WATER RAM

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Eng. Viktoriya Georgieva Kuncheva, PhD, Institute of Soil Science, Agrotechnologies and Plant Protection "Nikola Poushkarov" (ISSAPP)- Sofia, Bulgaria

1. Current challenges and issues to be solved

Climate changes lead to serious droughts, and Bulgaria is strongly affected by them. For example, just a few weeks after the start of summer this year, the insufficient flow of water sources was registered in several settlements, with small settlements where there is not a well-developed economy, being particularly affected. In addition to climate changes and the poor technical condition of water supply networks and their management, the main reason for this is the irrational use of water resources by the population, especially in the use of drinking water to water gardens and water animals.

The lack of financial opportunity to build wells (where there is high groundwater) on private properties is often a common reason for owners to irrigate their yards with centrally supplied drinking water. Since almost every settlement is located near a river, many property owners take advantage of this and meet some of their non-domestic needs through pumps. In the case of favorable terrain conditions, a property can be gravity-fed directly from the river, but this is rare. The most common are portable pumps, as they can be stored within the boundaries of the private property after their use. In any case, the use of a conventional pump is associated with the release of carbon emissions into the atmosphere (whether electric or diesel), complicated operation, especially for elderly people and, above all, significant financial resources for purchase and consumables. This creates serious problems for the population in their adaptation to climate change.

2. Description of the proposed solution

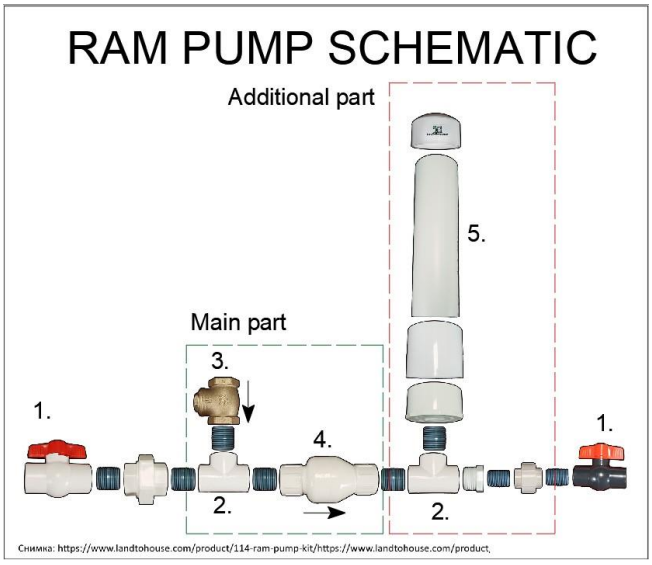
On a global scale, technologies that were known in the past, but for one reason or another never reached mass implementation in everyday life, are gaining more and more popularity. One such technology is hydraulic pumps (Ram pump or Venturo pump). They are devices that, in their simplest form, consist of two check valves connected by a tee. Once started, a cyclic series of hydraulic strokes is created in the suction-pump-pusher system, which results in water being transported to higher elevations than the free water surface, without the need for any power source (e.g. a motor).

The current plan is to create a specialized unit to develop RAM pump technologies and put them into practice.

2.1. Working principle

The theoretical premise on which the operation of the RAM pump is based is related to the equation for the potential energy of a body: $Pe=m.g.h$, where Pe is the potential energy of a body, with mass m, located at a height h relative to a selected plane, and g is the gravity acceleration which is a constant. This means that a body with a mass of 10 kg located at a height of 10 m has the same potential energy as a body with a mass of 1 kg located at a height of 100

m. The potential energy equation is the basis of the Bernoulli equation, which defines the main characteristics of the conservation of energy between two sections in a continuous fluid flow - potential and kinetic. Given the fact that water is an incompressible fluid, the basic principle of operation of a RAM pump can generally be summarized as that the greater part of the flow is removed from the system and its energy is transferred to the remaining, smaller part of the stream.



Legend:

1. Stop valve
2. Pipe tee
3. Waste valve (WV)
4. Delivery valve (DV)
5. Pressured chamber

Figure 1 Schematic of RAM pump

As mentioned above, RAM pumps work on cycles, which can be divided into two main phases.

Initial conditions: Before starting the pump, both check valves are closed. The free water surface in the water source (usually constant) and the one in the delivery pipe are at the same elevation since the whole system is in equilibrium and functions as communicating vessels (Figure 2)

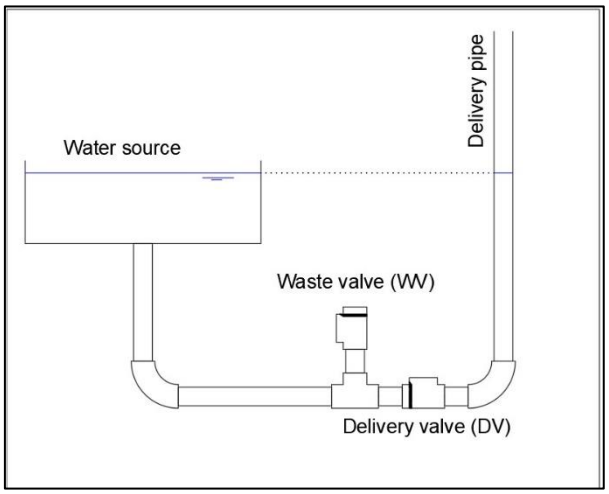


Figure 2: Initial set-up of RAM pump

Phase 1: After forcing the waste valve (WV) open, a flow is created that discharges water into nature. Once the water has gained enough velocity, the WV closes abruptly. Kinetic energy is converted into potential – ie. the pressure before the delivery valve (DW) rises sharply. The

balance of power before and after DW is disturbed and it opens. This allows the flow to enter the delivery pipe and causes the free water level to rise there.

