Investigation of Disc Filter Cleaning in Drip Irrigation

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Abstract - Disc filter cleaning in drip irrigation is the focus of this research. The disc filter cleans the borewell water containing sand, mud, micro particles which would be larger than 24 microns. The major problem faced by farmers in drip irrigation is to monitor and clean the disc filter. The clogging may occur due to settlement of particles between the discs. To overcome this problem a solution has been derived, by using the reverse flow process over the disc filter. It includes four solenoid valves and PCB. Printed circuit board transmit the signals to the solenoid valves. It provides mechanical support and electrical connections for electronic components. In mobile application, direction of flow in normal or reverse flow. In the pressure gauge the pressure difference is more than 0.5 gauge the reverse flow will occur. By the use of MIT application mobile app is created. In the prototype manually enter the value of inlet and outlet pressure and then the process will occur if it is reverse or not. By using this method, the dust particles that are sedimented in the disc filter can be cleaned. The reverse flow process of cleaning the disc filter has been investigated practically and by using prototype setup.

Keywords – Drip Irrigation, Disc Filter, Surface Irrigation, Filtering Efficiency, Particles.

I. INTRODUCTION

In applications where deposited solids must be removed by a pressurised water flow, automatic self-cleaning filters have been in use for decades. They are mostly utilised by hydraulic systems in big ships and deep sea industrial systems for oil platforms. The average 24 hour day is possible for marine engines. The important point that the engine and hydraulic system work efficiently and requires a minimum of break. For automotive engines, Oil changes are a routine task, but for marine engines, the operation-Oilers face hardship, prospect of oil spill to settle costs associated with the type of motor oil used and changes. Due to this, the compact and to remove particles from the lubricating fluid in ship diesel engines, many of the largest businesses in the world have developed automatic Self-cleaning filters to be used on large marine engines. It is so expensive for medium scale farms. To clean the disc filter manually is more time consuming. To overcome this process by reverse flow process using 4 solenoid valves and PCB board. There is an app to control all the solenoid valves.

The different types of irrigation and its applications

Surface Irrigation
Surface irrigation involves applying water to the soil's surface and letting gravity carry it through the area. Furrow irrigation, border irrigation, and flood irrigation are some of the methods used in it. In flat or gradually sloping terrain, surface irrigation is frequently employed for large-scale farming.

Sprinkler Irrigation
Sprinkler irrigation includes misting or spraying water over the ground to simulate rain. Sprinklers are used to apply water to crops; they can be fixed to above-ground pipes or mobile systems. This approach is adaptable, appropriate for a variety of crops and landscapes, and it may be automated for effective water distribution.

Drip Irrigation
Water is delivered precisely and effectively to the root zone of plants via drip irrigation, which also reduces water loss due to evaporation and runoff. It entails a system of tubes or emitters that disperse water evenly and gently close to the plants.

Subsurface Irrigation

Water is provided directly to plant roots by subsurface irrigation, which takes place below the soil's surface. Water is released at the plant root level using underground perforated pipes or tubes. Subsurface irrigation is effective and suitable for some land types because it can minimize weed growth and water loss due to evaporation. The above-mentioned irrigation are most commonly used for agriculture except surface irrigation, all types of irrigation using the disc filter for filtration.

The review study clarifies both the technical and non-technical facts of the drip irrigation system, a type of micro irrigation system. It is incredibly capable of preserving nutrients and water. The major goals are to decrease water shortage around the root zone and lower evaporation. The assessment of the yield and water productivity of cotton, pomegranate, and clementine cultivars, among other crops, is covered. The impact of drip irrigation on production, economic variables, fertilisation methods, and irrigation timing is investigated. The use of drip irrigation on a variety of cash crops, including cotton, jute, groundnuts, etc., in China, India, Japan, North Xinjiang, European nations, etc., is described [1,2]. Designs for spinning membrane disc filters are investigated using computational fluid dynamics. The issue of water leaking through a revolving membrane disc in a pressurised container has been simulated. The revolution of the disc causes a recirculating flow pattern of the fluid inside the vessel, just like a non-porous disc. As a result, a section of the membrane is exposed to a reversed flow of permeate, which lowers membrane area effectiveness and may harm the membrane. A Selection of the operating circumstances and design specifications can prevent this "back pressure" problem. Increased feed rate or lower disc diameter might lessen the tendency for "back pressure" [3].

