Design and fabrication of a tractor powered leaves collector machine equipped with suction-blower system

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Abstract: Leaves scattered on the parks, passages, and other places have a detrimental effect on the beauty of the environment, and decrease photosynthesis, hence, the efficiency of plants. Leaves are also used in the production of peat. This makes using leaves collectors in parks, and organizations with a green space useful. Due to the fact that leaves take up a high volume, their transportation is difficult. Using the machine introduced in this paper which was equipped with a suction-blower system, increases efficiency, and at the same time decreases the costs of green space, and their workforce cost. Focusing on overcoming the mentioned difficulties, this study was carried out in order to design and produce a tractor powered leaves collector equipped with suction-blower system. Various designs were studied and based on their advantages and disadvantages, the best design was selected. The initial modeling was carried out using the engineering software of SolidWorks. After designing different parts of the machine, such as the chassis, transmission system, the tank, handling system, suction-blower system, they were analyzed. Furthermore, the effects of pump suction duration, the length of suction pipe, and different intervals of PTO on the system's performance were studied. The required power for various parts of the system was calculated. The overall power consumption of the system was calculated to be 18,392 W which amounts to 25 hp.

Keywords: leaves collector, blower system, suction system, design, power, tractor

Citation: Mohsen Azadbakht, A. kiapey, and A. Jafari. 2014. Design and fabrication of a tractor powered leaves collector machine equipped with suction-blower system. Agric Eng Int: CIGR Journal, 16(3): 77−86.

1 Introduction

The remaining parts of plants and other agricultural activities are decomposed in a natural cycle. Then they are used as organic materials for modifying soil texture which is useful for the life of crops, garden plants, and greenhouse plants. Moreover, soil fertility is improved using green manure. Having been chemically and biologically processed, leaves are used as animal feed (Yarahmadi et al., 2006).

Using urea as a source for ammonia could be the best choice for processing leaves. Plants processing using various kinds of chemicals increase the nutritional value of animal feed. In order to prepare leaves as animal feed, they are processed using nitrogen (Rajan and Khan, 1978).

Leaves are some plant remainders that are detached from trees during summer or fall and scattered on the ground. Collecting them could be difficult depending on weather conditions and wetness. Collecting leaves off of the streets, lawn, and parks, and shrubberies is usually time-consuming, and is very costly. Water pressure or some machines similar to hand rollers with spikes on its cylinder are used to collect leaves off of green spaces (Mesrobian, 1972).

Machines and tools used for collecting leaves include two kinds of elementary and advanced machines. Paul Browning invented an elementary leaves collector in 1978. It rolled on two wheels and was pushed manually. It also had a petrol engine for operating its suction fan.

Received date: 2014-03-08 **Accepted date:** 2014-07-17

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A bag is placed between its two handles for storing collected leaves. One of its disadvantages was that it was pushed manually. Moreover, the leaf-collecting bag was not located on an appropriate place, since it scattered dust all around the user (Browning, 1978).

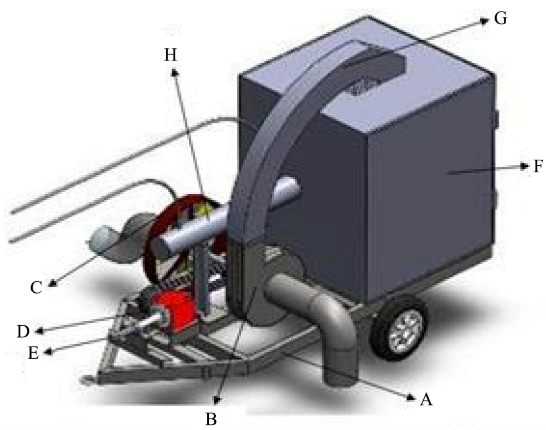
Another type of elementary leaves collectors has a separate suction motor. This type of leaves collectors work based on suction mechanism. They are equipped with a suction pump that operates with an independent electrical or combustion engine. Similar to vacuum cleaner systems, these leaves collectors take in leaves off of the ground. Leaves are then taken into the tank by air pressure (Anonymous, 2012).

Other types of leaves collectors are complicated machines that include tank-less pulling machines, and automatic machines with tanks. The tank-less pulling machine is used when leaves are piled on the sides of pavements or passages. It is pulled by a truck, and its engine is relatively high power. This leaves collector was equipped with a thick suction fan. Having been taken in, the leaves are then directed into the truck's trailer. The pipe used in this machine was of limited length and it is only useful when leaves are piled up in one place. During leaf collecting process, care must be taken that leaves do not get into the waterway. Moreover, rocks and thick branches should be collected in order that they do not hinder the process. To avoid wasting time and energy, it is better to pile all leaves in one spot. At least three to four workers are needed to use this machine. Furthermore, the machine should be mounted on the back of a truck or any kind of vehicle with a trailer. It is not economic, and lacks flexibility (Anonymous, 2009).

