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Performance analysis of the fabricated animal feed mixer machine

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ABSTRACT

This research focused on the development of an animal feed mixer machine to improve mixing capacity. The research used an experimental model and involved need analysis, design, development, implementation, and evaluation. The goal was to determine the optimal rotational speed of a stirrer screw for different types of animal feeds as well as understand the stages of making the machine and its working principle. The process involved manufacturing the frame, shaft, transmission, screw fins, sheet metal process, and assembly. The results shows that the animal feed mixer machine with a stirring speed of 312.3 rotations/minute was able to produce 958.3 kg of feed in one hour. This stirring speed provides the best fuel consumption, which is 676.5 ml/hour. The mixer has a safe element on the reduction shaft, with 115.8 kg.mm of torque and 5.82 kW of power. Thus, this mixer is an efficient and productive solution for the animal feed industry.

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1. Introduction

The livestock subsector is one of the subsectors that contribute to the national economy and is able to absorb significant labour, so it can be relied on in efforts to improve the national economy. This is illustrated by the results of the 2018 Inter-Census Agricultural Survey (SUTAS2018) that the number of livestock households in Indonesia reached 13.56 million households [1].

Along with the rapid growth of livestock in Indonesia, there are no visible problems that are starting to emerge, the first of which is the increasing demand for meat in Indonesia. The Ministry of Agriculture in the Beef Outlook document revealed that beef consumption in 2020 was 2.31 kg/capita/year. Multiplied by the population of 269.6 million people, the national demand is around 623.42 thousand tons. This deficit condition is expected to continue so that in 2022 the beef deficit will increase to 261.08 thousand tons. Then in 2023 and 2024, the deficit will be 261.67 thousand tons and 268.36 thousand tons respectively [2]. This increase in national meat demand must be accompanied by equivalent or even more meat production so that beef imports could be reduced. To support local meat production, feed must be sufficient.

In the Indonesian Animal Husbandry and Animal Health Law No. 18 of 2009, feed is a single or mixed food ingredient, both processed and unprocessed, which is given to animals for survival, production, and reproduction. One factor in the success of a cattle farming business is determined by feed. Feed is anything that can be eaten by livestock, whether in the form of organic or inorganic materials, which can be partially or completely digested and does not harm the health of the livestock [3]. The effect of feeding on the productivity of a farm is 70% and is influenced by animal genetics by 30%. This shows that insufficient feeding will have an impact on production results that do not meet the desired targets [4]–[6]. Therefore, the feed given to livestock must have the requirements to be good feed. Good feed is feed that contains food substances of adequate quality and quantity, such as energy, protein, fat, minerals, and vitamins, all of which are needed in the right and balanced amounts so that they can produce meat products of high quality and quantity [7]–[9].

Animal feed generally consists of forage and fortification ingredients (concentrate). Forage is all feed ingredients that come from plants or vegetation in the form of leaves, sometimes including stems, twigs, and flowers [10], [11]. Meanwhile, fortified feed (concentrate) is animal feed made from grains and waste resulting from food industry processes to increase low nutritional value to meet the normal needs of livestock for healthy growth and development [12], [13].

The process of making feed, especially concentrate, must go through a mixing process. This is because concentrate feed has a fairly complex composition [14]. The composition consists of rice bran flour, pollard, cassava cobs, onggok, cocoa skin, and many more mixed. Meanwhile, goat feed consists of peanut shells, coffee shells, minerals, and other ingredients that must be mixed. The mixing process may use a traditional method and a mixing machine. The traditional method uses conventional tools such as hoes and shovels using human power. The second way is to use a mixing machine or mixer, mixing using a machine that relies on fins or screws to mix the feed. In reality, most concentrate feed ingredients are still mixed using the traditional method, namely mixing using a hoe and shovel. Mixing using traditional methods is less effective in terms of time, and energy and produces an uneven feed mixture.