In agriculture, this essay discusses how to manage sprayer pressure and application rate. Using pre-made maps, precision farming determines the flow rate and regulates the pressure on sprayer booms. The kind of nozzle and operating pressure on the sprayer boom both have an impact on the droplet size-related application quality during spraying. However with conventional nozzles, the flow cannot be altered without simultaneously changing the pressure since the pressure relies on the flow. To provide the necessary flow, it is advised to activate a number of solenoid valves in a determined order [4, 5].

M. Meirles, An automatic self-cleaning filter removes particles from a fluid in a semi-continuous manner. In order to move the solid particle to the inlet chambers of N segmented elements that are arranged horizontally over the distributor, a distributor that is controlled by a hydraulic motor rotates on a regular basis and backflushes the final chamber. to test the effect of parameters like reverse process or pollution concentration and to describe the flow rate distribution in a disc-type element's various sectors [6]. the sedimented particles as well as the operating conditions for both perfect and imperfect back-flushing cleaning efficiency. The key outcomes are the expectation of the hour of stopping up, as well as a mathematical device to make as viable back-flushing time and contamination focus.[8]

Christophe A, research designs for rotating membrane disc filters, computational fluid dynamics is applied. For the scenario where water passes through a membrane disc that is rotating in a pressured enclosure, simulations have been done. Newtonian, incompressible, non-fouling, and isothermal assumptions were made about the water. For the turbulent flow in the vessel enclosing the revolving disc, a "model" was utilized. The rotation of the membrane disc causes the fluid inside the vessel to flow in a pattern similar to a non-porous disc. A localized rise in the permeate side pressure above the feed side pressure due to the centrifugal force acting on the permeate might, however, result in a negative transmembrane pressure. As a result, some of the membrane is exposed to reversed permeate flow, which decreases efficacy. [9]

Kuo effectiveness, six different spinning disc types were created and positioned above the filter membrane in a filter chamber. Fluent software was used to model 6 three-dimensional fluid flow fields in the filter chamber for different spinning discs, disc rotation speeds, and feed flow rates. A finite volume approach and the renormalization-group k-model were used to numerically solve the equations of continuity and momentum balancing. The simulated findings showed that rotation speed and disc structure were the most crucial variables. -Jen Hwang, Using computational fluid dynamics, it was possible to analyse how a rotating-disk dynamic filter's rotating-disk structure—including the size and number of its vanes—affected the distribution of fluid velocity and shear stress acting on the membrane surface (CFD). [10]

In this present work, a prototype was developed for examination of reverse flow inside the tap filter using MIT App Inventor. The application controls the solenoid valves through the relay switch for achieving the reverse flow process. The reverse flow process of cleaning the disc filter was validated using field survey.

II. LAYOUT OF DISC FILTER CLEANING PROCESS

The disc filter cleaning process would work on the back flush mechanism. During the normal process the gate valve 1 and valve 3 will be opened and water will flow through the disc filter as shown in the diagram **Fig 1**, and during the normal process the gate valve 2 and valve 4 will be closed.

When water flows through the disc filter, the disc filter will filter the water which contains the dust particles like (mud, sand and other micro particles), the dust particles will settle down between the layers of the disc filter. Due to these dust particles the pressure at inlet of the filter is differ with pressure at outlet. When the pressure difference between the inlet and the outlet of the disc filter is more than 0.5 gauge pressure the system is automated to flow in reverse direction. During reverse flow the gate valve 1 and valve 3 will be closed automatically and at the same time the gate valve 2 and

valve 4 will be opened and water will flow through the disc filter in reverse direction with the same pressure. Due to this pressure the dust particles that are settled in the disc filter layer will come out with water flow as shown in the diagram **Fig 2**.