The speed of leaf collecting in green spaces is crucial, since any delay in cleaning green spaces raises people's objection. Hence, the design of this leaves collector aimed at increasing the speed of the process. This leaves collector is a tractor powered machine which takes its power from a tractor PTO. It takes in the leaves by its suction system, and transfers them to its tank.

2 Materials and methods

In order to operate, this machine should first be mounted on a tractor's PTO. When the speed of suction axis is increased to a point high enough, a worker directs the leaves into the machine by moving the flexible pipe. Having been taken into the suction box, by the pressure impact of the fan leaves are then directed to the tank through the outlet (directing pipe). Leaves are transferred to the tank under the influence of two forces: (1) the rotation of the fan, and (2) the suction of the suction box. The rotational speed of the blower throws the leaves. Finally, a hydraulic jack in the tank compresses and empties the leaves. Regarding the fabrication of a leaves collector equipped with suction-blower system, in order to analyze the influence of various factors on power consumption, and the capacity of the tank, most parts employed in the machine are adjustable. If leaves are not collected using the duct, wind pressure or blower system is employed. Depending on its tank, this machine can collect 15 kg of leave in one minute. Having randomly collected leaves of different in 1 m^2, they were weighed. Then this amount was added to an average amount of 80 g leaves. Based on these circumstances, it could be estimated that the leaves collector equipped with the integrated system of suction and blower is designed for the 1.5 ha land. Having completed the analysis and designing of different parts of the machine, they were all mounted on it. Figure 1 shows the schematic diagram of the machine.



A. Chassis, B. Pump, C.Blower,D. Gearbox, E. Shaft, F. Tank,G. Leaves output, H. Hydraulic jack

Figure 1 Leaves collector equipped with suction-blower system

Providing the designing assumptions were required for presenting the prototype of the leaves collector attached at the back of a tractor. Assumptions provided were as follows: (1) it should work with usual tractors, (2) be able to move in narrow paths with a width of 1.5 m, (3) work smoothly in the maximum steepness of 20%, (4) have a high-capacity tank, (5) a belt PTO should be employed, (6) and it should be directly mounted on the back of the tractor.

2.1 Chassis

Due to their availability in the metal market and their frequent use in agricultural industry, standard channel profiles of 100 and 120 mm were used in designing the chassis. Technical specifications of this channel profile were taken from the German national standardization organization of Deutsches Institut für Normung (DIN), and they were considered in the design (Valinejad, 2005). Simple assembly and dismantling capability were of important factors in designing the chassis. Hence, this point was taken into consideration in its design. Two wheels were exploited for transporting the machine with the width, ring thickness, and tire thickness of 13, 45, 16.5 cm, respectively. The weight of its chassis was 145 kg, and the location of its mass center was calculated using SolidWorks which is illustrated in Figure 2.

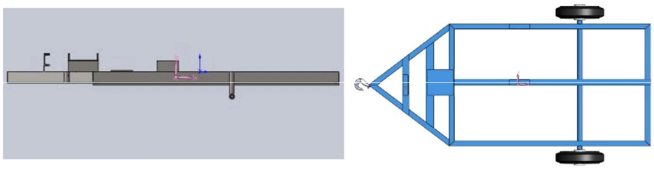


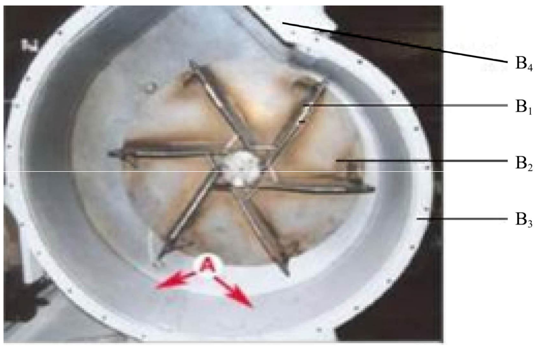
Figure 2 Location of chassis mass center along the width, length, and height axes

2.2 Gearbox

The power transmission system in this machine was designed in a way that suction-blower system gets their required power from the same place. If the power was separately transferred to the suction-blower part, more space would be required for their placement as well as the use of changeable pulleys and totally, costs would be saved through integration of power. Thus, Rotavator gearbox was used in this design, which was made by Badeleh Machinery, Sari, Iran. One change was only made in its design: the speed of input and output were reversed. This doubled the speed of leaves collector.

