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# HYDRAULIC PERFORMANCE OF IMPROVED IRRIGATION SYSTEM

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## ABSTRACT

Irrigation canals network in Egypt for all levels suffer from water deficit and un-equitable distribution of irrigation water among beneficiaries. So, its modernization became omnipresent to overcome the problem of water shortage by the end of canals. One of the improvement sectors of irrigation canals network is replacing an earthen mesqa by upraised lines or buried pipes. The hydraulic performance of the improved irrigation system is explored using a case study canal, where buried pipes system is applied as improved mesqa system. The case study is for the Hadaya canal which is one of the distributary canals that located in Assiut governorate. This canal services 19 mesqas with different lengths and area served. The hydraulic performance of mesqas is examined through different scenarios of operation of the mesqa pumping station and area served. Three scenarios of mesqa valves operation are considered .The first scenario is when all valves are operated at the same time all over the week. The second is when one valve operates for two days per week and the third is when all valves operate for one day. Also, three scenarios are considered for pump operation 14, 16 and 18 hours per day. Moreover, effect of different scenarios of mesqa operation on sudden transition of flow in pipes due to pump shut-down is studied. EPANET software was used for the hydraulic analysis. It was found that operating the pump 14 hours per day fulfill the minimum monthly cost. Also, operating the outlet valves according to scenario no. (3) gives the least operating cost. The maximum velocity in the pipeline is less than 1.2 m/s for all operating scenarios. Besides, effects of mesqas off-takes on the flow in distributary canal are studied.

***Keywords:*** improved mesqa, surface irrigation, distributary canal.

## 1. Introduction

The old land which is irrigated by surface irrigation is estimated as 79% of all agricultural areas in Egypt. So, it is very important to improve the irrigation system in this area by increasing the irrigation efficiency. Egypt began the improvements of tertiary canals (mesqas) at the nineteen’s of the last century. The improvements process includes changing rotational supply to continuous supply, upstream flow control to downstream flow control, Depeweg and Bekeit [1]. There are three alternatives for old mesqa replenishment, the first is pipeline mesqa, the second is open channel raised mesqa and the third one is improved mesqa.

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Depeweg and Bekeit [1] assessed the three alternatives on the basis of adequacy, reliability, equity and efficiency. They showed that the pipeline and the improved mesqa are compatible and they are recommended above the raised mesqa. They indicated that differences in field ditch discharges of 30% to 40% may occur between the first and last valve (or turn-out), even if all valves/ turn-outs have the same opening. Long pipeline mesqas have large difference in working head between the head and end valves, resulting in an unequal water distribution. Using buried pipes mesqa can save agricultural land in the range from 2.74% to 2.067% according to Saad Eddin et al. [14]. Radwan [12] mentioned that the average annual water saving from improved on-farm irrigation projects is about 4.67 billion cubic meters.

Radwan et al. [8] developed a program for design and calculating the total cost of the improved pipe irrigation system using variable control parameters which can be changed by the user. They detected the effect of design velocity on each of the cost items and the contribution of each item's cost on the total system cost. It was found that the contribution of pipeline cost, pumping station and civil work's cost, pump set cost, and fill cost on the total cost is 47%, 29%, 14%, and 10% respectively.

Radwan et al. [9] mentioned that the main two parameters that control choosing the suitable design criteria for IIP (improved irrigation project) are the unit stream size, and the total pipeline length. It was concluded that for short pipeline lengths less than 600 m, there is no limitation in choosing the suitable design criteria but for long pipeline lengths more than 600 m and for a specific unit stream size, the farmer has the option either design for fixed rotation and minimum cost or design for free operation with little increase in the total cost.

Radwan [11] discussed the required operational conditions to achieve equity water distribution between hydrants in case of varied land levels. He determined critical down word slope for achieving exactly equal water distribution regardless of the distance between opened hydrants. Also, he determined the maximum distance between opened hydrants for random land slopes to achieve specified difference in the discharge. According to Radwan [10], basic design for mesqa capacity is to allow for 100% rice cropping in the area served with a peak daily consumptive use for rice of 13.3mm. Assuming percolation losses of 1.00 mm/day, the total water requirement is increase by 10% for surface runoff. However the criteria in Upper Egypt are different.

Hydraulic models can be used to simulate the flow depth and discharge in irrigation canal network over space and time and thereby can help in understanding the hydraulic behavior of such system, Kumar et al. [4]. Many researchers studied one-dimensional free surface flow with a spatially varied discharge, among them are Moghazy et al. [6], Zerihum [16]. Misra [5] developed a mathematical model for the analysis of spatially varied flow in an irrigation canal. It was observed that the actual depth and discharge in the canal is significantly different from the design ones. Shahrokhnia and Javan [15] evaluated the influence of changes in the canal roughness on offtakes discharge using HEC-RAS modeling software. They indicated that these changes could be could be considered as an important factor in better water distribution of irrigation canals.

