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The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX5277 Machine Design [Paper II]**
Academic Year	:	2016/17
Date	:	November 20, 2017
Time	:	0930 hrs. – 1330 hrs.
Duration	:	4 hours

General instructions

1. This question paper has only one question.
2. Devote about 10 minutes to read the question carefully.
3. Following catalogues and data sheets are provided to you at the examination hall on your request.
   i. Motor catalogues
   ii. BSS for belt drives
   iii. BSS for keys
   iv. SKF Catalogues for rolling element bearings
   v. Instructions for design spur and helical gears.
4. At the end of the examination, hand over all such literature to the supervisor or an invigilator.
5. **Any missing data may be sensibly and reasonably assumed, provided that such data are clearly stated with reasons to accept them.**
6. Any ideas/opinions presented in the form of neatly drawn sketches are welcome in the place of written representation.
7. Any results from calculation should be presented with their correct units, unless they are dimensionless. All such answers should be underlined.
8. **It is important that candidates answer all parts of the question in the given order.**

Question

Sand is excavated from the earth for different usage. As examples, different types of mineral sand processed and transformed in to different types of mineral products, and sand dug from rivers and sea used for construction purposes. Excavated raw sand needs to be washed and cleaned to uplift the quality to obtain the required sturdiness and performance, conforming to standards of quality. **Figure Q1-A** shows sand cleaning equipment mainly consists with a rotary bucket elevator.