Many feed mixer machines are available, but most are designed for farmers with large production levels [15]. Therefore, it is difficult for novice breeders to have their feed mixing machine so they still use manual methods or human power so that feed mixing is less effective. This is known from the results of mixing large amounts of feed which requires a relatively long mixing time so that fulfilling the need for animal feed in large quantities is less than optimal. Apart from the mixing process, problems that often arise are the result of uneven mixing due to mixing large amounts of feed manually. Therefore, to provide optimal animal feed, an animal feed mixer was created to mix the feed more homogeneously in a relatively short time. Therefore, the research aimed to study the process of making an animal feed mixer machine to determine the performance of the animal feed mixer machine when experiencing changes in engine rotation speed so that optimum mixing capacity was obtained.

2. Material and Method

This research uses experimental methods to evaluate the effect of rotation speed on mixing time and fuel consumption. The research began with a literature study as an initial overview, followed by the development of an experimental design. After carrying out effectiveness tests and design validation, the resulting product was expected to be beneficial to society. The stages of this research can be seen in the flow diagram as shown in Fig. 1. The materials used in this research consist of rice bran, pollard, and cassava cobs. The tools used in this research include an animal feed mixer machine, measuring cup, digital scales, tachometer, and vernier callipers.

The parameters used are sought to determine which rotational speed of the screw is best to obtain optimum performance. The mixing capacity of the tool is calculated as the weight of the feed that comes out of the animal feed mixer machine every hour. Fuel consumption is calculated by dividing the volume of fuel used by the weight of the material being mixed. Initial measurement is calculated when the engine has been warmed up so the fuel flow is stable. The final measurement is calculated after the mixer machine is turned off.

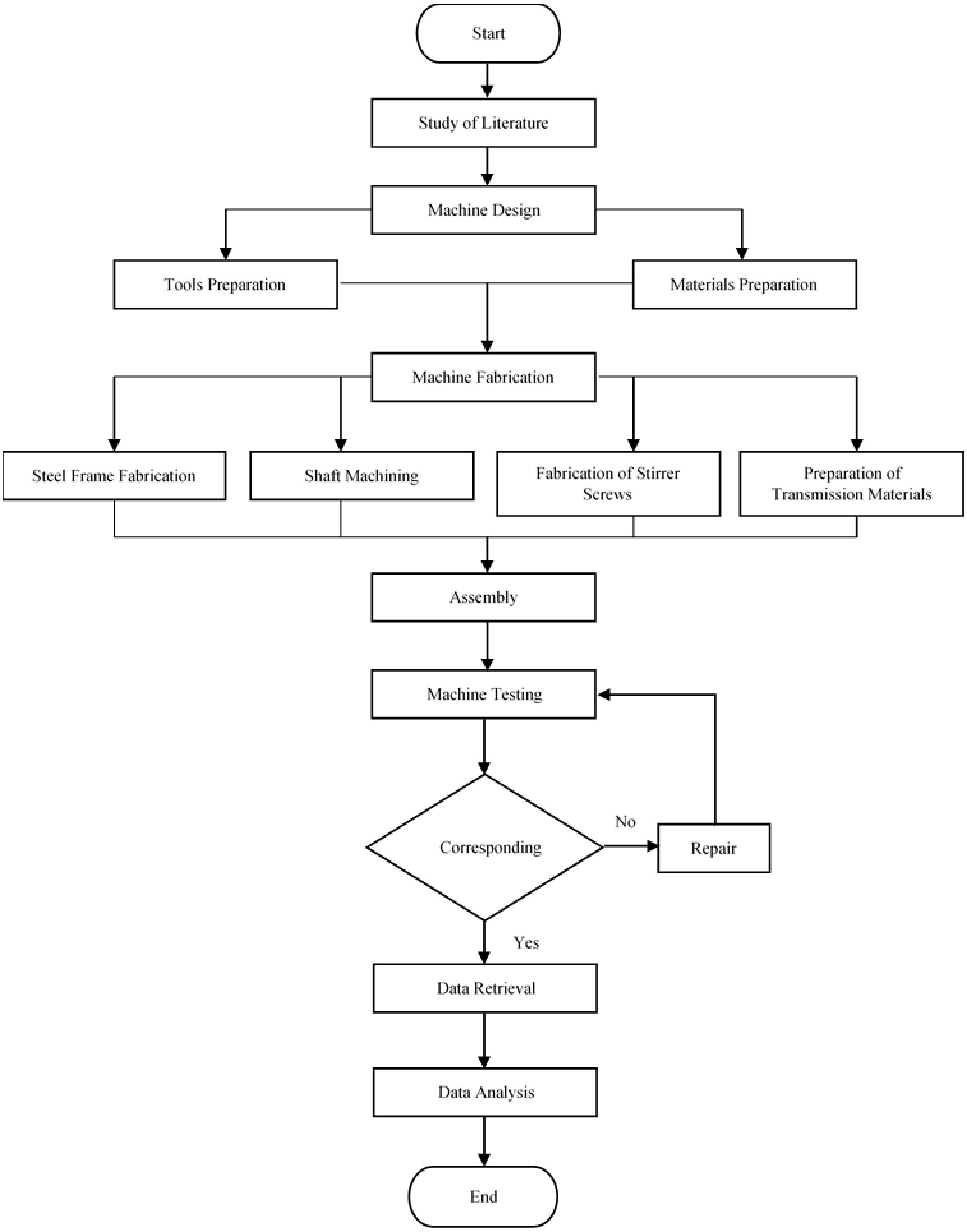
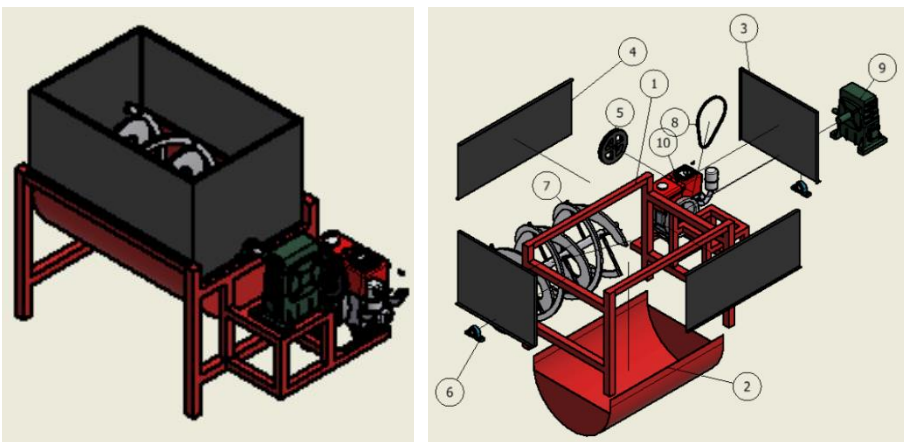


