Water-Flow uniformity through irrigation gated-pipes.

M.N. El Awady1, M.T. El Tantawy2, S.S. Hassan2 and A.O.M. El Ashhab2

ABSTRACT

Gated pipes are currently used extensively in sugarcane fields in Upper Egypt. The hydraulics of rectangular-gated pipes were studied by observing the distribution uniformity of flow, pressure along pipe and the discharge coefficient for the gate. Results included: (1) laboratory work to calibrate sliding gates under different pressures, outlet areas and discharge coefficients, (2) theoretical determination of suitable outlet area to give high distribution uniformity by a new mathematical-approach, and (3) field work to examine the results under calculated outlet areas along 6" (150mm) gated pipe. Results also showed great agreement between the theoretical gated pipe flow rate, based on newly derived equation and the corresponding fieldwork.

Rate of discharge through the gate was found to be a power function of the head for gate sizes 2.84, 5.67 and 11.34 cm^2 in the following form: $q = b\,h^{0.37}$

Where "q" is in m^3/s , " h" is in m. The coefficient 'b" took the 2.4 for the case where the gate- slit width "d = 38 mm".

The average discharge coefficient calculated for the gate, according to the conventional equation where "q" varies with "h" to the power of "1/2", is:

$$Cd = 0.83\,(h / d)^{-0.13}$$

For the case study, where q = 1.5 E^{-3} m^3/s , gate opening area " a" for uniform discharge distribution in m^2, resulted as follows:

$$a = 0.62\ E^{-3}\ h^{-0.37}$$

However, " h" is to be determined beforehand at each gate location. Gate opening and the corresponding width " a, w" were also estimated for uniform discharge along level line, via Eq. 12 in the text. " w" was estimated by approximating the aperture into square area as $w = d\frac{a}{a_0}$ Where " a_0" is the area of fully – open gate.

In the field experiment, the water distribution uniformity along the gated pipe of 18m-modules was about 96 % , thus corroborating the pervious equation. Modules are repeated for as much length of the distribution line as required by the large irrigated areas. However one module alone should be operated at a time.

Key words: Gated pipes, hydraulic analysis, surface irrigation, water distribution uniformity

---

1 Prof. Ag. Eng., College of Agriculture., Ain-Shams U., P.O.Box 68 Hadaek Shobra, Cairo 11241, Egypt.

2 Agricultural-Engineering Res. Institute, Nadi El Seid Street, Dokki, Giza, Egypt.

INTRODUCTION

Egyptian agricultural policies have been directed to improve the surface-irrigation, especially in the Old Nile-Valley, and sugarcane fields in Upper Egypt, by using gated pipes (GP). GP is an improvement on furrow irrigation, in which the conventional head ditch and siphons are replaced by an aboveground pipe. Irrigation water flows from gates, which are regularly spaced along the pipeline. Also, GP's are convenient means of distributing water to irrigated crops. They consist of relatively large diameter aluminum pipes, with gates usually corresponding to the furrow spacing. Currently, there are several brands or types of GP's available on the market. However, very little pertinent data are available from the manufacturers on their performance. Uniformity of flow is determined by setting the gates precisely, to deliver equal flow into furrows.

This research aimed to study the hydraulics of gate spacing describing the distribution of flow rate and pressure along the gated pipe and determine the gate discharge-coefficient.

