Study and Design of Inline Filter for Filtration of Irrigation and Industrial Water

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Abstract— **Water is not found in its purest from nature. It is always contaminated with physical, chemical and biological impurities. Proper filtration is of much importance to prevent low pressure diffuser like emitters from clogging. Inline filtration is a technology that has been used for portable water filtration. The inline filter is composed of a metallic body, gear crown, main drain, opening valve (backwashing), a pump for injecting clean water to the nozzles and a geared motor for rotation crown and measure and control elements running. The filtering element is a special screen, fixed to the rotation crown, for filtering all kinds of dirt particles, with a hydrodynamic profile that provides low head loss and reduces turbulences, reduces head losses and avoid dirt particles accumulation. All the materials are top-quality, in all the mechanic elements that are in contact with water it is used stainless steel or similar. The filter body is made of carbon steel. The mechanic elements are in the "clean water" side (water under the screen) in such a way that no foreign object can affect its performing or deterioration. Inline filters fit directly to the pipe by means of flanges, as it was one more element of the pipe. Only the electric and control elements require installation. It is a self-backwashing automatic filter that has minimum maintenance and low consumption. Water goes through the rotative screen and all the dirt particles bigger than the screen holes get filtered. When the default pressure differential, backwashing starts, this is made area by area, collecting waste materials to be expelled to the exterior. The backwashing cycle starts when the default differential pressure is detected on both sides of the screen. At that moment, filtration process is completed.**

***Index Terms*— Filtration, Automatic flushing mechanism, Head loss, less space require for installation.**

I. INTRODUCTION

Water is not found in its purest from nature. It is always contaminated with physical, chemical and biological impurities. Proper filtration is of much importance to prevent low pressure diffuser like emitters from clogging. This filters are used for filtration of irrigation, municipal, industrial water. Water filtration systems includes screen filters, disc filters, Self-cleaning filters, microfiber self-cleaning filters and Inline filters.

This filters are work as manual, semi-automatic and fully automatic and filters composed of polymeric and/or steel materials. All type of filters working principle are same like that impure water is enters into inlet port of filter then as per type of filtration process water is clean and this clean water is pass through outlet of filter. When the default pressure differential, backwashing starts, this is made area by area, collecting waste materials to be expelled to the exterior. The backwashing cycle starts when the default differential pressure is detected on both sides of the screen. PD sends signal to crown gear motor then gear motor operates, at the same time back flushing valves opens as gear motor operates. It drives pinion and hence element rotate slowly one rotation in 1 minute then as element rotates nozzles sprays water on element at high pressure so that total element can clean in 1 minute operation through nozzle spraying. As the cycle completed suddenly closes the back flush valve and crown gear motor operation. At that moment, filtration process is completed.

The main objective of this project is reducing installation space of filter and reducing construction material by 30% because increasing energy demand is the main problem linked with the adoption of more efficient irrigation techniques, particularly microirrigation. In microirrigation systems important pressure losses and therefore energy consumption, occur at the filters, which are a key component in preventing emitter clogging. In this project have shown that reducing filter size and reducing construction material by 30% but keeping the original pressure losses. This work shows the usefulness for assessing design strategies that could improve the sustainability of water filter.

The second objective of project is working of inline filter has fully automated. An automatic self-cleaning filter is a semi continuous machine operated for the removal of particles from a fluid. Technically, a distributor driven by a hydraulic motor rotates at regular intervals to feed the slurry to the inlet chambers of O segmented elements vertically stacked over the distributor and back-flushes the first chamber. In this work a practical computationally-affordable model has been developed to describe the distribution of flow rate in the different sectors of a mesh type element and to demonstrate the effect of parameters, such as backflushing time or pollution concentration, accounting for particle clogging and periodic operation conditions for perfect and imperfect efficiency of the cleaning by back-flushing. The key results are the prediction of the time of clogging, as well as a numerical tool to optimize critical backflushing time then clean the element.