Fig. 1. Research flow diagram

The animal feed mixer machine has several components as shown in Fig. 2. The specifications of animal feed mixer machines can be seen in Table 1.

Table 1. Animal feed mixer machine specification

Component	Parts	Information	
Engine	Diesel Motor	Brand	Kubota
		Power	6.5 HP
		Cylinder	1
Mixer	Dimension	Width	812 mm
		Length	1720 mm
		Height	940 mm
	Material	Frame	Hollow Steel
		Tube	Steel plate
	Hooper	Width	810 mm
		Length	1200 mm
		Height	510 mm
	Mixing Shaft	Material	St. 60
		Length	1680 mm
		Diameter	40 mm & 60 mm
	Stirrer Screw	Material	Eyser
		Thickness	34 mm & 20 mm
		Pitch	410 mm & 400 mm
		Radius	316.8 mm
	Stirrer Screw Holder	Material	Hollow Steel
		Width	1 mm
		Length	1 mm
		Thickness	0.1 mm
Transmission	Pulley	On Reducer	140 mm
		On Motor	50 mm
	V-Belt		B-28



Components list:
1. frame
2. base plate
3. side cover
4. front cover
5. pulley
6. bearing
7. stirrer
8. belt
9. reducer
10. diesel engine

Fig. 2. Animal feed mixer machine components

3. Results and Discussion

3.1. Mixing Time

To determine the most optimum rotational speed (RPM) in this research is firstly the stirring time. Stirring duration data is presented in Table 2.