Kincaid (1984) stated that the GP functions as both conveyance and distribution systems. **Jensen (1980)** reported that irrigators could increase the uniformity of water application to their furrow-irrigated crops by frequent regulation of the size of stream flowing into the furrow. For this reason, GP was specifically suggested. Small and easily adjusted gates facilitate controlling the size of the stream delivery to the furrows. Adjustable gated orifices minimize the effect of pressure head differences on discharge rate. GP is one of the ways to improve the efficiency of surface irrigation (border or furrow) **(Hassan, 1998).** He also found that the maximum water distribution uniformity along the 6 inch (150 cm) perforated pipe, is obtained from the 18 meter length (in modules to be repeated along far-reaching lines), 0.81 area ratio, 118 slenderness ratio and pump discharge 100 m^3/h at positive slope. Using corrugated portable gated-pipes, the irrigation efficiency of over 80 % can be attained under favorable conditions **(Zimmerman, 1966). Rady (1993)** found that using GP to irrigate long furrow (100 m) resulted in saving water by 20, 38 and 18 % and increasing its use efficiency by 58, 26 and 17 % for bean, corn and peas resp., compared with conventional short furrows (6-10 m long) in sandy soil.

Osman (2000) mentioned that good design of gated pipes with precision land-leveling improved the water distribution uniformity and saved irrigation water by 12 and 29 % in cotton and wheat resp.. **Tantawy et al. (2000)** reported that using perforated pipes increases crop yield, and saves more water. **Fischbach and Somerhalder (1971)** found that an automatic surface irrigation system with GP and re-used system can be very efficient in applying irrigation " 91.9 % water application efficiency".

Kruse et al. (1980) reported that there are several discrepancies in GP's. **Zimmerman (1966)** compared different types of gated pipes depending on their different materials as aluminum, galvanized iron, canvas hose, vinyl plastic reinforced, butyl rubber with nylon reinforcement, black polyethylene and flexible polyvinyl chloride (PVC). **Hassan (1990)** stated that there are many engineering factors affecting water distribution rates and uniformity of the perforated piping system such as, length of pipe, its diameter, orifice diameter, orifice spacing, pressure head and number of outlets operating simultaneously. **Smith et al. (1986)** stated that varying pipe slope, diameter, number of gates, gate area and mean outflow, affect uniformity of outflows. For the entire typical GP situation analyzed, maximum flow uniformity is obtained with the pipeline slope uphill in the direction of flow.

Omara (1997) mentioned that the analysis and design of GP requires only four equations, namely: mass continuity, energy conservation, pipe friction, and the gate outflow characteristic for the shape of gate used. **Kincaid and Kemper (1982)** reported that the parameters used to determine discharge from the gates along the GP are: the inside pipe diameter, roughness, and outlet size, gate spacing, and total inflow rates. The friction losses through gated pipe system are computed based on full pipe flow and the energy equation is used to determine the difference in piezometric head between two adjacent orifices. They also mentioned that most of the flow in gated pipes occurs at Reynolds number between 10^4 and 10^6, and they also used the Darcy-Weisbach formula to calculate the friction loss.

Hasting Co. (1986) in GP manufacturing recommended velocities in gated pipes around 5 ft/s (1.5 m/s) to 8 ft/s (2.4 m/s). At higher velocities, GP systems do not deliver water from gates properly, and in some cases water will not flow from gate at all. **El-Sayed (1998)** found that the pressure head needed to operate the system is fairly low. The required head to operate the GP system in the field is 50 cm or less. **Armin Co. (1989)** advised the flow capacities for the commonly available sizes of flexible plastic gated pipe range from 15 to 170 L/s (54 m^3/h to 612 m^3/h) and the diameter form 8.5 to 22" (about 220-550 mm) at hydraulic gradient of 0.003. **Hassan (1998)** found that the maximum distribution uniformity of using perforated pipe system is achieved with small uphill slope. The inside pipe diameter that can be used is 160 mm, number of outlets 24, the circular orifice shape is preferably of 25mm diameter.

Smith et al. (1986) in their theoretical analysis and subsequent discussion suggested that the additional energy loss caused by dividing flow is negligible with gates open or closed.. The range of values of the Hazen-Williams coefficient for rigid aluminum or PVC gated pipe would therefore appear to lie between 130 and 150. **Khurmi (1983**) reported that in long pipes, the major loss of head is due to friction in the pipe, and minor losses may be neglected. But in case of a short pipe, the minor losses, as compared with the friction losses, are of appreciable amount and thus, cannot be neglected.