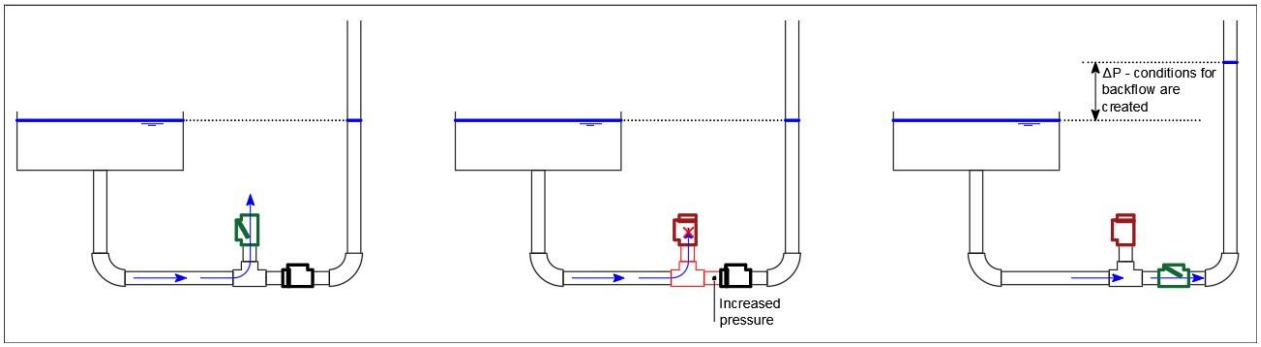


Figure 3: Phase 1 of RAM pump operation

Phase 2: The higher level of the free water surface in the delivery pipe causes the velocity of the water entering it to slow down and at some point, conditions for backflow are created, because the DW is still open. As a result, the DW begins to close, and the water level in the delivery pipe drops a little. After closing the DW, the reverse flow opens the WV and the cycle repeats – phase 1 begins, but already the water level in the delivery pipe is higher than the initial one.

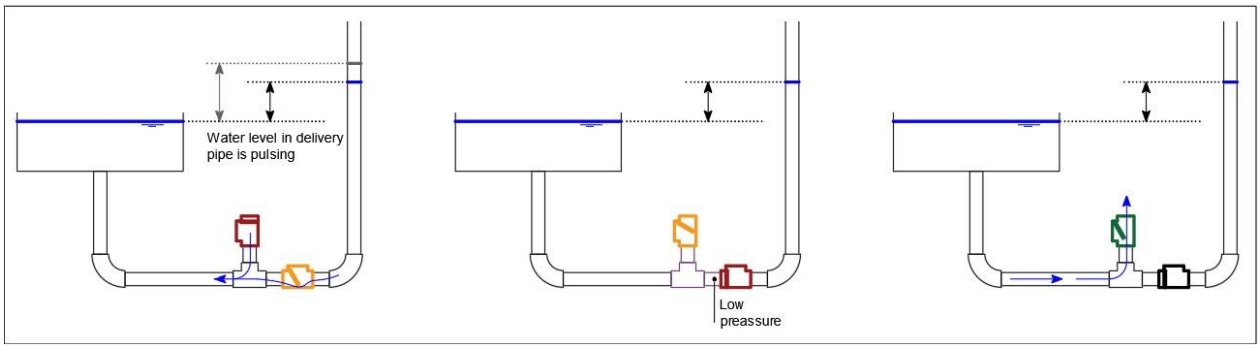


Figure 4: Phase 2 of RAM pump operation

Role of the pressured chamber: The maximum head that can be achieved using a RAM pump (ie the maximum height in the delivery pipe above the free water surface in the water source) is directly related to the energy losses in the system. To minimize them, a preassured vessel is often added after the delivery valve (DW). Most often, the vessel is filled with air (compressible fluid) and performs a function similar to a spring (or hydrophore). This significantly reduces pulsation in the delivery pipe, resulting in lower energy losses and higher efficiency.

It is considered that the capacity of the RAM pump in terms of the head created by it is directly proportional to the inlet head in a ratio of 7 to 1 - i.e. for every 1 meter of the head before the pump, the pump creates 7 meters of the head (or 6 m additional). In terms of performance, it is considered that around 90% of the water entering the inlet pipe is returned to nature through the waste valve, and 10% is fed to the delivery pipe.

