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HYDRAULIC ANALYSIS OF TELESCOPIC PERFORATED PIPES FOR SURFACE IRRIGATION SYSTEMS

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ABSTRACT

Controlled surface irrigation systems by using enclosed pipelines have been successfully demonstrated in recent years. The common type of pipes system is perforated pipes technique, which is a simplified type of gated pipes. The main objective of this study was to define orifice outflow characteristics for developed (telescopic) perforated pipes to achieve high degrees of accuracy under operating field condition. The telescopic perforated pipe was tested under five different inlet flow rates, which are 15.43, 21.25, 21.73, 22.38 and 23.80 m^3/h.

The results illustrate that, the trend of actual resultant pressure head and the actual discharge rate of the orifices along the telescopic perforated pipe increased as the flow rate of inlet the pipe increased. The resultant pressure head reached at the last orifice about from 103.96% to 103.28% of the original pressure head at the pipe inlet for the inlet flow rates. The changes of flow velocity inside the telescopic perforated pipe generate inertia forces (superimposed head) and high pressure may exit. The cumulative friction losses and the superimposed head increased as the pressure head at the pipe inlet increased. The average orifice discharge coefficient equals 0.503 based on the circular orifices that are 25 mm in diameter where, rubber seals are fixed in the edge of orifices. The outflow variation through orifices along the telescopic perforated pipe decreased as the inlet flow rate increased meanwhile the inlet pressure head increased. The theoretical performance of pressure component and outflow rates of orifices correlated experimental results.

***Keywords**:* Orifice discharge coefficient, Pressure head variation, Outflow orifices variation

INTRODUCTION

Water is the most valuable asset of irrigated agriculture. Egyptian farmers are known to have irrigated lands at least 4000 years ago, most likely using surface method.

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However, controlled surface irrigation systems by using enclosed pipelines have been successfully demonstrated in recent years. The perforated pipe technique is a simplified type of gated pipe. However, it consists of relatively large diameter aluminum or PVC pipes or flexible tubing, with gates or openings at desirable spacing. Gated opening may be fixed or adjusted in area.

In order to give delivering equal flow into furrows, which enhances uniform water distribution under operating field condition, the telescopic perforated pipes technique should be used experimentally determined outflow characteristics. However, this research aimed to study uniform discharge distribution from orifices and determine the orifice discharge coefficient.

Chu (1989) and **Chu and Bagherzadeh (1992)** described the hydraulic analysis of constant hole-spacing trail tube by using energy equation (Bernoulli's equation) compared with other equations, which continuity equation, the orifice equation, and the Hazen-Williams head-loss equation specify the relationships between variables the energy and flow balances.

Khurmi (1984) reported that the total energy of a liquid particle in motion is the sum of its potential, kinetic and pressure energies that expressed as a head unit. Also, he said that when the water is flowing in a pipe, it experiences some resistance to its motion; whose effect is to reduce the velocity and ultimately the head of water available. Though there are many types of losses, yet the major loss is due to frictional resistance of the pipe only. **Kincaid and kemper (1982)** described that the hydraulic analysis of the gated pipe irrigation system, based on assumption that the orifices are located in the top of the pipe. The friction losses are computed based on full pipe flow and the energy equation is used to determine the difference in piezometric head, between two adjacent orifices. **Smith et al. (1986)** cited

$$V = 0.849\, C_{HW}\, R^{0.63}\, S^{0.54} \quad \text{...(1)}$$

that an equation to describe the energy loss h_f due to pipe friction of each length L between the outlets, in this case the Hazen-Williams equation:

Where:

= Velocity of flow in the pipeline, m/s;

= Hazen-Williams coefficient;

= Hydraulic radius of the pipe = D/4, m and

= Rate of energy loss due to friction and equals the energy loss h_f (m) divided by the length of the pipeline L (m).

Kamand (1988) pointed that the Hazen-Williams friction coefficient is ranged from 134 to 150 for 25 to 1050 mm ID, PVC pipes; and ranged from

111 to 135 for cast-iron pipes with same sizes. **Anwar (1999)** mentioned that the head losses caused by friction in a pipeline with multiple outlet along its length will be less than that without outlets, due decreasing of flow capacity along the length of the pipeline.

Hassan (1990) reported that the resultant pressure head along the perforated pipe tended to drop gradually at the first portion of the perforated pipe, then there was a gradual increase in it in remaining length of the pipe. The length of this portion and the value of the minimum and the maximum resultant pressure depend on the number of outlets. As the number of outlets decreased the length of this portion decreased and the values of the minimum and the maximum resultant pressure head increased.

Morcos et al. (1994) defined that the superimposed pressure head (pressure head recovery) as the head generated by the decreasing of flow velocity in the pipe due to discharging flow from orifices into atmosphere through perforated pipe system. **El-Sayed (1998)** found that the pressure head needed to operate the gated pipe system is fairly low. The required head to operate the gated pipe system in the field is 50 cm or less, therefore pumping unit is not a must. **El-Awady et al. (2002)** mentioned that the measured pressure head increased gradually until it reached the pipe end because the gradual increase in superimposed pressure head overcome the effects of the accumulative friction head losses.

Jensen (1980) stated that the flow types are usually characterized with respect to Reynolds number as:

a) laminar flow at Re < 2000 b) unstable stage at 2000< Re <4000

c) partially turbulent at 4000< Re < 10000 d) fully turbulent at 10000 <Re.

However, the water velocity inside gated pipes becomes around 1.5 m/s and not become greater than 3 m/s in any a section is from gated pipe's interrupters. To the velocity of the water does not become greater from 2.25 m/s in the made systems are from Asbestos or PVC. **Kincaid and Kemper (1982)** mentioned that the most flow in gated pipes occurs at Reynolds number between 10^4 and 10^6.

