

New Threshing Drums for Energy Saving in Conventional Threshing Machinery

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Abstract:- Domestic thresher is one of the important machine in Turkey. The improvement possibilities of their drum construction for energy saving investigated. For this purpose, three new toothed drums designed and manufactured. Experiments carried out for energy consumption for two variety of wheat. The average power requirements of all experiments determined as 2.31 kW for original toothed drum, 2.16 kW for type A toothed drum, 1.98 kW for type B toothed drum, and 1.76 kW for type C toothed drum. Specific energy consumption saves 4.7%, 14.0% and 21.3% respectively in A, B and C type toothed drums as an average of all experiments compared to the original type toothed drum. Specific energy consumption (SCE) saves 4.7%, 14.0% and 21.3% respectively in A, B and C type toothed drums as an average of all experiments compared to the original type toothed drum.

Keywords:- Power Requirement; Specific Energy Consumption; Threshing Drum; Wheat Threshing

I. INTRODUCTION

In wheat production, the amount of labor associated with the processes during harvest may decrease in a more pronounced appearance compared to the processes before harvest by mechanization. In the United States, 9.4 h of labor was required to blend 1 ha of land area in 1940, while this amount decreased to 4.9 h in 1950 [1]. The proportion of the population working in agriculture in the United States to the total population was 4.8% in 1970 (Smith and Wilkes 1976) [2]. The proportion of the working population in the United States to the total population was 2.8% in 1990, 1.7% in 2000 and 1.5% in 2010 [3]. In Turkey, the proportion of the population working in agriculture to the total population was 73%, 40.0%, 35.1% and 23.7% respectively in 1970, 1990, 2000 and 2010 [4].

The threshing process is performed by hitting a fast-moving element into the material to be forged, rubbing, compressing, a combination of two or more of these effects, or by some other methods in which the forces required for threshing are applied [5] [6] [7].

A study conducted by keeping the opening between the drum and the concave constant at an average of 6 mm, the speed of the drum at 1480 rev/min and the speed of the feed band at 6.6 min found that variety, maturity and humidity, which are product parameters, are important in the blending of wheat [8]. As the maturity of wheat increases, the blending yield also increases. Reference [9] found blending efficiency with five wheat varieties increases up to 97%. Broken grain ratio was found to be 0.7-10.5% with experiments conducted by selecting the environmental speed of the drum 22-23 m/s [10]. The loss caused by increasing feed rate is insignificant [11]. In a study in which different drum diameters were used and the opening between drum and concave was kept constant, it was found that the ratio of non-forged grains decreased with increasing the environmental speed of the drum [12]. In a study conducted with closed concave, it was found that the ratio of broken grains was less than that of open concave [13]. Power requirement determine for rasp bar drum [14].

In multi-drum threshing systems, the power required for threshing is 25% less than in single-drum threshing systems if the appropriate environmental speed of the drum is selected [15].

The comparison, and evaluation based on the threshing efficiency related to the percent of un-threshed grain; the grain quality related to the percent of damaged grain; and the machine threshing capacity related to the drum speeds. The results showed that the wheat threshing efficiency was ranged from 96.8 to 99.3%, % for the developed thresher, while it was nearly from 92.6 to 97.25% for the Turkish thresher before development [16]. The values for highest visible grain damage, optimum thresher's output capacity, threshing and cleaning efficiency were observed at the maximum threshing drum speed of 1600 rpm for wheat [17].

In Turkey, the number of threshers is decreasing and the number of combine harvesters is increasing (Table 1).

In Turkey, the number of threshing machines decreased from 181320 to 161121 in 2018. The number of harvester increased from 15899 to 17266 in 2018 (Table 1). While Turkey's per capita GDP was US\$ 3,688 annually in 2002, this income reached US\$ 12,614 in 2013.

TABLE I. NUMBER OF THRESHERS AND COMBINES IN TURKEY. [4]..

Year	Thresher	Combine harvester
2014	181320	15 899
2015	173555	15 998
2016	170836	16 247
2017	167581	17 199
2018	160121	17 266

A dynamically balanced mechanism for cleaning the unit used agricultural threshing machine was carried out using a dynamically equivalent point mass system. CAD (Computer Aided Model) of the thresher machine is shown in Fig 1. [18].

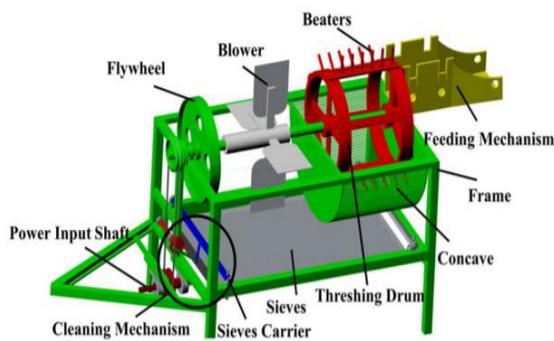


Fig. 1. CAD model of the thresher machine [18].

II. MATERIAL AND METHOD

In the study, toothed drums matching the $y=a x^n$ equation were designed. The toothed drums were manufactured from AISI 1020 HR material in 35 mm x 10 mm cross-section by hot forming process (Table 2).

