A STUDY OF DESIGNING BEACH CLEANING MACHINE

NGHIÊN CỨU THIẾT KẾ MÁY LÀM SẠCH BÃI BIỂN

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Abstract - This paper presents the results of a study of designing a beach cleaning machine, in order to provide the local factories with technical data for manufacturing beach cleaning machines. In the previous studies, we surveyed the rubbish on beaches of Danang City and studied the methods for separating and collecting beach rubbish; designed and manufactured some mechanisms for collecting rubbish on the sand and carried out necessary experiments on beaches; the optimum structure of the rubbish-collecting mechanism and optimum values for the main parameters of the machine have also been defined. Basing on the previous results, we have designed and manufactured a model of beach-cleaning machine. The machine is powered by a human physical strength, with beach-cleaning capacity can reach 1,250 m^2/h. The machine is powered by a tractor, with beach-cleaning capacity can reach 5,850 m^2/h.

Key words - designing machine; cleaning beach; manufacturing machine; separating beach rubbish; collecting beach rubbish.

Tóm tắt - Bài báo trình bày kết quả nghiên cứu thiết kế máy làm sạch bãi biển, nhằm cung cấp tư liệu cho các địa phương có thể tự chế tạo máy làm sạch bãi biển. Trong các nghiên cứu trước đây, chúng tôi đã tiến hành khảo sát rác trên các bãi biển thuộc Thành phố Đà Nẵng; tìm hiểu các phương pháp tách và gom rác trên bãi cát; thiết kế và chế tạo một số cơ cấu máy thu gom rác trên bãi cát; thực hiện các thí nghiệm cần thiết trên bãi biển; đã lựa chọn được cơ cấu hợp lý cho máy thu gom rác và xác định được giá trị tốt nhất cho các thông số chủ yếu của máy. Trên cơ sở các kết quả nghiên cứu đã đạt được, chúng tôi tiến hành thiết kế máy làm sạch bãi biển. Máy sử dụng người kéo năng suất làm sạch bãi biển đạt 1.250 m^2/h. Máy dùng máy kéo, năng suất làm sạch bãi biển có thể đạt 5.850 m^2/h.

Từ khóa - thiết kế máy; làm sạch bãi biển; chế tạo máy; tách rác trên bãi cát; thu gom rác bãi biển.

1. Introduction

With a coastline of 3,444 km, coastal tourism has brought a lot of benefits to Vietnam locals.

To develop coastal tourism, in addition to ensuring the society's safety and security and the convenience of transportation, we must to clean up the beach and keep the environment clean.

Currently, beaches in Vietnam are cleaned up manually. This takes a lot of labor. To implement the party's policy on mechanization of traditional industries, we have studied designing beach cleaning machines.

By surveying the rubbish on the beaches of Danang city, we have identified the components and the average proportion of each component of waste on the tourist beaches [4]. The wastes have diverse composition and vary in density. Therefore, it is difficult to collect all the rubbish for cleaning up beaches.

By studying the manual beach-cleaning methods of Danang urban environment workers and the cleaning methods of currently-available beach-cleaning machines, we have designed an optimal machine structure for collecting rubbish on beaches [3].

The mechanism of beach-rubbish collecting machine is shown in Figure 1. The rakes are mounted on the conveyor chain (or conveyor belt). When the chain gear is operated, the chain pulls the rakes sliding over an inclined sifting screen. The rakes scoop sand and debris onto the screen. Due to the inclined surface of the screen, the sand falls down while the debris is kept on the screen and being deposited into a container.

This mechanism is based on the manual cleaning method of workers: The workers shovel sand onto a screen to sieve the debris and then deposit the debris into a bucket. This method can clean the beach well. This rubbish-collecting mechanism is simple, ensuring a simple structure for the beach-cleaning machine.

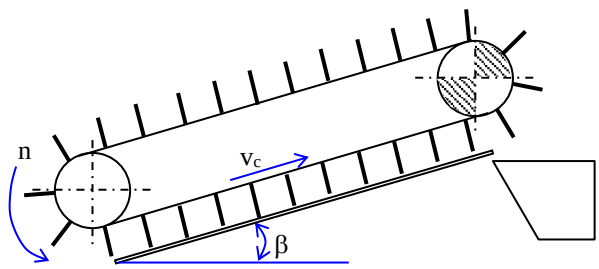


Figure 1. *The mechanism of beach-cleaning machine*

On the basis of our previous researches, we have designed two models of beach-cleaning machine and made trial manufacture of one model. The model worked efficiently, colleting most of the debris on the sand.

