Misr J. Ag. Eng., 24(2): 327-338 IRRIGATION AND DRAINAGE

DEVELOPMENT AND TESTING OF SCREEN FILTER FOR MICRO IRRIGATION SYSTEMS

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ABSTRACT

The principal aim of this research is to study the affecting factors on the design of a screen filter for micro irrigation system, and evaluate the designed filter in irrigation system, for easy operation and maintenance of irrigation system application and introduce a higher efficiency screen filter into the local market using economical local materials, and also to control emitter clogging during washing the filter screen. In addition, the designed screen filter is compared with other screen filters available in the local market.

The main results in this study can be summarized in the following:

** Average discharges ranged from 12 to 33 m^3/h, for imported filter, and 15 to 47 m^3/h for developed filter. Pressure drop ranged from 0.1 to 0.6 bar. (10 - 60 kPa)*

** The average filtration efficiency was 43 % and 45 % for imported and designed filters respectively.*

** Economical verification of the feasibility of using the developed and imported filters is discussed.*

INTRODUCTION

Screen filters are inexpensive and easy to install. Mesh filters work well if there are moderate to low contaminants in the water such as those coming from a well. Screen filters have a limited ability to store contaminants. Thus, if the water comes from a river or a holding pond, the screens will have to be flushed often. This could result in considerable down time in the system.. Clean water must be used to clean the system. Mesh screen sizes are between 20 and 200 mesh. The smaller mesh filters out small particles. The screens are made from stainless

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steel, nylon, or polyester. The maximum flow rate through a screen is 20 gpm/sq. m. of screen. **Hansen et. al. (1994)**

Suspended particles, biological growths and chemical precipitants can cause emitter blockage. Suspended particles such as sand, silt, clay, and any other particulate or organic matter in the irrigation water will plug a micro-irrigation system if allowed to reach the emitters. Any particles larger than the emitter opening must be eliminated before the water reaches the emitter. Most drip tape and emitter manufacturers recommend the removal of particles 75 microns and larger to prevent plugging the water emission orifices.

Karmeli and Keller (1975), **Jensen (1980)**, **and ASAE EP405 (1984)** reported that filter size is specified by its effective area, which is the area of the openings in the screen. It is specified in relation to cross-sectional area of the man pipe. A desirable ratio is 2 or more (area of openings is much larger than the cross-sectional area of the pipe). The mesh size of the filter (opening size) will depend on the smallest particle size to be removed from the irrigation water.

Finkel (1982) found that when estimating the appropriate size of filter for a specific application, one should consider the quality of water needed, volume of water required to be passed through the filter between consecutive cleanings, filtration area of the filter screen, and allowable pressure drop through the filter. A screen filter can handle a large range of discharges. However, discharges that are large in relation to the filtering surfaces will result in greater pressure losses, shorter life of the filter, and the requirement for frequent cleaning.

Robert (2002) reported that screen filters are effective at sand removal and should be used downstream of sand media filters to remove any sand washed out of the media filters. The use of screen filters as the primary filtration method is limited. Screen filters can be used as primary filtration under conditions where light loading of inorganic particles is large enough to be captured by the screen mesh. Screen filters should not be used when organic contaminates are present.

The aims of this research are:

1. Study the affecting factors on design of screen filter for micro irrigation system,
2. Test available materials to develop screen filter,
3. Evaluate the designed filter in irrigation system,
4. Conduct field experiments to identify optimum design parameters and most appropriate materials, and
5. Compare the designed filter with other screen filters available in the local market.

In order to facilitate operation and maintenance of irrigation system application, a higher efficiency screen filter is introduced into the local market using economical local materials.

MATERIALS AND METHODES

Field experiments: Field experiments were conducted to test the designed parameters of the screen filter including:

(a) Testing developed screen filter reliability in irrigation system,
(b) Identifying hydraulic and engineering characteristic for developed screen filter for comparison and optimization, and
(c) Compare the designed filter with other filters available in the local market.