This overall process will be controlled by the help of Arduino and relay switches. The pressure sensor will give the information to the Arduino when the pressure will differ in the disc filter and the Arduino will give the information to the relay switch, the relay switch will control the solenoid valve (close and open operation).

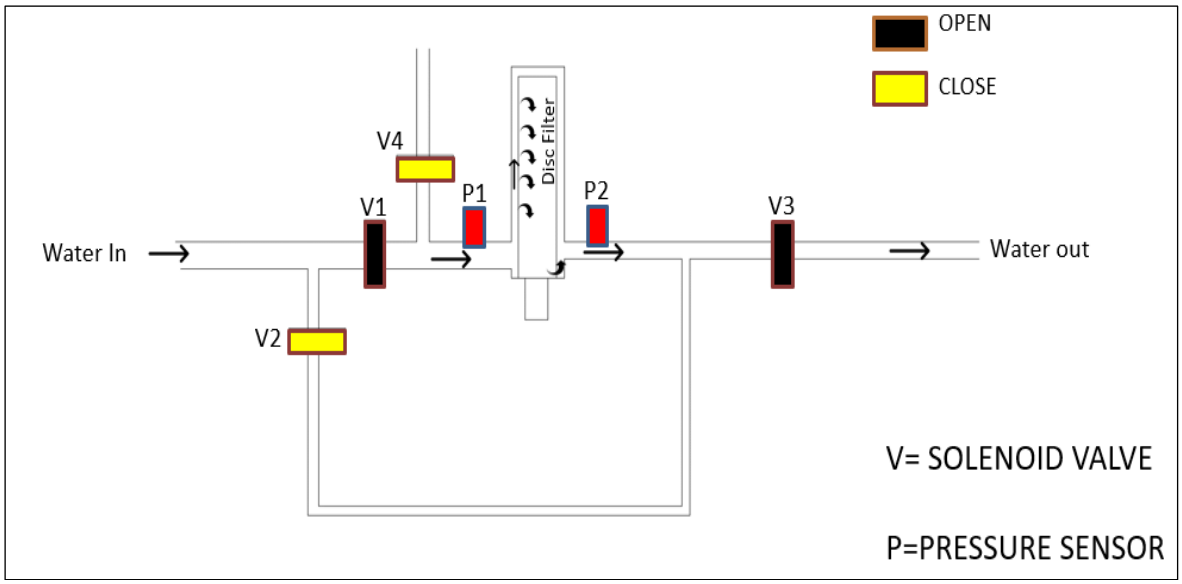

Fig 1. Normal Flow Process Block Diagram.