Table 2. Mixing Time

Rotational Speed (rpm)	Run /Repetition	Input (kg)	Mixing Time (minutes)	Average Time (minutes)
281	1	200	13.4	13.09
	2	200	12.52	
	3	200	13.36	
312.3	1	200	13.12	12.56
	2	200	12.24	
	3	200	12.32	
332.4	1	200	11.08	10.9
	2	200	10.58	
	3	200	11.04	

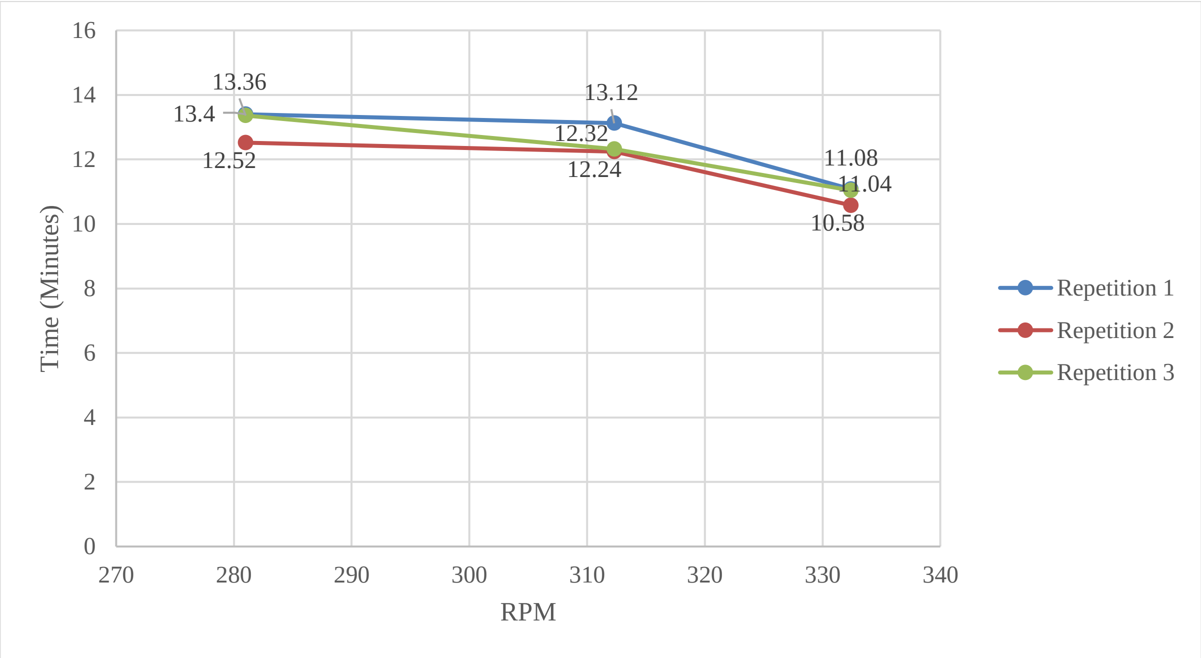


Fig. 2. Mixing Time

Based on Table 2, the results show that the mixing time ranges from 11 - 13 minutes. Based on variance analysis, it shows that F count > F table where this analysis explains that variations in RPM speed can affect the mixing time. After carrying out the stirring test, the results showed that in treatments 1 (281 RPM) and 2 (312.3 RPM), there was no significant difference, but in treatment 3 (332.4 RPM) there was a significant difference compared to the other treatments. This shows that a rotational speed of 332.4 RPM requires less stirring duration than a rotational speed of 312.3 RPM and 281 RPM. The difference in the mixing time is influenced by the rotation speed of the stirrer screw.

3.2. Mixing Capacity

The next thing in determining the best rotational speed (RPM) is to look for the mixing capacity of the machine. It can be found by calculating the weight of the mixing product and dividing it by the mixing time. Mixing capacity data is presented in Table 3.

Table 3. Mixing Capacity

Rotational Speed (rpm)	Run/ Repetition	Input (kg)	Output (kg)	Mixing Time (minutes)	Mixing Capacity (kg/hour)	Average Mixing Capacity (kg/hour)
281	1	200	200	13.4	895.5	917.4
	2	200	200	12.52	958.5	
	3	200	200	13.36	898.2	
312.3	1	200	200	13.12	914.6	958.3
	2	200	200	12.24	980.4	
	3	200	200	12.32	974	
332.4	1	200	200	11.08	1083	1101.4
	2	200	200	10.58	1134.2	
	3	200	200	11.04	1087	

