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Comparison of Operational Parameters of Feed Mixing and Distribution Machines with Different Structures

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ABSTRACT

Recent supports provided to livestock operations also supported the development of mechanization levels used in these operations. Technological progress especially in herd management systems, automatic milking, cleaning and hygiene systems led to significant progress also in feeding mechanization. Especially during the last 10 years, significant numbers were achieved in manufacture of feed mixing and distribution machines with a great role in animal feeding in livestock operations. In Turkey, various types of feed mixers with different capacities and constructions are manufactured. These machines generally have single or double augers positioned horizontally or vertically. Such differences in machine constructions are generally resulted from manufacture easiness, cost items and feed characteristics. In present study, considering the average size of livestock operations of Turkey, three feed mixing and distribution machines with different constructions and 6 m^3 vagon capacity were compared in terms of operational conditions and assessments were made accordingly.

1. Introduction

Ever-increasing populations, cost of energy required and used to sustain daily activities and continuously depleted resources obligate efficiency and cost-reduction in agricultural activities as it was in the other aspects of life. Different from plant production activities, animal production could be implemented independently from the seasons. Mechanization applications with a great progress in every aspects of agriculture also achieved significant progress in livestock activities. In livestock operations, different mechanization tools and equipment are used for special purposes. Among them, there are feed mixers and distributors able to chope and mix the feed ingredients at desired quality and properly distribute mixed feed into feeders. These machines, playing a great role in animal nutrition in terms of meat and milk yield, are manufactured at different constructions and capacities.

According to TUIK (Turkish Statistics Institute) data, number of feeds mixing and distribution machines increased significantly during the last 10 years and by the year 2019, the number reached to 37 851 machines. Potential use of professional agricultural mechanization tools and equipment, especially feed mixing and distribution machines, in livestock operations play an important role in performance and efficiency of the operations, especially for meat and milk yields.

In feed mixing and distribution machine tests, the time spend to transfer feed admixtures into the machine, mixing duration, pouring duration, mixture homogeneity, power and fuel consumption are evaluated (Anonymous, 1999).

Kop (2002) indicated the objective in fish feed production as homogeneous distribution of nutrients and performance of mixing in a cost, labor, energy and time-efficient fashion. The assessments were made based on CV values and the values <10% were indicated as perfect, the value of between 10-15% were indicated as well (mixing time should be increased by 25-30%), the values of between 15-20% were indicated as poor (mixing time should be increased by 50%) and the values >20% were indicated as highly poor.

Yalçın et al. (2007) compared two feed mixing and distribution machines (one was imported, one with 8 m^3 and the other one with 4 m^3 capacity) in terms of the time spend in loading, mixing and pouring processes. Size analyses were conducted for feed materials before and after mixing and homogeneity of mixture was determined with the use of 2% trace elements. Researchers indicated that experimental results varied based on structural characteristics of the machines,

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operational conditions and different behaviors of operators and further research was recommended for better assessment of distribution of resultant values.

Çakmak (2008) indicated feeding as the most time-consuming process after milking in dairy operations and pointed out that success could be achieved in feeding with the use of proper machines. It was also indicated that to improve milk yields, proper rations including sufficient quantities of roughage, green fodder, silage feed and concentrate feed, thus feed mixing and distribution machines should be designed and developed accordingly.

Şeflek (2018) conducted a study for manufacture and operation of 1.5 m^3 capacity self-propelled feed mixing and distribution machine and designed a prototype and manufactured the machine. Machine performance tests were conducted with the use of five different feed materials (maize silage, barley straw, concentrate feed, wheat bran and dry alfalfa) and a trace element (kernel corn). The machine was operated with 326.5 kg ration and following the chopping and mixing processes, average chopping length was identified as 8.97 mm and trace element variation coefficient was identified as 12.05%.

Sağlam (2019) indicated that differences in feed mixing machines are generally resulted from differences in vagon and auger structures. Feed mixers are classified based on auger position as vertical, horizontal and inclined-axis. It was also pointed out that a homogeneous mixture of feed ingredients should be supplied to animals to improve animal performance and yield levels.

In present study, feed mixing and distribution machines with 3 different constructions were compared in terms of operation performance, power and fuel consumptions.

2. Materials and Methods

Present experiments were conducted in Livestock Operation of Selçuk University Agricultural Faculty Animal Science Department. New Holland TD110 D model agriculture tractor (110 HP) was used as the power source. Feed mixing and distribution machines with 3 different constructions (so called as type A, B and C) and 6 m^3 vagon capacity were used in present experiments. Type A mixer has one horizontal auger at the bottom and two horizontal augers at the top; Type B has one vertical auger and Type C has two horizontal augers at the bottom. Augers were all so designed as to provide material circulation within the vagon while mixing. The blades on augers facilitate chopping of the feed materials. Specifications and powertrain of the machines are presented in Figure 1.

Four different feed materials (hay, dry alfalfa, bran and concentrate feed) and a trace element (corn) were used in present experiments. Relevant preparations were made before the machine tests, materials were weight and made ready for time and fuel measurements and relevant measurements were made under the same operational conditions. Power measurements were made with a pto-driven torque meter (Datum brand 2000 Nm torque measurement capacity) and fuel measurements were made with the use of fuel meter device (Aqua metro CONTOIL DFM-BC) integrated into tractor fuel system.

