

## Elevator was Worked by Water and Water Pump

<sup>1</sup>Mohammad Mehdi Masoumi and <sup>2</sup>Soheila Naderinezhad

<sup>1</sup>Department of Civil Engineering,

<sup>2</sup>Department of Electrical Engineering, Young Researchers Club, Science and Research Branch, Islamic Azad University, Fars, Iran

**Abstract:** In this research, it has been attempted to show that some elevators work with water and their energy consumption could be reduced because of water pump usage instead of powerful gear motor of the present day elevators. Power of gear motor elevators is between 3.7 to 7.5 kw and the power of water pump elevator is 1.5 kw. Water, a tank of counter weight and water pumps operate this elevator. Consequently, it can save energy especially when two or more elevators are placed adjacent to each other. The discussion of this study concentrates on the dynamic simulation and physics of this type of elevators.

**Keywords:** Elevator working with water modeling, energy saver, omitted elevator gear motor, variable counterweight mass, water, water pump motor

### INTRODUCTION

The history of lifting heavy objects vertically goes back to five thousand years ago, at the time of The Great Pyramid of Cheops at Giza. Stones weighing as much as five tons were moved into place with primitive lifting mechanisms (Elevator at conveyor-tech.com; Ambrose and Leroy, 1936). Temple of Diana in Ephesus used a ramp of sandbags to raise almost 2,000 stone columns supporting the roof of the edifice in the 600 BC, then the first reference to an elevator is in the works of the Roman architect Vitruvius, who reported that Archimedes (287-212 BC) built his first elevator probably in 236 BC ([www.theelevatormuseum.org/timeline.php](http://www.theelevatormuseum.org/timeline.php)). In some literary sources of later historical periods, elevators were mentioned as cabs on a hemp rope and powered by hand or by animals. It is supposed that elevators of this type were installed in the Sinai monastery of Egypt. In 1000, the Book of Secrets by Ibn Khalaf al-Muradi in Islamic Spain described the use of an elevator-like lifting device, in order to raise a large battering ram to destroy a fortress ([www.theelevatormuseum.org/timeline.php](http://www.theelevatormuseum.org/timeline.php)). In the 17th century the prototypes of elevators were located in the palace buildings of England and France. In 1793, a Russian mechanic and inventor created the first elevator that lifted its cabin using screw mechanisms. His elevators were installed in two Russian royal palaces Saint Petersburg and Moscow ([www.theelevatormuseum.org/timeline.php](http://www.theelevatormuseum.org/timeline.php)). Revolution in elevator technology began with the invention of hydraulic and electricity. Hydraulic elevators were most commonly used to transport freight goods on small vertical distances ([www.elevatorhistory.net/elevator-](http://www.elevatorhistory.net/elevator-history/history-of-elevator/)

[history/history-of-elevator/](http://www.elevatorhistory.net/elevator-history/history-of-elevator/)). They operated on a principle that water pump increased the pressure of the main plunger which pushed freight compartment upwards. This solution was not practical for tall buildings and was soon replaced with a rope-gear elevator with multiple pulleys, invented by the Henry Waterman of New York in 1850 ([www.elevatorhistory.net/elevator-history/history-of-elevator/](http://www.elevatorhistory.net/elevator-history/history-of-elevator/)). The first electric elevator was built by Werner von Siemens in 1880. Statistically speaking, cable-borne elevators are extremely safe and with more usage (Jon, 2010).

Modern elevators use powerful gear motors and gears to lift heavy thing. So they use a large amount of energy to rotate the gears, which causes the elevator to operate. In the present research, it has been attempted to show that water powered elevators could have low energy consumption because of water pump usage instead of the powerful gear motors of the present day elevators which has more energy consumption than water pumps. The water pumps use a rotating impeller to add the pressure of fluid. Fluid enters -in the pump- near the rotating axis and goes to chamber player faster and exit from the plumbing system down. So we can diminish the power by using a water pump instead of an electric motor in the elevator. The discussion of this study explains fully the dynamic simulation and physics of water elevators.

