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Multifunctional water tower

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Multifunctional water tower

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Abstract. The aim of this article is to present a new technical solution of the multifunctional water tower. The principle of the new designed a water tower is fundamentally based on self-sufficiency and independence of energy sources, either the energy of the sun or the wind is used. To the conversion of this energy into mechanical energy for pumping of water to storage tank is used a ball screw mechanism, which driving a high discharge displacement pump based on the piston principle.

1. Introduction

The aim of this work is created multifunctional patented solution of water tower reservoir for sustainability water management and energy use in smart cities or during irrigation in agriculture. The final solution combines several technological fields, such as solar, wind and water energy, electrical direct drive motion technology with remote control for industry 4.0 with the possibility of the storage water and battery back-up of storage energy. This technological solution is patented and suitable use especially for deep and narrow wells during with adjustable screw stroke in wide range length. And for building multifunctional farms serving as water reservoirs too.

At the end of the article is a design study of a new water tower, these is placed inside an unused building with cultural and social value.

2. The state of knowledge

The reservoir is a waterworks for a water accumulation. The purpose of the reservoir is to compensate the differences between inflows from the water source and consumer consumption. To ensure the necessary pressure on the water supply network and to ensure a sufficient water reserve in the event of a fire. Reservoirs can be built as underground or above the ground. Water towers are usually built in a flat land area.

The classical scheme of modern design water tower 'figure 1', which was built in 2019 in village Ohrazenice, Czech Republic. The whole structure is based on a monolithic concrete slab placed on six drilled piles. The glazed circular above-ground part provides, on the one hand, space for the operator's facilities and, on the other, a representative space for the owner of the water management infrastructure. A concrete staircase descends from the operating space to the armature chamber 'figure 3', from where the necessary pipes (discharge lines, supply lines, overflow from the reservoir, process water, electricity and data transmission) are led through a glass stair tube up to the sphere chamber of the tower reservoir 'figure 2', where is located the storage tank with volume 150 m³ of drinking water [1].



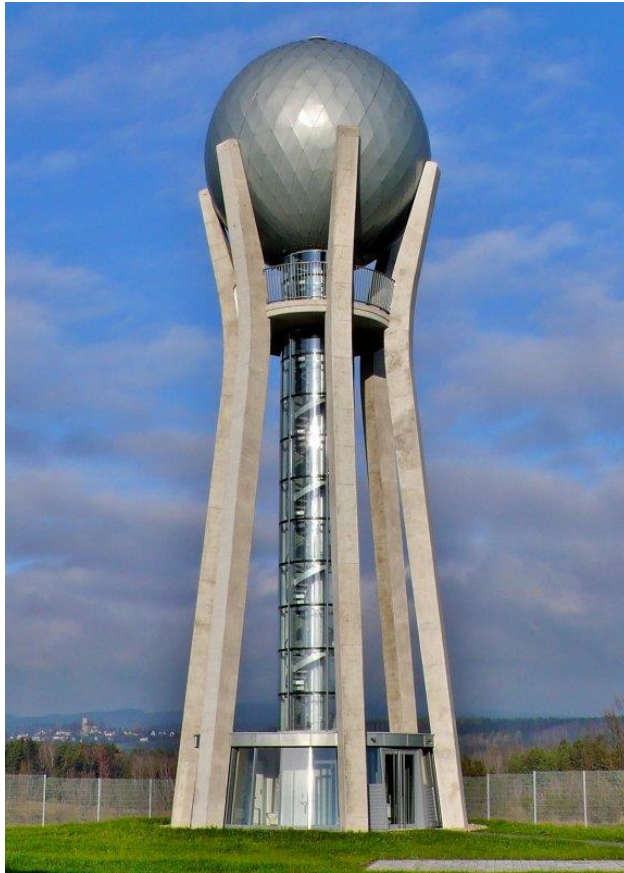


Figure 1. Water tower Ohrazenice, Czech Republic [2].