II. METHOD OF OPERATION

Wherever Times The filter is composed of a metallic body, gear crown, main drain, backwashing valve, a pump for injecting clean water to the nozzles and a geared motor for rotation crown and measure and control elements running. The filtering element is a special screen, fixed to the rotation crown, for filtering all kinds of dirt particles, with a hydrodynamic profile that provides low head loss and reduces turbulences, reduces head losses and avoid dirt particles accumulation. All the materials are top-quality, in all the mechanic elements that are in contact with water it is used stainless steel or similar. The filter body is made of carbon steel. The mechanic elements are in the clean water side in such a way that no foreign object can affect its performing or deterioration. Inline filters fit directly to the pipe by means of flanges, as it was one more element of the pipe. Only the electric and control elements require installation. It is a self-backwashing automatic filter that has minimum maintenance and low consumption.

Water goes through the rotative screen and all the dirt particles bigger than the screen holes get filtered. When the default pressure differential, backwashing starts, this is made area by area, collecting waste materials to be expelled to the exterior. The backwashing cycle starts when the default differential pressure is detected on both sides of the screen. At that moment, the crown starts spinning until an area is placed just in the backwashing chamber and then the backwashing valve is opened and the pump for water is started for water flooding through the nozzles, from the clean water screen side. A screen exhaustive backwashing is obtained by means of these nozzles. The backwashing valve stays open during the backwashing pre-set time and then it closes. The crown moves on to the following area and the opening and closing the backwashing valve and the water flooding pump cycle starts again. When the sector is placed in the backwash chamber, this remains watertight due to the nylon bristles, for this reason, when the backwashing valve is opened, water flows through the filtration screen in the opposite sense than the filtration process which means an important saving in backwashing water consumption.

An electronic system protects mechanically the equipment. It is composed of an electronic torque limiter, a progressive starting system and a crown position electronic control. In the case that any foreign object blocks the screen rotation, the system inverts the rotation alternatively until the foreign object is removed. In case it is too big, it will be extracted manually. An alarm signal will turn on if any system failure occurs.

When water flows through the filter, the dirt particles that are bigger than the filtration degree get retained on the screen. These particles produce an increase on the differential pressure. If this differential is not larger than 0.8 m.c.a, the filter backwashes according to the default time interval (8 hours, variable). If the scale 0.8 m.c.a. is not exceeded, the differential pressure system detects the same one and the backwashing cycle starts.

Inline filter has only a mobile piece and it is accessible from outside. The rest of the mobile pieces like engines and external valves are easily accessible. The rest of the maintenance is based on visual inspections and greasing. The necessary spare pieces change according to the dust quantity, sand and number of backwashing cycles.

The screen is composed of quality electrowelded angle frames arranged 90º between the longitudinal and the transversal angle frames. Screen size is 100 microns and material of screen is stainless steel 304. The particles retention angle frames are rhombus-shaped so that water flow is possible (decrease head loss). This rhombus shape makes screen backwashing easier by means of reducing backwashing time.

III. BACKWASHING CYCLE

The main purpose of backwash is to cleaning the filter element. When outlet pressure decreases due to more impurities like mud, sewage, etc. Then pressure differential controller detects drop between inlet and outlet port. Backwashing time cycle is 80 seconds, from which, during 54 seconds the backwashing valve is open.

PD sends signal to crown gear motor then gear motor operates, at the same time back flushing valves opens as gear motor operates. It drives pinion and hence element rotate slowly one rotation in 1 minute then as element rotates nozzles sprays water on element at high pressure so that total element can clean in 1 minute operation through nozzle spraying. As the cycle completed suddenly closes the back flush valve and crown gear motor operation.

IV. DESIGN FILTER PARTS

Design the filter parts after referring technical data and requirement as shown in following table 1.

Table 1: List of Filter Parts

Bill of Material			
Sr. No.	**Part Description**	**MOC**	**Make/Standard**
1	Gear Motor		SEW Eurodrive
2	Water Pump		Calpeda India
3	Butterfly Valve		Belimo Actuators
4	Filter Body	MS Class B	ASME/ANSI B36.19 B36.10
5	Manhole	MS Class B	ASME/ANSI B36.19 B36.10
6	Gear Motor Port	MS Class B	ASME/ANSI B36.19 B36.10
7	Backwashing Port	MS Class B	ASME/ANSI B36.19 B36.10
8	Nozzle Port	MS Class B	ASME/ANSI B36.19 B36.10

9	Flanges	MS Class B	BS 10 Table E
10	Bearing		SKF Bearing
11	Element	SS 304	
12	Mesh	SS 304	
13	Element Supporter	SS 304	
14	Bevel Gear	SS 304	
15	Shaft	Plain Carbon Steel 40C8	
16	Nozzles	Brass	
17	Nozzle Rod	MS Class B	
18	Filter Stand	MS Class B	
19	Controller	Standard	

1. Gear Motor

The flexibility of the geared motor means it can be used in a wide range of applications in all aspects of daily life. Sometimes, it can even be used where you wouldn't imagine a geared motor would be responsible for the movement of a machine. In this filter screen element is removed debris or mud in rotational motion by using power of gear motor.