All the previous studies are based on mesqa pipeline with stand tank, however, nowadays the stand tank is eliminated to reduce the cost through using direct pumps (El-Fetyany [3]). Also, the design standards considered that the land will be cropped with rice, however, the crops consumptive use vary from location to location and from season to season. The mesqa pipeline is assumed to operate 16 hours/day and the nominal unit stream size is taken as 30 l/s although the irrigation area can vary from turnout to turnout. Besides, spatially distribution of the mesqas offtakes on the flow in distributary canal is studied.

## 2. Materials and methods

Al Hadaya Canal is one of the distribution canals that located in Assiut governorate and irrigates the cropped areas of three villages named Al Hadaya, Burgh and Elwan. Al Hadaya canal is located at latitude 27 and longitude 32 and the agricultural land of it is at 50 meters above mean sea level. The length of the canal is about 4.000 kilometers and its intake located at km 8.000 at left bank for the Arab Almadabegh canal. Canal cropped area is 812.81 Feddan and is branched from it 19 mesqas on both sides as shown in Figure (1) and Fig. (2) show cross-sections at Km 1.0 and 2.7, respectively, along the canal. The new mesqa intake without stand pipe is shown in Fig. (3) and Fig. (4) shows the mesqa outlet using Alfalfa valves. Table (1) shows the cropping pattern of Al Hadaya canal through the winter and summer seasons. The meteorological data of the region is shown in table (2) .

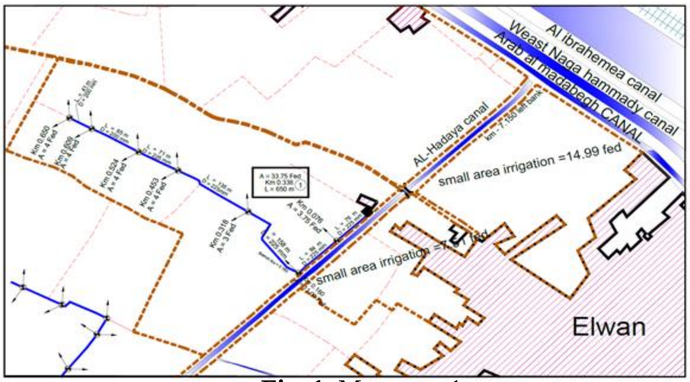


**Fig. 1.** Mesqa no 1.

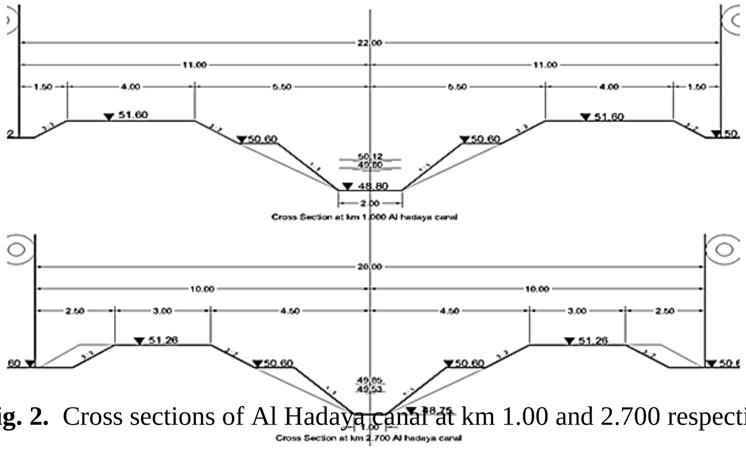


**Fig. 2.** Cross sections of Al Hadaya canal at km 1.00 and 2.700 respectively.

**Table 1.**
Cropping pattern for Al Hadaya canal

| Crop | % of area | season | Date of plant | Date of harvest |
|---|---|---|---|---|
| Wheat | 55 | winter | 01/11-15/11 | 30/04-15/05 |
| Bean | 20 | winter | 01/10-15/10 | 15/03-01/04 |

**Table 1. (Cont.)**

| Crop | % of area | season | Date of plant | Date of harvest |
|---|---|---|---|---|
| Clover | 15 | winter | 01/10-15/10 | 20/05-10/06 |
| Onion | 10 | winter | 15/11-01/12 | 01/05-15/05 |
| Yellow corn | 65 | summer | 15/05-01/06 | 30/09-15/10 |
| sorghum | 35 | summer | 15/05-01/06 | 30/09-15/10 |