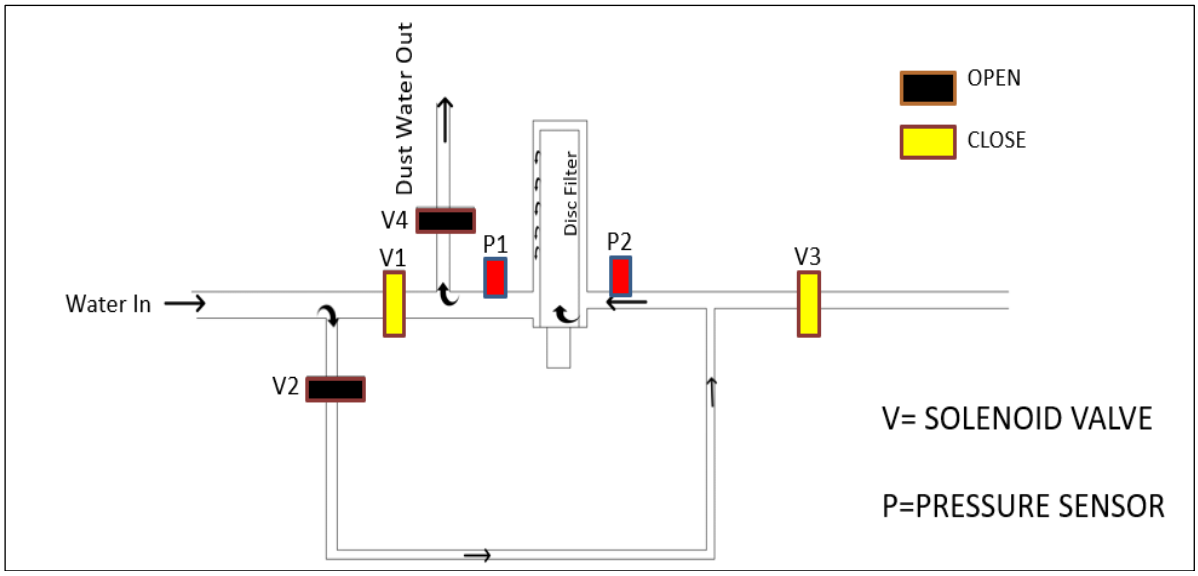

Fig 2. Reverse Flow Process Block Diagram.

There is an extra solenoid valve to control the motor power on/off and to separate the field into several parts to flow the water efficiently by controlling each field by separating the solenoid valves.

III. COMPONENTS

Disc filter

A disc filter is a type of water filter used for irrigation, however unlike other filters, its filter cartridge is formed of several plastic discs that are stacked one on top of the other like poker chips. Little grooves or bumps cover the whole surface of each disc. The holes in the discs (or rings) create a hollow cylinder at the centre of the stack. The contaminants are left behind as the water travels through the narrow spaces between them.

In general, the size of the smallest filtered particle is used to evaluate the filtration quality in microns. The usual range is 400 microns for the finest level of filtration and 25 microns for the finest level. Sometimes the equivalent mesh size of a similar screen filter is used to indicate the filtration grade. Mesh sizes typically vary from 40 to 600. The highest degree of filtration when using mesh sizes is 600, while 40 is the coarsest. Disc filters come in a variety of sizes, from compact units with a 3/4" inlet and exit used for drip irrigation systems in landscaping to very large banks of numerous filters folded together for filtering large volumes of water for agricultural and industrial applications. Mostly the polypropylene material is used for disc filter in drip irrigation system.

Fig 3. Disc Filter Used in Drip Irrigation.

Characteristic of the polypropylene material
Chemical Resistance
Polypropylene is highly resistant to a variety of chemicals, making it ideal for a variety of applications involving diverse liquids and gases.

Excellent filtering Efficiency
Nylon has a porous structure that makes for efficient filtering. To meet diverse filtration needs, the material can be produced with a variety of pore sizes. It effectively removes contaminants, solid particles, and particulate matter from liquids or gases moving through the disc filter.

Easy to Clean
Polypropylene discs are normally made to be readily cleaned. To eliminate accumulated sediments or debris from the filter medium and restore filtration effectiveness without harming the material, they can be washed or back-flushed.

Economical
In comparison to certain other filtration media, polypropylene is a comparatively cheap material. It is a common option for disc filters in many industries due to its affordability and advantageous filtration qualities.