**Experiment:** A simple water elevator was simulated and made from a wood framework with 60 × 60 × 250 cm dimensions as the elevator shaft, two pipes, an iron pulley, a bottle with 10cm diameter and 30 cm length which was used as a tank of counterweight, a water pump, weights, cotton ropes as cables and a small box

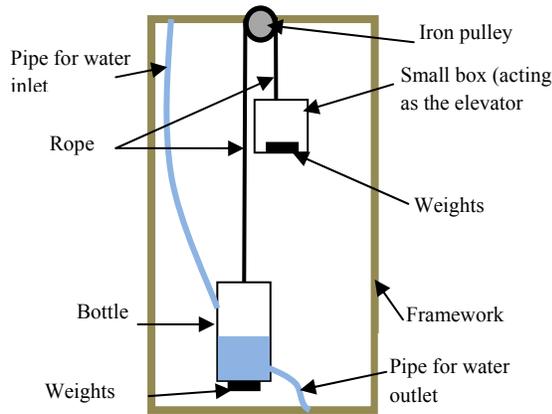


Fig. 1: Experimental illustration

as the elevator car which its dimensions were  $20 \times 20 \times 25$  cm. The arrangement is shown in Fig. 1. Some weights were chosen and put inside the box as the simulated passenger mass. Other weights were attached under a bottle which had two holes. One hole was at the top of the bottle and acted as the water inlet and the other hole which worked as the water outlet was placed on the opposite side and at the bottom of the bottle. A pipe was fixed to the top hole for flowing water in and another pipe was attached to the bottom hole for letting water to flow out from the bottle. The small box and the bottle were linked together by a cotton rope. The maximum length of the cotton rope was 250 cm and its diameter was 0.5 cm. The rope was passed over an iron pulley which was fixed at the top of the wooden framework. The iron pulley diameter was 5 cm and was fixed above of the wooden framework (Fig. 1).

This water powered elevator was working when water flow was started. When the volume of water in the bottle was increased, the small box could move up opposite the bottle. The outlet pipe was controlled manually to adjust the output water. The weight of the bottle when it was filled completely with water was approximately 1.5 kg.

In the next experiment was done by water pump. The water pump properties were: 380 voltages, 1.5 kw power, 3.5 A ampere. The water pump has been used for six stories building which its height is approximately 18 meter due to transfer water to stories and reservoir which placed on the roof of building. The volume rate flow was determined in each floors and reservoir which placed on the roof. The result of measurements was shown in Fig. 2 which height and volume flow rate have vice versa relation together.

In contrast the electrical-mechanical elevators used these days, this type of elevator should have a water pump and a load cell. Two water reservoirs placed on

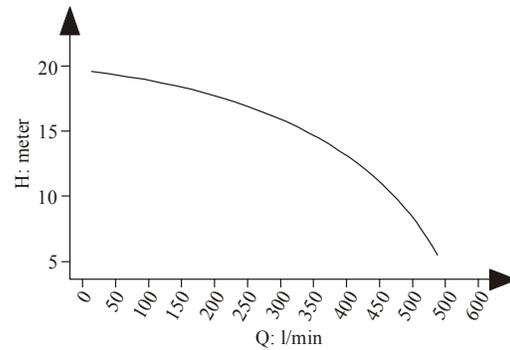


Fig. 2: Water pump properties of volume flow rate and height

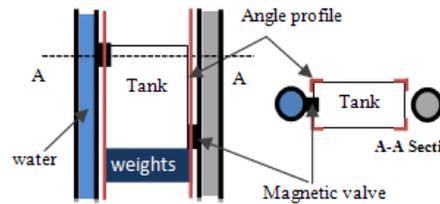


Fig. 3: The counterweight

the top and bottom of elevator shaft with two special pipes linked by reservoirs, a tank of counterweight is the connector between of pipes and eventually between reservoirs. The counter weight of elevators has variable mass which can be heavier or lighter than elevator. Water, a counter-weight's tank and water pumps have revolute elevator.