2.3 Suction system

Figure 3 shows the suction fan. It was comprised of two major parts: fan and snail shell. It also had a flange on which the fan and snail shell were mounted. The fan had six blades. The blades had been set 60 degrees apart and were welded, and the end of the blades was bent by 10 degrees. The thickness of each blade was 6 mm. The thickness of the back plate, axis, and the suction system were 10, 25, and 460 mm, respectively. The number of blades and the direction of its output were adjustable. Power transmission to the suction-blower systems was done by the gearbox shaft, belt, and pulley. This kind of power transmission decreased the costs of the production. At the same time, however, it made it impossible for the operator to adjust the speed of the blower independently. Through changing the arrangement of the pulleys in the power transmission to the blower system, the suction speed of leaves transmission was adjusted appropriately. Leaves were extracted into the pump and then were directed to the tank by the produced suction (Bleier, 1997).



B_1. Blade B_2. fan plate B_3. snail shell B_4. Outlet

Figure 3 Snail shell of a blower

2.4 Tank

Based on the chassis dimensions, the position of suction fan, and transmission system, the tank was made of metal sheets with the thickness of 3 mm. Based on the way it is positioned on the chassis, the tank was made with length, width, and height of 1,200, 1,200, and 1,400 mm, respectively. Its volume was calculated to be 2 m^3. The mass of leaves kept in the tank depends on their physical and chemical specifications which were 500 kg/m^3 on average. According to Equation (1), the mass of the leaves kept in the tank was calculated to be 1,000 kg. The total weight of the machine was 600 kg.

$$\rho=M/V \tag{1}$$

2.5 Leaf Shear Strength

Using laboratory equipment, a device was constructed (Figure 4) which included an upper blade (mobile), a lower blade (fixed), two leaf holder clamps to fix the leaves, and a wooden board bridged between a base on one side and the scale on the other side. The precision of the scale was 0.01 g and it was connected to a computer which recorded the applied force on the scale with special software. The upper blade angle and thickness were considered 45° and 5 mm, respectively. The up-and-down movement of the upper blade was performed with an electric motor and a belt and pulley system such that the motor motion was transmitted to the blade through the belt and pulley. The velocity of the blade was selected approximately equal to 0.1 mm s^{-1}. It should be noted that the leaves were tightly fixed by the clamps at both sides to prevent spending of a part of the obtained force due to bending of the leaf.

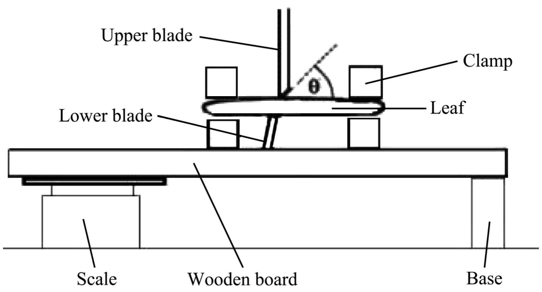
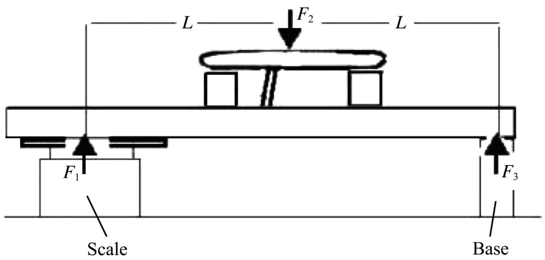


Figure 4 Schema of the experiment to determine leaf shear strength

Given the existence of a balance force as Figure 5, the force exerted on the scale was considered as the basis of calculation of leaf shear force.



F_1. Force from scalepan on wooden board (equal to the force from wooden board to the scale), F_2. Leaf shear force, F_3. Force from base to the wooden board.
$F_1 = F_3 \Rightarrow F_2 = 2 \times F_1$

Figure 5 Balance of action and reaction forces

Therefore, the force measured by the scale is one half of the shear force. In this experiment, samples of maple and sycamore leaves, as the major leaf in urban green space, were tested. At first, the thickness of each leaf was measured with a micrometer. Then according to the distance between the clamps, each leaf was cut to patches of 3×5 cm such that the shear width was 3 cm. After tightening of each patch by the holder clamps on sides, the shear experiment was performed by the upper blade of the device in triplicate for each type of the leaves.

Then the forces measured by the scale and recorded by the software were collected and the shear strength of the leaves was obtained according to Equation (2).

$$\tau = \frac{F}{b.t} \tag{2}$$

where, τ: Leaf shear strength (MPa); F: Leaf shear force (N); b: Leaf shear width (mm); t: Leaf thickness (mm).