Specification
In the research 3 inch disc filter is validated in field work. The specifications of the disc filter are shown in **Table 1.**

Table 1. Specification of Disc Filter

S.No	Specifications	Size / Capacity
1	Diameter	3 inch
2	Filter grade	120 mesh
3	Maximum Flow rate	28m^3/h

4	Maximum working pressure	6kg/cm²

Solenoid valves

It is the control component in fluidics that is most often employed. They must turn off, release, dosage, distribute, or blend fluids as shown in **Fig 3**. By surrounding an armature, or moving centre, with an electromagnetic field. The armature is moved by the electromagnetic field, and as it does so, valves or switches are opened and closed, transforming electrical energy into mechanical motion and power. These solenoids come in a variety of shapes and sizes, including AC Laminated Solenoid, DC C-Frame Solenoid, DC D-Frame Solenoid, Linear Solenoid, Rotary Solenoid, and Tubular Solenoid. **Fig 4** shows 12 V Solenoid Valve.

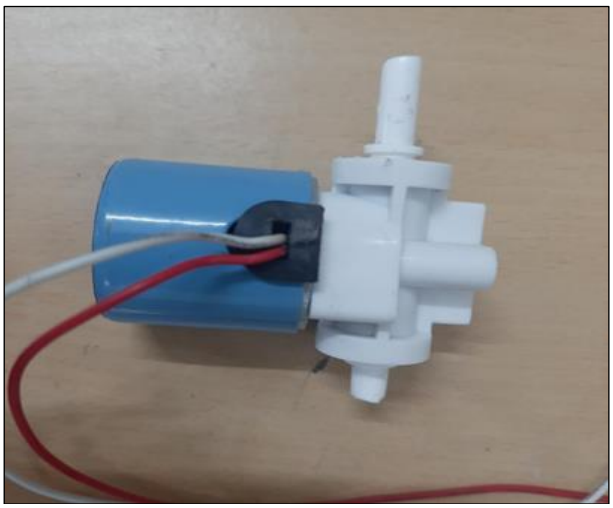

Fig 4. 12 V Solenoid Valve.

Node MCU board

Single-board microcontrollers and microcontroller kits for the construction of digital devices using open-source hardware and software are made by the firm Arduino. A range of microprocessors and controllers are capable of being used to construct Arduino boards. Input/output (I/O) pins on the boards can link to other circuits. The Arduino programming language can be used to programme the microcontrollers. The boards feature collections of I/O (input/output) pins for digital and analogue signals that can be connected to other expansion boards. Microcontrollers can be programmed using the C and C++ programming languages. **Fig 5** shows Node MCU Board.

Fig 5. Node MCU Board.

Relay switch

An electronic gadget that relies on electromagnetic induction is a relay switch. Relay switches are used in situations where physically establishing or breaking an electronic circuit would be impractical or dangerous. For instance, all of the large circuit breakers in power plants are managed by electrical relays, which are in turn managed by control screens. Relay can be utilised for a wide range of duties, including controlling the speed of electric motors, operating industrial motor starters, and determining whether an object is nearby so that a projector screen, door, or alarm can be turned on. .

The some other uses of relay also have the advantage of they will protect your circuit from high voltages. **Fig 6** shows 5V relay switch.

Fig 6. 5V Relay Switch.

Printed circuit board (PCB)

A circuit board, also known as a PC board, is made of a non-conductive substance that has been painted or etched with conductor lines. A functional circuit or assembly is created by connecting the symbols representing the electronic components mounted on a board as shown in **Fig 7**. The attachments in the PCB were listed as follows,

1. NodeMCU
2. Four 5V relay
3.Power connecter
4.LED
5.Diode

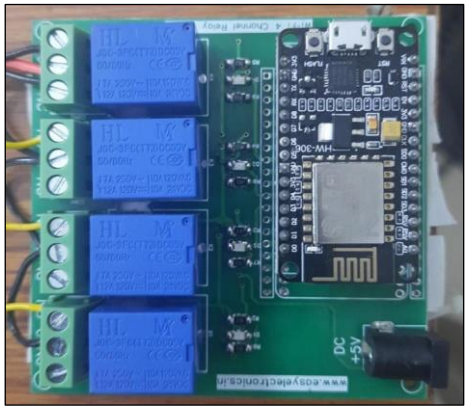

Fig 7. Printed Circuit Board.