**Table 2.**
Meteorological data of the region

| Month | Max. temp. ( $^o$c ) | Min. temp. ( $^o$c ) | Avg. tem. ( $^o$c ) | % RH max | % RH min | wind speed (km/h) | No. of sunny hours / day |
|---|---|---|---|---|---|---|---|
| JAN | 18 | 13 | 15.5 | 47 | 32 | 11.40 | 10.00 |
| FEB | 22.5 | 14.5 | 18.5 | 45 | 37 | 12.75 | 11.00 |
| MAR | 25 | 14 | 19.5 | 48 | 20 | 15.25 | 12.00 |
| APR | 29 | 18 | 23.5 | 42 | 17 | 14.20 | 13.00 |
| MAY | 32 | 14 | 23 | 41 | 19 | 14.75 | 13.00 |
| JUN | 36 | 28 | 32 | 45 | 32 | 13.75 | 14.00 |
| JUL | 37 | 30 | 33.5 | 41 | 21 | 12.20 | 14.00 |
| AUG | 34.5 | 28 | 31.25 | 44 | 29 | 11.00 | 13.00 |
| SEP | 29 | 20.5 | 24.75 | 44 | 29 | 11.75 | 12.00 |
| Oct. | 29 | 22 | 25.5 | 45 | 30 | 11.60 | 11.50 |
| Nov. | 27 | 17 | 22 | 46 | 32 | 9.25 | 11.00 |
| Dec. | 22.5 | 14 | 18.25 | 47 | 35 | 10.60 | 10.00 |

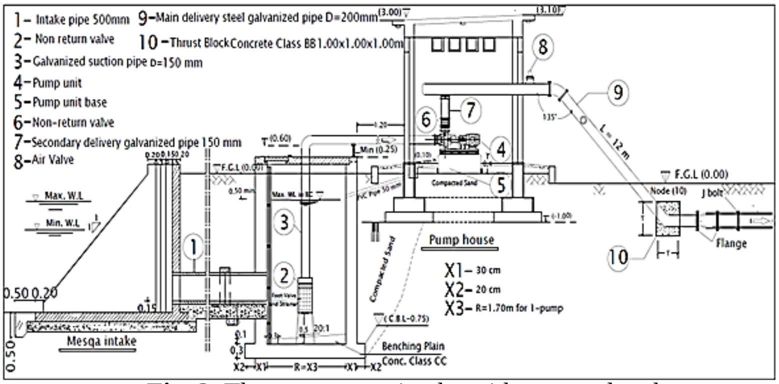

**Fig. 3.** The new mesqa intake without stand tank.

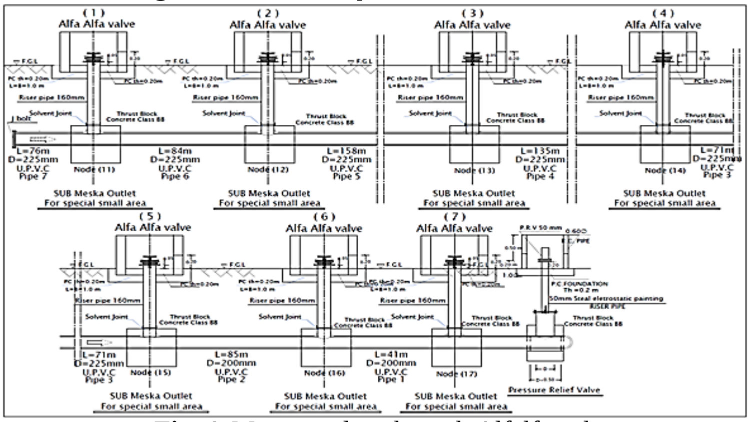

**Fig. 4.** Mesqa outlets through Alfalfa valves.

EPANET Software is used that can performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks can be simulated (Rossman [13], Mohamed and Abozeid [7]). The software simulates the behavior of hydraulics elements (head, discharge, velocity and pump electric power) in different operating cases when operating the pipeline with direct pumping system and steady flow during the daily operation period of the canal which is changed three times, i.e. 14, 16 and 18 hours in a rotational water supply system. Table (3) shows the used pump characteristics.

**Table 3.**
The pump characteristics.

| Q (l/sec.) | Head (m) |
|---|---|
| 38.89 | 13.00 |
| 44.44 | 12.00 |
| 50.00 | 10.60 |
| 55.55 | 8.40 |
| 61.11 | 5.60 |

Schematic diagram for the pipe mesqa (number1) is shown in Figure (5) and Table (4) shows (the length of the different pipes segments and its diameter. The pipes material used in mesqas are UPVC pipes and Hazen-Williams equation is used in the analysis with a roughness coefficient of 150.