Jensen (1980) reported an expression for evaluating flow (q) variation through orifices along lateral line (q_{var}).

$$q_{var} = \frac{q_{max} - q_{min}}{q_{max}} * 100 \quad \text{..........................(1)}$$

Chu (1984), Wu and Gitlin (1983), Kincaid and Kemper (1982) stated that

the pressure head (H) variation can be determined by:

$$H_{var} = (H_{max} - H_{min}) / H_{max} \text{..................... (2)}$$

For a practical design, the pressure variation is usually kept less than 20%, which is equivalent to 10% variation in lateral line flow along submain. **Jensen (1980)** stated that the flow in an orifice emitter is usually fully turbulent. Orifice flow rates are best characterized by empirically determining flow rates as a function of operating pressure. This empirical characterization is referred to as orifice flow function:

$$q = K_e H^x \text{..........(3)}$$

Where: K_e is a factor that characterizes the orifice dimensions, H is the operating pressure head and (x) is orifice exponent, which characterizes the flow regime. The coefficients K_e and x are determined by plotting "q versus H" on a log-log plot. The slope of the straight line is x, and the intercept at H = 1.0 is K_e. For laminar flow, the orifice discharge exponent x = 1.0, while = 0.5 for the turbulent flow, and for compensating flow = 0.0.

Hassan (1998) and **Van't Woudt (1964)** has used constant discharge coefficient, but recognized that outlet coefficient of discharge along the perforated pipe is not constant but dependent upon velocity in the pipe and somewhat dependent upon the pressure head. **Arora (1976)** showed that the value of the coefficient of velocity ranges from 0.95 to 0.99. The smaller value is for small orifices under low heads (h) ($\frac{v}{\sqrt{2gh}}$) The value of the coefficient of discharge ($\frac{q}{a\sqrt{2gh}}$) for sharp edged orifice ranges from 0.59 to 0.68. Its value depends upon the coefficients of velocity and contraction. **Barbara (1996)** reported that the orifice friction loss is incorporated in coefficients of discharge "C_d", which includes the loss of head encountered from passing through the meter. Its value depends upon the type of orifice chosen.

This research is devoted to evaluate the rectangular plastic gated pipes with circular orifices. The following work is carried out:

1- Laboratory experimental work to calibrate sliding plastic gates under different pressure heads and different outlet areas and determines the discharge coefficient.

2- Theoretical determination of suitable outlet area to give high distribution uniformity by a new mathematical approach, based on one-shot analytical derivation .

3- Field experimental work to examine the water distribution uniformity under the theoretical determination of suitable outlet areas along the six inches (150 cm) gated pipe.

4- Validation of the theory by experimental fieldwork, to verify the derived relations .

MATERIAL AND METHODS

Laboratory experimentation:

The laboratory experimental-work was conducted in the National Laboratory for Testing Irrigation Equipment; Agricultural Engineering Research Institute. Its main objectives were to calibrate sliding rectangular plastic gate with an orifice of 3.8 cm width, along along 6" gated pipe under different pressure heads and outlet areas, and also to determine the discharge coefficient of gates.

The laboratory setup comprises electrically driven centrifugal pump motor. A pressure manometer of range (0-1 bar) was used to measure piezometric head at the center of the gate. The specifications of the pumpset are shown in Table (1).

Table (1): Specifications of the pumpset.

Pump make	Motor power (kW)	rpm	Max. discharge (m^3/h)	Max. pressure. (bar)	I/O dia."
Alweiler	22	1460	50	5.5	3

The gate discharge was experimentally measured by direct method using bucket with capacity of 30 liter and stopwatch. Also, the discharge coefficient was experimentally determined.