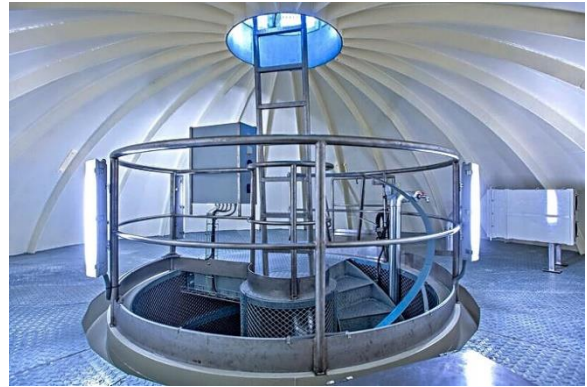


Figure 2. Handling chamber at the top of the sphere [3].



Figure 3. Underground valve chamber [4].

3. Concept of the multifunctional water tower

3.1. Multifunctional water tower

The invention aims to present a new patented concept of a multifunctional self-service and independence water tower, which includes a high-capacity displacement pump, which is powered by wind and solar energy, obtained from sources directly on the water tower.

The new design of multifunction water tank consists of a hollow support column anchored above a borehole or a storage tank. There is a water tank at the upper end of the column and a suction pipe is attached at the lower end, to which a piston positive displacement pump is connected. The water tower is designed so that the rotor of the wind turbine is placed on top of. A rod is connected to the piston of the positive displacement pump. Wind turbine rotor is powered by a wind energy and connected to a ball screw reverser nut. Rotation of the nut moves in a straight line the screw on which the rod is mounted. The rod passes through the pipe and is guided in the housings up to the piston of the displacement pump. The pump pumps water from a source at the end of a deep narrow well through a pipe into a water tank 'figure 4'.

The advantage is that a shell is formed above the surface of the container, the upper part of which is fixed to the tank below the level of the rotor or electric motor and the lower part of which is fixed to the supporting column. It is further preferred that either the shell or the reservoir is provided with solar panels on its outer surface. It is also advantageous if the overflow line is led out laterally from the support column or from the suction line the pipe leading to the storage tank and when the outlet pipe is led out of the support column from the overflow pipe and the outlet pipe are equipped with shut-off valves and turbines.

In the optimal case, the mantle is equipped with a walkway. The present invention achieves a new and higher effect in that the principle of filling the storage tank. The multifunctional water tower is based on independence from external energy sources when provided wind and solar energy obtained by a wind farm or solar panels that are directly part of the reservoir. If the tank is completely filled, pumped water is possible used for irrigation to recover energy by flowing water through a turbine connected to the mains. In addition, the reservoir can be used as a separate wind or solar power plant and also as a lookout tower if galleries or footbridges are built on its mantle.

According of individually specification, the multifunctional water tower can perform several operating modes:

- water tank for irrigation or technology which pumping water from the narrow well
- energy storage on the principle of the small pump storage power plant
- recovery and storage of the energy in conjunction with wind or solar energy
- to be a part of hiking trails and to perform, for example, the function of a lookout tower

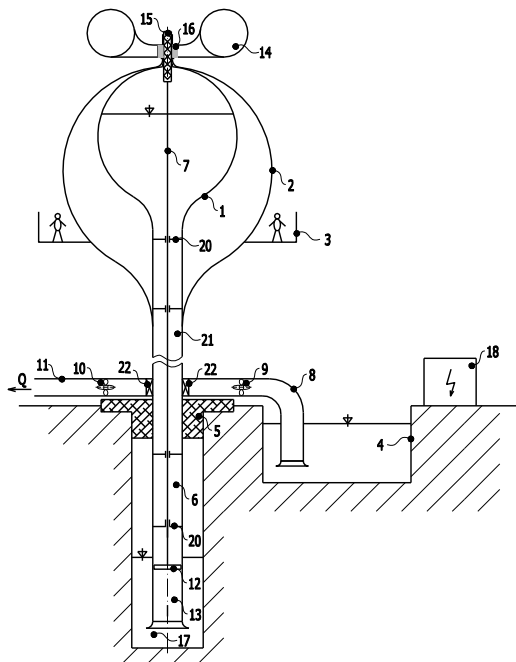


Figure 4. Patented multifunctional water tower solution [5].



