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Research Article

Analysis of Failure Frequency in Travelling Unit Components of Combine Harvesters

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ABSTRACT

The effective functioning of combine harvesters is crucial for the agricultural industry, especially in the harvesting of grain crops, which is vital for food security and economic stability. This study examines the replacement intervals of travelling unit spare parts in combine harvesters, employing data gathered from 87 combine harvesters across nine brands in various districts of Bangladesh. The study seeks to deliver quantitative insights into these essential components' lifespan and replacement requirements, emphasizing the monitoring of running hours and replacement intervals. The data analysis indicates considerable discrepancies in replacement intervals across various spare components and types of harvesters. The research revealed that approximately 45% of the harvesters required new sprockets, with head feed (HF) models exhibiting greater wear than full feed (FF) models. Nearly 47% of crawlers required replacement due to prolonged usage. Approximately 24% of rollers required replacement, with the majority exceeding 600 hours of usage. Conversely, 96% of carrier rollers remained in satisfactory condition without requiring replacement, indicating their durability. One-third (33%) of rear rollers needed replacement, with HF models requiring earlier substitutions than FF versions. Approximately 18% of guides were substituted, with HF models exhibiting reduced lifespans. Merely 10% of tension frames needed modifications, whereas HF models demanded modifications more frequently. HF harvesters necessitated repairs and component replacements more frequently, whereas FF harvesters exhibited greater longevity before needing maintenance. This study provides essential insights for industry stakeholders and policymakers when deciding equipment maintenance and management methods.

Introduction

The agriculture sector, which employed 45.4% of Bangladesh's labor force in 2022, experienced a slight decline to 44.42% in 2023 (The Financial Express, 2024). The slight drop underscores the growing urgency for efficient mechanization and proper maintenance of equipment like combine harvesters to maintain productivity despite the shrinking agricultural workforce. According to provisional estimates by the Ministry of Finance (2024), the agriculture sector experienced a slight decline in growth rate from 3.37% in FY 2022-23 to 3.21% in FY 2023-24, accompanied by a marginal decrease in its contribution to the national GDP from 11.30% to 11.02% during the same period (Ministry of Finance, Bangladesh, 2024). Due to rising demand, the consumption of staple foods, including wheat, maize, and rice, is expected to significantly expand (Godfray & Garnett, 2014). To ensure global food security, it is necessary to increase food production by more than double, with an estimated 100–110% rise in global crop demand projected between 2005 and 2050 (Tilman *et al.*, 2011). Therefore, acceptable rice production is the major method for ensuring Bangladesh's food security (Nath *et al.,* 2016). Several research findings indicated that mechanical intervention is one of the most effective approaches to boosting rice output, closing the yield gap, and reducing postharvest losses (Chandra Nath *et al.,* 2017; Hasan *et al.,* 2019; Mottaleb *et al.,* 2016).

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Combine harvesters are essential in modern agricultural practices, playing a vital role in enhancing productivity and efficiency during the harvesting process. Farmers in Bangladesh have gradually recognized the importance of these machines, with increasing adoption rates driven by their ability to reduce labor and ensure timely harvesting (Islam and Rahman, 2024). As of 2023, 9,704 combine harvesters have been imported into the country (Islam and Rahman, 2024). The Ministry of Agriculture aims to increase this number to 30,000 by 2030, underscoring its critical role in agricultural development and food security (MoA, 2016).

The widespread use of combine harvesters faces several challenges. These include mechanical disturbances during machine operation, a lack of spare parts in rural areas, and the shortage of skilled mechanics and operators, all of which impact their reliability and usability (Hossain *et al.*, 2015). A 2024 study by the Cereal Systems Initiative for South Asia (CSISA) and International Maize and Wheat Improvement Center (CIMMYT), surveying 2,608 Machine Service Providers (MSPs) across 21 districts in Bangladesh, found that key challenges faced by MSPs include machine damage, unavailability of spare parts, and operational difficulties, with machine damage being the most significant issue (CSISA-MEA, CIMMYT, and iDE, 2024). Proper maintenance and operator training are crucial to overcoming these issues. Best practices, such as maintaining clean work environments, storing machines indoors, and operating them at optimal power levels, can significantly reduce failures and extend machinery lifespan (Paman *et al.*, 2024). The functionality of combine harvesters, particularly the crawler chassis, must meet high-performance standards in terms of field pass ability, reliability, and operational simplicity to cater to the specific requirements of rice harvesting (Tang *et al.*, 2020). These technical demands emphasize the need for robust spare parts and reliable maintenance practices, particularly for high-wear components such as sprockets, rollers, and tension bolts. The variability in failure frequency of these components is often influenced by factors such as field conditions, operator expertise, maintenance practices, and machine overloading (Paman *et al.*, 2024).