Field apparatus called “Dirtiness index meter” was used to measure filter efficiency in irrigation system, including pressure gage range from 0 - 6 bar (0 - 600 kPa) with an accuracy of 0.1 bar (10 kpa) and flow meter with an accuracy of 0.0001 m^3 , and screen with 120 mesh (0.130 mm.-hole diameter) shown in fig. 1.

The dirtiness is assessed by the rate of sediment retention in the small filter introduced in the circle shown in the figure.

A centrifugal pump was used in irrigation system, with the following specs. Shown in table 1.

Table1: Pumpset specifications.

Pump type	Motor power, kW	R.P.M.	Discharge, m^3/h		Head, m.		I/O Diameter
			Min.	Max.	Min.	Max.	
Al Waillar	22.5	3000	50	85	1.75	3.25	4/3"

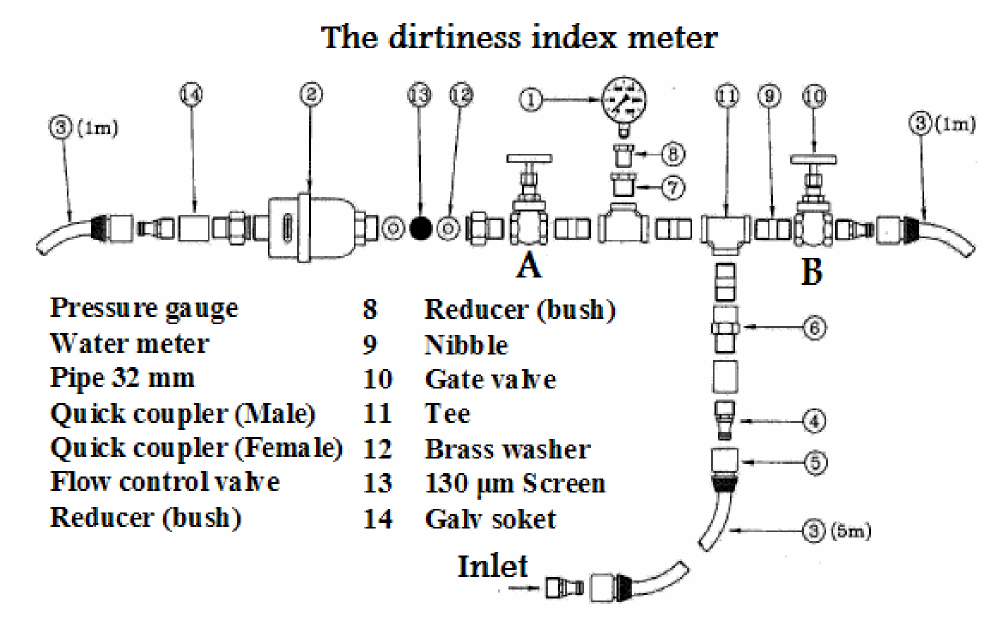

Fig. 1: Schematic apparatus constructed for filter test. (C.F. Van Nieker, 2006)

Components of the designed screen filter.

The developed screen filter consists of four parts, as shown in figs. **2** and **3** as follows. It has the advantage that washing sediments in water flows out without bypassing dirt inside.

(1) Filter body: The filter body was made of a steel pipe of 258 mm (8”) outside diameter coated with anti-corrosion material (epoxy). The total length of the filter body is 883 mm, branched into two pipes for inlet and outlet flow in the middle of steel pipe with length of 150 mm and 97.6 mm. (3”) outside diameter ending with movable flange.

(2) Screen: Two P.V.C. pipe (rating 10 bar.) of 168 mm (6”) outside diameter and length of 377 mm slotted 8 grooves along pipe length with an effective average diameter of 96 mm. The slot dimension was 15 mm x 4 with an increment of about 5 mm using a special machine, and covered with Nylon/polyester mesh of 120 (0.130 mm) (mean aperture diameter) welded outside pipe.