2.6 Transmission system

As Figure 6 shows, the transmission system used in this machine was a belt transmission system. The suction-blower systems supply their power simultaneously. Power was transmitted from tractor's PTO to the first axis through the propeller shaft to rotate the gearbox. The propeller shaft rotates at the speed of 540 r/min. As is mentioned before, two to one converter gearbox was used in the machine. As Figure 6 shows, pulley A transmits power to the suction and blower axes. Pulleys exploited for transmitting power to the suction and blower axes are four-belt pulleys. The diameters of pulleys A and B are 360 mm, and 120 mm, respectively. Due to the way the pulleys arranged, the rotational speed in the first level from the primary axis to the secondary one was tripled because of the thickness of pulleys A and B. Hence, the rotational speed of the suction axis is three times more than that of the primary axis. Depending on the product's conditions and changing the arrangement of the pulleys, various rotational speeds of 540 r/min for the PTO rotational speed or the input to gearbox, 1,080 r/min for the output of gearbox or pulley A, and 3,200 r/min for pulley B were attainable. The belts were adjusted by the primary and secondary axes.

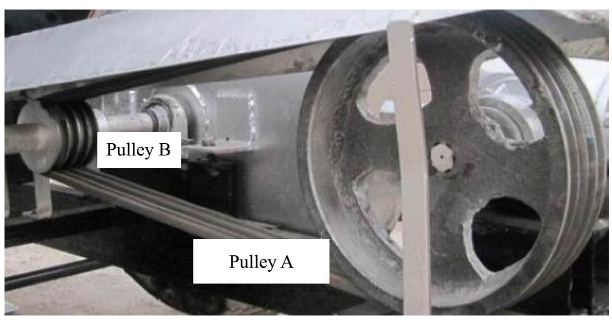


Figure 6 An illustration of pulley A and B

3 Discussion and conclusions

3.1 The static analysis of the chassis

According to the way the machine operated, forces exerted on the chassis, different parts of the chassis were studied. Moreover, the tension under static load was analyzed. The results of the studies are illustrated in Figure 7. In this stage, loads exerted on different parts of the chassis were determined in SolidWorks software. The analysis of the specified chassis was carried out using COSMOS Motion. The highest tension was exerted on the profile which was in the middle of the chassis (A).

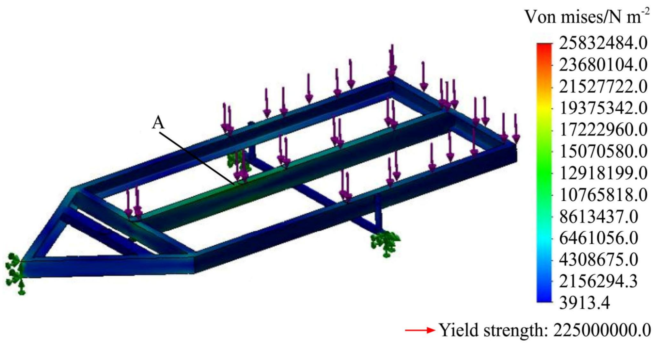


Figure 7 The force exerted on the chassis

3.2 The amount of displacement of the chassis

The amount of displacement of different parts of the chassis was calculated for forces applied on the chassis, while its tank was mounted on the chassis and was full of leaves. As Figure 8 shows, the maximum displacement was estimated as $8/16\times10^{-3}$ (mm) which took place at point B.

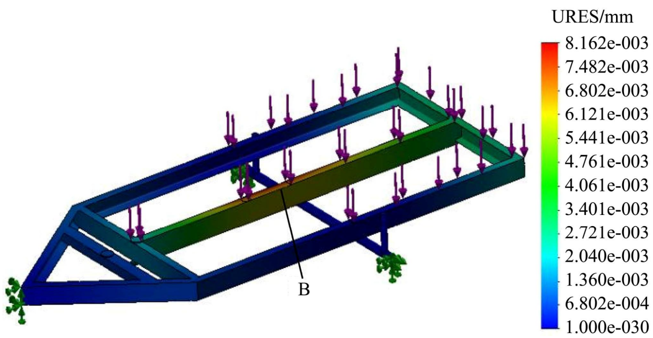


Figure 8 Displacement of various parts of the chassis

3.3 The strain of chassis

As is shown in Figure 9, the maximum strain was on the middle profile of the chassis (D), which was equal to $8/19\times10^{-7}$.

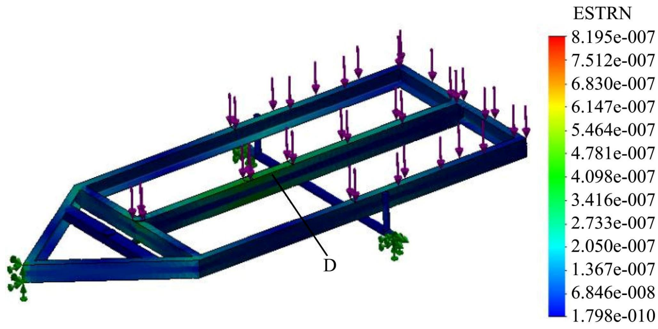


Figure 9 Determining the strain of the chassis

3.4 The safety factor of the chassis

According to the results, the maximum tension was applied on the profile in the middle of the chassis which was calculated to be 25,832,484 N/M^2 (Figure7, A). The steel used in most agricultural activities are 1.1213 steel No., and according to national German standardization organization of DIN, its fracture strength is 400 MPa. Hence, this segment can stand the exerted pressure with a safety factor of 48.15 (Wegst,1992).