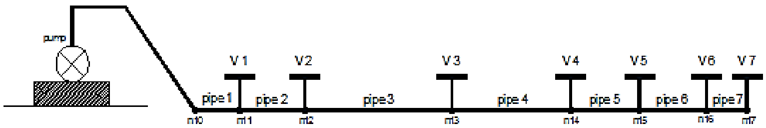


**Fig. 5.** Pipe mesqa number 1.

**Table 4.**
Lengths and diameters of pipe mesqa number 1.

| Part | Node | Length(m) | Diameter (mm) |
|---|---|---|---|
| 1 | 10 - 11 | 76 | 250 |
| 2 | 11 - 12 | 84 | 250 |
| 3 | 12 - 13 | 158 | 250 |
| 4 | 13 - 14 | 135 | 250 |
| 5 | 14 - 15 | 71 | 250 |
| 6 | 15 - 16 | 85 | 200 |
| 7 | 16 - 17 | 41 | 200 |

## 3. Results and discussions

### *3.1. Crop consumptive use estimation*

The reference evapotranspiration $ET_o$ was estimated, using available meteorological data at Manfaloot local weather station as shown in Table 2. Six different methods are used to calculate it. Fig. 6 shows the reference evapotranspiration at different months calculated using Balney – Criddle, Thornthwaite, Jensen-Haise, FAO- Blaney-Criddle (temperature method), Penman- Monteith, and Hargreaves- Samani method, respectively. It is clear the agreement between the different methods except Jensen-Haise method.

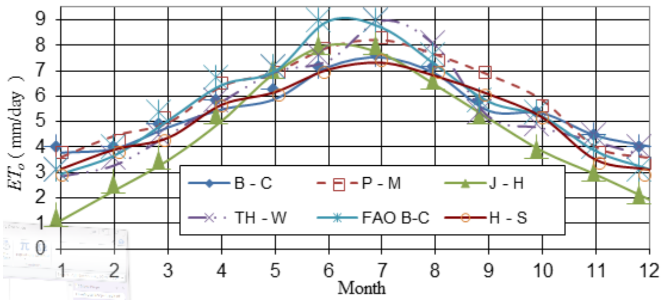


**Fig. 6.** Monthly variation of reference evapotranspiration.

## 4. Mesqa discharge computation

The water is lifted to meskas in rotation and at specific hours during on-days, and the water is conveyed from pipe meskas to earthen marrwas through valve **outlets**. In this study, it is assumed that the area served by a mesqa is cultivated by the same ratio of cultivated crops in the area served by distributary canal. The mesqas and outlets discharge are computed using approach introduced by El-Enany et al. [2] as follows:

$$WC = \sum_{i}^{N_c}(ET_o\, K_{ci}A_{ci}/1000) \times 4200/86400 \quad (1)$$

where $WC$ is the water consumptive needed for the area served by a distributary canal during a month ($m^3$/sec.), $N_c$ is the number of cultivated crops in the area served by a distributary canal according to cropping pattern, $ET_o$ is the monthly average evapotranspiration for the area served by a distributary canal (mm/day) , $K_{ci}$ is monthly average crop coefficient, and $A_{ci}$ is the area cultivated by a crop $i$ (feddan).

$$Q_d = WC \times \frac{N_1}{N_2} \times \left(\frac{24}{T_e - T_s}\right) \times (1 + L_R)/\eta \quad (2)$$

Where $Q_d$ is the discharge of distributary canal during hours of irrigation ($m^3$/sec.), $T_e$ is the assumed day hour at which irrigation ends, $T_s$ is the assumed day hour at which irrigation starts, $L_R$ is the leaching requirement, which is a ratio of water consumptive use (%), and $\eta$ is the irrigation efficiency for distributary canal, where conveyance and on-farm efficiencies are included (= 0.71).

$$Q_m = \frac{WC}{A_T} \times \frac{N_1}{N_2} \times \left(\frac{24}{T_e - T_s}\right) \times (1 + L_R)/\eta_m \quad (3)$$

Where $Q_m$ is the discharge of mesqa during hours of irrigation ($m^3$/sec/fed), $A_T$ is the total area served by distributary canal (feddan), $N_1$ is the rotation length (days), $N_2$ is the number of on days (days), $T_e$ is the assumed day hour at which irrigation ends, $T_s$ is the assumed day hour at which irrigation starts, $L_R$ is the leaching requirement, which is a ratio of water consumptive use (%), and $\eta_m$ is the irrigation efficiency for mesqas.