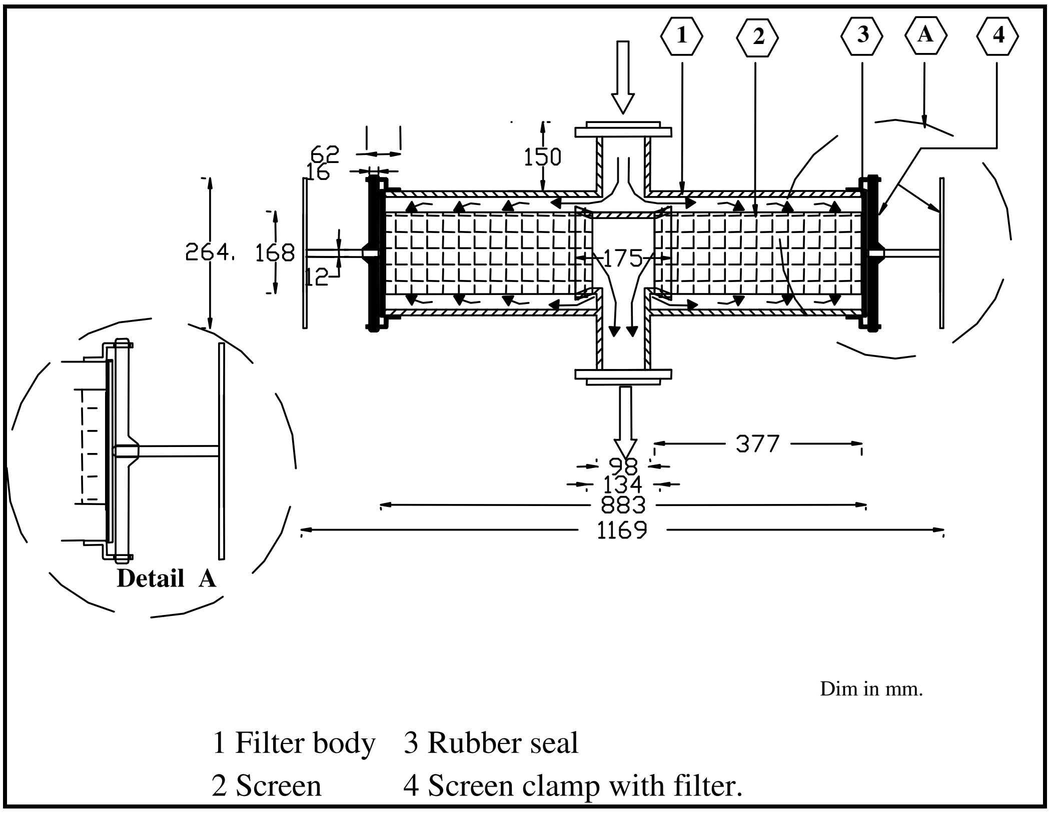

Fig. 2: Schematic of developed screen filter.