Harvesting rice manually is a demanding process in terms of time, cost, and labor, typically involving 100 to 150 workers to harvest a hectare of paddy field within an hour (Alizadeh *et al.*, 2013). Bangladesh has seen a growing reliance on combine harvesters, with 5,600 head feed and 4,104 full feed models (Islam and Rahman, 2024). As the agricultural machinery sector evolves, trends toward larger, more powerful, and self-propelled machines with advanced sensors, improved power-splitting transmissions, and automation technologies are driving productivity and reducing operator workload, factors that are likely to influence the lifespan and maintenance intervals of critical components in agricultural equipment. (Kutzbach, 2000). The repair and replacement costs associated with farm machinery are key determinants of their cost-effectiveness. The rate of increase in repair costs over time influences the recommended replacement age of machinery, thereby significantly affecting total ownership costs (Ward *et al.*, 1985). It is emphasized that operating a combine harvester at minimal cost is essential for achieving optimal efficiency (Spokas and Steponavicius, 2011). Repair and maintenance costs (R&M), included in the annual operating expenses, typically account for approximately 10% to 15% of the total mechanization costs (Rotz and Bowers, 1991, Calcante, Fontanini, and Mazzetto, 2013). Additionally, repair and maintenance costs generally increase with the machine's age, making them a crucial factor in deciding the optimal time to replace the machine (Calcante *et al.*, 2013). Optimizing replacement intervals for critical spare parts can not only reduce downtime but also minimize operational expenses for farmers.

This study focuses on analyzing the replacement intervals of travelling unit spare parts in combine harvesters, considering 87 machines across nine brands operating in different districts of Bangladesh. It aims to identify the factors that affect spare part reliability, including brand variations, harvester types, and regional influences. The findings are expected to guide manufacturers in improving product durability, assist policymakers in developing strategies for spare parts availability, and help farmers adopt more effective maintenance practices. The study draws on existing research and industry data to propose actionable recommendations that address gaps in maintenance, operator training, and spare parts management, thereby supporting the sustainable growth of mechanized agriculture in Bangladesh. Specifically, this study will analyze spare parts replacement time for combine harvesters and compare spare parts replacement intervals across a couple of types of combine harvesters.

Methodology

Study design and sampling strategy

This study employed a quantitative, cross-sectional research design to investigate the replacement time of travelling unit spare parts in combine harvesters across various regions of Bangladesh during the year 2024. The study aimed to capture variability in spare parts replacement across different operational environments, harvester types, and machine brands.

The sample consists of 87 combine harvesters randomly selected from the population of harvesters operating in eight districts: Patuakhali, Borguna, Dinajpur, Rangpur, Sirajgonj, Sunamgonj, Tangail, and Hobigonj (Figure 1). This geographic spread was chosen to reflect variations in soil types, crop types, and harvesting conditions that may influence the wear and replacement of spare parts.