This paper presents the results of the study of designing two models of beach-cleaning machine: a man-pulled model and a tractor-towed model. These results provide local factories with technical data for self-manufacture of beach-cleaning machines, contributing to the development of marine tourism of Vietnam.

2. Man-pulled beach-cleaning machine

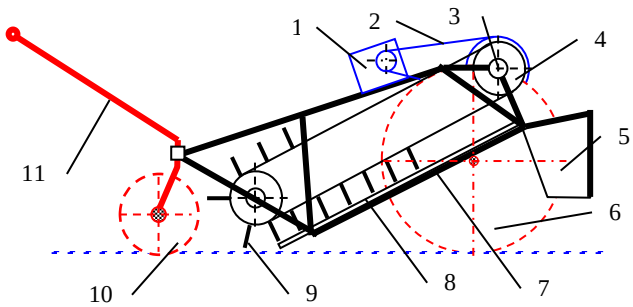
The diagram of the man-pulled beach-cleaning machines is shown in Figure 2.

The machine is propelled by three wheels. Users hold a handle to pull the machine. The handle has a swivel which can be self-adjusted to suit the height of users.

The motor transmits the motion to the driveshaft through a gear box and a belt drive. The belt drive is used to protect the motor from overload.

The rakes are mounted to the conveyor chain. When the chain moves, the rakes rake sand and debris onto the sifting

screen. The screen inclines with a large angle against the horizontal direction, allowing sand to fall down easily. The debris is kept on the screen, the being dragged into the container by the rakes.



1- Motor and gear box
2- Belt drive
3- Drive shaft of conveyor chain
4- Chain gear for pulling rakes
5- Waste container
6- Big wheel
7- Machine frame
8- Sifting screen
9- Rake mounted on the conveyor chain
10- Small wheel
11- Handle

Figure 2. *Layout of beach-cleaning machine*

The values of the working parameters of the man-pulled beach-cleaning machine were chosen as follows [5]: The machine velocity (v_m) was selected to ensure that the workers can work for long time without being tired. We selected v_m = 2.5 km/h = 0.69 m/s.

The moving speed of rakes: v_c = 1.18 m/s. The length of the sifting screen was 1,200 mm. The screen inclined with an angle of 25^0 against the horizontal direction. The screen has mesh size of 15×15 mm. The man-pulled beach-cleaning machine is shown in Figure 3.

Figure 3. *Man-pulled beach cleaning machine*

Working capacity (P_{ct}) of the conveyor chain was selected according to the reference [1], P_{ct} = 0.52 kW. We selected a gasoline engine with the capacity of 0.735 kW and standard revolution of 1500 rev/min to drive the machine.

We selected the sprocket diameter d = 151.6 mm. The moving speed of the rakes reached 1.18 m/s. Thus, the number of revolution of sprocket-carrying shaft was 150 rev/min. The transmission system from the engine to the axis of the conveyor chain has a transmission ratio of u = 10. We used a belt drive with transmission ratio of 1 and a two-speed cylindrical gearbox.

The structure of the sifting screen is shown in Figure 4. The screen frame was welded from flat steel, then being covered with steel wire mesh with mesh size of 15x15 mm.