IV. APP DEVELOPMENT

MIT APP Inventor

It is a web-based development environment that was developed by Google (MIT). It allows them to create mobile apps for two different operating systems, namely iOS and Android, which is user-friendly for beginners. On July 8, 2019, it is undergoing final beta testing. It is a dual-licensed piece of free and open-source software known as a Creative Commons Attribution Share. A graphical user interface is employed (GUI). It is very similar to the programming tool Scratch, which enables users to create mobile applications by simply dragging and dropping the built-in code (typically represented as blocks), while a Mobile Companion, while the programme that enables the app to run and debug on iOS running devices is still in the development stage. Google has invested a lot of time and effort into researching computing for education before creating the App Inventor programme. Google has also worked hard to provide online environments for building mobile applications. The application's screen is first constructed, and then it is manually modified [8]. The widgets are then inserted with the use of built-in functionalities. The widgets may be customised by the user and given certain roles. Button based mobile application used to control the system. The mobile app is made using MIT app inventor. It is a software which is useful in making lightweight applications. The app can be created using arranging the code blocks. First of all the layout of the app can be easily created in the design section using just dragging and dropping the components on the screen. As soon as the components are dragged and dropped on the screen, the code blocks for

each of the components are created in the blocks section, where the code for the app is done. **Fig 8** shows the front end designing platform in MIT AppInventor and **Fig 9** shows the back end developing platform in MIT App Inventor. Fig 10 shows the front end display for tap filter cleaning using MIT App Inventor.

The features used this app are

1. Horizontal arrangement - It is a layout, which arranges the component in a horizontal orientation.
2. Switch - This widget is similar to a button which changes the state, only when it is clicked or changed.
3. Button - It is a widget which changes the state and returns to its original state after clicking.
4. Notifier - It is a notification function when that notifier function gets executed it pushes the notification.
5. Textbox - It is to get input value to the variable.

By the use of ON OFF buttons, we can control the Arduino by sending the signal through the database (fire base).

We can check the status of the valve (ON/OFF).

When the back flow process gets started the notification will pop up.

When we enter the pressure value in the input field and press ok button it will check if both values are more than 0.5 then reverse flow gets executed.