Gear motor has shown in figure 1, which is connected to pinion of shaft and it is fitted on the port of gear motor at upper side of filter. Outlet pressure is decreases than inlet pressure then backwashing cycle is start that time screen element is rotates with power of this motor by using bevel gear mechanism.

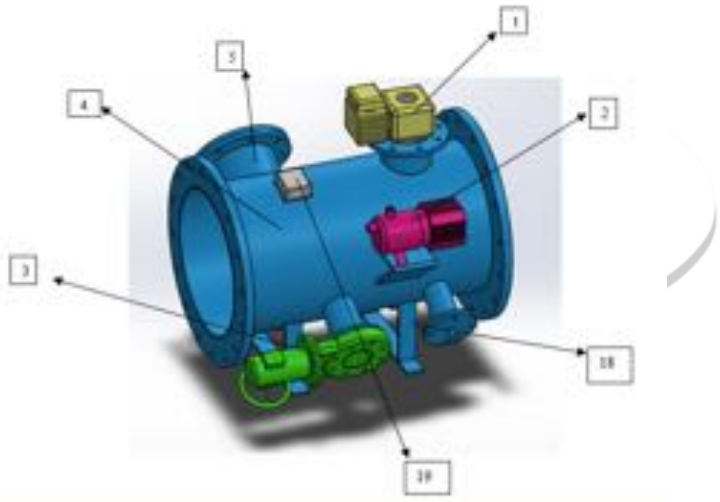

Fig 01: Inline Filter Parts

2. Water Pump

A mechanical device used to transport fluids by the conversion of rotational kinetic energy to the hydrodynamic energy of the fluid flow. Centrifugal pumps are the most popular pump used and are the chief pump type in the class of kinetic pumps. Used in various sectors such as: agriculture, power generation plants, municipal, industries, domestic purposes, etc. and medium Common uses include as air, water, sewage, petroleum, petrochemical pumping.

Fig 02: Water Pump

Pump has converts mechanical energy from a motor to energy of a moving fluid. Centrifugal pumps include a shaft driven impeller that rotates inside a casing. Energy conversion is due to the outward force that curved impeller blades impart on the fluid. When the impeller rotates, the fluid surrounding it also rotates. This imparts centrifugal force to the water

particles, and water moves out. Pressure and kinetic energy of the fluid rises due to rotational mechanical energy transferred to the fluid.

In this filter pump has used for the spray the water on the element. Debris or mud is catch on the screen element then after decreasing outlet pressure backwashing cycle is start that time pump is used for spraying the water on element for removing mud or debris. Filtering water media is suck from the outlet of filter and it is control by controller unit. As shown in figure 1 Pump has fitted on the filter body. Head of pump is 68 to 22m and discharge is 5 to 25 m^3/hr. and material of impeller and casing is SS304 because water application.

3. Butterfly Valve

Butterfly fly valve used for the removed debris from the filter at the time of backwashing process. Outlet pressure of water is decreases than inlet pressure of water then pressure difference switch is providing signal to butterfly valve. Then butterfly valve is opened and debris is removed from backwashing port. Outlet pressure is increases due to debris or mud is removed in filter then again butterfly valve is closed.

Butterfly valve has installed on backwashing port as shown in figure 1 and selecting model specification as size of butterfly valve is 100 MM, Pressure rating is PN 10and medium temperature has between -20 to 120^0, Leakage is not acceptable, Nominal voltage is 230 V, Running time for open and close is 150 Sec for 90^0 opening.