Field experimentation:

The field experimental work was conducted at Toad, Luxer, Quena, Governorate. The field experimental work aimed to examine the water uniformity distribution under the theoretical determination of suitable outlet areas along the 6" gated pipe. The specifications of the centrifugal pump and Diesel engine are shown in table (2).

Table (2): Specifications of the field-pumpset.

Pump Make	Motor Power (kW)	rpm	Max. "q" (m^3/h)	Max. pressure (bar)	I/O dia"
Local Diesel (Shobra)	5.9	1460	130	1.0	6

Portable, gated aluminum pipe, had 160 mm O.D.. The gates were located at approximately 0.75 m spacing (the same spacing between furrows) and had a circular shape of 38 mm in diameter when fully open. The pipe is available in 6-m lengths and uses quick coupler with rubber ring jointing. Each pipe had 8 gates. Therefore an 18-meter long of 160 mm O. D.. pipe was used with closed end having 24 sliding plastic gates, thus forming a module in a much longer pipe. However, one module must be open at a time according to limited discharge capacity. The Field experimental setup carried out tests through water recirculation, in which the pumping unit received water from long lining canal constructed in the field.. Measurements include pressure head, velocity at each outlet and flow rate passing at pipe-section before any orifice. The friction losses and the imposed pressure head were estimated.

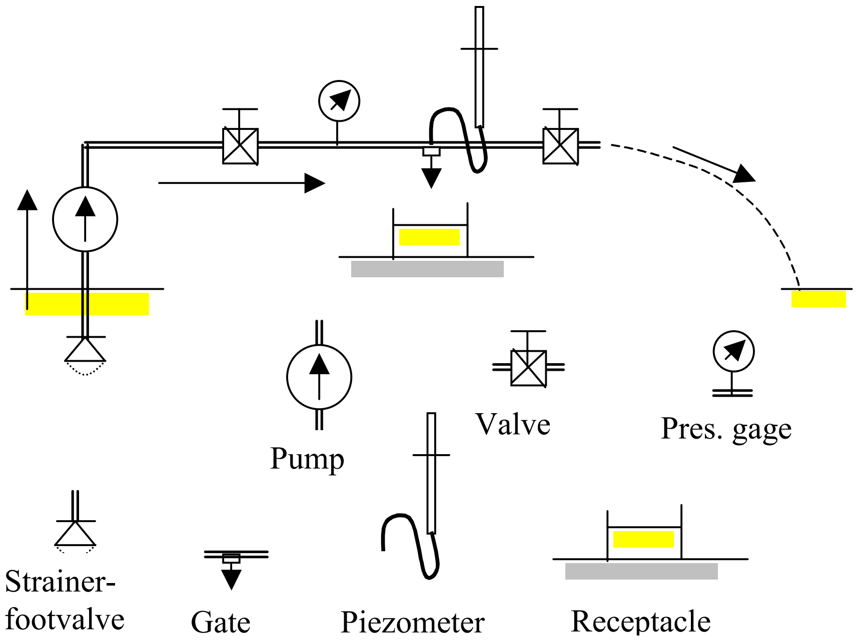

Fig.1: Lab setup.

RESULTS AND DISCUSSION

Lab work

This work was carried out to determine the discharge rate "q" and its coefficient "Cd" for heads " h" and gate opening – areas " a" , according to the well – known formula :

$$q = Cd \quad a \sqrt{2\,gh} \quad ....(4)$$

Where: "q" is the gravitational acceleration.