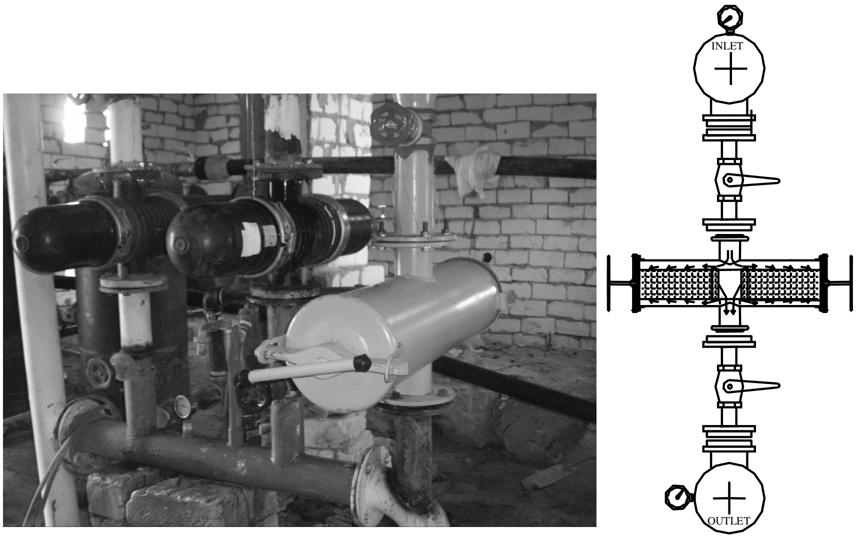

Fig. 3: Typical installation of developed screen filter.

(3) Rubber seal: of 255 mm diameter and 7 mm thickness.

(4) Screen clamp with filter: A steel removable clamp (for easy opening and cleaning filter). Welded opening outside filter body was made to fasten rubber membrane with filter body during filter operation.

Calculation of the dirtiness index and filtration efficiency. (Van Niekerk, 2006)

$F = 6.32 \times 10^{-3} \times \mu m^{2.1}$ (for 120 mesh screen size)

Where: F: Screen factor and µm: Screen size, micron.

$$\text{Dirtiness index} = \frac{1}{\text{Clogging volume (Liter)}} \times \text{Screen factor}$$

$$\text{Filter efficiency} = \left(1 - \frac{\text{Dirtiness index after filter}}{\text{Dirtiness index before filter}}\right) \times 100$$

Correlation between measured and calculated data.

$$\text{Correlation } (R^2) = \frac{\sum (x - \bar{x})(y - \bar{y})}{n.\sigma_x.\sigma_y}$$ (Nigm, 1993 in Arabic).

Estimation of sediment load.

The sediment retained on the filter screen was estimated by washing, separation on blotting paper, drying, and weighing.

RESULTS AND DISCUSSION

Hydraulic characteristics of designed filter.

Fig. 4 shows the relation between flow capacity and pressure drop of both imported and designed filter. It is clear that about 29 % increase occurred in the average discharge of designed filter compared with imported type.

The relation between pressure drop and flow capacity for both imported and designed filter is expressed in two equations, shown in fig. 4 for each filter with correlation of 99 % between measured and calculated data.

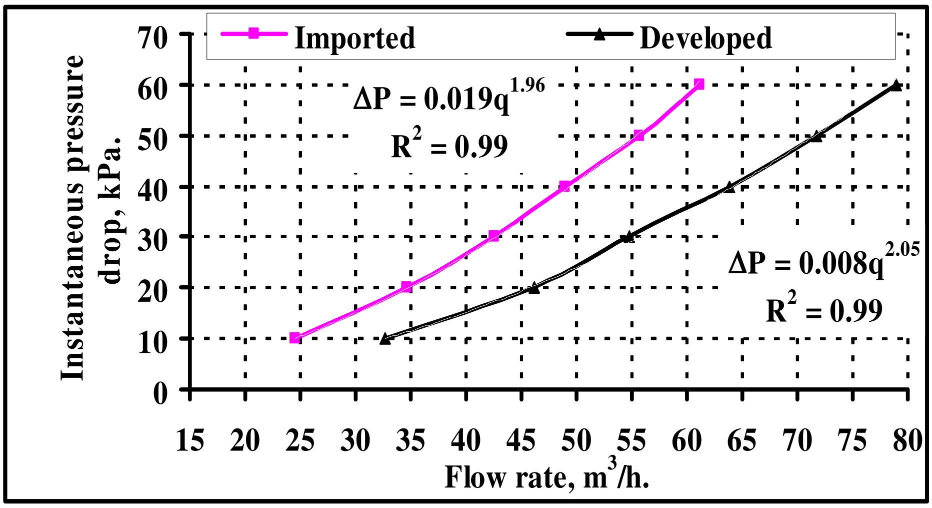

Fig. 4: Hydraulic characteristics of imported and developed filters.