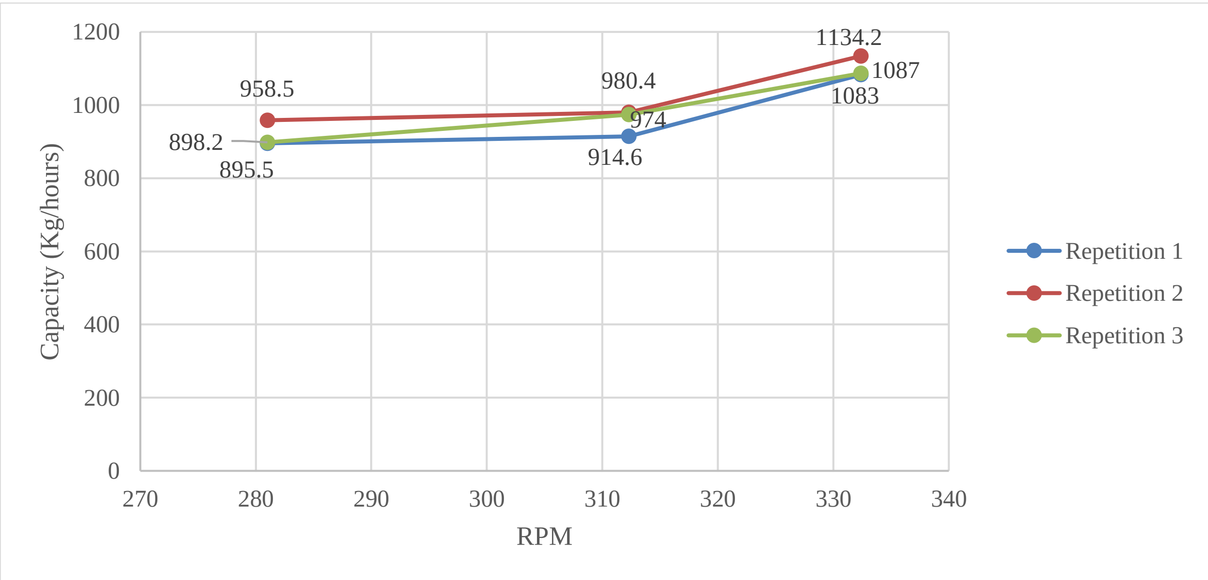


Fig. 3. Mixing Capacity

From Table 3 it can be seen that differences in RPM values affect work capacity. The Analysis of Variance shows that F count > F table, where this analysis explains that variations in RPM speed can affect the mixing capacity. After carrying out the stirring test, the results show that treatment 1 (281 RPM) and treatment 2 (312.3 RPM) did not have a significant difference, but in treatment 3 (332.4 RPM) there was a significant difference from the other treatments. This shows that a rotational speed of 332.4 RPM produces a higher working capacity than a rotational speed of 281 RPM and 312.3 RPM.

3.3. Fuel Consumption

The last thing in determining the best rotational speed (RPM) in this research is fuel consumption. The calculation of fuel consumption was aimed to see the fuel needed to mix animal feed in one run. Fuel consumption data is presented in Table 4.

Table 4. Fuel Consumption

Rotational speed (rpm)	Fuel (ml)	Time (minutes)	Fuel Consumption (ml/hour)	Average Fuel Consumption (ml/hour)	Mixing Capacity (kg/hour)	l/kg	l/ton	l/hour
281	175	13.4	783.6	764.1	895.5	0.00083	0.83	0.76
	150	12.52	789.9		898.2			
	175	13.36	718.9		958.5			
312.3	150	13.12	686	676.5	914.6	0.00071	0.71	0.68
	137.5	12.24	674		980.4			
	137.5	12.32	669.6		974			
332.4	200	11.08	1083	1101.4	1083	0.001	1.00	1.09
	200	10.58	1134.2		1134.2			
	200	11.04	1087		1087			