Figure 5. Experimental multifunctional water tower.

At the hydraulic laboratory of the Victor Kaplan dept. of Fluid Engineering is made an experimental model of the multifunctional water tower prototype with small dimensions 'figure 5'. There is possible to test individual functions of the multifunctional water tower.

3.2. Multifunctional water tower farm

The water tower is designed to create a small solar power plant at the same time. If groups of water towers are used, it is a small solar farm with multifunctional use. The pumps simultaneously or alternately supply water to the storage tank of each multifunctional reservoir on the farm. When there is excess energy, water is used for irrigation. Depending on the excess pressure, turbines

can be used to recover energy and store it in battery storage. The system enables the interconnection of individual multifunctional water towers to optimize farm processes.

It is developed technical solutions and in cooperation with designers from Tomas Bata University in Zlín and also some artistic (architectural) solutions. For example, project of water towers inspired by a chess pieces 'figure 6'.



Figure 6. Idea of the multifunctional water tower farm „Chess Towers“ [6].

4. Pump drive mechanism

Actuator drive of the piston pump is a unique ball screw reverser 'figure 7' which provides automatic reciprocating motion. Screw ball reverser can be operated in two modes. Principle of the ball reverser function is when nut is turning and rod with helix moves straight or rod with helix is turning and nut moves straight.



Figure 7. Ball screw reverser mechanism.

In our case a ball screw reverser is a mechanism where the nut performs a rotational movement in only one direction of rotation and the double helical rod performs a reciprocating translational movement.

The load capacity of the screw depends on the size of the middle guide ball used in the mechanism 'figure 8'.

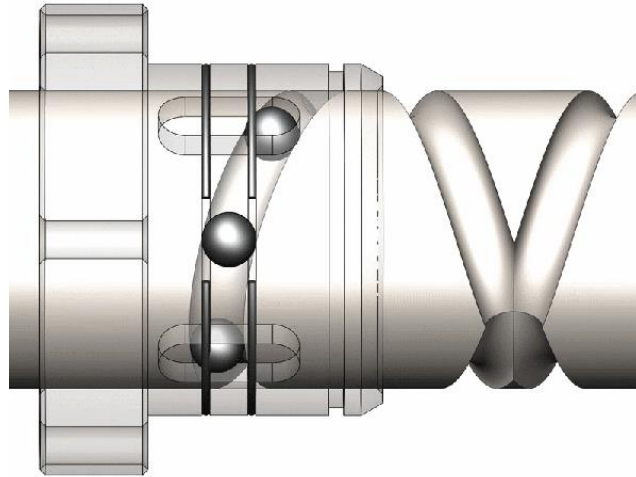


Figure 8. Principle of the ball reverser screw [7].

Ball screw reverser can be driven by bevel gear motor with hollow shaft 'figure 9', low-speed electric motor with high torque (DDR - direct drive technology) 'figure 10' or can be driven by wind turbine too. In these cases, nut of the screw rotates and the rod is guided by a longitudinal groove and in addition, rod is guided in a pair of a plain bearings.

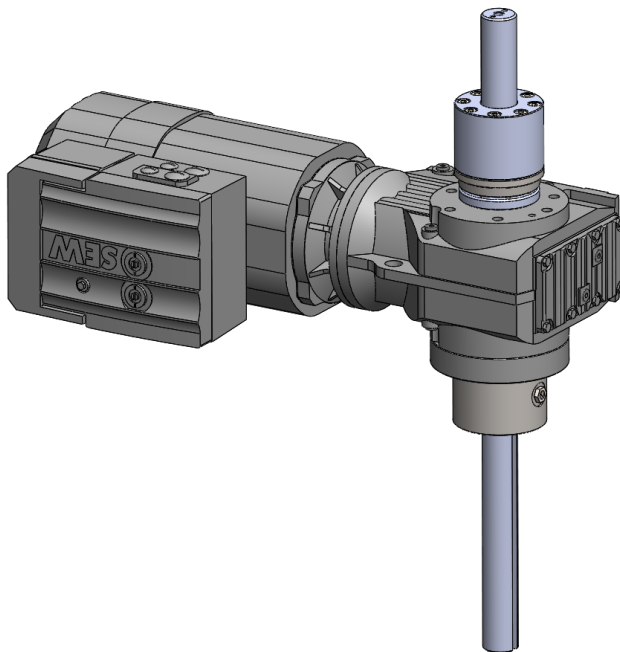


Figure 9. Ball screw reverser driven by gearbox.