Smith et al. (1986) stated that measure gated pipe uniformity is required, so that the effect of the variation of particular parameter an outflow uniformity can be quantified. The measure of variability selected was the range of the outflows, which is defined as the difference between the maximum and minimum outflows along the pipeline, expressed as a percentage of the mean outflow. **Douglas et al. (1985)** and **Massey (1990)** reported that there are two reasons for the difference between the theoretical and actual discharges. First, the velocity of the jet is less than that given by Torricelli's equation because there is a loss of energy between the velocity at the free surface and the velocity of the jet. Second, the paths of the particles of the fluid converge on the orifice and the area of the issuing jet at Vena contracta is less than the area of the orifice. **Khurmi (1984)** concluded and defined the discharge orifice coefficient "C_d" as the ratio of actual discharge through an orifice, to the theoretical discharge. **Jain (1993)** reported that the discharge coefficient "C_d" is, in general, dependent upon Reynolds number "Rn" and the diameter ratio orifice diameter/pipe diameter. **El-Yazal et al. (2002)** showed that the flow variation through 12 meters spacing of the perforated piping system was about 5.3%. Therefore the uniformity distribution of flow through orifices along the perforated pipes was about 94.7%. The specific objectives of this research were to define orifice outflow characteristics for developed (telescopic) perforated pipes to achieve high degrees of accuracy under operating field condition. To achieve this objective, the following work was carried out as follows:

1- Hydraulic studies of the telescopic perforated pipes under different inlet flow rates to define the suitable inlet discharge rate; determine the orifice discharge coefficient (C_d), and find out the variation of flow through orifices along the pipelines

2- Comparative study of the theoretical and actual hydraulic performance of the telescopic perforated pipes.

MATERIALS AND METHODS

1. Telescopic perforated pipes (Figs. 1 – 6):

1.1. Geometrical description:

Developed perforated pipes using telescopic technique was used to alternately sequence the flow into quarters of the area being irrigated. This

system consists of form of a T-section shape made of PVC with suitable dimensions to fit inner PVC pipes of 110 mm in diameter (3.5 mm in thickness), however, this form is bound in support of a T-section shape. It also has two flange joints with faucet rubber ring to hold the inner PVC pipes, which have flange joints. The inflow side of the form was joined by a discharge valve and flow meter. The form was used for distributing irrigation water flow in both sides. Each side includes inner PVC perforated pipe of 110 mm in diameter (3.5 mm in thickness) and 6 m in length placed into outer PVC perforated pipe of 125 mm in diameter (3 mm in thickness).
The orifices are circular in shape with 38 mm in diameter and located along the two sides of the inner pipe at approximately 0.7 m spacing (the same spacing as the furrows being irrigated). Each side consists of eight orifices. Orifices diameter are reduced to 25.4 mm by rubber seals that are fixed in the edge of orifices. Rubber seals prevent water leakage around the pipes (clearance between inner and outer pipes) during discontinuation of parts from the system. Centering bush are cemented the inner perforated pipe at 0.3 m spacing using the solvent weld process for PVC. An analog pressure gauge fixed just in the inlet of the inner perforated pipe. Pressure gauge connections were used to measure the pressure head by a hypodermic needle assembly and dial pressure gauge, which are installed just before at each orifice along the inner perforated pipe in the right side of the system only. Portable plugs are installed the end of the inner perforated pipes.
Also, the circular orifices of 38 mm in diameter located along the two sides of the outer pipe at approximately 0.7 m spacing. But, the placing orifices in one side are located at the distance intervals 0.1 m to the placing orifices in the other. These pipes are put on guide of a U-section shape 0.2 m above base plate.
Metallic clamps are fixed in both outer perforated pipes. Two pull bars are installed both metallic clamps to connect between the outer perforated pipes. One of metallic clamps has gear guide and gear that is geared the rack in the left side of the system for moving outer perforated pipes horizontally.

1.2. Operational plan:

Telescopic perforated pipes technique is water distribution lines with uniformity spaced outlets. Accordingly, water is conveyed in an enclosed system of the source amidst the furrows where telescopic perforated pipes technique is being laid at the middle of a field.

In the beginning, the right side of developed system was delivered water flow into the first half of furrows (the first quarter of the area being irrigated) till the front water reaches furrows' end. Afterwards, the outer perforated pipes were moved horizontally amounting to 10 cm (this amount is the distance between openings in the two sides of the outer pipes) by means of gear proved in the outer pipe and geared the rack in the left side of the system. Timely, the orifices from which the water flowed into the first quarter of the area being irrigated were closed. In the same time, the orifices located in the other side of outer pipe to deliver water the second half of furrows (the second quarter of the area being irrigated) were opened. On finishing irrigation of the second quarter, the water was cut out from the orifices by moving outer perforated pipes horizontally in the distance of 10 cm. The orifices located in the lift side of system to deliver water flow the first half of furrows (the third quarter of the area being irrigated) were opened, in time. Also, the second half of furrows (the fourth quarter of the area being irrigated) was irrigated according the previously steps.

2. The experimental pumping unit:

The pumping unit consists of one pump with a Diesel powered motor. The specifications of the pump and Diesel engine are shown in Table 1.

Table 1: The specifications of the pump.

Type of pump	Dry weight (kg)	Motor power (hp)	rpm	Suction pipe diameter (inch)	Delivery pipe diameter (inch)
Centrifugal	18	4	1500	3	3

The pump was connected through connecting tubes, spools, elbows, tees and other pipefitting in order to facilitate obtaining a variable range of discharge rates. The pump was equipped with an individual suction pipe and 3 inch hose ending with a trash screen and non-return valve. The discharge side of the pumping unit was connected to the inlet of tested perforated pipe through a discharge valve and flow meter.