Pressure drop increased from 0.1 to 0.6 bar. (10 - 60 kPa), while filter flow capacity increased from 32.7 to 78.9 m^3/h and from 24.5 to 61.2 m^3/h, for imported and designed filters respectively.

Hydraulic and engineering characteristic details for the designed screened filter are summarized in table 2. Field data of the design filter flow rate ranged from 15 to 47 m^3/h, with discharge increase of 30 % compared with imported type, and maximum operating pressure of 10 bar. In addition, some engineering details give good idea about the developed filter performance.

Filtration efficiency.

Fig. 5 reflects the effect of pressure drop on filtration efficiency without effect of sedimentation load. It was notice that the average filtration efficiency was 43 and 45 for imported and designed filters respectively. It was clear that there is no significant difference in filtration efficiency between designed and imported filters.

It is clear that, with pressure drop increased from 0.2 to 0.6 (20-60 kPa.), filter flow rate decreased from 46.2 to 25.8 m^3/h, while sedimentation load increased from 50 to 245 g and filtration efficiency increased from 45 to 69% For the developed filter as shown in figure 6.

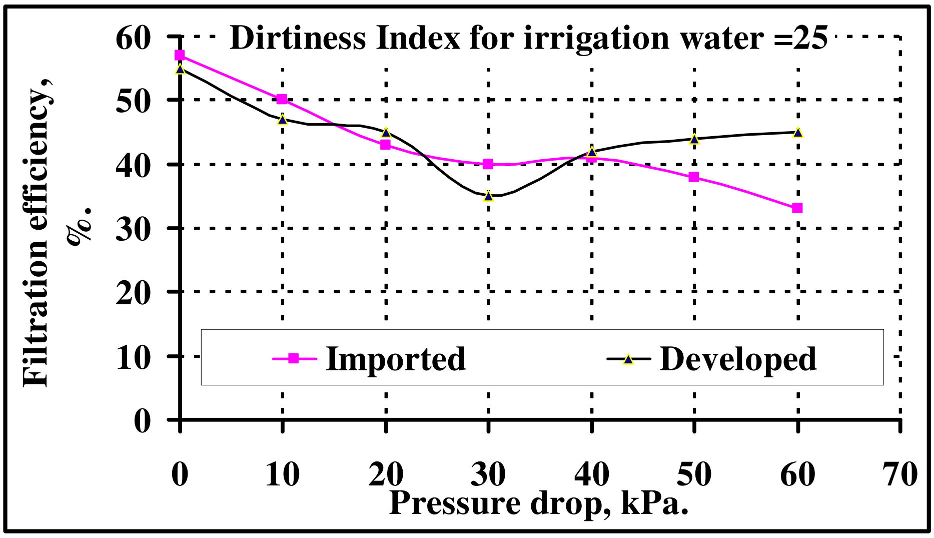

Fig. 5: Effect of pressure drop on filtration efficiency.