## EXPERIMENTAL RESULTS, DISCUSSION AND SIMULATION

**Mechanical parts modeling:** The elevator and the counterweight are attached together by cables, that some of these cables can guide the electric current to the counterweight. The counterweight contains two parts, a tank on the top and weights on the bottom of the counterweight. The weight mass was equaled half of the  $M_a$  and  $M_a$  was assumed as the mass of elevator and half of its capacity (passenger's mass). The tank volume when filled by water completely equals the mass of elevator. Whole mass of counterweight approximately equaled one and half of  $M_a$ . The counterweight's gear wheels connected with angle profiles which look like rails for enhanced moving and brakes placed on gear wheels due to stopping while elevator car stopped (Fig. 3). Two special pipes were placed beside the counterweight along its length (Fig. 3). One of pipes was full of water because it was connected to the upper water reservoir and another pipe was connected the lower reservoir to

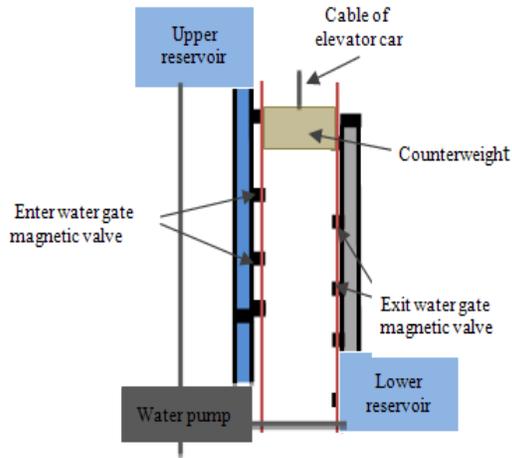


Fig. 4: The counterweight operation

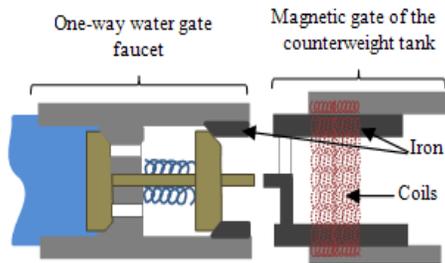


Fig. 5a: Water gate and magnetic gate before electromagnetic induction

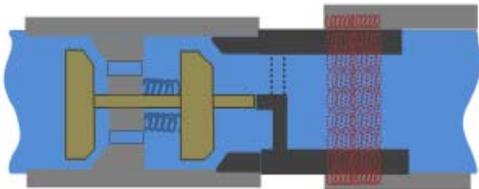


Fig. 5b: Water gate and magnetic gate after electromagnetic induction

collect water from the tank of counterweight then water was pumped to the upper reservoir by the water pump (Fig. 4). Amount of water moved from the upper reservoir to the lower reservoir had to be equal the water pumped to the upper reservoir. Mostly the upper reservoir filled by water, in contrast of the bottom reservoir often was empty.

On the two pipes some gates have been placed which should be adhered to the magnetic gates of counterweight. Number of gates equaled number of stories. For each story where the elevator stopped besides gates, the counter-weight was stopped by brakes. Thus everywhere the counterweight stops, the

counterweight's gates must adhered to the pipe gates, i.e., when the counterweight stops, it could connect to the special pipes to prepare for enter or exit water.

The magnetic gates of counterweight were adhered to special pipes. One magnetic gate was placed above the tank due to adhere to the full water pipe for water entered and another is bottom to exit or convey water to the lower reservoir. When the counterweight has to be heavier thus the amount of water could increase then the upper magnetic gate has to adhere to the water pipe to enter water in the tank (Fig. 5 cross section of water gate and magnetic gate). Water gates work as one-way faucet while in output a metal rig was placed to connect the magnetic gate of the tank. The magnetic gate has coils around the iron pipe which moves, to electromagnetic induction then iron changed to magnet temporary and connected to water gate. in the other pipe, just an iron ring has been placed on output of faucet but without one-way faucet because this pipe conveys water to the lower reservoir. The distance between pipe gate and magnetic gates of tank approximately was considered less than 0.5cm. increasing and decreasing the water of the tank may take several seconds and can be controlled by increasing the diameter of gates and increasing volume flow rate too, so process time decreases, the elevator is prepared to move earlier.