Butterfly valve has a body, a resilient seat, a butterfly disc and an actuator. The resilient seat is under compression when it is mounted in the valve body, thus making a seal around the periphery of the disc and at both the upper and lower points where the stem passes through the seat. Packing is provided to form a positive seal around the stem for added protection in case the seal formed by the seat becomes damaged. To close or open a butterfly valve, the actuator is turned only one-quarter turn to rotate the disc from 0 to 90◦. Actuators used on butterfly valves vary based on the application and size of the valve. A simple handle oriented in the same direction of the metal disc (to indicate valve position) is common. Some larger butterfly valves may have a hand wheel that operates through a gearing arrangement to operate the valve. This method is used especially where space limitation prevents the use of a long handle. Actuators may also be air driven or electrically operated when used as part of an automated control system.

4) Filter Body

In this filter various sizes of pipe are used for manufacturing of inline filter. This pipes are selected as per standards ASTM A312, A358, A778, A53, A106, API 5L, ASME/ANSI B36.19 B36.10. As per objective of paper, Area of filter has same of inlet and outlet connections of pipe lines. Filter pipe is shown in figure 1.

Manhole, Gear motor port, Backwashing port, Nozzles port pipes are selected as per above standards as shown figure 1 and 2 and also all sizes of pipes are checked by PV Elite software

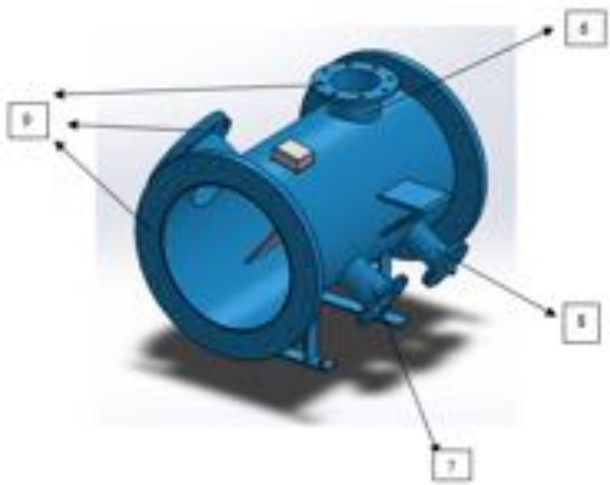

Fig 03: Inline Filter Parts

5) Flanges

Flange is selected from the standard of BS 10. British standard BS 10:1962 specification for flange and bolting for pipes, valves and fittings. This covers plain, boss, integrally cast or forged and welding neck type flanges in ten tables. Although BS 10 is obsolescent, it remains in use for the dimensions of light duty, economy stainless steel flanges in applications where corrosion resistance and/or hygiene, rather than high pressure and temperature, are the primary considerations. The following table's details applicable standard dimensions from tables D, E, F and H of BS 10.

In this filter Table E is refer for tacking dimensions of flanges. Various sizes of flanges has used for installation of filter like 20" flange for filter body, 8" flange for manhole, 8" blind flange for manhole, 6" flange for gear motor port, 4" flange for backwashing port, 3" flange for nozzles port. This all types of flanges are shown in figure 3.

6) Bearing

Bearing is a mechanical element that permits relative motion between two parts, such as the shaft and the housing, with minimum friction. Element of filter is mounted on the shaft and this shaft is connected to the element supporter. Bearing

is fix in the element supporter as shown in figure 4. As per calculations of forces ball bearing 6210 is used for this applications.

7) Element and Element supporter

Element is used for removed debris or mud from the filter through backwashing port. 100 No Mesh is fitted on element of filter. element has design as per application of filtration process as shown figure 4. Element is rotate with bevel gear mechanism. Material of element has SS 304 because it is continuously work in water. Element supporter is welded in inner body of filter. It is support to element for rotary motion. Material of supporter has MS class B.

8) Mesh

Micron is the measure of length most frequently used to describe tiny particle size. The term micron is actually a commonly used shorthand for micrometer. Mesh size is the mesh number (a US measurement standard) and its relationship to the size of the openings in the mesh and thus the size of particles that can pass through these openings. Figuring out the mesh number is simple. All you do is count the number of openings in one linear inch of screen. This count is the mesh number. A 4 mesh screen means there are four little square openings across one inch of screen. In this filter 100 no mesh is used for filtration as shown in figure 4. A 100 mesh screen has 100 openings per inch, and so on. Mesh is manufacture as per standard ASTM E11-17, ISO 565-1990 and ISO 3310-1:2016.