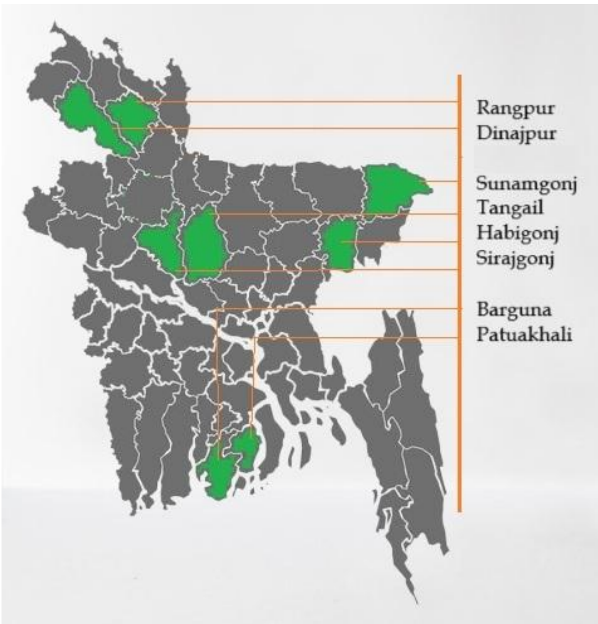

Fig. 1. Study locations

The travelling units of the selected combine harvesters are equipped with key components, including sprockets, crawlers, rollers, carrier rollers, rear rollers, guides, tension frames, and tension nuts and bolts (Islam and Rahman, 2024). Data collection was conducted using a structured questionnaire, which was administered to combine harvester operators in the selected districts. The questionnaire captured essential variables such as operating hours, annual usage, and breakdown reasons for each of the spare parts. Among the 87 combine harvesters studied, 40 were head-feed type and 47 were full-feed type. This diversity in harvester types enabled the study to analyze differences in spare part replacement patterns across distinct operational modes. Additionally, including 9 different brands ensured broad industry representation, enhancing both the generalizability and robustness of the research findings.

Data collection

Data for this study was collected based on detailed information on the operational lifespan of specific travelling unit spare parts in combine harvesters (Figure 2). The questionnaire gathered data on the operating hours (OH) and replacement hours (RH) for each identified spare part, including sprockets, crawlers, rollers, carrier rollers, rear rollers, guides, tension frames, and tension nuts and bolts. In addition to spare part usage metrics, the questionnaire also recorded contextual information such as the operator’s contact details, harvester brand, model, type (head-feed or full-feed), and the geographic location of operation. This supplementary data was essential for understanding the influence of regional and machine-specific factors on spare part wear and replacement patterns.

The data collection process was carried out systematically across the selected districts to ensure consistency, accuracy, and reliability. Enumerators were trained to maintain meticulous records and verify responses by cross-checking machine logs or operator accounts when available.

(a)

(b)

