analysis of grain damage percentage can be viewed on Figure 3.

![Figure 3](image_url)

**Figure 3.** Relation between grain damage percentage and engine speed for each sample checkpoint

**Table 2.** Result analysis of broken grain (GKP) percentage

| Engine Speed (RPM) | Sample Checkpoint | Broken Grain (%) | Δ Broken Grain (%) |
|--------------------|-------------------|-------------------|-------------------|
| 2300               | 0                 | 0,37              |                   |
|                    | 1                 | 1,14              | -0,76             |
|                    | 2                 | 2,12              | -0,98             |
|                    | 3                 | 2,23              | -0,12             |
|                    | 4                 | 2,50              | -0,26             |
|                    | 5                 | 2,92              | -0,42             |
|                    | 6                 | 3,11              | -0,19             |
| 2500               | 0                 | 0,37              |                   |
|                    | 1                 | 1,82              | -1,44             |
|                    | 2                 | 2,59              | -0,78             |
|                    | 3                 | 2,67              | -0,08             |
|                    | 4                 | 2,79              | -0,12             |
|                    | 5                 | 3,22              | -0,43             |
|                    | 6                 | 3,53              | -0,31             |
| 2700               | 0                 | 0,37              |                   |
|                    | 1                 | 1,73              | -1,35             |
|                    | 2                 | 2,65              | -0,92             |
|                    | 3                 | 2,83              | -0,18             |
|                    | 4                 | 3,48              | -0,65             |
|                    | 5                 | 3,50              | -0,02             |
|                    | 6                 | 3,80              | -0,30             |
Table 2 shows that the highest amount of grain damage percentage on 2700RPM engine speed is about 1.35% occurs in null checkpoint to 1\textsuperscript{st} checkpoint whereas on 2500RPM engine speed is about 1.44% that located in the same position. 2300RPM resulting the highest amount of grain damage percentage for about 0.98% that located in 1\textsuperscript{st} checkpoint to 2\textsuperscript{nd} checkpoint.

3.2 The causes of grain damage analysis.

Based on previous research [1], there’s some modification on the Screw A (1\textsuperscript{st} Checkpoint) and Screw B (2\textsuperscript{nd} Checkpoint) that can be viewed on Figure 4 and Figure 5 below.

![Figure 4](image-url)

**Figure 4.** 2D view and 3D view of Screw A (a) and Screw B (b) 1\textsuperscript{st} combination

![Figure 5](image-url)

**Figure 5.** 2D view and 3D view of Screw A (a) and Screw B (b) 2\textsuperscript{nd} combination

With those modification, 1\textsuperscript{st} combination resulting grain damage weight for about 34.94 gr/kg sample whereas 2\textsuperscript{nd} combination resulting grain damage weight for about 31.12 gr/kg sample. There’s an improvement on the total amount of grain damage weight after readjusting screw conveyor to the newest combination based on previous research [1].
4. Conclusion
The highest amount of whole grain percentage located on Screw A (1st checkpoint) to Screw B (2nd checkpoint) for about 1.21% (2300 RPM), 1.15% (2500 RPM), 1.14% (2700 RPM) respectively. On the other parameter, the results of grain damage percentage is about 1.44% (2500 RPM), 1.35% (2700 RPM), 0.98 (2300 RPM) respectively. Most of them are occurs on null checkpoint to 1st checkpoint. The 2nd combination of screw conveyor are the best option to be installed in Daedong Combine Harvester DSF75GT.

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