2.2. Technical limitations

RAM pumps have a limited application, which is most often determined by two conditions: 1. A constant incoming flow of water, with a large part of it being released back into nature

immediately after passing through the waste valve, and 2. The presence of a head before the pump - i.e. RAM pump can only be used for surface water.

2.3. Operational features and area of applicability

RAM pumps operate automatically, without the need for specialized maintenance, as long as air is not allowed to enter the system or flow is interrupted. Even if this happens, restarting takes a few minutes and is extremely easy - just force the discharge valve open. Despite everything, periodic maintenance is necessary - cleaning from leaves and mud, technical inspection of the pump elements and others. Suitable places to place these pumps are rivers and/or dams.

3. Feasibility analysis

3.1. Resources needed

The current proposal is for the creation of a specialized department of at least 3 people. The main directions in which they will work are:

1. Development and optimization of ready-to-use RAM pumps for customers;
2. Initial installation of RAM pumps;
3. Marketing of the RAM pumps.

Human resources: The total required number of people in the working is directly dependent on the set goals. For the current proposal, which is focused on individual users and given the tasks at hand, the minimum staffing requirement is 3 full-time and/or part-time people, which will be: 1 manager with knowledge in the field of marketing and project management, 1 engineer with knowledge of hydraulics and fluid dynamics, 1 worker with technical knowledge of piping systems.

Materials: The individual parts for manufacturing and installing the RAM pump are cheap and widely available. No specialized equipment is required for assembly and installation. A means of transport is required.

Working space: Not much labour is needed for construction and testing. An equipped hall of approx 15-20 m^2 will be enough.

Administration: Considering the specifics of the work, the administration and accounting of the project can be performed by the team leader or an external service can be hired.

Marketing and dissemination: Suitable places to advertise the product are social networks and targeted events - farmer's fairs, assemblies, and conferences.

3.2. Time plan

The time required for the technical development and release of a finished product is expected to be within 4-6 months.

3.3. Financial aspects

Estimated investment costs are as follows:
Human resources: 2500 eur per month
Materials: 50 eur per pump
Working space: 300 eur per month

Administration: included in human resources
Marketing and dissemination: 5,000 eur per year
Other spending (fuel, car maintenance, etc.): 400 eur per month

The total price per year amounts to about 43,500 eur, not including the material costs for making the product. This investment can be significantly reduced if the specialized unit is part of a well-developed company in the field of construction or irrigation. In such a case, the costs of the production, installation and marketing of the product will be based mainly on the salaries of the workers, as well as the need for advertising and marketing.

3.4. Target groups

The proposed solution is focused on the applicability of hydraulic pumps to transport surface water for single consumers, to meet the needs of watering gardens, technical water and others. The emergence of hydraulic pumps on the market as a ready-to-use product at an affordable price may be of great interest to several users, especially those located in remote locations without reliable power supply (for example, huts, cabins and other single buildings or facilities).

It is important to mention that studies are being done on a global scale to use RAM pumps for electricity production as well as for field irrigation.[1]

3.5. Current development and potential

At present, a hydraulic RAM pump prototype has been developed, consisting of piping fittings - all 3/4" size (some of which have been used in the past for other purposes), check valves - 3/4", an empty PVC bottle, hoses - 13 mm and vessel for air release before inlet - 30 litres. The prototype was tested in field conditions. The test results showed potential, but technical improvement in the design, optimization and further research to define specific technical parameters is needed. Video and photos of the field tests can be found here:
https://drive.google.com/drive/folders/1FQ5F2vXS2fX9kD9AsoELQRK3TT9exz43?usp=sharing

3.6. Similar and comparable products on the world market

The widely distributed product, to which the RAM pumps are an alternative, are the portable diesel pumps, the price of which starts from 500 eur. The main advantage of conventional diesel pumps is that they do not have specific requirements regarding terrain conditions. They are portable and therefore the risk of vandalism is low. The main disadvantages are that they are heavy and difficult for elderly people to operate. They require additional fuel costs and are not environmentally friendly.

Currently, ready-to-use RAM pumps are sold in the US, with prices ranging between $80 and $170 per piece[2]. Shipping to the Balkans is $75. This does not include installation and additional expenses for piping and storage facilities, which can vary drastically depending on the specific place.

[1] https://pureportal.strath.ac.uk/en/publications/zero-energy-distributed-micro-pumped-hydro-scottish-regional-appr
[2] https://www.landtohouse.com/rampumpsales/

4. SWOT analysis

Strengths:

- ✓ Energy free
- ✓ Easy to use – automatic work
- ✓ Low investment and maintenance costs compared to conventional alternatives
- ✓ Environmentally friendly

Weaknesses:

- × Terrain dependent
- × Relatively low flow

Opportunities:

- → Potential for future development for industrial use
- → Innovative technology - no similar products at regional level

Threats:

- ⊘ Placed not in private property – risk of vandalism
- ⊘ Limited market

5. Conclusion

The proposed solution has economic potential, although the market is limited. The low investment cost for the developing of the product and potential for industrial application compensate for the economic risks, especially if this technology is developed by a well-established on-the-market company in the field of waters.