The square–root power of "h" characterizes turbulent flow, which is normal under prevailing conditions. During test, "h" varied between 5 and 80 cm; with three gate openings: 2.84, 5.67and 11.34 $cm^{2.}$ "q" measurements are shown on log-log scales in Fig. (2). Slopes of the resulting lines are essentially the same. This suggests

relations of the same power (0.37) for "h" in the following form:

$$q = b \; h^{0.37} \quad ....(5)$$

When "q" is in m^3/s , " h" is in m, the coefficient 'b" took the following values for different gate openings "a".

a - $cm.^2$	b - $m^{2.63}/s$
2.84	7.7 E^{-4}
5.67	1.4 E^{-3}
11.34	2.9 E^{-3}

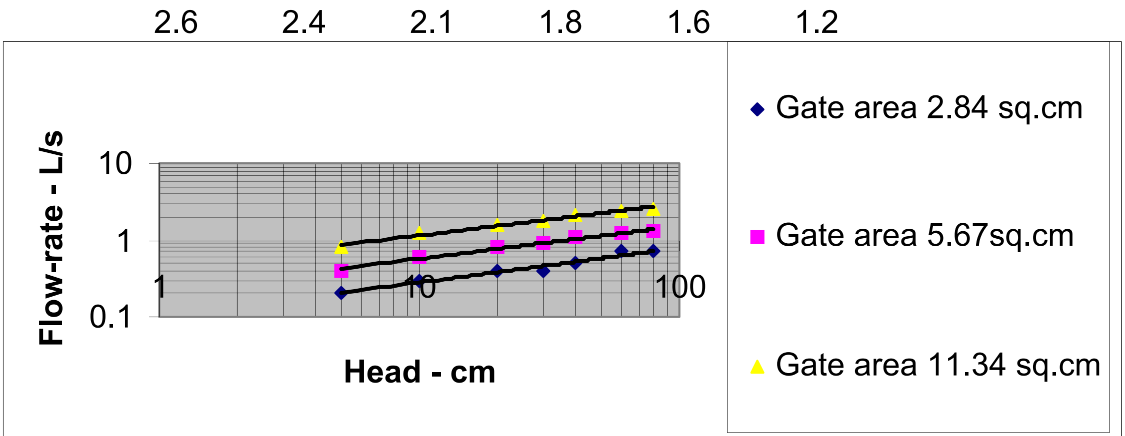

Fig.2: Gate flow-rate vs. head and are

Comparing Eq's. 4 and 5, it is inferred that "Cd" varies with "$h^{-0.13}$", since the square-root power of Eq. 4 is certain . Reduction of " Cd" with " h" is due to contraction of the jet area upon emerging from the gate. Indeed " Cd" is assumed to vary with "h" according to the following functional form, since contraction depends on the dimension of constriction within the flow:

$$Cd = f(h, d), \ldots\ldots\ldots\ldots\ldots..(6)$$

Here : "d" is taken as the constant width of the gate slit (3.8 cm for the present setup). According to dimensional concepts and the above argument,

$$Cd = C\,(h/d)^{-0.13} \ldots\ldots\ldots\ldots\ldots \quad (7)$$

Here the coefficient "C' remains constant for the experiment conditions.

Average Cd-values computed from Eq:12 for different areas "a" are plotted vs. " h/d" in **Fig.3** in the form of Eq.7. It uses log-log scales, and shows the reduction of " Cd" with "h" which agrees with **Duckworth (1977).** The exponent (- 0.13) is thus confirmed. " Cd" is deduced as follows:

$$Cd = 0.83\,(h/d)^{-0.13} \ldots\ldots\ldots\ldots\ldots \quad (8)$$

Again, Eqs. 4, and 8 give the final relation for "q" in more general terms, rather than the form of Eq. 5, which is easier to use for the specific gates under experimentation.

$$q = 0.83\,(h/d)^{-0.13}\; a\sqrt{2gh}\;, \ldots\ldots\ldots\ldots\ldots(9)$$

Here units have to be homogeneous on both sides of the equation. In simple form:

$$q = 0.83\sqrt{2g}\; a\; d^{0.13}\; h^{0.37}\;, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots...(10)$$

For our particular case, where $d = 0.038$ m:

$$q = 2.40\;\; a\, h^{0.37}\;, \ldots\ldots\ldots\ldots\ldots\ldots\ldots \;(11)$$