3.5 The performance of the suction pump

Factors influencing the performance of the suction pump were the rotational speed of the suction fan, the length of suction pipe, and the internal friction of suction pump. Results of the experiments showed that the performance of the suction pump increases up to a limit as the speed of the suction axis increases (Figure10). What is meant by “limit” is that if the speed of the suction attains the speed of sound, the suction system of the machine shuts down. Hence, in this case, any increase or decrease of flow rate does not affect the performance of the suction pump. By increasing the rotational speed of the suction axis, the number of the impacts applied on leaves increases in the unit of time, which throws the leaves higher.

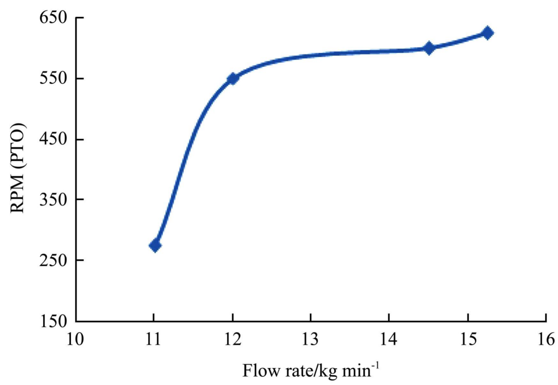


Figure 10 The diagram of performance for PTO rounds

3.6 The evaluation of the suction pump working duration, suction pipe length, and different speeds of PTO

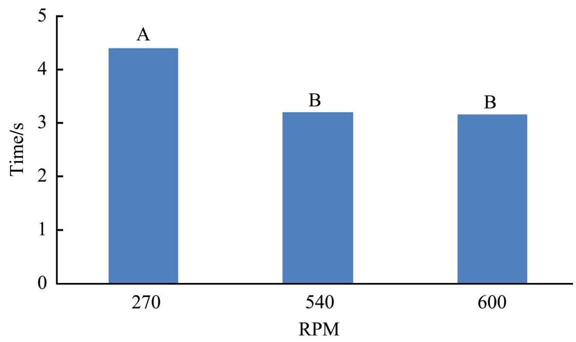
The effects of different suction pipe length; tractor's revolution on the duration of suction was studied by factorial experiment in the form of randomized factorial experiment. Results of variance are shown in Table 1.

Table 1 The decomposition of the effect of variance, and the length of suction pump on the duration of suction based on factorial experiment in the form of completely randomized blocks

Degree of freedom	The average of squares	The sum of squares	*F* value	Source of Change
2	4.4	81.8	39.17**	Revolution
2	78.6	576.13	8.26**	Length
2	26	53	1.06 ns	Block
4	27	29.1	1.08 ns	Revolution times length

Figure 11, Figure 12 and Figure 13, compare the amounts of main revolution effect, suction pump length, and the reciprocal effects of revolution and length, respectively.

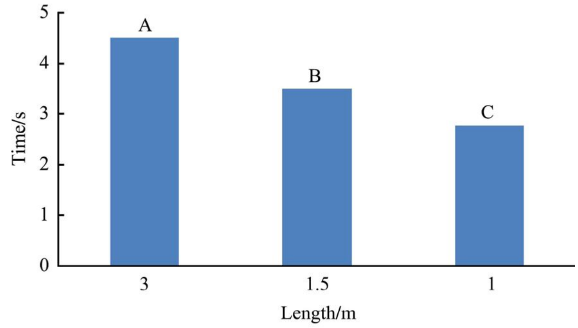
As shown in Figure 11, by increasing PTO rotational speed, the duration of leaf suction decreases. In other words, performance or the efficiency of the suction pump has increased. However, as Figure 10 shown, increase of rotational speed increases the performance only up to a level. After the speed of 625 r/min, it has a falling trend. It shows that the increase of the rotational speed does not significantly affect the pump performance.



Note: The same letters on bars signifies that they are of no significant effect at the level of 5%.

Figure 11 Effect of different revolutions on suction duration

Figure 12 clearly shows the effects of pipe length on leaf collecting time. The duration of leaf collecting decreases by decreasing the pipe length. In other words, the performance increases.



Note: The same letters on bars signifies that they are of no significant effect.