9) Bevel Gear Mechanism

A gear is a rotating machine part having cut teeth, which mesh with another toothed part to transmit torque. Gear device can change the speed, torque and direction of power source. In this filter bevel gear mechanism is used for transmit the power to element because shaft angle is 90^0.

Gear size, pressure angle, number of teeth. We introduce the basic terminology, measurement, and relational expressions necessary to understand basic gear technology. Using ISO (International Organization for Standardization) guidelines, Module Size is designated as the unit representing gear tooth-sizes.

In this inline filter water is filter through element by using mesh, this element is rotate due to arrangement of bevel gear. Straight bevel gear set is combined a 25 tooth bevel and a 161 tooth gear with a module of 3 mm and pressure angle is 20^0. This arrangement of bevel gear as shown in figure 4 and also material of bevel gear has SS 304.

10) Shaft

Shaft has assemble in element supporter and also element, rotation of element by using this shaft as shown in figure 4. After calculations of forces shaft diameter is taking 50 MM. and material of shaft is plain carbon steel 40C8.

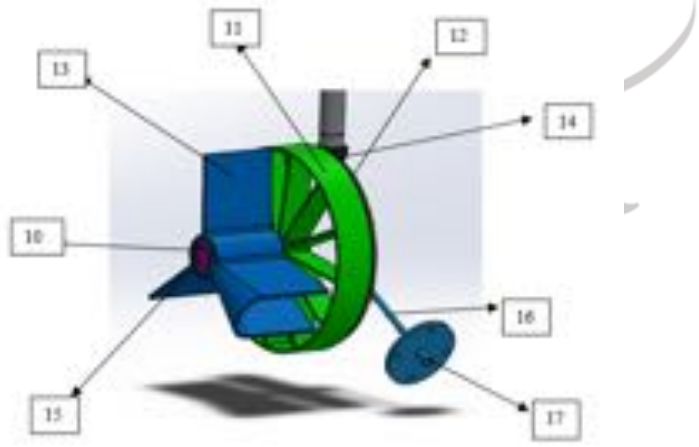

Fig 04: Inline Filter Parts

11) Nozzles and Nozzle Rod

The debris or mud is catch on the screen element, which debris or mud is removed from element by using water spraying process. This water is spraying by using the nozzles and nozzle rod. Nozzle rod has connected to outlet of pump, after starting of backwashing cycle, Nozzles are start to spraying water. Material of nozzles is brass and nozzle rod is MS respectively. This arrangement of nozzles and nozzles rod as shown is figure 4.

12) Controller

The filtration process is work fully automated by using the controller. Gear motor, butterfly valve and pump are connected to controller and also this all operates automatically through controller programming. At time of filtration process as water is passed through inlet to outlet of filter then debris and mud is catch on screen filter that time outlet pressure of filter is decreases than inlet filter. Pressure difference indicating device is activate after decreasing outlet pressure, then pressure indicating device is transfer signal to controller. This signal has transfer through controller to butterfly valve and pump, that time backwashing cycle is start. Butterfly valve and pump has start, water is spraying on element and debris or mud is removed from element and this debris and mud is removed from filter by backwashing port. Outlet pressure is increases after removing

debris or mud from filter then after leveling of pressure difference, backwashing cycle is stop also close the butterfly valve and pump through controller.
All parts are design by reference to above information and Completed inline filter is shown in figure 5.

Fig 05: Assembly of Inline Filter

V. ACKNOWLEDGEMENT

The design work was completed by support Jain Irrigation System Limited and Mechanical department of Sandip University. Jain Irrigation and Sandip University have honest appreciation for design Inline Filter.

VI. CONCLUSION

We presented an inline filter for filtration of irrigation and industrial water. The model has work automatically and also self backwashing system is established in this filter. Backwashing is fix for flushing the debris or mud from filter. Clogging scenario as a function of particle concentration and backflushing time were also investigated. The inline filter is simply modified and it is also easy for maintenance. Filter is design for decreases the area of model and also new filtration solution is found. Other filters are install in some space but this filter is not required any other space for installation because area of filter same as pipe line diameter. Inline filter in second feature is develop as it is work fully automatically. Because all commands are control by controller. Hence it easy to operate and smoothly in operation aiming at optimizing the operation of the automatic filter and/or optimizing its design.

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