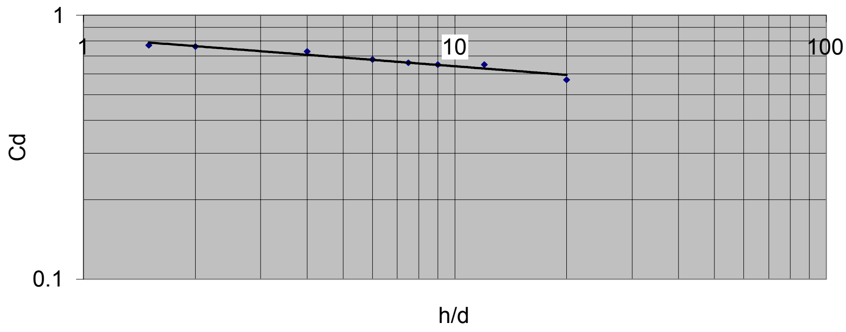

Fig.3: Cd vs. h/d.

Condition for uniform discharge along line.

Sliding gates give opportunity of adjusting uniform discharge along line against varying head. In previous work, **Morcos et al. (1994)** computed discharge step by step with friction drop from one emitter to another.

In this work, a more rigorous and direct approach is developed which proves to be very precise and applicable depending on Eq. 10.

$$a = \frac{q}{0.83 \sqrt{2g} \quad d^{0.13}} h^{-0.37} \quad \ldots\ldots\ldots\ldots\ldots\ldots \ (12)$$

The variable area "a" computed thus can vary with "h" along the line to give constant "q" as required. For more generality, and other advantages, a simple dimensional analysis would give the same relation in following form:

$$\frac{a}{d^2} = \frac{q}{0.83 \sqrt{2g} \quad d^{2.5}} \left(\frac{h}{d}\right)^{-0.37} \quad \ldots\ldots\ldots\ldots\ldots(13)$$

Otherwise, simpler relation can be obtained for the conditions of the present case, where d = 0.038 m, 0.0015 $m.^3/s$, " a" results in $m.^2$.

$$a = (0.62 \times 10^{-3}) \ h^{-0.37} \quad \ldots\ldots\ldots\ldots\ldots\ldots \ (14)$$

However, "h" has to be determined beforehand at each gate location.

h – determination along gate line.

The head at starting is "h_o". It declines along the line due to friction by "Δh_f". Strange enough, but basically correct, it picks up by "Δh_v" due to velocity reduction along line, due to gates outflow.

The head "h" at any gate point thus becomes:

$$h = h_o - \Delta h_f + \Delta h_v \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(15)$$

Friction losses "Δh_f" is computed according to the well- known formula:

$$dh_f = f\,\frac{dL}{D}\,\frac{V^2}{2g} \qquad \text{(notice that "}V\text{" is variable)}$$

$$= f\,\frac{dL}{D}\,\frac{Q^2}{2\,g\,A^2} = k\;Q^2\;dL \ldots\ldots\ldots\ldots\ldots\ldots(16)$$

Here "f" is friction factor, "D" pipe dia., "A" its cross section area $= \pi\,D^2/4$, "V" is the variable velocity at any point, "Q" is the corresponding rate of flow , and "k" is constant along the pipe:

$$k = \frac{8\,f}{\pi^2\,g\,D^5} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(17)$$

Thus from Eq. 16:

$$\Delta h_f = k\int_0^L Q^2\;dL \ldots\; \ldots\ldots\ldots\ldots\ldots\ldots(18)$$

"Q" Varies linearly along line, for uniform q -emission:

$$Q = Q_0 - q\frac{s}{L},$$

where: "Q_0" is total flow rate at pipe entrance, and "s" is the gate opening.

$$\Delta h_f = k\int_0^L \left(Q_0 - q\frac{s}{L}\right)^2\;dL$$

$$= k\left[Q_0^2\;L - \frac{q\,Q_0}{s}L^2 + \frac{q^2}{3\,s^2}L^3\right]\ldots\ldots\ldots\ldots\ldots\ldots(19)$$