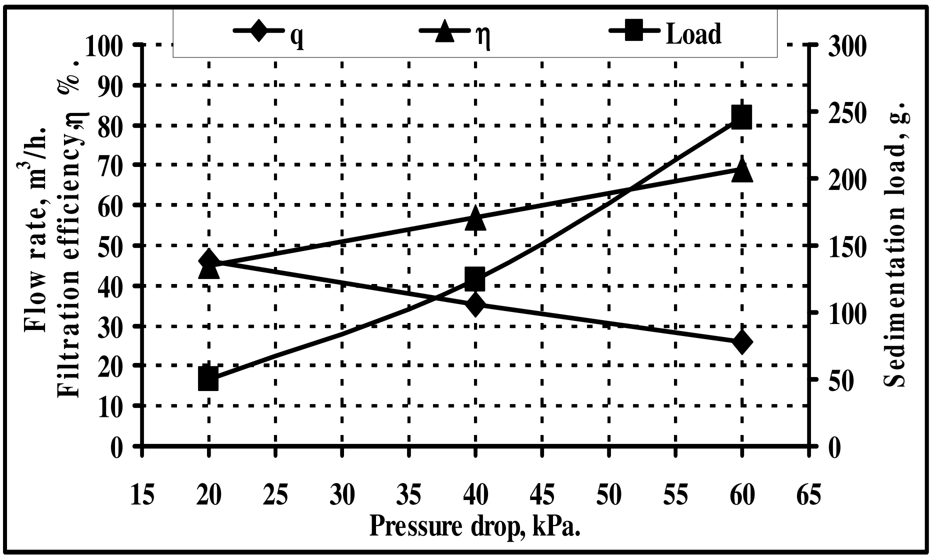

Fig. 6: Effect of pressure drop on filtration efficiency, sedimentation load, and flow rate.

Fig. 7 shows the effect of operating time on hydraulic characteristics of developed filter. The filter efficiency increased from 45 to 69 %, sedimentation load increased from 50 to 245 g, pressure drop increased from 0.2 to 0.4 bar (20 to 60 kPa.), while flow rate decreased from 46.2 to 25.8 m^3/h. and outlet pressure decreased from 2.2 to 2.6 bar (260 to 220 kPa) when operating time increased from 2 to 6 h. So the standing time between filter flushing must not exceed 5 hours.

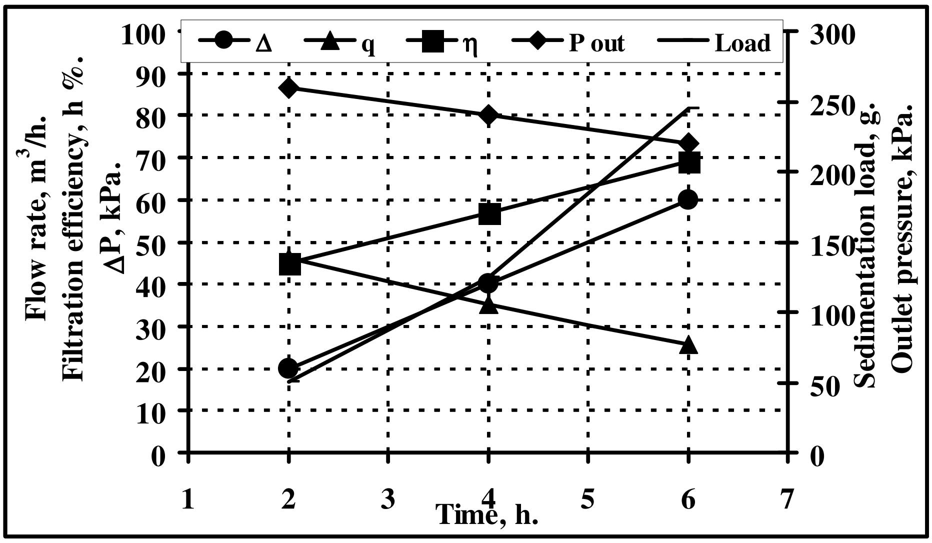

Fig. 7: Effect of time on flow rate, filtration efficiency, pressure drop sedimentation load, and outlet pressure.

Cost comparison.

Table 3 shows that the total cost required for designed and imported filters were 950 and 2065 L.E. respectively.

As a result of using developed filter in irrigation system, a saving of 117 % was obtained compared with using imported filter.

Table 2: The hydraulic and engineering characteristic details for the developed and available filters in local market.

Data	Screen filter type	
	Developed	Imported
Pressure	10 bar (1000 kPa)	10 bar (1000 kPa)
Flow rate at mesh size (0.130 mm (130 µm)	(15 - 47 m^3/h)	(12 - 33 m^3/h)
Filtration surface area	3790 cm^2	1900 cm^2
Filtration volume	6064 cm^3	2450 cm^3
Filter length	883 mm	865 mm
Filter width	258 mm	320 mm
Distance between end connections	558 cm	320 mm
Mass with flange	75 kg	13.95 kg
Construction materials	Steel	Reinforced Polyamide

Table 3: Cost details and comparison between designed and imported filters.