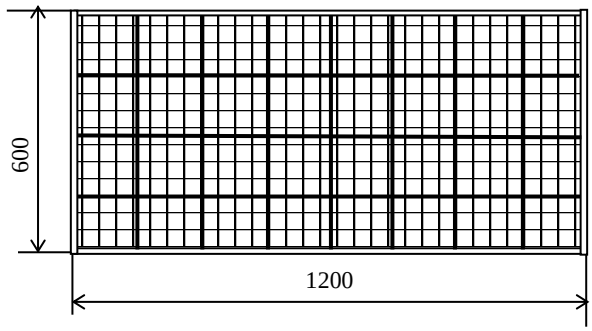


Figure 4. *Sifting screen of man-pulled beach-cleaning machine*

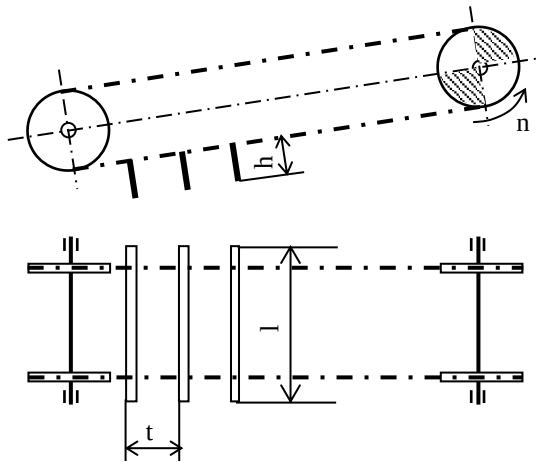


Figure 5. *The rakes of man-pulled beach cleaning machine*

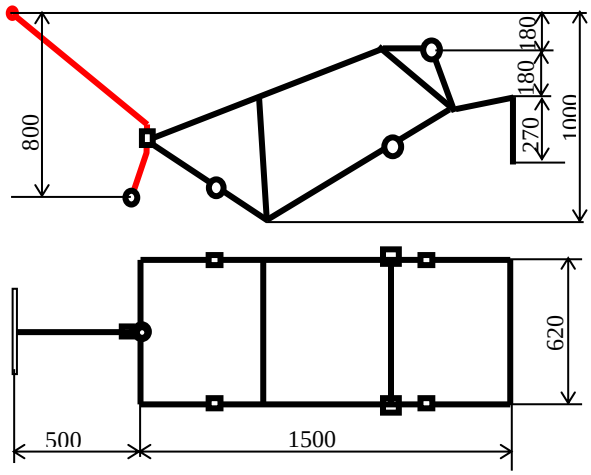


Figure 6. *The frame of man-pulled beach cleaning machine*

With working capacity of the machine P_{ct} = 0.52 kW, the velocity of the rakes v_c = 1.18 m s, the efficiency of the

transmission system η = 0.92, we calculated the force acting on the chain F_k = 432.2 N. Here we selected a roller chain with pitch of 15.875 mm, and a sprocket with the number of teeth equals 30 [2].

The structure of rakes and mounting method are shown in Figure 5. The rakes were manufactured from 0.5 mm steel sheet. Each rake has height h=120mm, length l=560 mm. Rakes were mounted to conveyor chain by rivetting. The distance between two adjacent rakes t=158.75 mm.

The structure of the machine frame is shown in Figure 6. Machine frame was made from 60×30 mm rectangular steel tubes. The steel tubes were assembled together by welding.

Man-pulled beach-cleaning machine has simple structure, compact size and is easy to operate. The pulling force is not large thus the machine can be propelled by one person (Figure 7).

Figure 7. *Rubbish collecting by man-pulled beach cleaning machine*

The average moving speed of the machine on the beach was 2.5 km/h, the cleaning width was 0.5 m. Thus, the average cleaning capacity of the man-pulled beach-cleaning machine reached 1,250 m^2/h.

The man-pulled beach-cleaning machine has low cleaning capacity. However, it has low cost and is easy to be manufactured. It has compact size and is convenient for cleaning small or crowded beaches.

3. Tractor-towed beach cleaning machine

To increase beach-cleaning productivity, we have designed a tractor-towed beach cleaning machine.

There are two options for designing a tractor-towed beach-cleaning machine:

- The drive and control units are installed on the rubbish collecting machine. This type of machine has high cost and is complex to be manufactured.

- Beach-cleaning machine is manufactured separately and is towed by an industrial tractor (Figure 8). With this design, the beach-cleaning machine has simple structure and low cost. The tractor, besides being used to tow beach-cleaning machines, can be used for other purposes. Tractors are quite common in Vietnam. They have relatively low cost, therefore can suit local investment capacity.

The diagram of the tractor-towed beach-cleaning machine is shown in Figure 9.

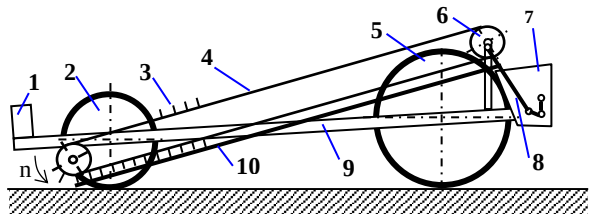
The values of main parameters of the machine are selected as follows [5]:

- Moving speed of the machine on the beach, v_m = 4 km/h = 1.11 m/s.

- Moving speed of the rakes on the sifting screen, v_c = 2 m/s.

- Sifting screen has dimensions of 3,000×1,500 mm. Mesh size is 20×20 mm. The screen inclined an angle of 30^0 against the horizontal direction.

