

エネルギー教育素材としての撃力ポンプ

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Ram pump for energy education

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Summary

Ram pump is a water pump developed during 19th centuries. It is driven only by water current without using external driving power such as oil or electricity.

However, under the development of modern energy technology, ram pump was forgotten like other natural energy. Today, worldwide environmental problems are compelling people to remind the use of these natural energy. Not only the problem of environmental pollution, basic comprehension of modern technology is getting more and more difficult for many students. Simplicity and pollution free are the remarkable feature of ram pump (photo 1, 2). On these points, we built a small model for science and energy education.



Photo1

1. Introduction

(1) History of Ram Pump

One of the most important conditions for mankind can live is the availability of water. But since the

historic age carrying water have been heavy labor for all people. Natural energy such as windmill and watermill have been used as the alternatives for human labor. Ram pump had been used as one of these natural energy systems.

More than 200 years ago, in England, pipe burst accidents of water supply system were reported very often. (1) They improved the system extending by-path tube from the bibcock to the position higher than the level of water supply tank. Pipe burst accidents were avoided by the improvement. But still the water erupted from upper end of the pipe. They should extend the pipe up to the position higher than water supply tank. So they could lift water at the moment when the bibcock was closed. From these experiences, in 1772, Whitehurst invented manual system that can lift water by itself (without using extra power). This pump lifts water every moment bibcock is closed. (fig.1)

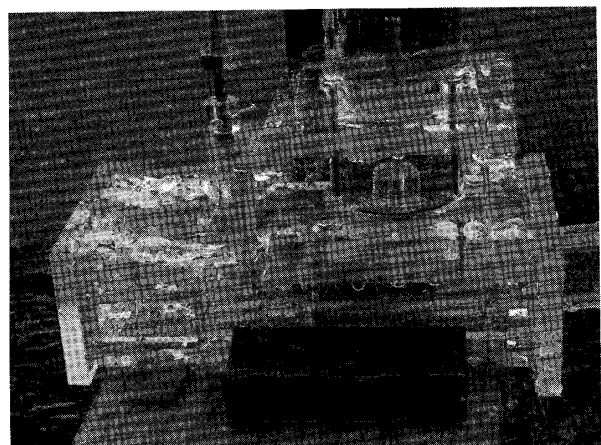


Photo2

In 1796, Montgolfier improved the system to automatically driving pump. (Fig2) Since then, the improvement and utilization spread all over the world. Also in Japan, as our land have many precipitous terrain, many rivers and high rainfall, many local people had been used ram pump since the beginning of the first quarter of 20 centuries. In 1957, 1500 ram pumps were produced. However, since then the production decreased. Today in Japan, only few people know the existence of the pump.

(2) What is Ram Pump ?

When closing the bibcock water quickly every one feels that bibcock pipe vibrate at the moment. This is because water pressure increases when water current suddenly blocked. This phenomenon is called water hammer phenomenon. Because it is just like hammer hit nail, blocked water current hit and vibrate the pipe nearby. From the age of Whitehurst, water hammer phenomenon has been big problem for pipe laying works.

The idea of ram pump is turned demerit to merit. Increase of water pressure is proportional to water current velocity if valve is closed quickly. For instance, water current of 4 m/s can generate the pressure of 4 atoms. This is why ram pump can lift water higher than from the position of water source.

Theoretically, this is a kind of potential energy converter through water hammer phenomenon. If efficiency were 100% then

$$V_s \times h = V_l \times H$$

where V_s is volume of source water flow into the pump

V_l is volume of lifted water

h and H is shown in Fig. 3

Actual efficiency of ram pump is around 60%. It depends on design. The water supply system of Seattle city in America was reported 90%. (3)

The features of Ram pump are

- 1 Very simple and reliable. Main structure of ram

pump consists only of 2 valves as moving parts, air vessel and pipes. These mean it can be built in developing country, which has no high technology.

- 2 So, maintenance is easy and inexpensive because no fuel or electricity and lubricating oil is required.