According to the crop pattern, rotation period for canal and operation times for mesqas, the discharge of distributary canal and mesqa can be estimated from equations 1-3. Discharge of a mesqa no.(1) during hours of irrigation ($m^3$/ sec/fe), ($m^3$/sec), at 14,16 and 18 hours when $\eta = 0.71$ , $\eta_m = 1$ ( at pipeline ) , $L_R$= 0.05, $N_1$,$N_2$ = 14,7 days are shown in Table (5).

**Table 5.**
Areas and discharges of different valves for pipe mesqa number 1.

| valve | Km | Area (fedd.) | Discharge (L/sec.) At 14-hours 54 L/sec. | At 16-hours 47 L/sec. | At 18-hours 44 L/sec. |
|---|---|---|---|---|---|
| 1 | 0.076 | 3.75 | 6.00 | 5.22 | 4.89 |
| 2 | 0.160 | 11.00 | 17.60 | 15.32 | 14.34 |
| 3 | 0.318 | 3.00 | 4.80 | 4.18 | 3.91 |
| 4 | 0.453 | 4.00 | 6.40 | 5.57 | 5.21 |
| 5 | 0.524 | 4.00 | 6.40 | 5.57 | 5.21 |
| 6 | 0.609 | 4.00 | 6.40 | 5.57 | 5.21 |
| 7 | 0.650 | 4.00 | 6.40 | 5.57 | 5.21 |

Three operation scenarios of mesqa outlets are considered. In scenario (1), all valves are working during daily operation hours. The valves feed all the cropped area at the same time and the discharge of mesqa is distributed to all valves according to served area. In the second scenario, the discharge of the mesqa is distributed to all valves such that every irrigate the served area in one day. In the third scenario, each valve will irrigate the served area in two consecutive days. Table (6) show the schedule of all valves of mesqa no. (1) for the three scenarios of operation for 14 hours of operation per day.

**Table 6.**
Operation schedule for mesqa no (1) at 14 hours daily pump operation.

| Case | Day | Valve | V1 | V2 | V3 | V4 | V5 | V6 | V7 |
|---|---|---|---|---|---|---|---|---|---|
| | | Km | 0.076 | 0.160 | 0.318 | 0.453 | 0.524 | 0.609 | 0.650 |
| Case1 | Sat-Fri | Disch L/sec | 6.00 | 17.60 | 4.80 | 6.40 | 6.40 | 6.40 | 6.40 |
| Case2 | Sat | Discharge (L/Sec) | off | 12.20 | off | off | off | off | 44.80 |
| | Sun | | off | 12.20 | off | off | off | 44.80 | off |
| | Mon | | off | 12.20 | off | off | 44.80 | off | off |
| | Tue | | off | 12.20 | off | 44.80 | off | off | off |
| | Wed | | off | 12.20 | 33.60 | off | off | off | off |
| | Thur | | 42.00 | 12.20 | off | off | off | off | off |
| | Fri | | off | 50.00 | off | off | off | off | off |
| Case3 | Sat | Discharge (L/Sec) | off | off | off | off | 22.40 | 22.40 | 22.40 |
| | Sun | | off | off | off | off | 22.40 | 22.40 | 22.40 |
| | Mon | | off | 61.60 | off | off | off | off | off |
| | Tue | | off | 61.60 | off | off | off | off | off |
| | Wed | | 21.00 | off | 16.80 | 22.40 | off | off | off |
| | Thur | | 21.00 | off | 16.80 | 22.40 | off | off | off |
| | Fri | | off | off | off | off | off | off | off |

## 5. Flow through mesqa pipe no. (1)

Fig. (7) shows the maximum discharge in mesqa no.1 for the three scenarios of valves operation at periods of irrigation 14, 16 and 18 hours, respectively. It can be shown from this figure that the discharge decreases by increasing the pump operation hours except for scenario 2 where the discharge increases by in increasing the pump operation hours. In general, scenario1 gives the minimum discharge for the three pump operation condition.

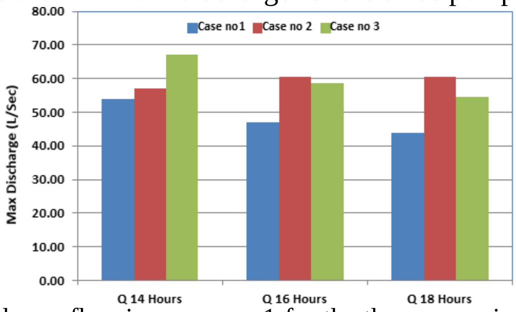


**Fig. 7.** Maximum discharge flow in mesqa no.1 for the three scenarios of operation at period of irrigation 14, 16 and 18 hours.

Fig. (8) shows the minimum discharge in the pipe line mesqa for the three scenarios of outlets operation at periods of irrigation 14, 16 and 18 hours. It is noticeable from this figure that the smaller discharge in the pipe line at scenarios no.1.