Figure 8. *Tractor-towed beach-cleaning machine*



1-Joint for connecting machine to tractor
2- Small wheel
3- Rake (mounted on the conveyor belt)
4- Belt drive for pulling rakes
5- Big Wheel
6- Drive belt sheave
8- Waste container lifting and waste disposing systems
9- Machine frame
10- Sifting screen

Figure 9. *Layout of tractor-towed beach-cleaning machine*

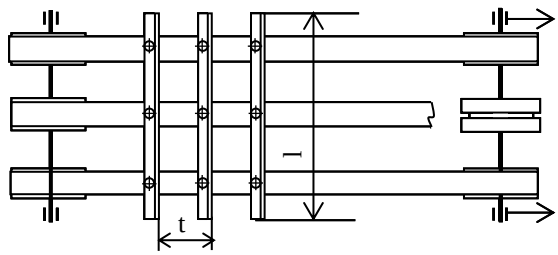


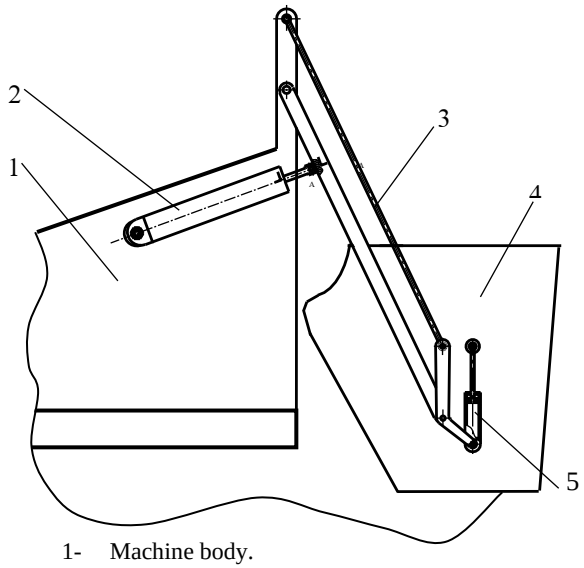
Figure 10. *Method for mounting rakes on the belt*

Figure 10 presents the method for mounting rakes on the conveyor belt.

Each rake has length l = 1,440 mm with the distance between two adjacent tines is t = 160 mm.

We used three rubberized fabric belts. Each belt is 200 mm wide and 7.5 mm thick. The belt sheave has a diameter of 300 mm, and is 225 mm wide. The sheave has groove to accommodate caps of bolts used for mounting rakes on the belt. Initial tension of the belts is 2,700 N.

The layout of container-lifting mechanism is shown in Figure 11.



1- Machine body.
2- Hydraulic cylinder for container lifting.
3- Hinge mechanism.
4- Waste container.
5- Hydraulic cylinder for waste disposing.

Figure 11. *The diagram of container lifting and waste disposing systems*

The waste container can be raised or lowered by two hydraulic cylinders located on either side of the machine body. The container can be tilted to dispose of its content by two hydraulic cylinders located on either side of the container.

We identified the working capacity of the conveyor belt P_{ct} = 4.86 kW. We selected an internal combustion engine with a capacity of 5.5 kW and standard revolution of 1,500 rev/min.

We selected sheave diameter d = 300 mm, moving speed of rakes was 2.0 m / s, the number of revolution of the sheave was 127.3 rev/min. Thus, the transmission ratio of the transmission system u = 11.78. A two-speed cylindrical gearbox was selected for motion transmission.

With working capacity of the machine P_{ct} = 4.86 kW, the moving speed of the rakes v_c = 2.0 m / s, the efficiency of the transmission system η = 0.92, we calculated the force acting on the chain F_k = 2,235.6 N.

The average moving speed of the machine on the beach was 4.5 km/h. Cleaning width was 1.3 m. Thus, the average cleaning capacity of the tractor-towed beach-cleaning machine reached 5.850 m^2 /h.

We selected a rubber-tire tractor to pull the beach-cleaning machine. Rubber-tire tractors have high maneuverability and move fast on the road. Tires with high treads were selected to mitigate the swiveling of the drive wheel on the sand. The maximum towing force to propel the beach-cleaning machine on the sand is 30 kN. We thus selected a small tractor with the traction of 100 kN.

Tractor-towed beach cleaning machine has high cleaning capacity but has relatively high cost. It has large size and moves at high speed; thus should be used to clean large beaches when there are no tourists.

4. Conclusions

This paper presents the results of designing two models of beach cleaning machine, in order to provide the local factories with technical data for beach-cleaning machine manufacturing.

The man-pulled beach cleaning machine has cleaning capacity of 1,250 m^2 /h. It has compact size and is convenient for cleaning small or crowded beaches.

The tractor-towed beach-cleaning machine has cleaning capacity of 5,850 m^2/h. It has large size, high productive and is convenient for cleaning large beaches.

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