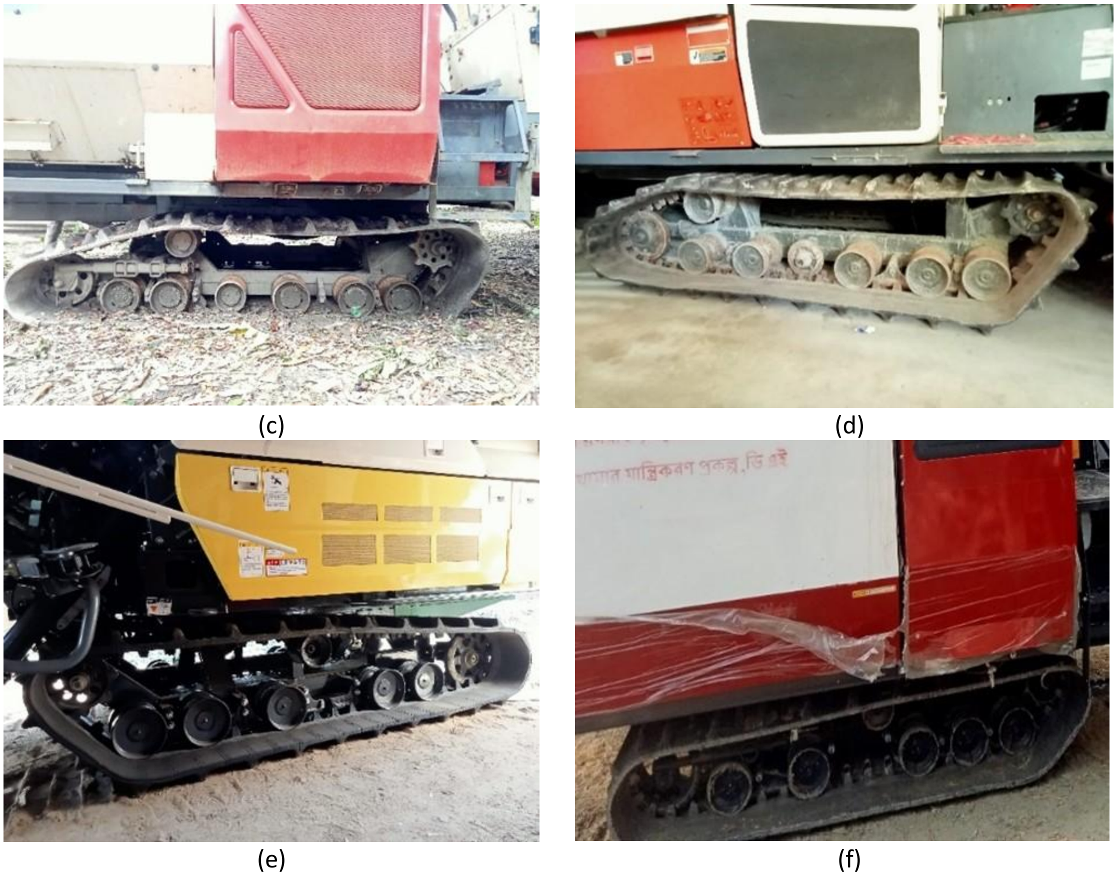

Fig. 2. travelling unit of different combine harvester: (a) Lovol RG108 plus, (b) FM World 4LZ-4.0E, (c) Field king FKCH2100, (d) Kubota DC70G, (e) ISEKI, (f) Yanmar AG600A

Table 1. Brand name, model and crawler size of the surveyed combine harvesters

Brand Name	Model	Crawler Size (mm)		
		A	B	C
LOVOL	Lovol RG108 plus	500	90	56
FM World	4LZ-4.0E	500	90	53
Massey Ferguson	MF-2168	500	90	49
Yanmar	Yanmar YH700	500	90	54
Zoomlion	FH100	500	90	53
Kubota	DC70G	500	90	53
Field King	FKCH 2100	500	90	56
Marksan	MS-1200	500	90	54
Daedong	DXM 73GF	450	90	51
Yanmar	AG600	450	90	47

The dimensions "A x B x C" typically represent the dimensions of a track or crawler used in combine harvester (Table 1). The first number (A) represents the track's width in millimeters. The second number (B) represents the track's pitch, which is the distance between the centers of two consecutive links on the track, also measured in millimeters. The third number (C) represents the track's number of links, measured in number.

Data Analysis

Collected data was entered into Microsoft Excel and subsequently analyzed using descriptive statistical methods. Metrics such as mean, standard deviation, and frequency distributions were computed to evaluate patterns in spare part usage and replacement. The analysis aimed to identify trends and differences based on harvester type, brand, and geographic region.

Descriptive statistics are employed to summarize the replacement time data, offering insights into the average longevity of different spare parts in combine harvesters. Comparative investigations are undertaken to discern variations in replacement intervals among different types, brands, and geographic regions of combine harvesters. This enables a thorough analysis of maintenance requirements and operational patterns in the agriculture sector, promoting informed decision-making and the enhancement of maintenance practices.

Average operating time =

$$\frac{\sum_{i=1}^{N} Operating\ time, i}{N} \quad \text{------------------------(1)}$$

Where, N= total no. of harvesters observed and Operating time,

i = operating hours for the *i*-th harvester

Average yearly operating time =

$$\frac{\sum_{i=1}^{N} Yearly\ operating\ time, i}{N} \quad \text{-------------(2)}$$

Where, Yearly operating time, *i* = annual operating hours for the *i*- th harvester

Replacement time =

$$\frac{(n_{HF}\ x\ L_{HF}) + (n_{FF}\ x\ L_{FF})}{n_{HF} + n_{FF}} \quad \text{------------------(3)}$$

Where,

n_{HF} = Number of HF harvester observed for that part

L_{HF} = Average lifetime (hours) for that part in HF harvester

n_{FF} = Number of FF harvesters observed for that part

L_{FF} = Average lifetime (hours) for that part in FF harvester

Results and Discussion

Operating hours of combine harvester

The mean operational duration for all studied harvesters is almost 975 hours, but the annual average operational time is about 390 hours, providing insights into the operational patterns of combine harvesters.