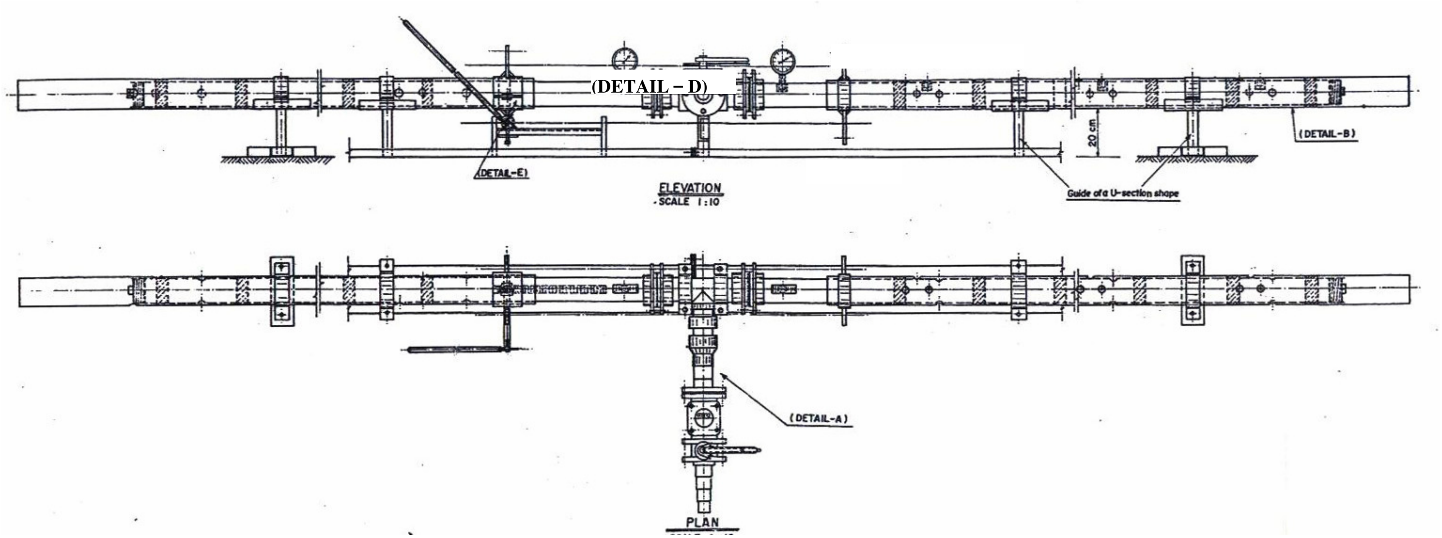
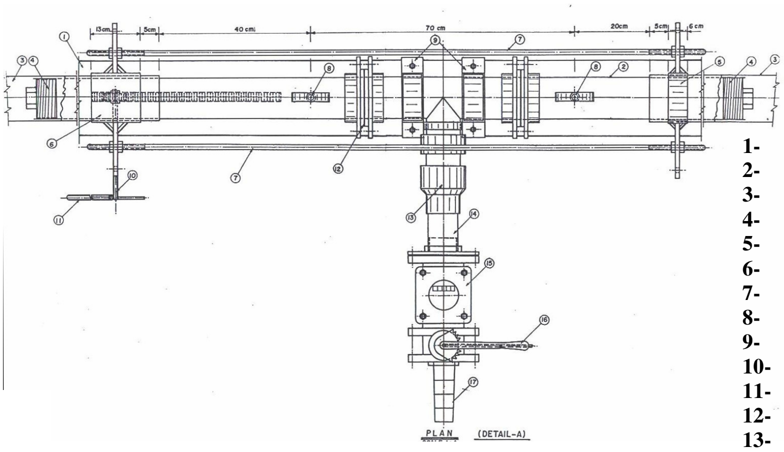
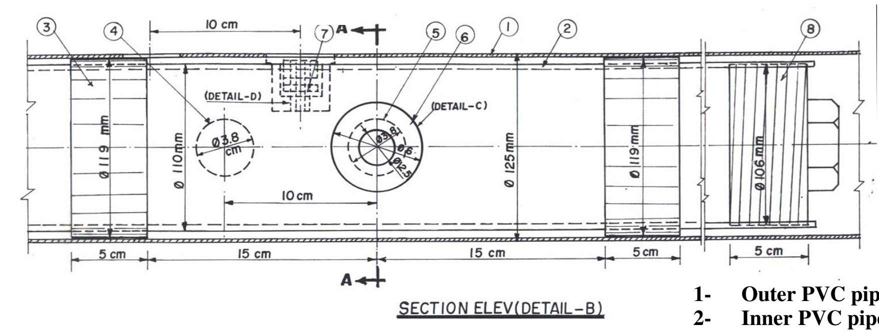


Fig. 1: The telescopic perforated pipes system.



1- Base plate.
2- Inner PVC pipe.
3- Outer PVC pipe.
4- Portable plug.
5- Metallic clamp.
6- Metallic clamp, gear and rack.
7- Pull bar.
8- Pointer pressure gauge.
9- Support of a T-section shape.
10- Stroke arm.
11- Lever.
12- Flange joint.
13- Reducer ¾.
14- Pipe.
15- Flow-meter.
16- Discharge valve.
17- Entry pipe.

Fig. 2: Details of the form (T-section shape).



1- Outer PVC pipe.
2- Inner PVC pipe.
3- Centering bush.
4- Circular orifice of outer PVC pipe.
5- Circular orifice of inner PVC pipe.
6- Rubber seal.
7- Pressure gauge connection.
8- Portable plug.

Fig. 3: Details of the components were assembled inner pipe.

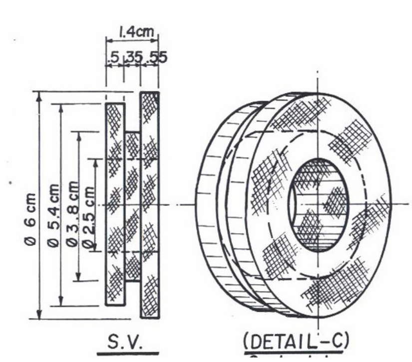
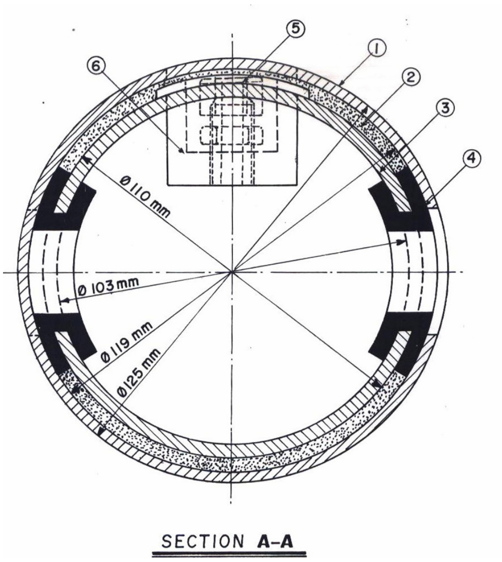
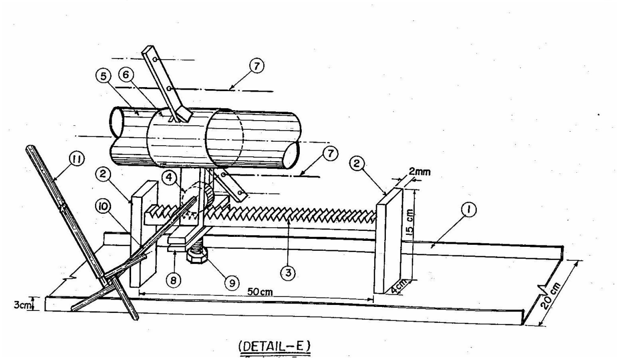


Fig. 4: Details of the rubber seal.