TABLE II. NEW DESIGNED THRESHING DRUM TEETH

Tooth form	a	N
Type A	1	2
Type B	0.1667	3
Type C	0.0278	4

To determine the drum torques Hottinger Baldwin Messtechnik T2, 100 N.m transducer and HBM illuminated oscillography were used.

Yayla 305 and Lancer wheat varieties were used in the experiments. IS 1124 test code considered [19].

Stationary thresher is the thresher which performs the threshing operation while the machine itself is being stationary. Power thresher is a machine operated by a prime mover, such as electric motor, engine, tractor, power tiller used for threshing [20]. Main components of power thresher are concave and drum. A concave shaped metal grating partially surrounding the cylinder against which the cylinder rubs the grain from the plant or ear heads and through which the grains fall on the sieve. Drum is a balanced rotating assembly combining rasp, beater bar or spikes on its periphery and their support for threshing the crop [21]. In this study, the term tooth was used instead of beater bar as following Arnold

[11]. In experiments one original toothed drum and three new designed type toothed drums used shown in Fig. 2 [22], [23].

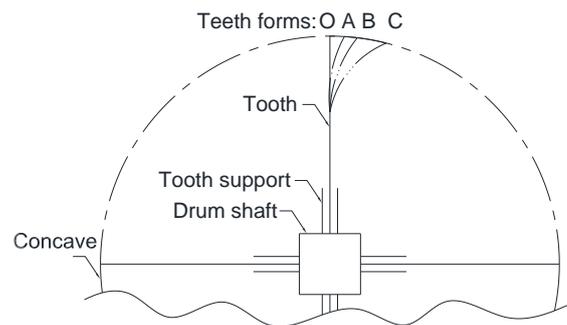


Fig. 2. New designed teeth.

Fastening the tooth to the support, the two plates were fixed to the drum shaft by electric arc welding. Three bolts were used to fasten the tooth to the support. Support detail shown in Fig 3.

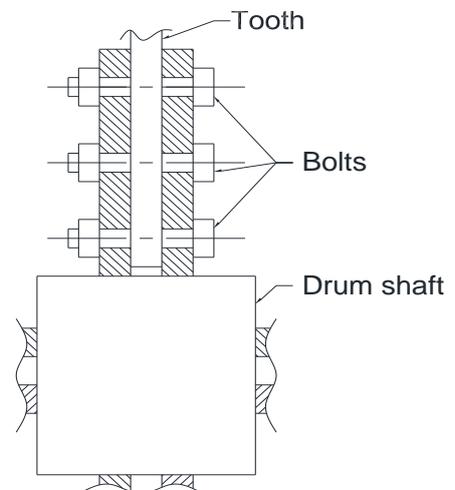


Fig. 3. Detail of toothed drum shaft fastening.

III. EXPERIMENTAL RESULTS

A. Average Torques

When the drum peripheral speed was 30 m/s and wheat variety Yayla 305, the largest and smallest torque were found to be 31.6 N.m (O type) and 24.8 N.m (C type), respectively. When the drum peripheral speed was 30 m/s and wheat variety Lancer, the largest and smallest torque were found to be 33.9 N.m (O type) and 23.3 N.m (C type), respectively. When the drum peripheral speed was 35 m/s and wheat variety Yayla 305 the largest and smallest torque were found to be 31.7 N.m (O type) and 23.3 N.m (C type), respectively. When the drum peripheral speed was 35 m/s and wheat variety Lancer, the largest and smallest torque were found to be 29.4 N.m (O type) and 22.8 N.m (C type), respectively. When the drum peripheral speed was 40 m/s and wheat variety Yayla 305, the largest and smallest torque were found to be 29.1 N.m and 24.0 N.m, respectively. When the drum peripheral speed was 40 m/s and wheat variety Lancer, the largest and smallest torque were found to be 27.1 N.m and 24.3 N.m, respectively (Fig 4).

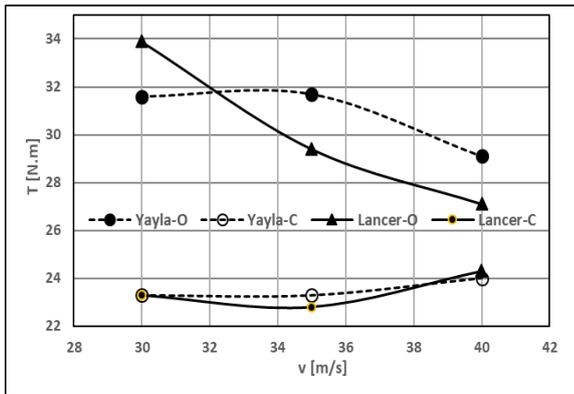


Fig. 4. Average torques T [N.m] versus drum peripheral speed v [m/s].