Table 2. Operation of combine harvester

Total Observation	Head feed	Full Feed	Avg. Operating time (Total), hr.	Yearly avg. operating time (Last year), hr.
87	40	47	975	390

Replacement time calculation of sprocket

Approximately 45% of the surveyed combine harvesters required sprocket replacements during the study period. Notably, the average replacement interval for sprockets varied significantly between harvester types. Head-feed harvesters exhibited a mean replacement interval of 327 operating hours, whereas full-feed harvesters demonstrated a longer interval of 607 hours, double that of their head-feed counterparts (Table 3).

This discrepancy in replacement intervals can be attributed to differences in design characteristics and operating conditions. The durability of travelling unit components, particularly in head-feed harvesters, is adversely affected by the operation in high mud depths.

According to manufacturer guidelines, head-feed harvesters are recommended for use in mud depths not exceeding 6 inches due to their lower ground clearance. In contrast, full-feed harvesters can operate in conditions with mud depths of up to 18 inches.

However, in many regions of Bangladesh, head-feed harvesters are frequently used in fields with mud depths ranging from 10 to 12 inches. This practice imposes excessive mechanical stress on key components such as sprockets, rollers, and rear rollers. The resulting strain accelerates wear and shortens the service life of these parts, leading to more frequent replacements and increased maintenance demands.

Table 3. Replacement time of sprocket

Sprocket observation, Nos.		**Operating time, hr.**		**Sprocket replacement**		**Sprocket replacement time, hr.**	
Not changed	Changed	Not changed	Changed	Head feed	Full feed	Head feed	Full feed
48 (55%)	39 (45%)	764	1231	27	12	327	607

Replacement time calculation of crawler

Analysis of the observation data indicates that 47% of the crawlers in the surveyed combine harvesters were replaced during the study period. Replaced crawlers exhibited a significantly higher average operating time of 1,237 hours, compared to 741 hours for those that had not yet been replaced. The average crawler replacement interval also varied by harvester type. In head-feed harvesters, crawlers were replaced after an average of 650 operating hours, whereas in full-feed harvesters, the average replacement interval extended to 821 hours (Table 4). This suggests that full-feed harvesters may provide better durability for crawler components under typical operating conditions.

One contributing factor to crawler wear is the misalignment between the header unit and the travelling unit, particularly when machines are maneuvered along field edges or curves. This misalignment places additional strain on the crawler and associated components, increasing mechanical stress and the likelihood of premature failure. Such operational practices highlight the need for proper machine alignment and operator training to prolong the service life of crawler systems.

Table 4. Replacement time of crawler

Crawler observation, Nos.		Operating time, hr.		No. of head feed		No. of full feed		Replacement time, hr.	
Not changed	Changed	Not changed	Changed	Not changed	Changed	Not changed	Changed	Head feed	Full feed
46 (53%)	41 (47%)	741	1237	10	30	36	11	650	821

Replacement time of roller

The study found that 24% of the observed rollers required replacement, with an average operational lifespan of 956 hours prior to failure. Replacement intervals varied between harvester types, with full-feed combine harvesters showing a longer average interval of 654 hours, compared to 520 hours for head-feed models (Table 5). These findings indicate that rollers in head-feed harvesters are subjected to higher levels of wear and may require more frequent maintenance.

The structural design of the rollers also plays a significant role in their durability. Certain combine harvester models utilize single-ended rollers, which are mounted on only one side of the chassis frame. These configurations are inherently less stable and more prone to damage during field operations. In contrast, models equipped with double-ended rollers, attached on both sides of the chassis, offer greater stability, which contributes to extended component life and improved performance under stress.

These results highlight the importance of both operational practices and equipment design in influencing component longevity. Selecting harvester models with more robust roller designs and aligning operations with recommended guidelines can help reduce maintenance frequency and improve machine reliability.

Table 5. Replacement time of roller

Roller observation, Nos.		Operating time, hr.		No. of head feed		No of full feed		Replacement time, hr.	
Not changed	Changed	Not changed	Changed	Not changed	Changed	Not changed	Changed	Head feed	Full feed
66 (76%)	21 (24%)	980	956	30	10	36	11	520	654

Replacement time of carrier roller

The findings related to carrier rollers in combine harvesters reveal a low frequency of replacement, indicating high durability under typical operating conditions. Specifically, 95% of the observed carrier rollers did not require replacement during the study period. These non-replaced rollers exhibited an average operational lifespan of approximately 982 hours.