1- **Outer PVC pipe.**
2- **Centering bush.**
3- **Inner PVC pipe.**
4- **Rubber seal.**
5- **Pressure gauge connection.**
6- **Bush.**

Fig. 5: Cross-section of outer and inner pipes.



1- **Base plate.**
2- **Rack support.**
3- **Rack.**
4- **Gear.**
5- **Outer PVC pipe**
6- **Metallic clamp.**
7- **Pull bar.**
8- **Greased slide plate.**
9- **Bolt.**
10- **Stroke arm.**
11- **Lever.**

(DETAIL – D)

Fig. 6: Details of metallic clamp, gear and rack.

3. Hydraulic analysis:

The hydraulic analysis for developed perforated pipes was conducted to study the orifice discharge coefficient (C_d) and distribution uniformity of outlet discharge along pipeline. The developed perforated pipe was tested under five different inlet flow rates, which are 15.43, 21.25, 21.73, 22.38 and 23.80 m^3/h.

The perforated pipe is connected by a pumping unit throughout discharge valve and flow meter. The pressure gauge and flow meter were fixed at the inlet of the perforated pipe was used to determine the inlet pressure head and the quantity inflow. Also, pressure gauge connections were fixed just before at each orifice on the top of the pipe to determine the pressure head using a hypodermic needle assembly and dial pressure gauge. A plastic bucket and a stopwatch were used to measure outflow from the orifices along pipeline.

4. Methods of calculations of the parameters:

4.1. Outlet discharge coefficient "C_d":

Outlet discharge coefficient along the perforated pipe was calculated by Khurmi **(1984)** in the following equation**:**

$$C_d = \frac{\text{Actual discharge}}{\text{Theoretical discharge}} = \frac{\text{discharge measured from outlet}}{a\sqrt{2gh}} \quad \text{..... (2)}$$

Where:

a = Area of the orifice, m^2;

g = Gravity acceleration, m/s^2 and

h = Head of water at the orifice, m.

4.2. Outflow distribution uniformity and pressure head at orifices:

The expression of distribution uniformity through the variation of flow at orifices along the perforated pipe named flow variation along the perforated pipe "q_{var}". The distribution uniformity increased as flow variation decreased, as calculated by **Jensen (1980)** as in the following equation:

$$q_{var} = \frac{(q_{max} - q_{min})}{q_{max}} \times 100 \quad \text{.............. (3)}$$

Where:

q_{var} = Orifice flow variation, %;

q_{max} = Maximum orifice flow along the pipe line, l/s and

q_{min} = Minimum orifice flow along the pipe line, l/s.

Also, the pressure head variation can be determined by **Wu and Gitlin (1983)** in the following equation:

$$H_{var} = \frac{(H_{max} - H_{min})}{H_{max}} \times 100 \text{ .... (4)}$$

Where:

H_{var} = Pressure variation along the pipe line,

H_{max} = Maximum pressure along the pipe line, m, and

H_{min} = Minimum pressure along the pipe line, m

4.3. Theoretical performance of outflow and pressure head along telescopic perforated pipes:

The hydraulic parameters, which are outflow and pressure component at each orifice, were calculated from formulas used by **Morcos et al. (1994)** based on the actual inlet inflow rates and pressure heads experimentally measured from the pumping unit and assuming orifices discharge rates had similar values for all the orifices along the telescopic perforated pipe length. The calculated hydraulic parameters comparison with actual results. Formulas are:

$$Q_n = Q_t - \sum_{n-1}^{N} q_n \text{ .... (5)}$$

$$V_n = \frac{0.001 Q_n}{A} \text{ .... (6)}$$

$$h_{fn} = 2.98 \times 10^{-5} \times \left(\frac{Q_n}{C_{HW}} \right)^{1.852} \times D^{-4.87} \times s \text{ .... (7)}$$

$$h_{ft} = \sum_{n-1}^{N} h_{fn} \text{ .... (8)}$$

$$h_{sn} = \frac{\left(V_{max}^2 - V_n^2 \right)}{2} \text{ .... (9)}$$

$$h_c = h_p + h_{sn} - h_{ft} \text{ .... (10)}$$

Where:

Q_n	=	Flow rate inside the perforated pipe just before any orifice, l/s; Inlet flow rate, l/s;
Q_t	=	Measured orifice discharge, l/s;
q_n	=	Inside perforated pipe diameter, mm;
D	=	Spacing between orifice along the perforated pipe, m;
s	=	Hazen- William coefficient was listed by the manufacturer as about 140,
C_{HW}	=	dimensionless;
h_{fn}	=	Friction head losses inside the perforated pipe just before any orifice, m;
h_{ft}	=	Total friction head losses inside the perforated pipe just before any orifice, m;
V_n	=	Flow velocity inside the perforated pipe just before any orifice, m/s;
A	=	Perforated pipe cross section area, m^2;
h_{sn}	=	Superimposed pressure head, m;
V_{max}	=	Maximum inside flow velocity at perforated pipe inlet, m/s;
g	=	Gravitational, m/s^2;
h_c	=	Resultant pressure head at any discharging orifice, m and
h_p	=	Pressure head of the tube inlet produced by the pump, m.

