DEVELOPMENT OF AUTO-START GRADUATED SIPHON TUBE FOR DIVERTING AND MEASURING IRRIGATION WATER

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Auto-start graduated siphon tube has been developed that has helped solve the problem of priming and measurement of hydraulic head differential while irrigating the field. This siphon tube is very simple in construction and is primed only once in the beginning of irrigation season of a crop. Development of the siphon tube has facilitated the recording of head differential and the corresponding flow passing through it.

INTRODUCTION

Measurement of the available water supply on the farm is important for obtaining increased water use efficiency. The devices presently available for use in the country for the purpose offer certain problems during water measurement on account of flat gradient in the watercourse system. Thus there is a need to develop a device that can measure and divert water into the fields without being affected by the flat gradient.

Siphon tubes which are used to remove water from a head ditch for distributing it over a field through furrows or borders are also used to measure the rate of flow into these distribution systems. The disadvantage is that these need to be primed individually before use. The priming is the principal labour requirement which makes the use of siphon cumbersome for the farmers (Ali, 1982). Measurement of hydraulic head differential is also another difficult task for them during measurement. They, thus, usually seem reluctant to employ it for water diversion and measurement inspite of its extreme usefulness for the purpose. The development of an auto-start siphon tube was needed to solve the problem of priming and measurement of hydraulic head differential while irrigating the fields.

MATERIALS AND METHODS

Design of an auto-start siphon: The auto-start siphon is equipped with a cup on each end that holds water over the ends of the siphon so that air cannot enter the tube when the water supply level recedes or leaves the watercourse (Fig. 1). The cups hold enough water to maintain the water level above the tube ends for 10 to 14 days (between intervals of irrigation). The bottom of the inlet and outlet cups must be at the same elevation or the water in the higher cup will be lowered excessively and the siphon would not remain primed for the maximum period. The tube end sections are each bent to 45 degree angle with the tube center section. The inlet leg then conforms to the side of watercourse which usually has a side slope of 1:1. However, the tube length must be long enough to extend well down into the ditch, over the bank, and well outside the bank to achieve a maximum head difference between the water in the watercourse and lip of the outlet cup. The flow rate under these conditions is similar to that of standard siphon tube.

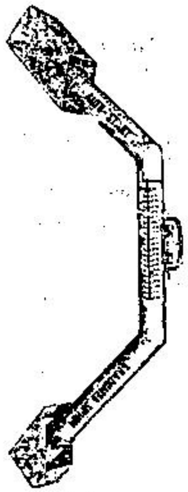

Fig. 1. Auto-start graduated siphon tube.

The lip of the inlet cup is kept at a 5 cm high elevation than the lip of the outlet cup (with bottom at the same elevation) so that water in the ditch can flow past below the siphon inlet until the water level is raised with a check for distribution through the siphon.

The first prime: The siphon tube is primed initially by complete immersion. This is done by putting one end in the water, then lowering the length of the tube under water while permitting air to escape from the other end which is kept above water until the last moment. After the tube is filled with water, it is turned upright in the watercourse and quickly lifted into level position over the watercourse bank. The level position of the siphon is obtained with the help of the spirit level fixed on the top of the central limb. With a little practice the siphon can be started easily. If they are left in place, priming is required only once in a season. After fabrication, the tube was calibrated both in the laboratory as well as under the actual field conditions by varying the head differential and measuring the discharge volumetrically.

RESULTS AND DISCUSSION

Discharge measurement: The inlet and outlet legs of the tube are graduated above the lip of the water depth on both sides. The inlet leg is graduated from 5 cm and above, while the outlet leg is graduated from zero and above. The graduations start from the lips of both the cups. The head differential is calculated by reading the water levels at both legs. The calibration data consisting of differential head, actual discharge and coefficient of discharge are presented in Table 1.

The discharge through the siphon tube calculated by using the orifice formula was compared to the value obtained by actual volumetric measurement for estimating the coefficient of discharge for that size of the tube. The siphon tube discharge may be computed by the formula given below Anonymous (1962):

$$Q = C.A\sqrt{2.g.H}$$

where

Q = discharge in cubic feet per second,

C = discharge coefficient for the tube,

A = cross-sectional area of the tube in square feet,

g = acceleration due to gravity 32.2 feet per second, and

H = operating head in feet.

Fig. 2 showing the actual discharge of the siphon tube operating at various heads was prepared. Fig. 2 reveals that the actual discharge of the siphon tube is a linear function of differential head. Fig. 3 revealed that coefficient of discharge (Cd) has a linear relationship with the differential head causing the flow in a siphon tube.

Table 1. Effect of water head on the discharge as well as on the coefficient of discharge in a graduated siphon tube

S. No.	Head causing flow (cm)	Theoretical discharge $Q_{th} = A\sqrt{2g.H}$ (l/s)	Depth of water stored in drum (d) (cm)	Volume of water stored = 2.552 d (l)	Time interval during flow (s)	Actual discharge Qact. = Vol./time (l/s)	Coefficient of discharge Cd = Qact./Qth
1	22.45	8.077	80.5	205.416	60	3.424	0.4239
2	21.20	7.849	62.9	160.506	48	3.344	0.4261
3	19.35	7.499	69.5	177.347	56	3.167	0.4224
4	16.00	6.819	68.0	173.536	62	2.795	0.4098
5	12.30	5.978	71.0	181.192	77	2.353	0.3936
6	08.00	4.822	64.5	164.604	88	1.871	0.3880
7	05.60	4.034	64.3	164.094	114	1.439	0.3568

Diameter of siphon tube = 7.000 cm; cross-sectional area of siphon tube = 38.485 cm^2 ; diameter of drum for water storage = 57.000 cm; area of drum = 2551.759 cm^2

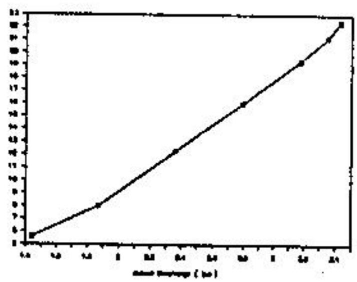

Fig. 2. Head-discharge relationship.

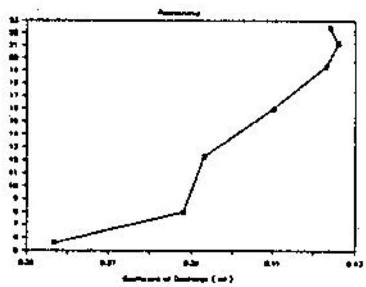

Fig. 3. Head-coefficient of discharge.

As mentioned in Table 1 and shown in Fig. 3, the coefficient of discharge at high head is 0.42 and its value decreases with the decrease of head. This decrease in Cd may be due to the relative increase in the entrance losses when the head is low. This may be due to the fact that when the head is high water enters in the cup from above due to greater gravity force. But when head is low water enters in the cup from the side which adds to entrance loss. Usually the siphon will be operated at higher heads, so the value of Cd can be taken as 0.42.

The central section of the auto-start siphon tube has been graduated considering the values of Cd obtained during calibration. The central section reads different values of head differential and the corresponding flow rates for that size of the siphon tube. The water depths on the inlet and outlet are read and the differential head is calculated. The discharge through the siphon is read corresponding to the value of differential head on the central section.

REFERENCES

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