On the other hand, the head gain "Δh_v" due to velocity reduction can be expressed as follows:

$$\Delta h_V = \frac{1}{2\,g\,A^2}\left[Q_0^2 - \left(Q_0 - q\frac{s}{L}\right)^2\right]$$

$$= \frac{1}{2\,g\,A^2}\left[\frac{2\,qQ_0}{s}L - \frac{q^2\;L^2}{s^2}\right]\ldots\ldots\ldots(20)$$

A special computer program was prepared in "Q–Basic" to calculate "$\Delta h_f, \Delta h_v, h$" according to Eqs. 16, 20 , and 15 resp.

Gate opening and corresponding width "a, w" are also estimated for uniform discharge along level line, via Eq. 19. "w" was estimated by approximating the aperture into square area .

$$W = d\,\frac{a}{a_0},$$

where "a_0" is the area of fully–open gate.

Fieldwork

Fieldwork was carried out to verify the head determination along gated pipe, with gate openings calculated for uniform flow. Conditions of the test were: pipe dia.= 0.15 m. , gate dia.= 0.038m., gate spacing "s" = 0.75 m., friction factor for pipe was estimated "f = 0.17" according to **Awady (1978)** where roughness for drawn pipes " e" = 2E – 4 cm , Reynolds No. was estimated at 2 E5, total pipe length = 18 m, gate discharge = 0.0015 m^3/s , and initial head = 0.5m.

Fig. 4 shows that the gate discharge 'q" was almost uniform at the required value (1.5 L/s). The lower part of the figure shows program-calculated values of " h_f , h_v , h m". Calculated " h m" conforms typically with measurements. The measured " h m" dropped slightly in the first portion of the gated pipe and this dropping ended near 21.0 % of gated pipe length, because the cumulative friction-head losses were greater than superimposed pressure head " h_v " and thus overcomes its effect. After that, the measured pressure-head increased gradually until it reached the pipe end at about 96% of the original pressure-head at the gated pipe inlet, because the gradual increase in " h_v " overcomes the effects of the cumulative friction head losses.

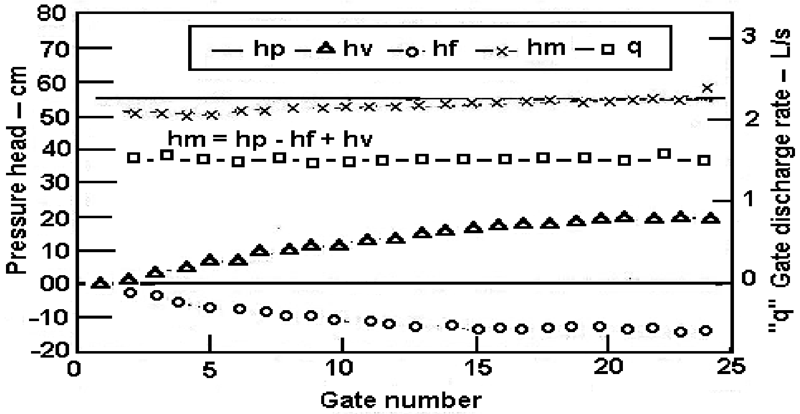

Fig.4: Discharge distribution along the gated pipe under field conditions.

REFERENCES

Armin, Co., 1989: The profitable way to irrigation. Armin poly-pipe-Catalogue. California. pp: 1-6.

Arora, K. R., 1976 . Fluid mechanics and hydraulic machines. B, NAT. SAAK-Delhi, pp.1169.

Awady,M.N.,1978. Irrigation and drainage engineering, Col.Ag.,Ain-Shams U., Texbook, "Flow in pipes":41-46 . (In Arabic)

Barbara, H. 1996 : Practical hydraulic handbook. Lewis Publisher CRS. 355 pp.