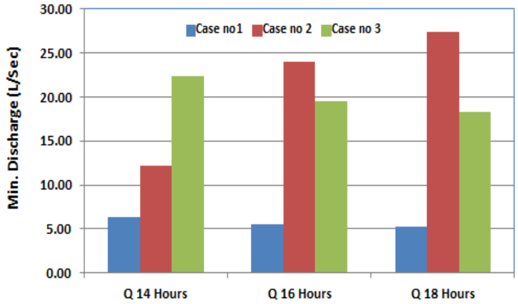


**Fig. 8.** Minimum discharge flow in mesqa no.1 for the three scenarios of operation at period of irrigation 14, 16 and 18 hours.

Figures (9) and (10) show the maximum and minmum velocity respectively, in pipeline mesqa for different scenarios of operation. It can be seen from Fig. (9) that the maximum velocity in the pipe line less than 1.5 m/sec and higher than 0.9 m/sec for all operation scenarios and the maximum velocity decreases by increasing the pump operation hours. As shown from the Fig. (10), the minimum velocity for scenario no.1 is less than 0.20 m/sec, however this small velocity may be occurring in last reach of the pipeline.

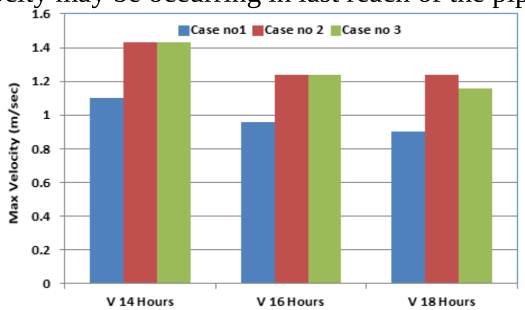


**Fig. 9.** Maximum velocity in mesqa no. (1) for different operation scenarios.

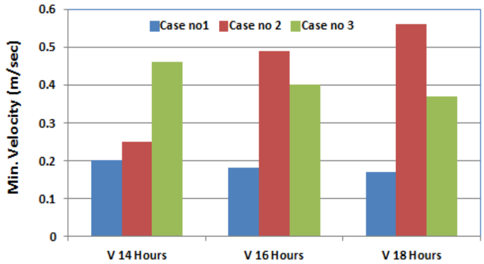


**Fig. 10.** Minimum velocity in mesqa no.(1) for different operation scenarios.

Fig. (11) shows the maximum head loss in the pipeline mesqa for the different scenarios of operation. As shown from this figure, the smaller head loss is at operation according to scenario no.1 (distribution of pump discharge on all valves) for all periods of pump operation and the maximum is for scenario no. (3) i.e. distributing the discharge on two valves.

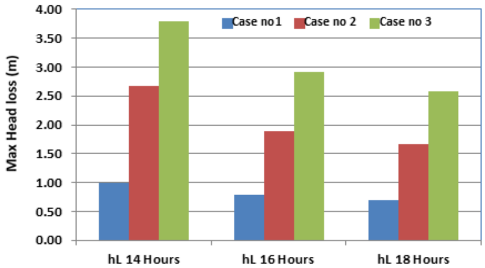


**Fig. 11.** Maximum head loss in pipe mesqa no. (1).

Fig. (12) shows the minimum head loss in the pipeline for different operation scenarios and it can be shown that the minimum head loss is for scenario no. (2), i.e. operating the valves separately for one day.

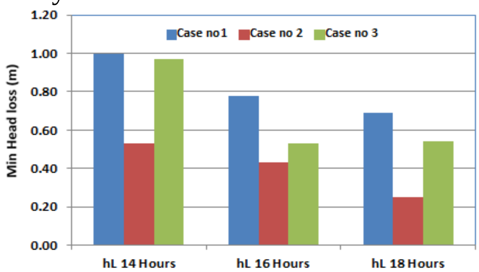


**Fig. 12**. Minimum head loss in pipe mesqa no. (1).

Fig. (13) shows the maximum electric power required for the operation of pump at different scenarios of operation. It can be shown that there is no clear trend for power required for the different scenarios due to the variation in areas irrigated by each valve.

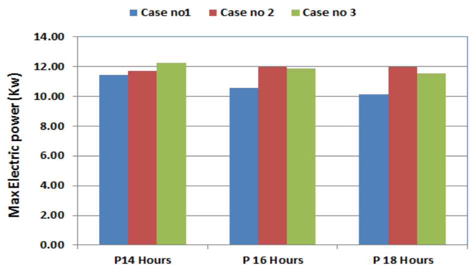


**Fig. 13.** Maximum motor power for pipe mesqa no. (1).

Fig. (14) shows the minimum electric power required for the operation. It can be shown from this figure that case no. 2, i.e. operating one outlet daily gives the minimum power for all hours of operation. In comparison between Fig,(13) and Fig.(14),there is no high difference between the maximum and minimum power.