RESULTS AND DISCUSSION

1. Internal flow characteristics along the telescopic perforated pipes system:

Fig. 7 illustrates that the trend of measured resultant pressure head at the orifices along the perforated pipe increased as the discharge rate of inlet the pipe increased. The measured resultant pressure head gradually increased along the perforated pipe without any drop in pressure until it reached at the last orifice about 103.96%, 103.62%, 103.37%, 103.31% and 103.28% of the original pressure head at the pipe inlet for the inlet flow rates of 15.43, 21.25, 21.73, 22.38 and 23.80 m^3/h, respectively. This is due to the gradual increase in superimposed pressure head overcome the effects of the cumulative friction head losses. This is in agreement with **Smith et al. (1986)**.

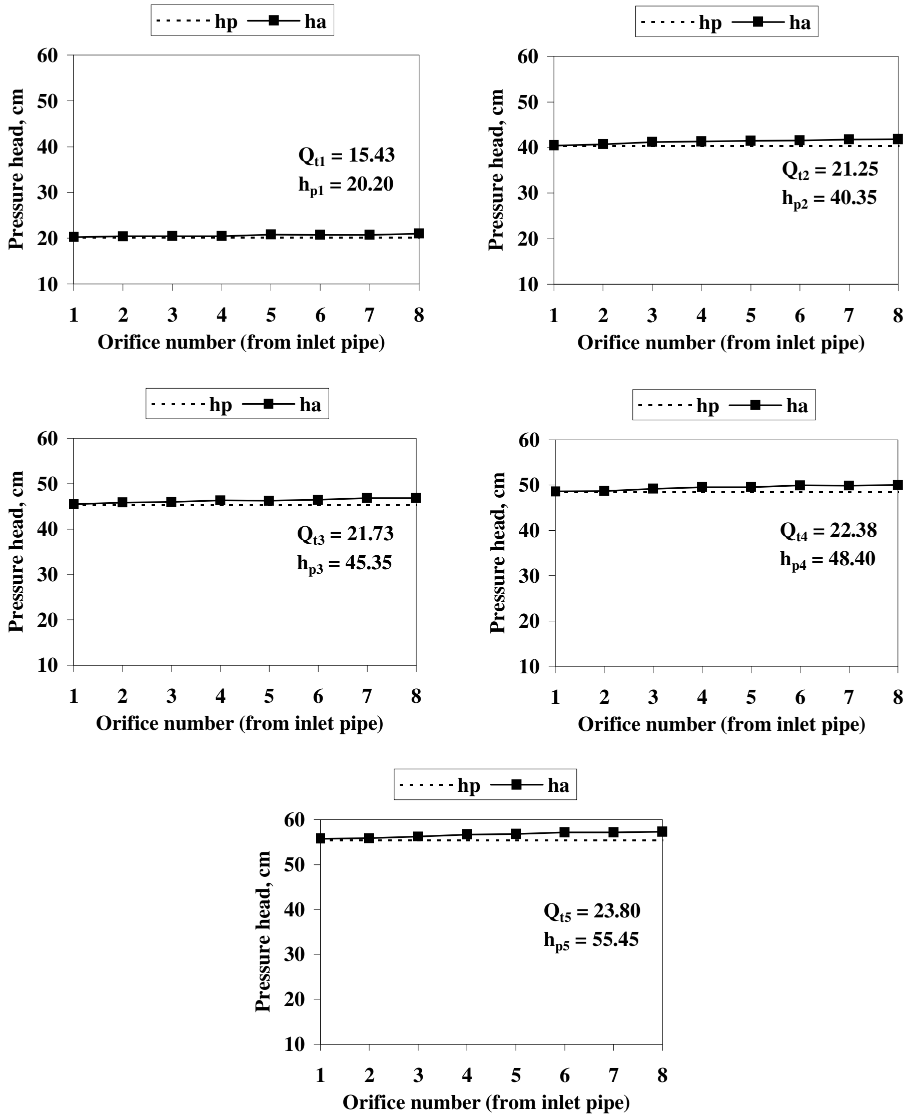


Fig. 7: Resultant pressure head at the orifices along the telescopic perforated pipes for different inlet flow rates (Q_t, m^3/h) and inlet pressure heads (h_p, cm).

The total friction loss was greater gradually from the first portion of the perforated pipe until it reached a maximum at the last portion of the perforated pipe. The slope of the curves of the cumulative friction losses increased as the inlet discharge rate increased as shown in Fig. 8. The cumulative friction losses values ended at about 0.735, 1.333, 1.382, 1.449 and 1.602 cm for the inlet flow rates of 15.43, 21.25, 21.73, 22.38 and 23.80 m^3/h, respectively. This was due to the fact that the friction losses have a positive trend with the flow rate. This is in agreement with **Morcos et al. (1994)** and **Anwar (1999)**.