In contrast, only 5% of the observed rollers required replacement, with those showing an average operational duration of 800 hours prior to failure. Despite the small replacement percentage, notable differences were observed between harvester types. Head-feed combine harvesters had a significantly shorter replacement interval, averaging 480 hours, whereas full-feed harvesters demonstrated a longer average replacement interval of 700 hours (Table 6).

These results suggest that while carrier rollers offer extended durability, their performance is still influenced by the operational environment and machine configuration. The shorter replacement interval in head-feed harvesters may be attributed to greater exposure to mud and uneven terrain, which imposes additional stress on the carrier roller system.

Table 6. Replacement time of carrier roller

Carrier roller observation		Operating time, hr.		No. of head feed		No. of full feed		Replacement time, hr.	
Not changed	**Changed**	**Not changed**	**Changed**	**Not changed**	**Changed**	**Not changed**	**Change d**	**Head feed**	**Full feed**
83 (95%)	4 (5%)	982	800	20	3	63	1	480	700

Replacement time of rear roller

Replacement data for rear rollers in combine harvesters are summarized in (Table 7). Of the total observations, 58 cases (67%) did not require rear roller replacement during the study period. These rollers demonstrated an average operational time of approximately 881 hours. In contrast, 29 instances (33%) involved roller replacements, with an average running time of 1,162 hours prior to failure.

Further analysis reveals significant differences in replacement intervals between harvester types. Rear rollers in head-feed harvesters exhibited a considerably shorter average replacement interval of 264 hours. In comparison, full-feed harvesters showed greater durability, with rear rollers averaging 625 hours before requiring replacement. These findings highlight the increased wear experienced by rear rollers in head-feed harvesters, which may be attributed to more frequent exposure to high mud depths, sharp turning maneuvers, or less robust design specifications. The data underscore the need for improved maintenance practices and potential design enhancements for rear rollers in head-feed systems to reduce premature component failure.

Table 7. Replacement time of rear roller

Rear roller observation		Operating time, hr.		No. of head feed		No of full feed		Replacement time, hr.	
Not changed	Changed	Not changed	Changed	Not changed	Changed	Not changed	Changed	Head feed	Full feed
58 (67%)	29 (33%)	881	1162	14	6	44	23	264	625

Replacement time of guide

Data on guide replacements indicates that 18% of the observed guides required replacement during the study period. The replacement of guides showed a higher average operational time of 1,203 hours, compared to 926 hours for those that were not replaced. This suggests that prolonged usage contributes to the increased need for maintenance and potential component failure.

Moreover, variations in maintenance intervals were observed between head-feed and full-feed harvesters. Guides used in head-feed operations had a shorter average replacement interval of 535 hours, while those in full-feed operations had a slightly longer average interval of 557 hours (Table 8). These differences highlight how operational conditions, such as the type of harvester and its working environment, can influence the frequency of guide replacements.

Table 8. Replacement time of guide

Guide observation		Operating time, hr.		No. of head feed		No. of full feed		Replacement time, hr.	
Not changed	Changed	Not changed	Changed	Not changed	Changed	Not changed	Changed	Head feed	Full feed
71 (82%)	16 (18%)	926	1203	20	5	51	11	535	557

Replacement time of tension frame

The data on tension frame replacements reveal that only 10% of the observed tension frames required replacement, suggesting a relatively low frequency of maintenance within the sample. The tension frames that did need replacement had a higher average operational time of 1,133 hours compared to those that were not replaced, underscoring the impact of prolonged usage on the possibilities of failure.

Further analysis showed that maintenance intervals for tension frames varied depending on operational context. Tension frames in head-feed operations had a shorter average replacement interval of 350 hours, whereas those in full-feed operations were replaced less frequently, with an average interval of 475 hours (Table 9). These differences indicate that the demands placed on tension frames may be more strenuous in head-feed harvesters, possibly due to increased stress from operating conditions such as mud depth and uneven terrain.

Material quality and structural integrity also play a crucial role in the longevity of tension frames. Poor-quality materials and weak structural design may lead to faster deterioration, particularly under heavy operational loads, contributing to shorter replacement intervals.