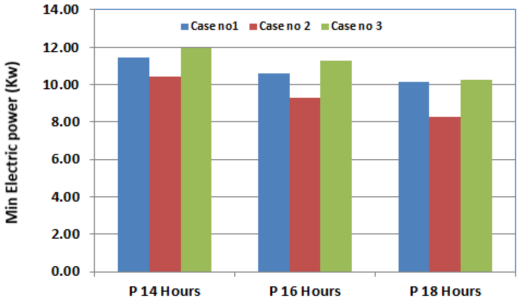


**Fig. 14.** Minimum motor power for pipe mesqa no. (1).

Fig. (15) shows the pump energy cost for different scenarios. It can be depicted from this figure that the minimum energy cost at 14 hours operation and for mesqa outlets scheduling according to scenario no. (3).

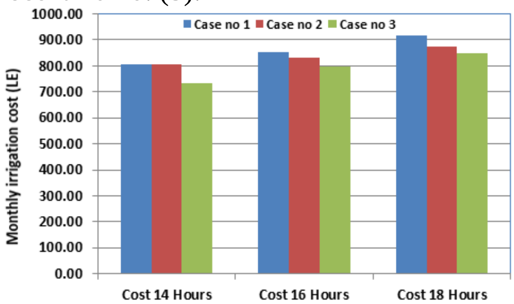


**Fig. 15.** Monthly cost of energy for pipe mesqa no.(1).

Figures (16) and (17) show the variation in maximum and minimum pressure heads along mesqa (1) pipeline respectively, due to the sudden shut down of the pump, for the different studied cases (case 1, 2 and 3). Firstly, there is no a big difference in the maximum pressure between the three studied cases. Secondly, the figures reveal that case 1 (all valves are working) is the best one, because the average minimum pressure equals -4 m $H_2O$, while case 2 (one separate valve operate in one day) has a minimum pressure of -5 m $H_2O$. Case 3 ( 2 valve operate in one day) is the worst case, because the pipeline completely has a negative pressure of – 10 m $H_2O$, which may lead to column separation or the possibility of intrusion and contamination of the system.

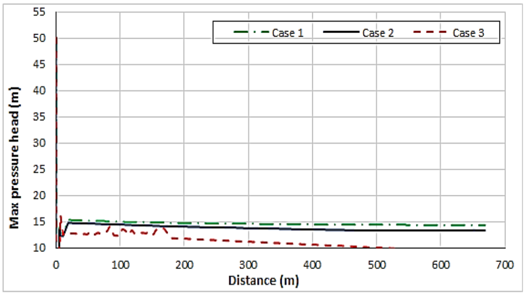


**Fig. 16.** Maximum pressure heads along the pipeline due to the sudden shutdown of pump for the different studied cases.

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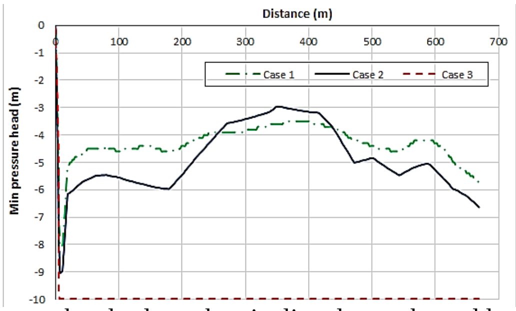


**Fig. 17.** Minimum pressure heads along the pipeline due to the sudden shutdown of pump for the different studied cases.

## 6. Flow in distributary canal

Irrigation canals are designed such that the flow is constant along the canal, however, the actual flow is spatially varied flow. Fig. (18) shows the variation of water depth in distributary canal for constant and spatially varied flow respectively. As shown from that figure, considering the flow is constant in the canal results in smaller water depth along the canal compared with varied flow.

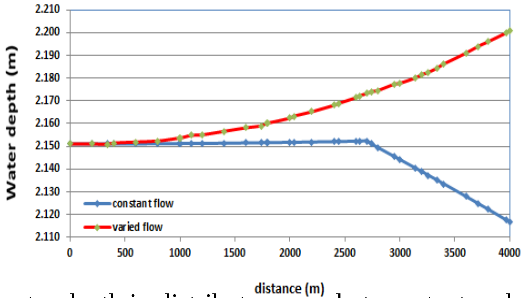


**Fig. 18.** Variation of water depth in distributary canal at constant and varied discharge along the canal for 14 hours mesqa operation.