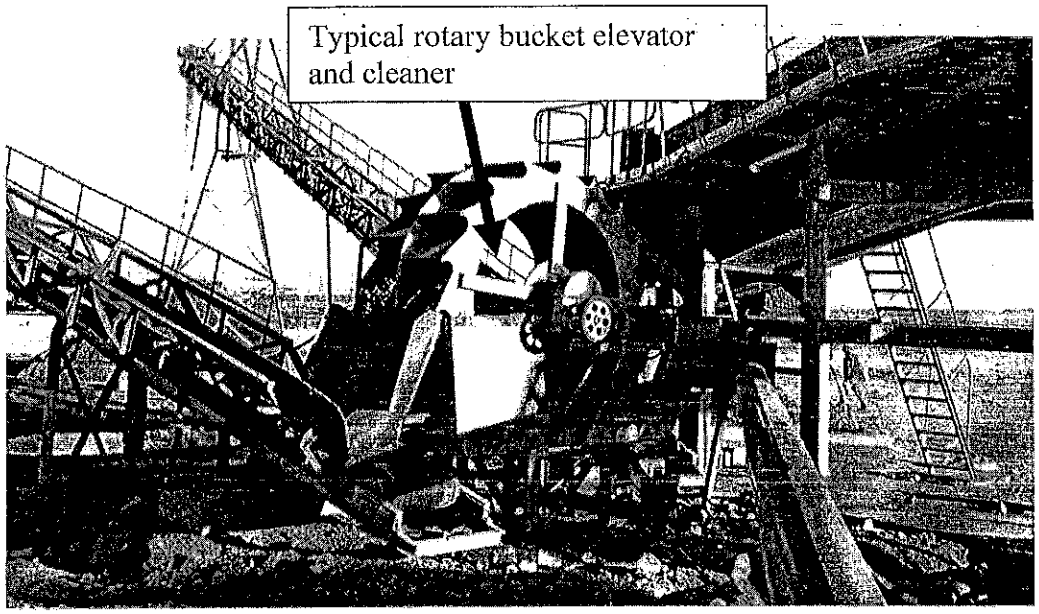


Figure 1

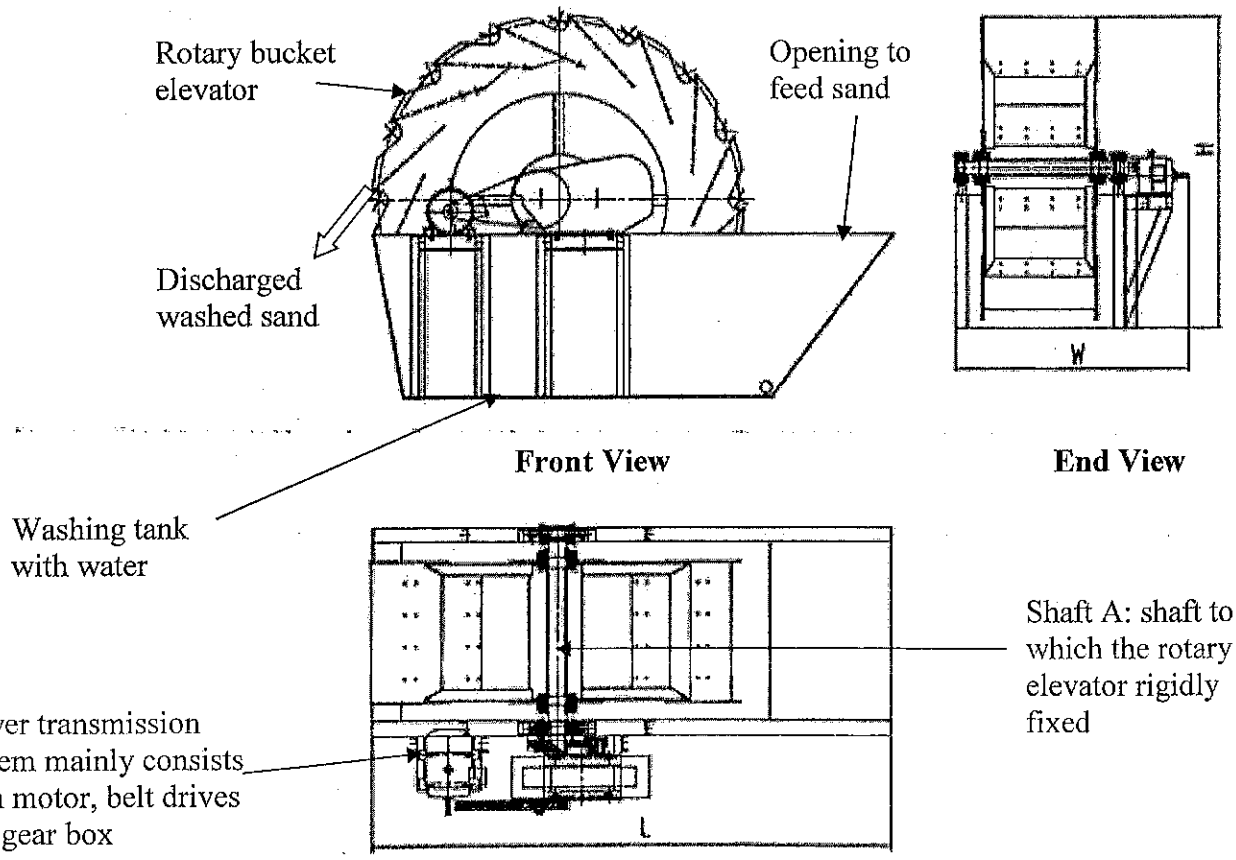


Figure 2

Figure 2 shows the layout of the washing plant. **Figure 3 and Figure 4** illustrates the process of discharging of the washed sand from the circular bucket elevator and the washer. The rotary bucket elevator consists of inbuilt buckets, which are identical and equally spaced around the periphery of the rotor to contain the sand. The buckets have holes perforated on the body to drain out water from sand. The structure of the rotary elevator is fabricated with steel sheets formed and welded between two sideway rimmed discs. Each bucket holds wet sand. The tank receives sand from the sand input device (may be a screw conveyor not shown in the figures). During its operation the rotary elevator scoops up the wet sand from the tank and then discharges out to the go-down, which is also not shown in the figure.