Table 9. Replacement time of tension frame

Tension frame observation		Operating time, hr.		No. of head feed		No. of full feed		Replacement time	
Not changed	Changed	Not changed	Changed	Not changed	Changed	Not changed	Changed	Head feed	Full feed
78 (90%)	9 (10%)	957	1133	19	5	59	4	350	475

Replacement time of tension nut and bolt

The study data on tension nuts and bolts in combine harvesters indicate that these components generally require minimal replacement. Of the 87 observed instances, 73 (84%) did not require replacement, with an average operational time of approximately 883 hours. However, the remaining 14 instances (16%) that required replacement had a significantly longer average running time of about 1,468 hours.

Further analysis revealed differences in replacement intervals between head-feed (HF) and full-feed (FF) harvesters. Tension nuts and bolts in HF harvesters had a shorter average replacement interval of 239 hours, while those in FF harvesters exhibited a considerably longer replacement interval, averaging 619 hours (Table 10). These findings suggest that operational demand may be lower for full-feed harvesters, leading to less frequent replacement of these components.

Table 10. Replacement time of tension nut and bolt

Tension nut and bolt observation		Operating time, hr		No. of head feed		No. of full feed		Replacement time	
Not changed	Changed	Not changed	Changed	Not changed	Changed	Not changed	Changed	Head feed	Full feed
73 (84%)	14 (16%)	883	1468	10	5	63	9	239	619

Replacement time variation between head feed and full feed combine harvester

Figure 3 presents a summary of the average replacement times for various travelling unit parts in combine harvesters, illustrating the differences in replacement intervals between head-feed (HF) and full-feed (FF) models. The data highlighted that several parts in head-feed harvesters require earlier replacement compared to full-feed harvesters. For instance, sprockets in head-feed harvesters require replacement at 327 hours, whereas full-feed harvesters require sprocket replacement at 607 hours. Similarly, crawler replacement is needed at 650 hours for head-feed harvesters, compared to 821 hours for full-feed harvesters. Rollers in head-feed models need replacement at 520 hours, whereas those in full-feed harvesters last longer, requiring replacement at 654 hours.

The trend continues for other parts, with carrier rollers in head-feed harvesters requiring replacement at 480 hours, compared to 700 hours for full-feed harvesters. Rear roller replacement intervals also show considerable variation, with head-feed harvesters requiring replacement at 264 hours and full-feed harvesters at 625 hours. Guides in head-feed harvesters are replaced at 535 hours, while full-feed harvesters show a slightly longer replacement interval of 557 hours. Tension frames in head-feed models require replacement at 350 hours, whereas full-feed harvesters reach an average of 475 hours before replacement. Finally, tension nuts and bolts in head-feed harvesters need replacement at 239 hours, while those in full-feed harvesters last longer, with an average replacement interval of 619 hours.

These variations in replacement times can be attributed to several factors, including model design, material properties, and operational differences. Full-feed harvesters are generally built to handle more demanding conditions, such as deeper mud depths, and tend to experience less strain on certain components. On the other hand, head-feed harvesters, which are typically used in more challenging terrains and under higher operational stress, show quicker wear and shorter replacement intervals.