Demerits are

- 1 Placing point is limited only where water source with drop is available.
- 2 Because of noise from water hammer phenomenon it is difficult to place close to house, (but possible to decrease using modern material).
- 3 Theoretically, impossible to lift total volume of source water.

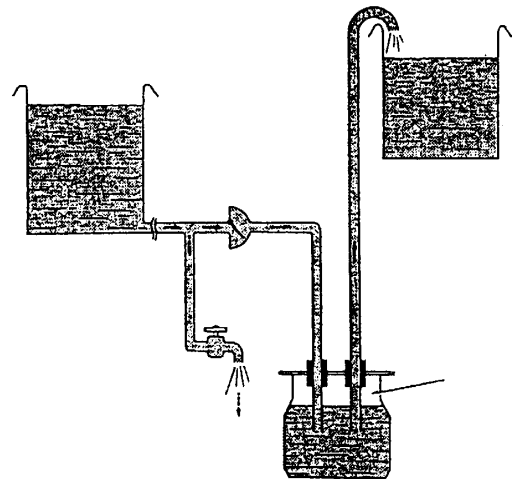


fig. 1 Ram Pump by Whitehurst

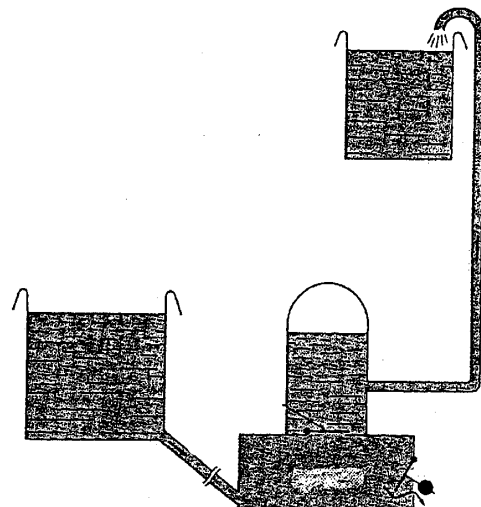


fig. 2 Ram Pump by Montgolfier

2 Working theory of ram pump

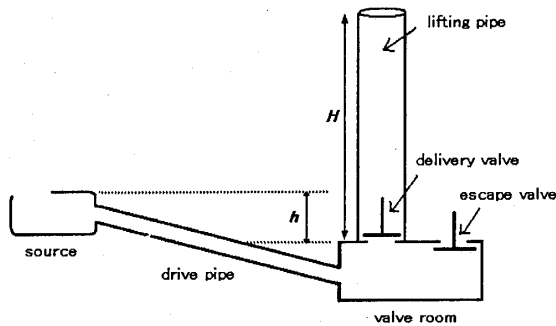


fig. 3 Illustration and working cycle of the ram pump

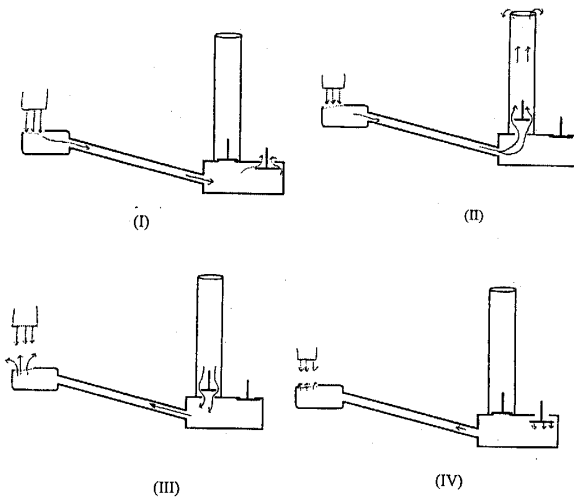


fig. 4 Ram Pump Cycle

In our experimental model we used straight pipe of open upper end. Practical pump equips air vessel for smoothing pulsing current. Smoothing is better for chassis strength and efficiency. Later, we changed the pipe for air vessel.

In every preceding material, the explanation why automatic operation possible, why escape valve open again at the beginning of the working cycle, seems not clear.