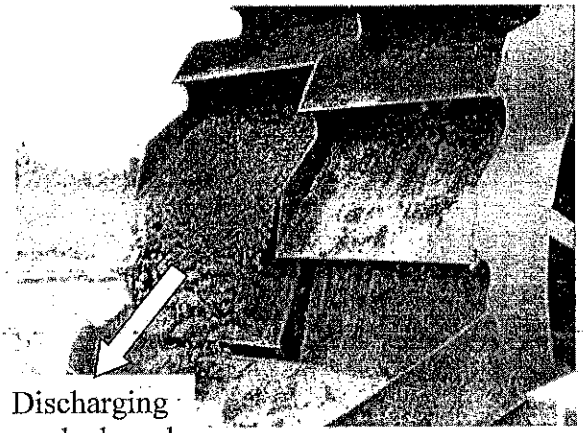


Figure 3

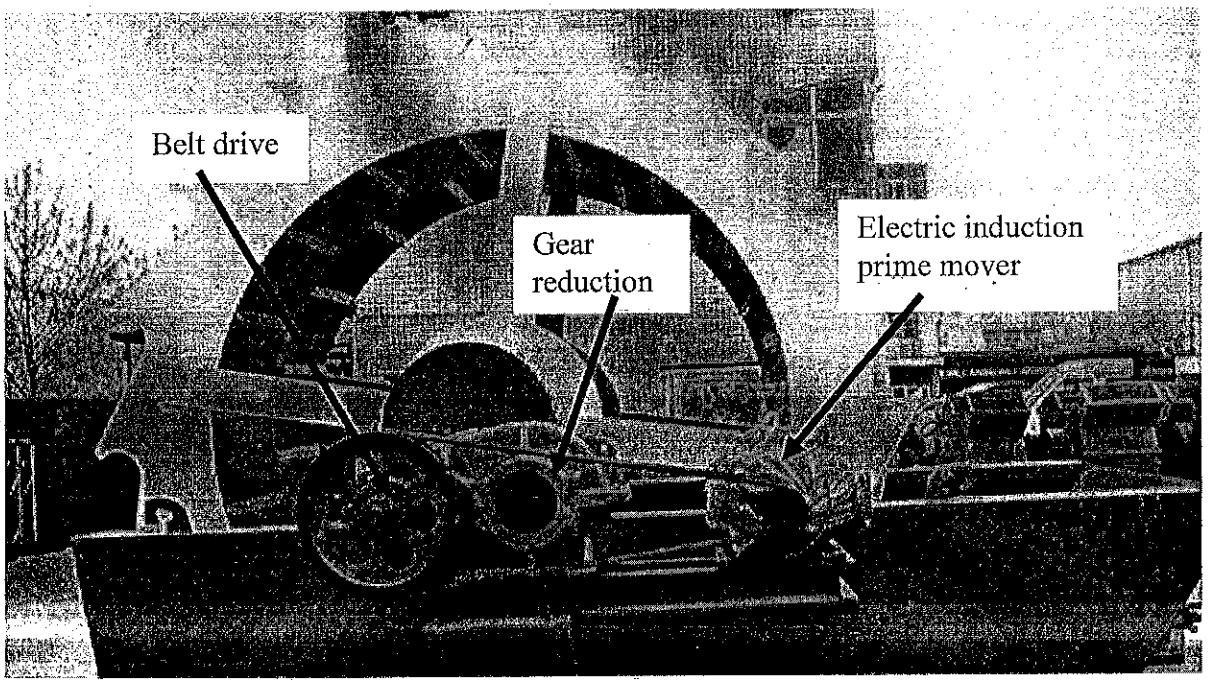


Figure 4

Function of sand washer

1. The electric motor runs the rotary bucket elevator after its speed reduced by a belt drive and a gear train.
2. Sand and water enters into the tank from different directions mixes with each other and an impeller performs the mixing operation in the washing area.
3. The impurities contained in the sand is washed away with the cross flow.
4. By adding water with adequate quantities, and maintaining the correct flow rate of water, the waste and some low-weight debris are taken away from the washing launder.
5. Through the above process the cleaning function is done.
6. The cleaned sand is lifted up by the rotor buckets, while the residual water is being drained out through the perforated holes of the buckets.

Power transmission to rotary bucket elevator

Power transmits from the electric prime mover (motor) first through a V-belt drive system and then a reduction gear train. The pinion wheel of the gear train is mounted on the driven pulley shaft, and the power output shaft of the gear train is coupled through a coupler to the shaft (Shaft A shown in the plan of Figure 2), which carries the rotary bucket elevator. The power transmission system is mounted on the chassis as shown in the Figure 3. All power transmission shafts are parallel to each other, and their axes lie on the same horizontal plane. For a V-belt drive system, the pulley diameters are selected subject to the limitation that the centre distance, $C < 3\ (D+d)$, where D is the larger pulley diameter and d the smaller pulley diameter.

Following technical details are given,

Diameter of the rotary bucker elevator	1 m
Rotating speed of the rotary bucker elevator	10 rpm
Weight of the rotating bucker elevator without sand	4000 N
Weight of the wet sand one bucket can accommodate at its full capacity	150 N
Total number of buckets	15
Time to reach the rotary elevator to 10 rpm	10 s

Answer the following questions as if you were the consultant in this exercise.

1. Calculate the total weight of the rotary bucket elevator.
   Note: *you may consider ten (10) identical buckets are filled to its full capacity when operating at its maximum operational condition.*

2. Calculate the power demand of the motor and estimate the design motor power.
   Notes:
   - *Power transmission efficiencies are; Belt Drive: 90%, Spur Gear Drive: 95%.*
   - *You may assume the rotary bucket elevator as a rotating disc which the total load is distributed uniformly around the periphery of a rotating wheel.*
   - *Apart from the power required to rotate the elevator with its full capacity, the prime mover has to meet the power required to overcome dredging drag load as the bucket scoops up the sand from the tank, which is 20% of and the friction torque at bearings which is 2% of that needed to rotate the elevator at its full capacity.*

3. Select a suitable induction motor from the motor catalogue.

   Note: *you may select a motor with low rpm.*

4. Find the overall velocity ratio and decide the velocity ratios relevant to the belt drive system and gear train.

   Note: *Select the velocity ratios of belt drive and spur gear train sensibly. Accordingly, the velocity ratios should be decided, in such a way that the rotary elevator rotates at 10 rpm, whatever the speed of the selected motor is.*

5. Illustrate the belt arrangement according to your speed reduction and design the belt drive system completely. If the multiple belts are required based on the design power, the driver and driven pulleys should have equal same number of grooves as that of the belts.

6. Illustrate gear arrangement according to your speed reduction method and design one gear mesh which consists with the pinion shaft connected to the input shaft of the gear train. A gear enclosure can be envisaged depending on the circumstances and gear train. ***Note:*** *you may use only spur gears.*

7. Design the input shaft of the gear box.

8. Suggest a suitable keyed joint to couple pinion wheel of the power input shaft of the gear box.

9. Select two rolling element bearings for the power input shaft of the gear box.

10. Illustrate the most suitable type of coupling which can be used to connect the output shaft of the gear box to the shaft A of the rotary elevator. List the step by step procedure of designing the proposed coupling.

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