B. Average Powers

When the drum peripheral speed was 30 m/s and wheat variety Yayla 305, the largest and smallest power were found to be 2.07 kW (O type) and 1.63 kW (C type), respectively. When the drum peripheral speed was 30 m/s and wheat variety Lancer, the largest and smallest power were found to be 2.22 kW (O type) and 1.53 kW (C type), respectively. When the drum peripheral speed was 35 m/s and wheat variety Yayla 305, the largest and smallest power were found to be 2.43 kW (O type) and 1.78 kW (C type), respectively. When the drum peripheral speed was 35 m/s and wheat variety Lancer, the largest and smallest power were found to be 2.25 kW (O type) and 1.74 kW (C type), respectively. When the drum peripheral speed was 40 m/s and wheat variety Yayla 305, the largest and smallest power were found to be 2.54 kW (O type) and 2.10 kW (C type), respectively. When the drum peripheral speed was 40 m/s and wheat variety Lancer, the largest and smallest power were found to be 2.37 kW (O type) and 2.12 kW (C type), respectively. The average required power for the drum to run idle at 30 m/s peripheral speed was found to be 0.62 kW. The average required power for the drums to run idle at 35 m/s peripheral speed was found to be 0.73 kW. The average required power for the drums to run idle at 40 m/s peripheral speed was found to be 0.83 kW. These values are close to the 0.91 kW value given for the power required by the drum with a 20% wider drum length [24]. In the Lancer wheat variety, the power was found to be greater than in the Yayla 305 wheat variety (Fig 5).

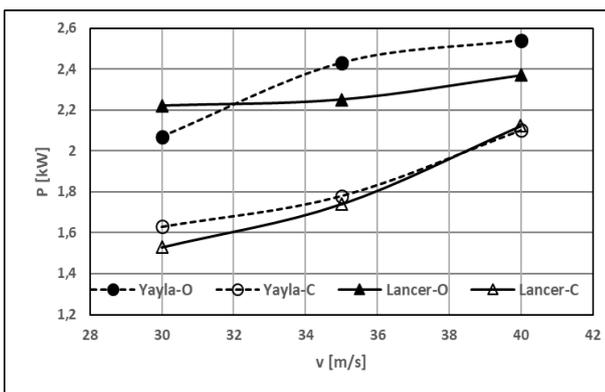


Fig. 5 Average powers P [kW] versus drum peripheral speed v [m/s].

C. Specific Energy Consumption

When the drum peripheral speed was 30 m/s and wheat variety Yayla 305, the largest and smallest SEC (Specific Energy Consumption) were found to be 1.47 kWh/t (O type) and 0.99 kWh/t (C type), respectively. When the drum peripheral speed was 30 m/s and wheat variety Lancer, the largest and smallest SEC were found to be 1.35 kWh/t (O type) and 1.07 kWh/t (C type), respectively. When the drum peripheral speed was 35 m/s and wheat variety Yayla 305, the largest and smallest SEC were found to be 1.48 kWh/t (O type) and 1.13 kWh/t (C type), respectively. When the drum peripheral speed was 35 m/s and wheat variety Lancer, the largest and smallest SEC were found to be 1.62 kWh/t (O type) and 1.16 kWh/t (C type), respectively. When the drum peripheral speed was 40 m/s and wheat variety Yayla 305, the largest and smallest SEC were found to be 1.58 kWh/t (O type) and 1.38 kWh/t (C type), respectively. When the drum peripheral speed was 40 m/s and wheat variety Lancer, the largest and smallest SEC were found to be 1.69 kWh/t (O type) and 1.37 kWh/t (C type), respectively. Specific energy consumption (SCE) saves 4.7%, 14.0% and 21.3% respectively in A, B and C type toothed drums as an average of all experiments compared to the original type toothed drum (Fig 6).

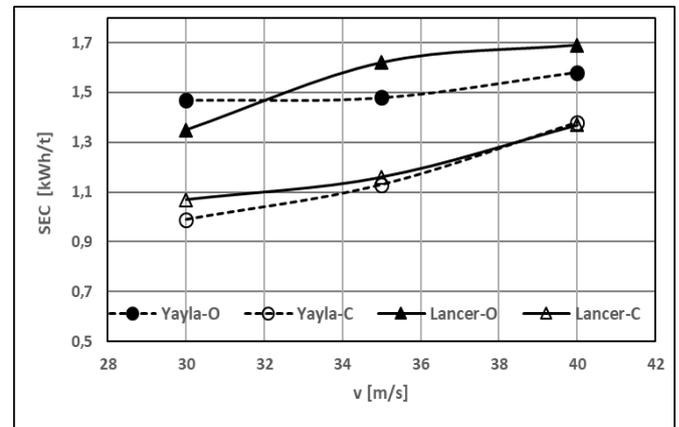


Fig. 6 Average specific energy consumption SEC [kWh/t] versus drum peripheral speed v [m/s].

IV. CONCLUSION

In this study, three new toothed drums were designed and manufactured to improve the energy consumption of the domestic threshing machine. Experiments have been conducted for the energy consumption of two varieties of wheat; Yayla 305 and Lancer. According to the experimental results, as the drum peripheral speed increased the average torques decreased, the average power and the average specific energy consumption increased, for both types of wheat. However, the rising slope of the average specific energy consumption is less than that of the average power.

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