Feed materials to be loaded into the machines were weighed and classified before the experiments. Each machine was operated with similar feeding conditions and relevant measurements were made throughout the experiments with the use of a chronometer. In present measurements, time spend to load the materials into the machine, mixture time following the loading of all materials and total pouring time following the mixture were measured. Total operation time was limited for 30 minutes for each machine. The time, power and torque measurements made throughout the experiments were used to assess operational performance of the machines.

3. Results and Discussion

Measured values throughout the experiments are provided in Table 1. Differences in measured values were mostly resulted from differences in machine design. Considering the time spend in loading the feed materials into the mixer vagon, the lowest value (396 s) was observed in Type A and it was respectively followed by Type C (459 s) and Type B (555 s) mixer. The reason for high loading time of Type B is greater vagon height and two-stage control of unloading of loading bucket (rising the bucket to vagon top and unloading position). Lower vagon heights and single-stage operation of loading bucket facilitated loading process in Type A and C machines.

In terms of instantaneous torque and fuel consumptions of the machines, generally low values were seen during concentrate feed loading process. Instantaneous torque and fuel consumptions started to increase with the loading of roughage into the machines. The lowest average torque need (118.70 Nm) and fuel consumption (3.75 l h^{-1}) were observed in Type C machine. The greatest torque and fuel consumption values were seen in Type B because of greater auger rpm of this type as compared to the others and quite different construction characteristics from the others. In terms of total mixture duration, lower feeding times increased the mixture durations.

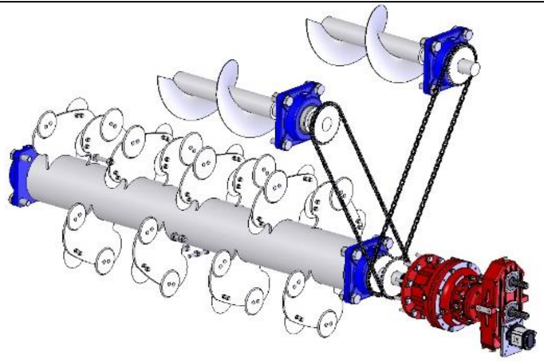
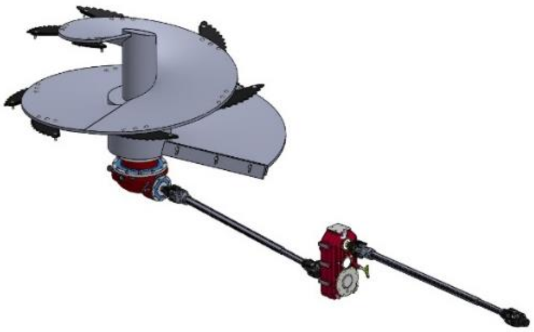
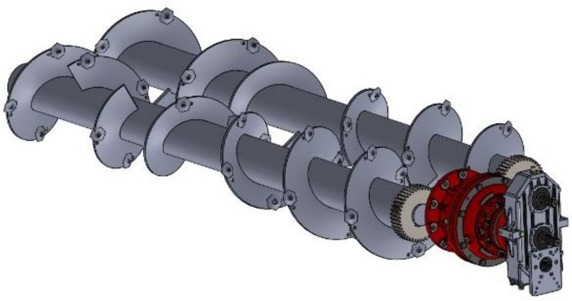
Type	**Powertrain**
6 m^3 vagon capacity one horizontal auger at the bottom and two horizontal augers at the top (**Type A**)	
6 m^3 vagon capacity one vertical auger (**Type B**)	
6 m^3 vagon capacity two horizontal augers at the bottom (**Type C**)	

Figure 1
Specifications and powertrains of experimented feed mixers

Table 1
Experimental Results

Machine type	Concentrate feed loading			Roughage loading			Feed mixing			General outcomes			
	Time (s)	Instantaneous fuel consumption ($l\ h^{-1}$)	Instantaneous torque (nm)	Time (s)	Instantaneous fuel consumption ($l\ h^{-1}$)	Instantaneous torque (nm)	Time (s)	Instantaneous fuel consumption ($l\ h^{-1}$)	Instantaneous torque (nm)	Average fuel consumption ($l\ h^{-1}$)	Average torque (nm)	Total operation time (s)	Total pouring time (s)
Type A	213	3.25	94.55	183	4.12	153.08	414	3.97	141.04	3.78	129.55	810	145
Type B	348	3.13	87.62	207	4.81	179.72	396	5.30	209.36	4.41	158.90	951	75
Type C	228	2.71	48.38	231	4.17	137.40	381	4.37	170.34	3.75	118.70	840	110

4. Conclusion

Improved efficiency in agricultural mechanization applications entails input cost reductions. In this sense, torque requirements and fuel consumptions of three different feed mixer machines with the same capacity to mix and chop the feed ingredients were compared in this study. In terms of operational conditions, purchasing costs, amortizations and economic lives of the machines should also be taken into consideration while selecting among available machines. Improvements could be achieved in torque requirement and fuel consumption of the machines with research and development activities on machine design and constructions.

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