Figure 12 Effect of suction pipe length on suction duration

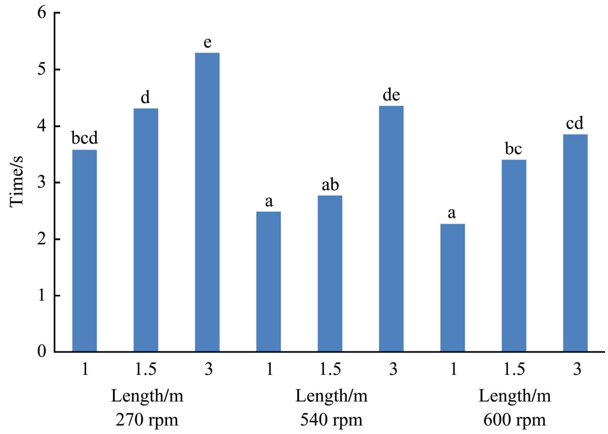


Figure 13 Effects of length and revolution on suction time

Figure 13 shows the subjects of the experiment. The subject with a length of 3 m and a revolution of 270 r/min is indicated with the letter "e", which is not significantly different from the subject with a length of 3 m and a revolution of 540 r/min is indicated with the letters "de". But the subject marked with "e", significantly differs from other subjects at the significant level of 5%.

3.7 Analysis of input and output airways in the suction fan

One of the important parts of the leaves collector is the desired design of suction pump. The pump was analyzed by COSMOS Motion software. Airflow lines with a maximum flow rate of 4 m^3/s were directed from the input section to the output section, and they were analyzed (Figures 14, Figure 15, Figure 16 and Figure 17).

In order to analyze the suction fan, the revolution of suction fan, barometric pressure, and the temperature were considered to be 3,200 r/min, 1 atm, 2.293°K, respectively. The analysis results are illustrated in Figures 14, Figure 15, Figure 16 and Figure 17 which indicate that the maximum air speed is 287.8 m/s (marked in red). According to the calculated speed, it could be concluded that the pump of the leaves collector does not shut down during its duty cycle, providing that its speed does not increase up to the speed of sound.

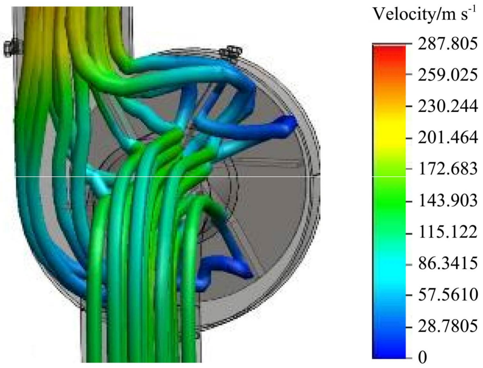


Figure 14 Results of suction fan analysis in the air input section

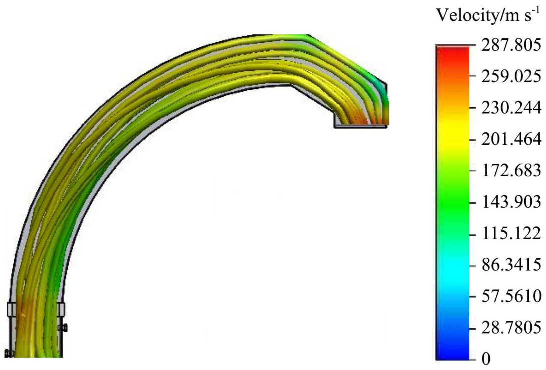


Figure 15 Analysis of speed in the output pipe of the suction fan

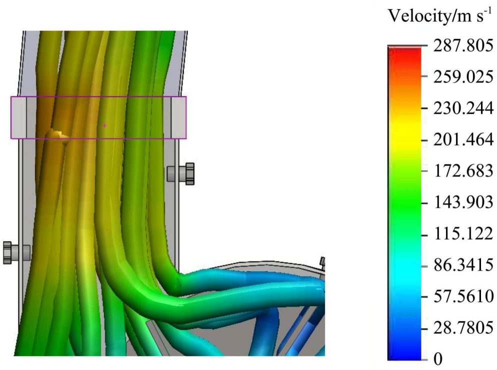


Figure 16 Analysis of speed at the venture section of the suction fan

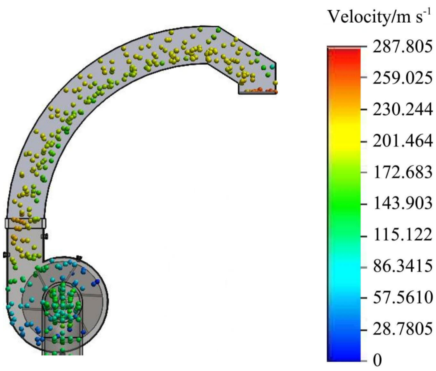


Figure 17 Results of analysis from the suction pipe to the output pipe

3.8 Drawbar power

The power consumption of the leaves collector was calculated under four assumptions. The first one is that the ground should be inclined. As research shows, the permissible degree of inclination is 20% (α=11.31°) (Sirvastava et al. 2000). The inclination of ground does not affect the performance of the tractor's rubber. The advancing speed of the tractor is 3.9 km/h, which is equal to 1.084 m/s (Sirvastava et al. 2000).