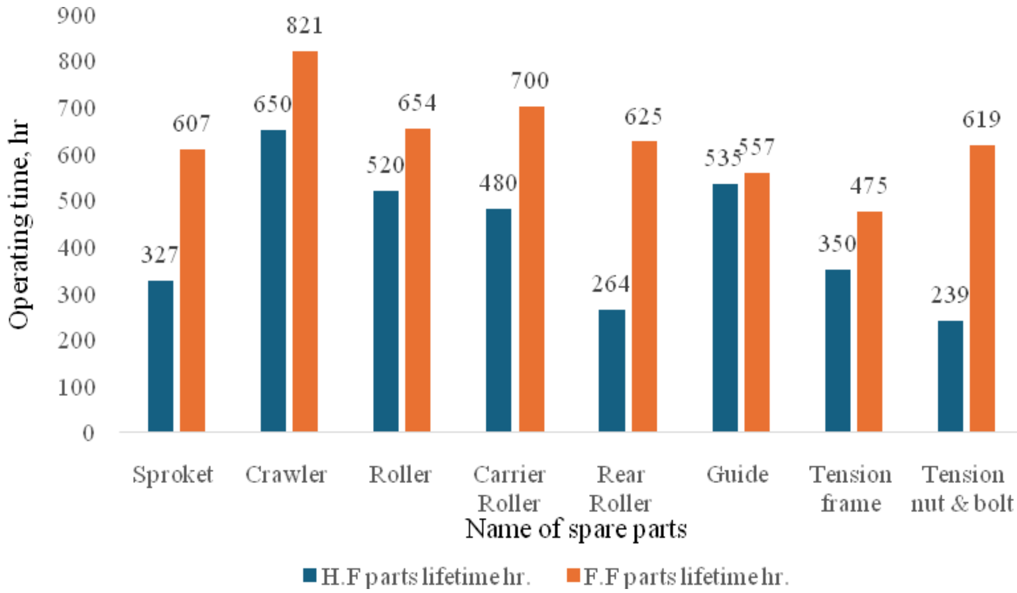

Fig. 3. Travel unit parts lifetime comparison between HF and FF

Replacement schedule

The replacement schedule reveals notable differences in component durability between head-feed (HF) and full-feed (FF) combine harvester models. FF models demonstrate significantly longer replacement intervals across most parts, indicating enhanced longevity and potentially lower maintenance costs. Sprockets in FF models last nearly twice as long (607 hours) compared to HF models (327 hours), suggesting design or usage differences that impact wear rates. Similarly, tension nuts and bolts in FF harvesters require replacement at over 600 hours, more than double the 239 hours for HF models. This disparity may reflect variations in mechanical stress or operational efficiency. The relatively shorter lifespan of parts in HF models underscores the importance of tailored maintenance strategies and highlights the potential economic benefits of investing in FF models for operators seeking reduced downtime and maintenance expenses. Furthermore, these findings emphasize that proactive replacement planning based on model-specific intervals. Adhering to these replacement intervals ensures optimal performance, minimizes operational disruptions, and helps operators maintain their harvesters in good working order.

Table 11. Travelling unit parts replacement schedule

Travelling unit part	Replacement schedule, hr.		
	Average	Head feed	Full feed
Sprocket	413	327	607
Crawler	695	650	821
Roller	590	520	654
Carrier roller	535	480	700
Rear roller	550	264	625
Guide	552	535	557
Tension frame	406	350	475
Tension nut and bolt	483	239	619

Conclusion

This study provides valuable insights into the spare parts replacement intervals of combine harvesters, specifically comparing the head-feed (HF) and full-feed (FF) models. The results show that HF models tend to require more frequent replacements, especially for components like sprockets, crawlers, and rollers, due to their shorter lifespans. The findings highlight the importance of implementing tailored preventive maintenance schedules to minimize unexpected breakdowns and maximize machine performance, particularly for HF models. The research also underscores the need for regular inspections and timely replacements of parts of the travelling unit of combine harvesters. Based on these observations, It is recommended that implementing a preventive maintenance schedule tailored to the harvester type to minimize downtime and ensure smoother operation. For HF models, critical components such as sprockets (replace around 320 hours), rear rollers (replace around 260 hours), and tension nuts and bolts (replace nearly240 hours) require more frequent inspection and proactive replacement. For FF models, replacement intervals are longer, but parts like sprockets (around 600 hours) and crawlers (over 800 hours) should still be regularly monitored to maintain optimal performance. Maintenance programs should prioritize early detection and timely replacement of high-wear parts in HF harvesters to extend equipment life and improve operational efficiency. Spare parts inventory management must align with these replacement schedules to ensure the availability of high-failure components, especially for HF models, to reduce downtime. However, the study has some limitations, including the reliance on operator and owner surveys, which may introduce recall bias, and the narrow geographic scope, as the data was gathered from only eight districts in Bangladesh, potentially limiting its national representativeness. To address these limitations, future research should incorporate longer-term tracking, real-time data collection, and a wider geographic coverage to improve the accuracy and generalizability of the findings. Additionally, exploring advancements in materials and design for combine harvester components could further enhance their durability and performance, contributing to more efficient and sustainable agricultural practices.

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Competing interests

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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