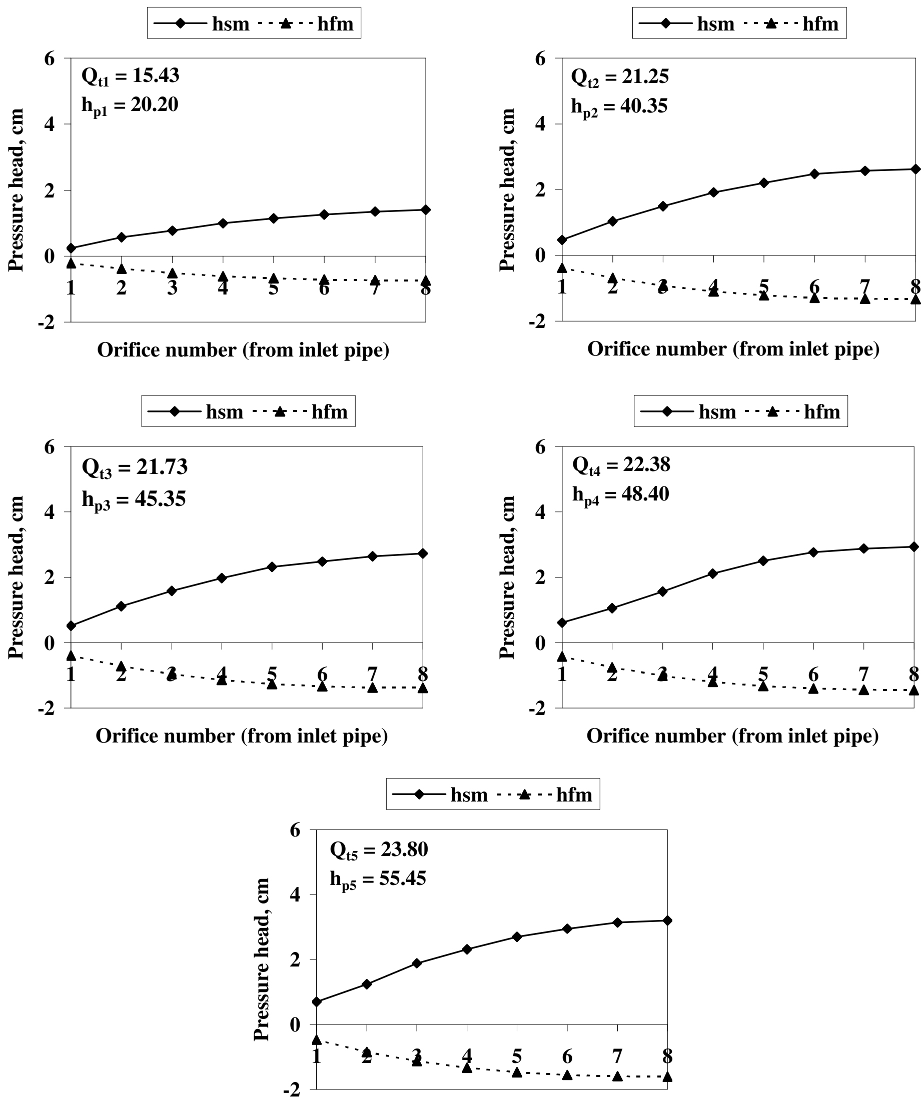


Fig. 8: Measured superimposed pressure head (h_{sm}) and measured cumulative friction head losses just before any orifice (h_{fm}) along the telescopic perforated pipes for different inlet flow rates (Q_t, m^3/h) and inlet pressure heads (h_p, cm).

The superimposed head, which generated from decreasing of flow velocity inside the perforated pipe due to the discharge from all the orifices along its length. The slope of the curves of the superimposed head increased as the inlet discharge rate increases due to increased difference between the maximum and the minimum values of the inflow velocity along the perforated pipe as shown in Fig. 8. The superimposed head valuesended at about 1.535, 2.793, 2.912, 3.049 and 3.422 cm for the inlet flow rates of 15.43, 21.25, 21.73, 22.38 and 23.80 m^3/h, respectively. Also, Fig. 8 shows the friction losses increased as the superimposed head increased. This is in accordance with **El-Sayed (1998)**.

2. Actual discharge rates through orifices characteristics along the telescopic perforated pipes:

Fig. 9 shows the trend of actual discharge rate of the orifices along the perforated pipe increased as the inlet flow rate increased. The actual discharge rate of the orifices gradually increased along the perforated pipe for the different inlet flow rates (15.43, 21.25, 21.73, 22.38 and 23.80 m^3/h). This is ascribed to the gradual increase in resultant pressure head at the orifices along perforated pipe length.

The outflow (q_m) from each orifice generally is a function of the pressure head (h_m) at the orifice. This relationship, which is of the form:

$$q_a = 0.1437\ h_a^{0.4341}$$

The experimentally exponent (0.4341) is close to exponent (0.5) in the theoretical equation. It showed that the flow in orifice along the telescopic perforated pipes is turbulent and increasing effect of pressure head on the orifice discharge. This is according to **Jensen (1980)**.

The orifice discharge coefficient is calculated from theoretical discharge rate through the orifice based on the actual pressure head at the orifice and actual discharge rate of the orifice. The average orifice discharge coefficient equals 0.503 based on the circular orifices that are 25 mm in diameter where, rubber seals are fixed in the edge of orifices. The values of orifice discharge coefficient the most likely lie in between range 0.4 to 0.9, according to **Smith et al. (1986)**.

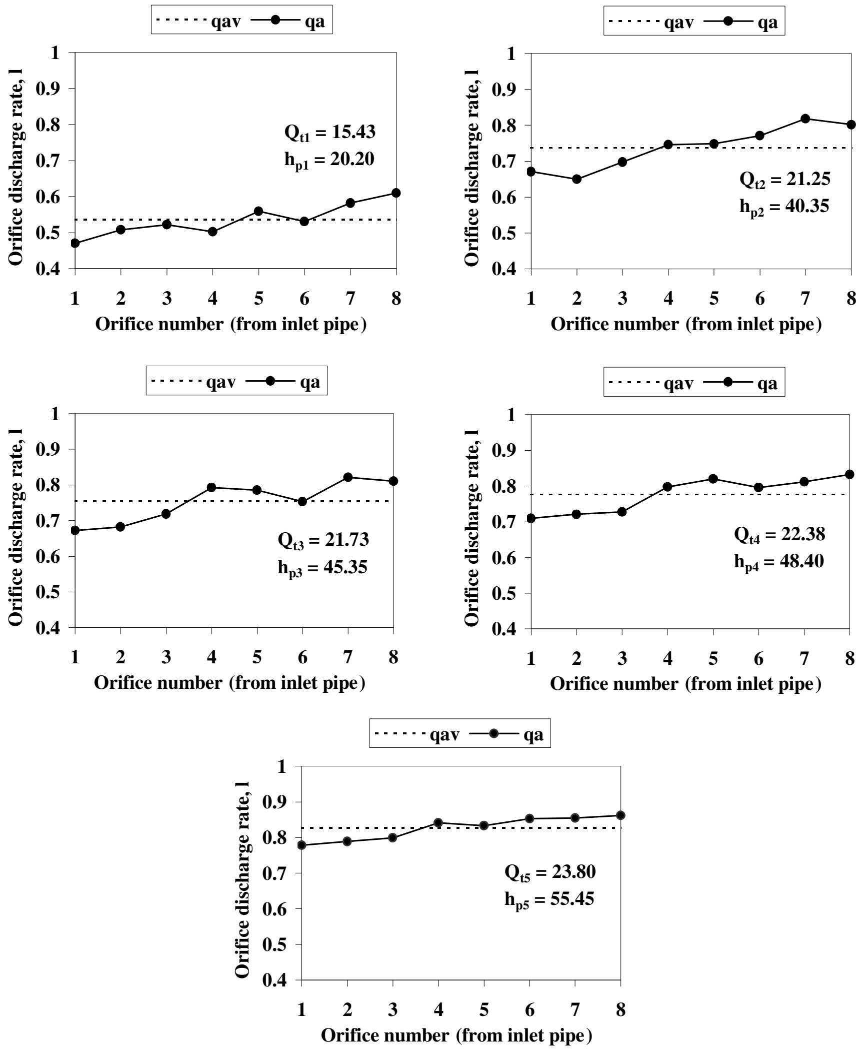


Fig. 9: Orifices discharge rate along the telescopic perforated pipes under different inlet flow rates (Q_t, m^3/h) and inlet pressure heads (h_p, cm).