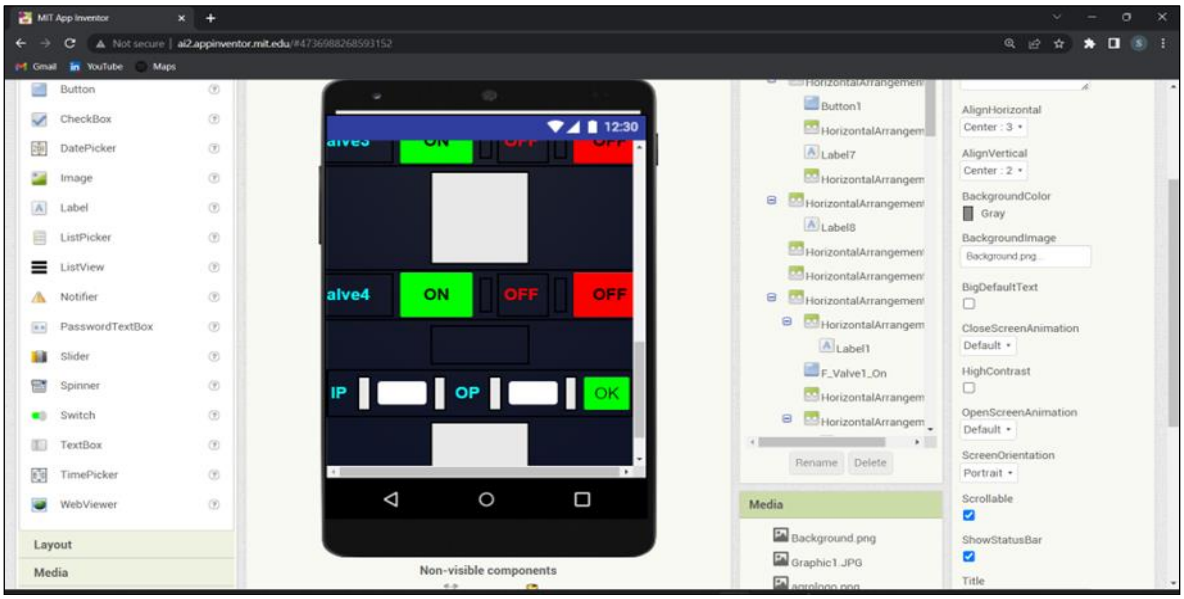

Fig 8. Front End Designing platform in MIT AppInventor.

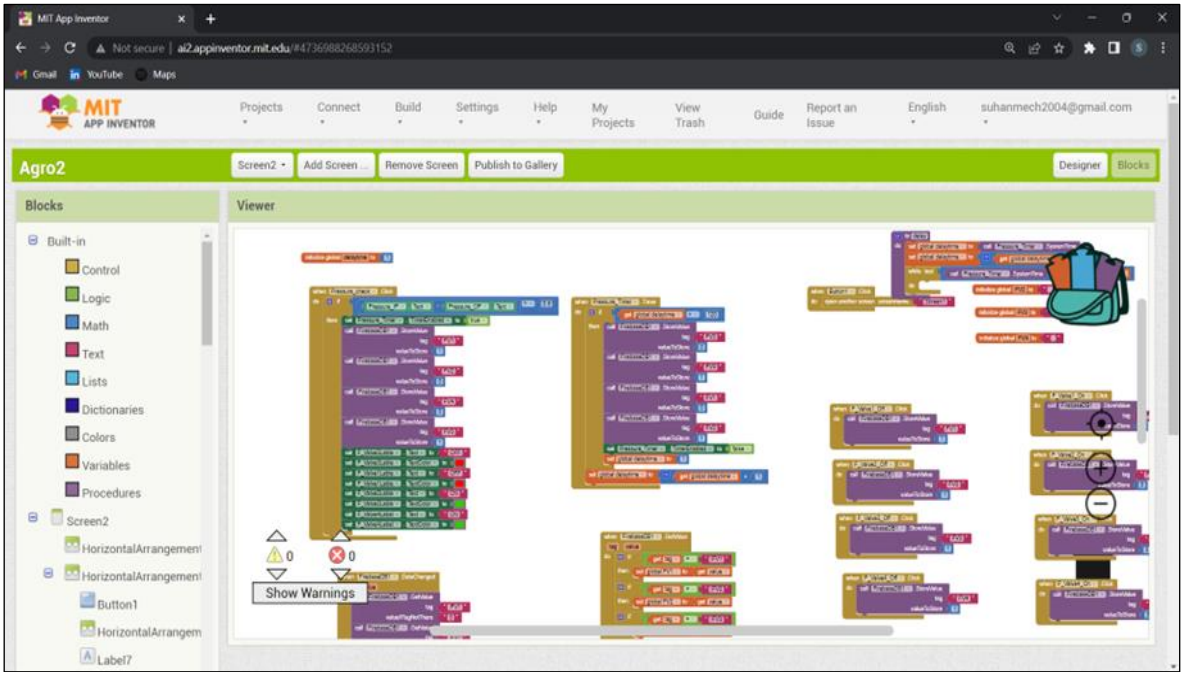

Fig 9. Back end developing platform in MIT App Inventor.