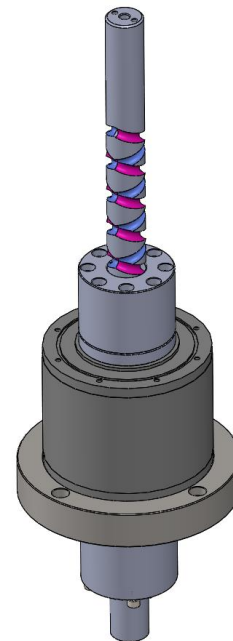


Figure 10. Ball screw reverser driven by direct drive rotary.

On the 'figure 11' is experimental stand for a screw fatigue tests and verification of the function and motion fluidity of the coupled mechanism with pumping displacement pump. And detail of the rod cross-section of the helix grooves is shown on the 'figure 12'.

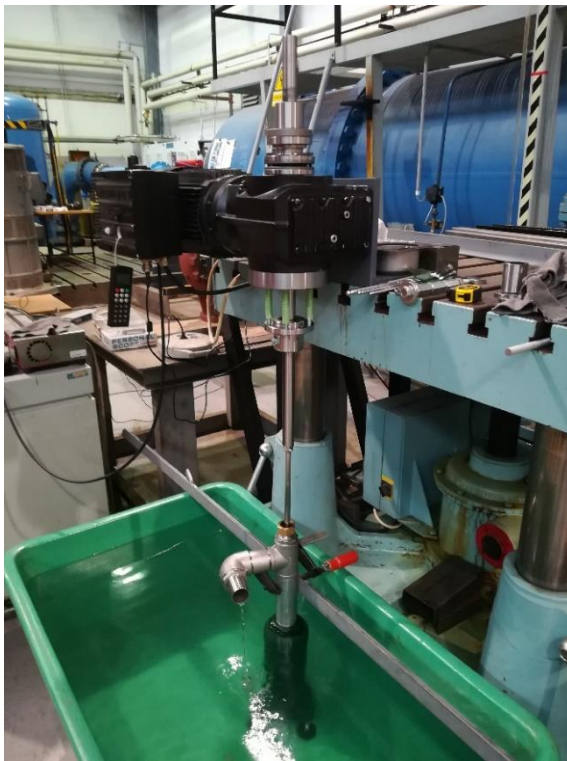


Figure 11. Experimental stand for testing.



Figure 12. Detail of the ball reverser.

5. Challenge of using water tower in the smart cities

Usability of multifunctional water tower may be found for the new project design or rehabilitation of existing conservation facilities that have cultural or technical value. For example - in city Brno is located brownfield Špitálka 'figure 13'. There is planned to rehabilitate old cooling tower to new local district dominant 'figure 14'.



Figure 13. Brownfield district Brno - Špitálka, Czech Republic [8].



Figure 14. Master plan for the re-construction of a smart city district Brno - Špitálka [9].

Brno University of Technology try to find a way to use the part of the cooling tower of heating plants that will no longer serve heating purposes and is preparing for the reconstruction and creation of a new smart district Brno - Špitálka with the latest trends. The area embodies the industrial heritage of the city and the new district will, according to plans, respect the genius loci of this valuable area near the city center. Brno - Špitálka should become a symbol of progress and modern technologies in the city Brno.