Based on the mentioned assumptions the power consumption of the leaves collector is calculated. In its formula W is the weight of leaves collector with a full tank, W_1 is the weight of the leaves collector with a full tank on wheels axis, and W_2 is the weight of the leaves collector on the junction point to the tractor. If the mapped weight of the whole system is multiplied by the advancement speed of the tractor, drawbar power will be estimated. The mass of the leaves collector is 600 kg. Based on the dimensions of its tank, it can contain 10 kg of leaves. Hence, the overall mass will be 1,600 kg. By calculating the torque relative to the center of gravity of the machine, the force exerted on the wheels was calculated as follows:

W = 15696 N, W_1 = 12556.8 N and W_2 = 3139.2 N

Also, Equation (3):

$$F_1 = W_1 \sin\alpha = 2462.6 \text{ N} \tag{3}$$

F_1 is the mapping of the weight force of leaves collector with a full tank on wheels axis. Hence, taking into account the weight of the leaves collector, the drawbar power is calculated as following Equation (4):

$$P_1=F_1\times V=2462.6\times 1.084=2669.4(W) \tag{4}$$

Except for the power that the leaves collector produces, the power required for neutralizing the rolling resistance of the leaves collector's wheel is calculated using Equation (5) and Equation (6). Assuming that the tank is full of leaves, that the wheels bear the weight of the machine and the weight force of leaves and the machine is moving on the ground, then Bernake rolling resistance coefficient is 0.08 (Sirvastava et al. 2000).

$$F_2=\mu\times W_1=0.08\times 12556.8=1004.5\ (W) \tag{5}$$

Hence, the power needed to overcome the rolling resistance is

$$P_2=F_2V=1088.9\ (W) \quad . \tag{6}$$

Hence, the overall drawbar of the machine is (Equation (7))

$$P_{dp}=P_1+P_2=3758.3\ (W) \tag{7}$$

3.9 The power required for crushing the leaves

Having performed experiments to determine the shear strength of different kinds of leaves, the highest shear force values were calculated for buttonwood and maple leaves, being 1.016, and 0.85 kg, respectively.

According to Equation (2), the maximum shear strength for the leaves of buttonwood and maple were calculated to be 0.034, and 0.028 MPa, respectively. Moreover, the torque of the pump was calculated by Equation (8).

$$T=F\times r=227\ (\mathrm{N\cdot mm}) \tag{8}$$

where, F is shear force, N; and r is the radius of suction fan, mm.

Taking into account the torque and the rotational speed of suction pump, the power consumed for crushing the leaves was calculated by Equation (9)

$$p_3(w)=\frac{Tn}{9550000}=76(w) \tag{9}$$

where, n is the rotational speed of suction, and T is the torque on the suction fan, which equals 3,200 r/min and 227 N·mm, respectively.

The suction pump of the machine has six blades. Taking into account all of the six blades, the required power for crushing the leaves is $p_3(w)=456(w)$.

3.10 Calculating the power consumption of the blower

Excluding the resistance due to air friction, the power consumption of the blower was calculated using Equation (10) (Felezi, 2004).

$$p_4(w)=C_p\rho\omega^3d^5 \tag{10}$$

where, ρ is air density that is equal to 1.2 kg/m^3; ω is the rotational speed in rad/s, and d is the air pressure thickness in m, respectively; C_p is the power coefficient that was equal to 0.16 (Felezi, 2004).

Taking into account the reduction in the costs, the blower pump with a diameter of 0.5m and the suction pump were mounted on one axis with the rotational speed of 3,200 r/min. In Equation (11), we have

$$\omega=\frac{n}{60}=53.3\left(\frac{rad}{s}\right) \tag{11}$$

where, n is the rotational speed measured in r/min.

Hence, the power consumption of the blower fan was calculated to be 923 W using Equation (10).

3.11 Calculating the static pressure

In order to estimate the static pressure, the volume of the air in a sector of the suction fan should first be calculated. Then, the obtained value should be multiplied by the number of blades in order to estimate the whole transmitted air in a round of suction fan. The thickness of the suction pump selected for this design was D=0.46 m, the length of each blade was L=0.2 m, the width of each blade was W=0.16 m, and the rotational speed of the suction fan was 3,200 r min^{-1}. Hence Equation (12)

$$A=0.166\ \mathrm{m}^2 \tag{12}$$

where, A is the area of the suction fan measured in m^2.