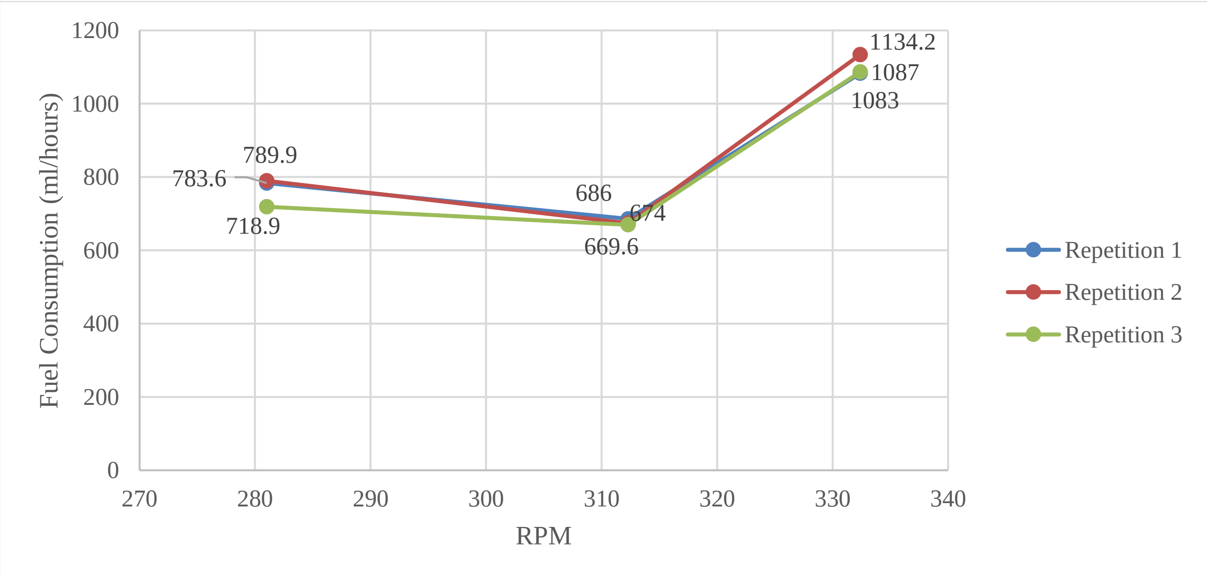


Fig. 4. Fuel consumption Chart

From Table 4 it can be seen that differences in RPM values affect fuel consumption. The Analysis of Variance shows that F count > F table, where this analysis explains that variations in rotational speed can affect fuel consumption. The results showed that there was no significant difference in treatment 1 (281 RPM) and treatment 2 (312.3 RPM), but in treatment 3 (332.4 RPM) there was a considerable difference from the other treatments. This shows that a rotational speed of 332.4 RPM requires more fuel than a rotational speed of 281 RPM and 312.3 RPM.

Based on the data above, it can be observed that the most optimum RPM to use is 312.3 RPM. This is because 312.3 RPM has a capacity and time that is almost close to treatment 3 (332.4 RPM but requires the least fuel, even less than treatment 1 (281 RPM). Therefore, it can concluded that the most optimum rotational speed in this research was 312.3 rpm.

3.4. Comparison of Results

As presented in Table 5, The animal feed mixer machine increases the mixing capacity from 125 kg/hour to 958.3 kg/hour with the new RPM. This machine uses 0.68 l/hour of diesel, saving 146.5 litres or Rp 996,200.00 per year in production costs.

Table 5. Results of application of animal feed mixer machine

No.	Description	Manual	Before experiment	After experiment
1.	main power source	manpower	diesel motor	diesel motor
2.	capacity	125 kg/hour	740.17 kg/hour	958.3 kg/hour
3.	operation	less effective	effective	effective
4.	mixed product	less homogeneous	homogeneous	homogeneous
5.	energy needs	-	0.74 l/hour	0.68 l/hour

The homogeneous mixed product was a substantial parameter in this mixer machine as previous studies [16]–[18]. Numerous disadvantages are still addressed by this machine, such as the necessity for additional study into the angle and thickness of the screw to improve mixing and reduce machine load.

4. Conclusion

Testing of the animal feed mixer machine using variations in mixing rotational speed resulted in the most optimum rotational speed, namely 312.3 rotation per minute, where at this speed the animal feed mixer machine can produce 958.3 kilograms of feed in one hour with the most economical fuel use, namely 676. 5 ml/hour. This animal feed mixer machine still has many shortcomings, such as further research is needed regarding the angle and thickness of the screw to get better mixing and reduce the load on the machine.

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