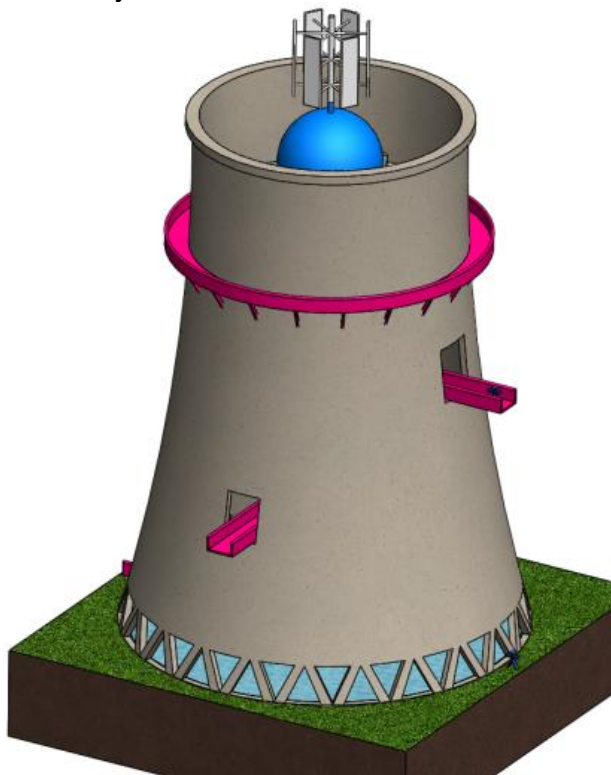


Figure 15. New design of the cooling tower.

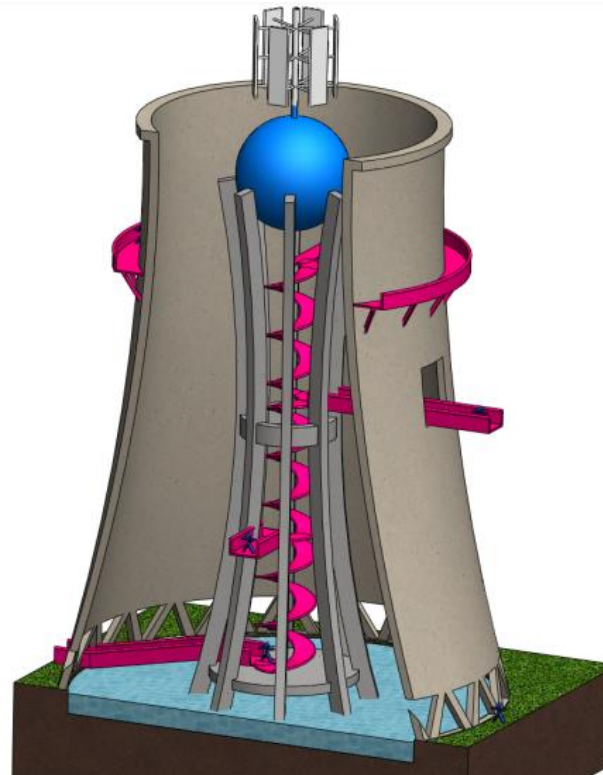


Figure 16. Water tower with a lower reservoir inside a cooling tower.

For the future appearance of the new smart district was created design with multifunctional water tower 'figure 15 and 16'. Which could be used for irrigation of roof gardens or for domestic water management. Inside old cooling tower is placed multifunctional water tower with storage tank inside a sphere and second larger storage tank in the lower pool too. The water tower can be supplemented with a narrow well too. The solar panels can be placed on the tower shell. Possible usability of old cooling tower rehabilitation with water tower depends on the decision of the city chief architect commission and could be a part of a suitable architectural concept.

6. Conclusion

This article provides a basic overview of the concept of a multifunctional water tower. The multifunctional water tower arose from the idea of combining water accumulation and producing of electricity energy. The water tower can be equipped with solar panels or a wind turbine to drive the pump. On the one hand, the water tower serves to store water, but when it is drained, the potential energy can be used to produce energy when the pump is running in turbine mode. The concept of the pump with a ball screw reverser is suitable for narrow or deep wells, where longer piston strokes can be easily adjusted by the length of the working part of the ball screw rod. The water reservoir can be part of the top floor of a residential or office building, but it can also be free-standing and, with a suitable architectural concept, an interesting diversification, such as a lookout tower, or it can be underground.

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