Chu, S. T., 1984 : Hydraulic of perforated irrigation trail tube. J . of Irrig. And Drain. Eng. ASCE, 110 (1) : 88 - 97.

Duckworth, R.A.1977 : Mechanics of fluids. Longman, London. Introd. Eng. Series, Edited by G.Webester, 85-253, 275 pp

Fischbach, P. E. and B. R. Somerhalder, 1971 : Efficiencies of an automated surface irrigation system with and without runoff re-use system. Trans. of the ASAE, 14 (4) : 717 - 719.

Hassan, S. S. A., 1990 : The performance of perforated tubes for surface irrigation in small holdings in Egypt. M. Sc. Th., Agric. Eng. Dept., Cairo Univ.

Hassan, S. S. A., 1998: Engineering studies for increasing water distribution uniformity of perforated pipes for surface irrigation system. Ph.D.Th., Agric. Eng. Dept., Cairo Univ.

Hastings Co., (1986). Gated aluminum irrigation pipe. Hasting Co. Catalouge, Neberaska . U.S.A.

Jensen, M. E., 1980 : Design and operation of farm irrigation system. ASAE, Monogr. 3, ASAE., St. Joseph, MI, 829 pp.

Khurmi, R. S., 1983. A text book of fluid mechanics. Pub. by S. Chand Co. Ltd Ram Nagar, New Delhi, 11 Th. Ed : 630 pp.

Kincaid, D. C. and W. D. Kemper 1982. Cablegation : 11. Simulation and design of the moving plug gated pipe irrigation system. Trans. of the ASAE 25 : 388 - 395.

Kincaid, D. C. 1984. Cablegation. V: Dimensionless design relations. Trans. of the ASAE. 27(3) : 679 - 722.

Kruse, E.G, D.D. Fangmier, A.S. Humpherys and H.L. Manges, 1980. Irrigation challenges of the 80 th. Proc. of the ASAE Puplication, (6-8), 2 nd. Int. Irrigation symposium, page: 60-68.

Morcos, M. A., A. F. El-Sahrigi, M. Hanafy and S. S. Hassan 1994. A mathematical approach to predict the pressure head inside the perforated tubes. Misr. J. Agr. Eng. 11 (4) : 1041 - 1065.

Omara, A. I. 1997. Implementation and evaluation of gated pipe for furrow irrigation system. M. SC. Th. Agric. Eng. Dept. Alex. univ.

Osman, H.E. (2000). Gated pipes techniques for improved surface irrigation. 8 th Conf. Agric. Dev. Res. Agric., Ain Shams Univ. Cairo, November 20-22, 2000. 145-155 Pp.

Rady, M. Abdel-Hady 1993. Project evaluation of irrigating system on sandy and calcareous soils, cairo.

El Sayed, G.H. 1998. Hydraulic studies for gated pipes distribution system. Egypt. J. agric. Res., 76 (1). 387-403.

Smith, R. J., P. J. Watts and S. J. Mulder, 1986. Analysis and design of gated irrigation pipelines. Agric. Water Mang. (12): 99 - 115.

El Tantawy, M.T., H.E. Osman.S.S., S.S.Hassan, and S.I. El- Khatib (2000) . Evaluation of surface irrigation under perforated pipe on sugarcane in old valley , Egypt. 8th Conference of Misr Socity, Agr. Eng. 25-26 October 2000. 23 - 33.

Van't Woudt, B. D. 1964. Uniform discharge from multi-orificed pipes. Tran. of the ASAE, 7 (3) : 352 - 355.

Wu, I. P. and H. M. Gitlin, 1983. Sprinkler irrigation for uniformity on slopes. Trans. of the ASAE, 26 : 1698 - 1703.

Zimmerman, H. D. 1966. Irrigation. John Wileys Sons, Inc. N.Y. 522 pp.