Fig. 10 shows that the average orifice discharge coefficient decreased as the pressure head at the pipe inlet increased meanwhile the inlet flow rate increased. This may be due to increase Reynolds number, then the flow becomes more turbulent and diminishes the contact between the flow and the orifice edge, therefore the contraction effect dominates.

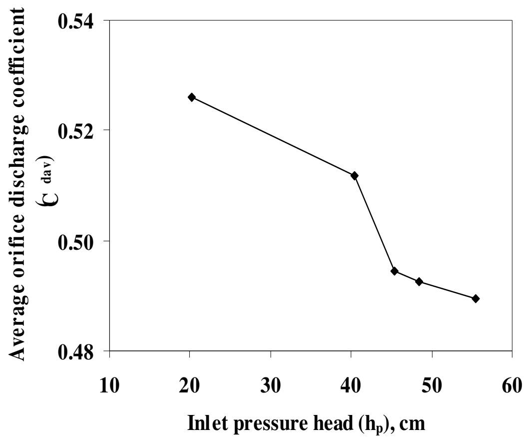


Fig. 10: Average orifice discharge coefficient with respect to the inlet pressure head for the telescopic perforated pipes.

3. Pressure head variation, discharge rate variation and outflow distribution uniformity through orifices along the telescopic perforated pipes:

With regard to pressure head and orifices discharge rate variations, data revealed that there is a negative trend with inlet pressure head, as shown in Fig. 11.

With respect to the outflow distribution uniformity through orifices along the perforated pipe, data revealed that an increasing had been observed with increasing the inlet pressure head. This is referable to decreased difference between the maximum and minimum values of orifice discharge. Data of the studied parameters and reasonable are in agreement with that obseved by **Hassan (1998)**.

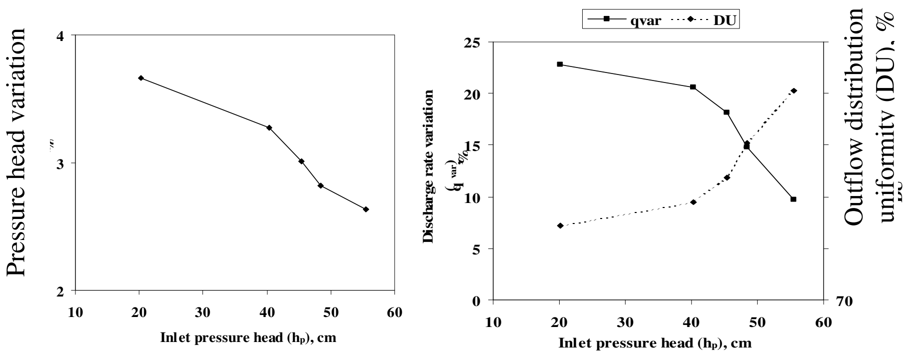


Fig. 11: Pressure head variation, discharge rate variation and outflow distribution uniformity through orifices along the telescopic perforated pipes versus inlet pressure head.

Values of flow variation through orifices along the telescopic perforated pipe for the cases the inlet flow rates of 23.80, 22.38 and 21.73 m^3/h, meanwhile pressure heads at the pipe inlet 55.45, 48.40 and 45.35 cm considered as acceptable because those values are less than 20%. Hence, acceptable water uniformity distribution (value of flow variation is less than 20%) is achieved increase as the flow discharge at the pipe inlet increases. In conclusion, it can be recommended that the inlet pressure head not be less than 50 – 60 cm in order to get high degree of uniformity, as well as eliminating the pressure losses during operating the telescopic perforated pipes.

4. Calculated vs. measured data of the hydraulic analysis parameters of the telescopic perforated pipes:

The difference between the actual and calculated resultant pressure head, which was found to be about – 0.04 cm (– 0.17 %), + 0.09 cm (– 0.22 %), – 0.04 cm (– 0.09 %), + 0.10 cm (+ 0.20 %) and + 0.07 cm (+ 0.11 %) at the middle of the pipe length for the inlet flow rates of 15.43, 21.25, 21.73, 22.38 and 23.80 m^3/h, respectively. While at pipe end, the difference was about + 0.02 cm (+ 0.1 %), + 0.15 cm (+ 0.36 %), + 0.17 cm (+ 0.36 %), + 0.12 cm (+ 0.24 %) and + 0.12 cm (+ 0.21 %) under the inlet flow rates of 15.43, 21.25, 21.73, 22.38 and 23.80 m^3/h, respectively. In Fig. 12, there was a very close agreement in the trend between the actual and the calculated results for resultant pressure head where, the observed high "r" value equaled 0.999.

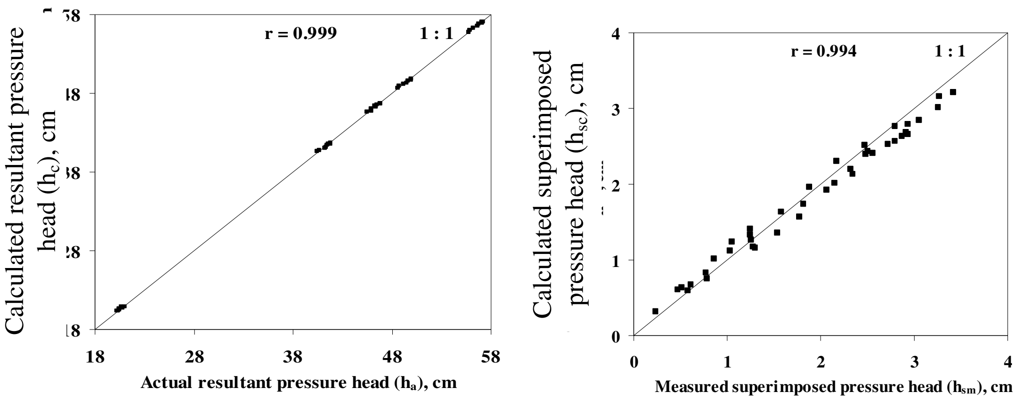


Fig. 12: Calculated vs. actual (measured) data of the resultant pressure head and superimposed pressure head.