Fig. (19) shows the water depth along the distributary canal for the three scenarios of mesqa pumps operation, i.e. at 14, 16 and 18 hours respectively. It is noticeable from that figure the water depth increases by decreasing the hours of pump operation.

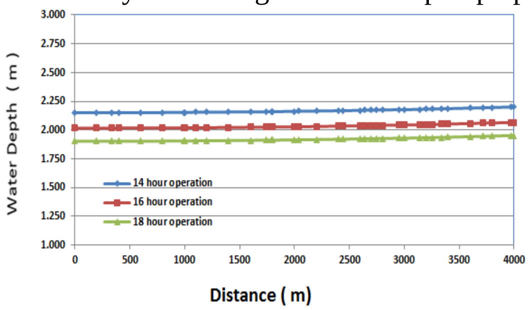


**Fig 19.** Water depth in distributary canal for different scenarios of mesqa pumps operation.

## 7. Conclusions

In the current study, hydraulic performance of pipe mesqa during operation is studied. Three scenarios for operation of mesqa outlets are suggested with three alternatives for the daily pump operation i.e., 14, 16 and 18 hours, respectively. In the first scenario, it is suggested the all pipe outlets operated daily and its discharge is proportional to the area served. In the second scenario, it is assumed that each outlet operates once a week. However, in the third one, the outlets are assumed to be operated twice a week. Many parameters are assessed among of them the maximum and minimum discharge flow in pipe line, the maximum and minimum velocity, maximum and minimum head loss, pump electric power and energy cost. It was found from this study, that operating the pump 14 hours per day fulfills the minimum monthly cost. Also, operating the outlet valves according to scenario no. (3), gives the least operating cost. The maximum velocity in the pipeline is less than 1.2 m/s for all operating scenarios. It was found from this study that case 3 gives the maximum negative pressure due to pump suddenly shut-down. Moreover, it was found that considering the discharge as a constant along the distributary canal under-predict the water depth along the channel.

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# الاداء الهيدروليكي لنظام الري المطور

## الملخص العربى


تعاني شبكة الترع في جمهورية مصر العربية علي جميع مستوياتها من نقص المياة و التوزيع غير العادل لمياة الري بين المنتفعين . ولذلك اصبح تطوير الري مطلبا ملحا للتغلب علي مشكلة نقص المياة في نهايات الترع.

ويقوم قطاع تطوير الري احد قطاعات وزارة الموارد المائية و الري باستبدال المساقي الترابية العادية بمساقي مواسير مدفونة او مساقي مبطنة مرفوعة . ويتم دراسة الاداء الهيدروليكي لنظام الري المطور باستخدام احد ترع التوزيع حيث يتم تطبيق الدراسة علي نظام المواسير المدفونة . ويتم تطبيق الدراسة علي ترعة الهدايا وهي احد ترع التوزيع التي تقع ضمن زمام الري بمحافظة اسيوط .وتقوم بتغذية عدد 19 مسقي بمياة الري و المساقي لها اطوال وزمامات مختلفة . ويتم دراسة الاداء الهيدروليكي لمسقي المواسير المطورة من خلال سيناريوهات مختلفة لتشغيل وحدة الرفع وسيناريوهات مختلفة لتشغيل مسقي المواسير . مع الاخذ في الاعتبار دراسة ثلاثة حالات تشغيل للمسقي من خلال تشغيل محابس الري علي المسقي . السيناريو الأول هو عندما يتم تشغيل جميع الصمامات في نفس الوقت طوال الأسبوع . والثاني هو عندما يعمل صمام واحد لمدة يومين في الأسبوع والثالث هو عندما تعمل جميع الصمامات ليوم واحد. أيضا ، يتم النظر في ثلاثة سيناريوهات لتشغيل وحدة الرفع لمدة 14 و 16 و 18 ساعة في اليوم . علاوة على ذلك ، يتم دراسة تأثير السيناريوهات المختلفة لتشغيل وحدة الرفع على الانتقال المفاجئ للتدفق في المواسير بسبب إغلاق وحدة الرفع . تم استخدام برنامج EPANET للتحليل الهيدروليكي. وجد أن تشغيل المضخة 14 ساعة في اليوم يحقق الحد الأدنى من التكلفة الشهرية . ايضا ، تشغيل صمامات المخرج وفقا لسيناريو التشغيل رقم (3) يعطي أقل تكلفة تشغيل . الحد الأقصى للسرعة في خط المواسير هو أقل من 1.2 متر / ثانية لجميع سيناريوهات التشغيل. إلى جانب ذلك ، يتم دراسة تأثيرات تشغيل ماخذ المساقي علي السريان في ترعة التوزيع.