Material	Cost, L.E.*	
	Designed	Imported
Filter body	500	850
Screen	120	900
Valves	180	280
Rubber	20	35
Manufacturing	130	0
Total	950	2065

*Material cost according to local market price, 2007.

SUMMARY AND CONCLUSION

A new screen filter was designed and tested in irrigation system consisting of four main parts: (1) Filter body, (2) Screen, (3) Rubber seal and (4) Screen clamp with filter.

The advantages of the developed filter are:

(1) Innovated design to minimize emitter clogging during filter washing and cleaning, (2) Simple design and manufacturing, (3) Fabricated from available materials, (4) Reliable and easy to install and maintain in the

irrigation system and (5) High flow capacity with an economical cost compared with imported filter.

Two equations derived from curve fitting of characteristics curve can be used to get the pressure drop from clean filter flow with a good correlation of 99 %, for designed (Eq. 1) and imported (Eq. 2) filter respectively as following equations:

$$\Delta P = 0.008q^{2.05} \text{--------(1)} \qquad \Delta P = 0.0190q^{1.96} \text{ -------- (2)}$$

Where: "q" is the rate of flow, m^3 /h, "ΔP" pressure drop, kPa .

The average of filtration efficiency was 43 % and 45 % for imported and designed filter respectively.

The total cost of designed and imported filter was 950 and 2065 L.E. respectively that gave a saving of 117 % when using the designed filter in irrigation system.

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الملخص العربى

تصميم واختبار مرشح شبكى لأنظمة الرى الدقيقة

د / أحمد ماهر محمد الليثى [*]

يهدف البحث الى تصميم و إختبار مرشح شبكى بمعدل تصرف عالى لأنظمة الرى الدقيقة، و تسهيل تنفيذ وصيانة المرشح عمليا عن طريق استخدام خامات محلية بأسعار اقتصادية، بالاضافة الى تقليل إنسداد النقاطات الحادث نتيجة تسرب المياه غير النقية داخل شبكة الرى اثناء عملية غسيل شمعة المرشح، دراسة العوامل الهيدرولية والهندسية المؤثرة فى تصميمه. و تتلخص النتائج فيما يلى:

* تم الحصول على متوسطات تصرف المرشح المصمم والمستورد (12إلى33م3/ساعة) و (15إلى47م3/ساعة) على الترتيب، فى مدى إنخفاض فى الضغط يتراوح بين 0.1- 0.6 جوى (10-100 كيلوباسكال).

* وجد أن متوسط كفاءة المرشح المصمم حوالى 45 %، بينما وجد ان كفاءة المرشح المستورد حوالى 43%.

* تم توفيق معادلة رياضية لحساب انخفاض الضغط كدالة فى معدل التصرف لكل من المرشح المصمم (معادلة 1) والمستورد (معادلة 2)، والتى أظهرت معامل ارتباط جيد بنسبة 99% ، كما يلى :

$$\Delta P = 0.008q^{2.05} \text{--------(1)} \qquad \Delta P = 0.0190q^{1.96} \text{ -------- (2)}$$

حيث: " ΔP " تمثل إنخفاض الضغط بوحدات كيلو باسكال (kPa) بينما، "q" تمثل تصرف المرشح بوحدات م3/ساعة.

* يتميز المرشح المصمم بزيادة معدل التصرف عن المرشح المستورد بحولى 29%، كما يتميز تصميم المرشح بمنع مرور الرواسب الى داخل الشبكة اثناء عملية غسيل المرشح.

* يوصى بغسيل المرشح المصمم كل 5 ساعات تشغيل (وذلك تحت ظروف التجربة).

* يتميز استخدام المرشح المصمم بتوفير مقداره 117 % عن استخدام المرشح المستورد، حيث وجد أن تكاليف تصنيع أو شراء المرشح المصمم والمستورد هى 950، 2065 جنيه على الترتيب.

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