The deviation between measured (h_{sc}) and the calculated (h_{sm}) data of superimposed pressure head were most evenly and tightly distributed around 1:1 line, where the observed "r" value equaled 0.994 as shown in Fig. 12.

The cumulative friction losses based on the actual measurements were slightly higher than that based on theoretical computations (the maximum difference was – 0.067 cm). High value of correlation coefficient (0.999) are observed in Fig. 13, it indicated excellent correlation of measured data with theoretical computations of cumulative friction losses, which were most evenly and tightly distributed around 1:1 line.

On the other hand, Comparing the calculated discharge rate of the orifice (q_c) with the actual one (q_a), the difference at the middle of the pipe was about – 0.01 l/s (– 1.04 %), + 0.01 l/s (+ 1.20 %), + 0.03 l/s (+ 4.31 %), + 0.03 l/s (+ 4.01 %) and + 0.01 l/s (+ 1.25 %) for the inlet flow rates of 15.43, 21.25, 21.73, 22.38 and 23.80 m^3/h, respectively. While at pipe end, the difference were + 0.06 l/s (+ 9.65 %), + 0.07 l/s (+ 8.52 %), + 0.06 l/s (+ 7.11 %), + 0.04 l/s (+ 5.11%) and + 0.03 l/s (+ 3.32 %) for the same cases respectively. Fig. 13 revealed that high value of correlation coefficient (0.917) was observed, therefore it can be pointed out that a good correlation between calculated and the observed data of discharge rate had been gained.

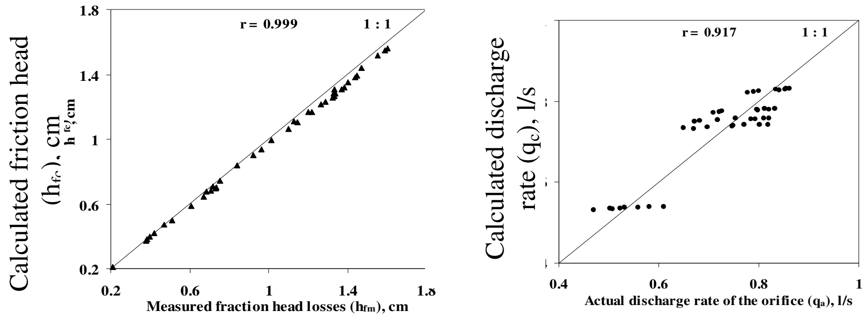


Fig. 13: Calculated vs. measured (actual) data of the fraction head losses and discharge rate of the orifice along the telescopic perforated pipes.

CONCLUSIONS

From the previously mentioned results in the study the following conclusions can be obtained:

1- The actual resultant pressure head gradually increased along the telescopic perforated pipe without any drop in pressure until it reached at the last orifice for the different inlet flow rates.

2- The actual discharge rate of the orifices gradually increased along the telescopic perforated pipe for the different inlet flow rates.

3- The average orifice discharge coefficient decreased as the inlet pressure head increased meanwhile the inlet flow rate, flow velocity and Reynolds number increased.

4- The inlet pressure head not be less than 50 – 60 cm in order to get high degree of uniformity, as well as eliminating the pressure losses during operating the telescopic perforated pipes.
5- There is an agreement between the theoretical (calculated) hydraulic parameters and the actual (measured) measurements.

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الملخص العربى

التحليل الهيدروليكي للأنابيب المثقبة التلسكوبية لنظم الري السطحي

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في الأعوام الأخيرة استخدمت الأنابيب المغلقة للتحكم الناجح في أنظمة الري السطحي. وتمثل تقنية الأنابيب المثقبة نوعاً مبسطاً من نظام الأنابيب المبوبة. والغرض الرئيسي من هذه الدراسة هو إيجاد خصائص السريان الخارج من الفتحات للأنابيب المثقبة المطورة (التلسكوبية) للحصول على أعلى درجات الدقة في التشغيل الحقلي. واختبر الأنبوب المثقب التلسكوبي باستخدام خمس معدلات سريان داخلة هي ١٥,٤٣ ، ٢١,٢٥ ، ٢١,٧٣ ، ٢٢,٣٨ و٢٣,٨٠ م٣/ساعة.

بينت النتائج زيادة الضاغط الهيدروليكي ومعدل التصرف للمياه الناتج عند الفتحات على طول الأنبوب المثقب كلما زاد معدل سريان المياه الداخلة للأنبوب ، حيث يتراوح عند آخر فتحة بين ١٠٣,٢٨ ٪ إلى ١٠٣,٩٦ ٪ من الضاغط الهيدروليكي الأصلي عند مدخل الأنبوب تحت مختلف معدلات السريان الداخل نتيجة لتولد قوى قصور ذاتي من التغيرات في سرعة سريان المياه داخل الأنبوب ، فينتج ارتفاع في الضاغط. وهذا يفسر ارتفاع الضاغط الهيدروليكي عند الفتحات عن الضاغط عند مدخل الأنبوب. تزداد فواقد الاحتكاك التراكمية والضاغط المتولد نتيجة انخفاض السرعة كلما يزداد معدل التصرف الداخل للأنبوب. ومتوسط قيمة معامل التصرف للفتحة مساوية ٠,٥٠٣ حيث أن الفتحات دائرية بقطر ٢٥ مم بعد تثبيت موانع مطاطية على حوافها. ويقل الاختلاف في السريان الخارج من الفتحات على طول الأنبوب المثقب كلما زاد معدل السريان الداخل للأنبوب. ويوجد توافق بين الأداء النظري لمكونات الضغط ومعدلات التصرف الخارجة والنتائج التجريبية (الفعلية).

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