In order to calculate the air volume in the suction pump we have Equation (13)

$$V=AW=0.02656\ \mathrm{m}^3 \tag{13}$$

where, V is the air volume measured in m^3/s; W is the blade width measured in m.

Then, the flow rate is calculated from Equation (14):

$$Q=V\times n=1.41\ \mathrm{m}^3/\mathrm{s} \tag{14}$$

where, Q is the air flow rate measured in m^3/s; V is the air volume in suction fan measured in m^3, and n is the rotational speed measured in r/min.

The producible static pressure of every suction output working at any given time changes appropriate to the flow rate of its output. In other words, if a hypothetical suction produces a specific flow rate, the pressure difference between its input and output should not raise above a specified limit. Otherwise, the flow will decrease. The diagram of this phenomenon is unique for every type, size, and speed of suction (Bleier, 1997).

The static pressure of the pump in question is calculated using Equation (15) (Bleier, 1997).

$$SP=\rho u_2^2-\frac{\rho Q u_2}{\pi d_2 b_2 \tan\beta_2} \tag{15}$$

where the air density is ρ=1.2 kg/m^3.

Based on standard pictures and related formulas, other values are calculated (Bleier, 1997).

d_1 is the internal diameter of the suction fan, while d_2 is its external diameter which are 0.1 m and 0.23 m, respectively. Hence, $\frac{d_1}{d_2}=0.43$ for the angle of β_1=20°, and β_2=65° (Bleier, 1997).

Having decomposed the suction fan velocity vectors, β_1 is the angle in the beginning of the blade, and β_2 is the angle at the end of the blade. Then Equation (16) is

$$\tan\beta_2 = \frac{v_{f2}}{u_2 - v_{u2}} \tag{16}$$

where, v_{u2} is the velocity of the beginning of the blade; u_2 is the peripheral speed of the suction fan; v_{f2} is the radial force of speed of v_2 at output and v_2 is the relative air speed at the end of the blade.

v_{f2} is calculated in this way Equation (17)

$$v_{f2} = \frac{Q}{\pi d_2 b_2} = 9.75 \text{ m/s} \tag{17}$$

where, Q (m^3/s) is the volumetric flow rate of air; d_2 (m) is the external diameter of suction fan, and b_2 (m) is the width of the blade passage at the output.

Considering the values of β_2=65°, $v_{f2} = 9.75\frac{m}{s}$ and the linear velocity of suction pump (Equation (18)), v_{u2} is calculated by Equation (19).

$$u_2 = \frac{\pi d_2 n}{60} = 77 \text{ m/s} \tag{18}$$

$$v_{u2} = u_2 - \frac{v_{f2}}{\tan\beta_2} = 72.44 \text{ m/s} \tag{19}$$

Hence the static pressure of the pump is 6,272.24 Pa.

3.12 Calculating the required power for the suction pump

The power transmitted to the suction for transferring a given amount of air to a blower with an efficiency of FAN_{eff} with a value of 75% to 85% is defined as follows. The power consumption of the suction pump is calculated by Equation (20) (Bleier, 1997).

$$P_p = Q \times SP = 8843.45W \tag{20}$$

hence Equation (21)

$$P_{bhp} = \frac{P_p}{\eta} = 11791.26W \tag{21}$$

3.13 The total power consumption in the leaves collector

Having carried out the calculations, the power consumed in different parts of the machine is shown in Table 2.

Table 2 The power consumed in different parts of the machine

Power consumption value/W	The power consumption of different parts of the machine
456	Leaf crusher's power consumption (P_3)
11791.26	Suction pump's power consumption (P_{bhp})
923	Blower fan's power consumption (p_4)

Since the efficiency of mechanical gearboxes is 90%, the total power consumption of the machine is calculated using Equation (22) (ASABE Standards, 2006).

$$P_T = \frac{P_3 + P_{bhp} + P_4}{0.9} = 14633.61W \tag{22}$$

Since the drawbar power was calculated to be 3785.3W using Equation (6), and the power consumption of the machine is 14633.61W based on Equation (21), the total power consumption is 18391.91W.

4 Conclusions

This study aimed at designing and producing a leaves collector equipped with suction-blower systems. The machine had a tank with the capacity of 2 m^3. Since the average density of leaves is 500 kg/m^3, it could be concluded that the tank can keep 1,000 kg leaves. The static pressure of the suction pump of the machine was 6,272.24 Pa. The power consumption of moving dragging the machine, blower fan, and suction fan were 3757.3W, 923W, 11791.25W, respectively. The total power consumption of the machine was calculated to be around 14634W. The tractor that can provide the required power for the leaves collector should have 25 hp power.

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