An American company's material only written like this (3)

----- Meanwhile, the closing of the delivery valve creates a slight vacuum or suction, which

permits the valve poppet (escape valve in the fig. 3) to drop open again. This allows water from the drive pipe to escape through the waste valve (escape valve in the figure 3) opening, creating a new cycle.

The explanation may not wrong, but it is not clear the reason why the closing of the check valve (delivery valve in the figure 3) creates a slight vacuum or suction enough to open escape valve in spite of the position of the valve room is lower than water source.

In Japanese book written like following. (2)
----- Water current, which lost the destination from the closing of the delivery valve, flows back to drive pipe. -----

May be, this expression is wrong because water should be regarded incompressible fluid in the physical range of our discussion.

We observed the movement of air bubble in water, some amount of pushed up water begin to go back through delivery valve to drive pipe by every cycle. From this observation we thought the phenomenon as following. If the delivery valve were an ideal check valve, even a drop of water cannot flow back. But real check valve allows some amount of flow back current. . Water pressure of valve room suddenly decreases just after the delivery valve was shut completely (generate negative water hammer phenomenon). Negative pressure makes escape valve open again. Thus we understand the reason why automatic operation is possible.

Our explanation of working theory is as following.

- (I) Water flows outside through escape valve until water current close escape valve quickly
- (II) Increased valve room pressure make water rise up and flow out from lifting pipe.
- (III) Water in lifting pipe flow back until delivery valve completely closed.
- (IV) Negative water hammer phenomenon generates

just after the closing of delivery valve. Pressure decrease in valve room makes escape valve open again.

3 Ram pump as natural energy education material

The purpose of energy education should not develop irrelevantly to existing industrial structure of mass production, mass consumption and mass disposition, but to create environmental friendly technology under natural restriction. Natural energy is constrained strongly under local condition. We are not allowed to extract natural energy resources completely from ecological restrictions. Very often we cannot consume as much as we want. Sometimes natural energy acts violently. So, utilizing natural energy need quite different and difficult technology compared to the conventional technology, though it is not despairing difficult such as nuclear technology. From this point of view, simple and local technology like Ram pump should be revived one of the basic technologies for future society.

We have a fixed thinking that water runs only toward lower location. So, the ram pump can lift water higher than the location of water source seems like magic. Still now in Japan, water-lifting mill for rice field has been used for irrigation. The mill lifts water from the stream flowing under the rice field. We can say the water mill lift water higher location than the location of water source without using extra energy source. From mechanical explanation, these are a kind of tool transforms the relation between force and displacement. Anyway surprise or excitement from the 'magic' could be starting point of further understanding of the phenomenon.

We started a model production all from the beginning by hand made. We have no blue print except the illustration figure. Practical ram pump has air vessel for pressure accumulator. For our experiment, structure of our model simplified to straight lifting pipe. (Fig 3) As we don't want 'black

box', we made of transparent acrylic material easy for observation (front picture). This is because not only us but also for demonstration for other teachers or students who don't have ever seen. Used fabrication machine were table lathe, milling machine and boring machine. All of these machines are small for hobby use not needed professional expertise. Even a student who has no training could operate. In every working process needed many thinking, so we needed 6 months until we succeeded test-driving. Self-building is good educational method to get complete understanding and hints for improving.

When a child and student think about the use of natural energy, it is important that they observe a ramb pump using energy of a current and lifting up water. As for the making and observation of a ramb pump, a thought comes to extend to what the other natural energy use submits much load to for environment. When they form a general idea of the use of clean energy, the teaching materials of a ramb pump are useful.

4 Conclusion

In our daily life we have few experience about water hammer phenomenon, which cause so much increasing of pressure. Indeed, we had real feeling of the pressure increase only through the actual driving of the model. Also, reason why the pump can operate automatically seemed so difficult to understand for us.

In the home page of 'The Ram Company' (3), we find an article written like this ' In 1879, The People's Cyclopedia included the hydraulic ram among the 55 most important inventions in the history of mankind'. We can imagine how the people in this day thought ram pump useful. The history of modern windmill development shows that new technology is created from old technology (4). We can say the same thing in the development of new ecological and clean future technology.

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