**Electrical parts modeling:** The water elevator is equipped with sensors that have been placed in the counterweight tank of calculate the amount of water inside and a load cell to calculate the loads on the elevator floor. On the counterweight gear wheels sensors have been placed to control moving and stopping and especially the adhering of the magnetic gates to the pipe gates. Increase and decrease of water amount depends on load cell and vertical moving direction of the elevator, which command to the magnetic gates of the tank. If the counterweight moves up, it has to be lighter so the bottom gate starts working or if the elevator moves from the first story to third story, the counter weight has to be heavier, so the upper magnetic gate starts working (opens then water comes into the tank) and amount of water entrance is calculated by set (such as indicators) that connects to the load cell and water while entering is controlled by the sensor inside the tank. Acceleration is considered for the elevator movement which ranges between 1.25 to 1.5 m/s<sup>2</sup>. The elevator mass, its full capacity mass and the counterweight mass is considered respectively  $m_1$ ,  $m_2$  and  $m_3$  so:

$$\sum F = m_2 \cdot a \quad (1)$$

$$\implies m_3 \cdot g - (m_1 + m_2) \cdot g = 1.5 m_2 \quad (2)$$

$$\implies 9.8 m_3 = 11.3 m_2 + 9.8 m_1 \quad (3)$$

The elevator acceleration and the gravitational acceleration is assumed, 1.5 and 9.8 and water mass is considered  $m_w$ . As we cited before, the counterweight mass equals one and a half times of Mass:

$$m_3 = 0.5 m_1 + 0.25 m_2 + m_w \quad (4)$$

$$\implies m_w = 11.05 m_2 + 4.9 m_1 \quad (5)$$

$m_w$  shows the maximum water mass. The elevator mass was constant and its capacity is calculated by load cell.

The power of gear motor elevator is between 3.7 to 7.5 kw and the power of water pump is 1.5 kw. So we can reduce power by using a water pump instead of an electric motor in the elevator.

As we know from the ohm's law:

$$V = RI \text{ (Jerry and Whitaker, 2007; Halliday, 2008)} \quad (6)$$

And we have:

$$P = W/T \text{ (Halliday, 2008)} \quad (7)$$

So it proved that:

$$P = VI \quad (8)$$

The power decrease is a result of voltage or current decrease. Since the voltage usage of motors is fixed by the manufacturer, accordingly the power decrease is a result of current decrease.

When the current decrease; we can prove from the formula, we have reduced energy. (According to that R & T are constant.)

Also we can say that in a certain time the energy will reduce if the power reduces too.

In experiments major survey is done on water movement from one reservoir to another reservoir. Two flexible pipes are fixed to the bottle so when the counterweight moves vertically pipes moved too. One pipe is fixed by a water reservoir that is placed higher than the wood framework. Water was moves manually

so that the box mass stays constant and with increased or decreased water inside the counterweight becomes heavier and lighter when water increase or decrease inside the counter weight. Thus the box moves vertically. In other experiment the water pumps to the height of 5 to 18 m. In Fig. 4 the relationship between height and volume flow rate is shown. A pedestrian overpass with 12 m height and 15 m height between the upper and the lower reservoir is considered too. According to the Fig. 4, the water pump can transfer 300 L water/min.

This elevator is better for low height, such as small apartment with three or four stories, especially public places such as subway stations or pedestrian overpass. And if two or three elevators placed besides could be had one reservoir above and one reservoir bottom of elevator shafts which shared to gather so was used one or two water pump (s) for transferred water to above reservoir which is the main advantage of water elevator.

## CONCLUSION

The counterweight mass is variable which cause moving of the elevator. The water elevator system has water flow, reservoir and tank as part of the counterweight, gear motor instead of has water pump. Consequently, it is energy saver especially when two or more elevator placed besides.

## REFERENCES

- Ambrose, H.S. and R.S. Leroy, 1936. Load distribution and strength of elevator cable equalizers. *J. Res. Natl. Bur. Stand.*, 17(2): 291.
- Halliday, R., 2008. *Fundamentals of Physics Extended*. 8th Edn., Wiley India Pvt. Ltd., India, pp: 1224, ISBN: 8126514426.
- Jerry, C. and A.C. Whitaker, 2007. *Power Systems Handbook*. 3rd Edn., Morgan Hill, Taylor and Francis Press Group, California.
- Jon, B.H., 2010. *The Vertical Transportation Handbook*. George, R.S. and S.C. Robert (Eds.), 4th Edn., John Wiley and Sons, New York, pp: 624, ISBN: 0470404132.