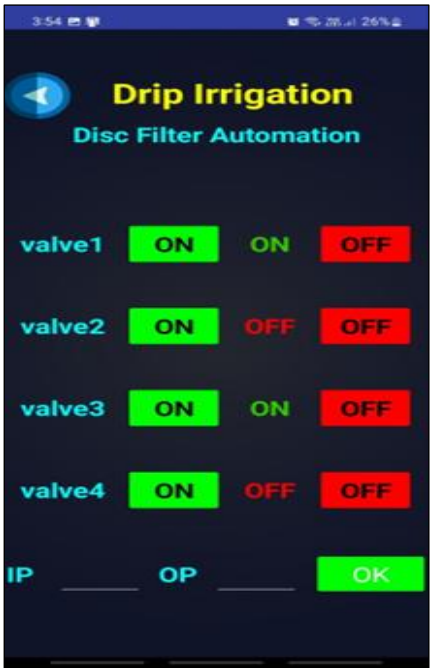

Fig 10. Front End Display for tap filter cleaning using MIT App Inventor.

Alternative App

For this research MIT App inventor is used for creating the mobile application. The MIT App inventor can be referred to with journal [7]. We can use all types of mobile app creating websites or software to create this kind of application. some example websites are BuildFire, Appy pie etc.,

V. EXPERIMENTAL VALIDATION

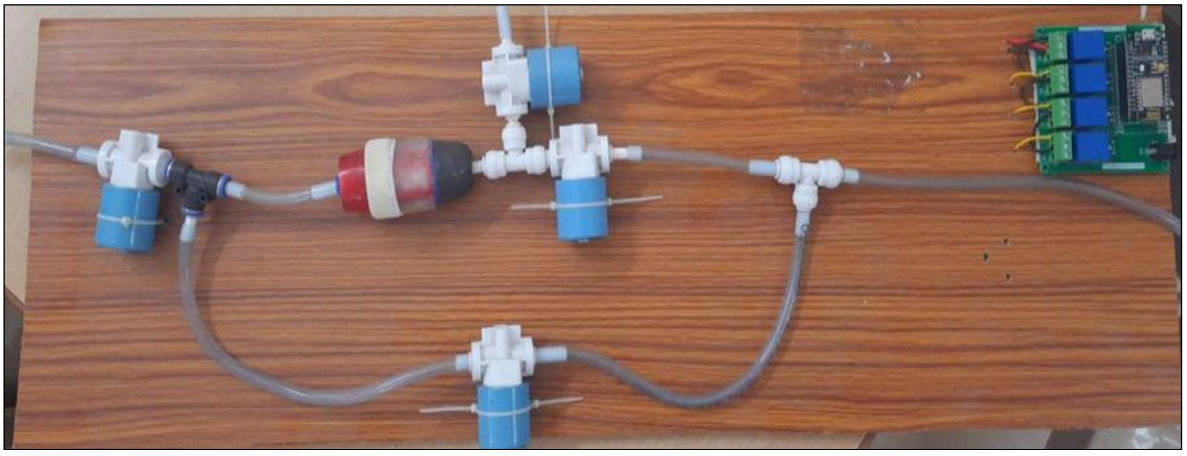

Fig 11. Prototype for reverse flow examination in the tap filter.

MIT APP validation using prototype

In the prototype all the relays and solenoid valves get working successfully. after connecting wifi to the PCB, PCB get activated and by the use of app the input pressure and output pressure is given to the app when the pressure difference more than 0.5 then automatically even valves get open and odd valves get closed then notification also get pop up. After two minutes the even valves closed and Odd valves is opened. App is working successfully. Fig 11 shows the prototype for reverse flow examination in the tap filter.

Reverse Flow process validation in field work

By use of disc filters in agricultural fields by manually noted the input pressure and output pressure of the filter. After some time there is a pressure drop in output. By dismantling the filter **Fig 12** there is a dust clog in the filter.

Fig 12. 3 inch disc filter in the field before cleaning.

Fig 13. 3 inch disc filter in the field before cleaning.

After closing the filter by manually filter is changed to pass water in reverse flow. Water gets passed through the filter for two minutes. Then after removing the filter. The dust in the filter gets cleaned **Fig 13**.

Calculation of cleaning time

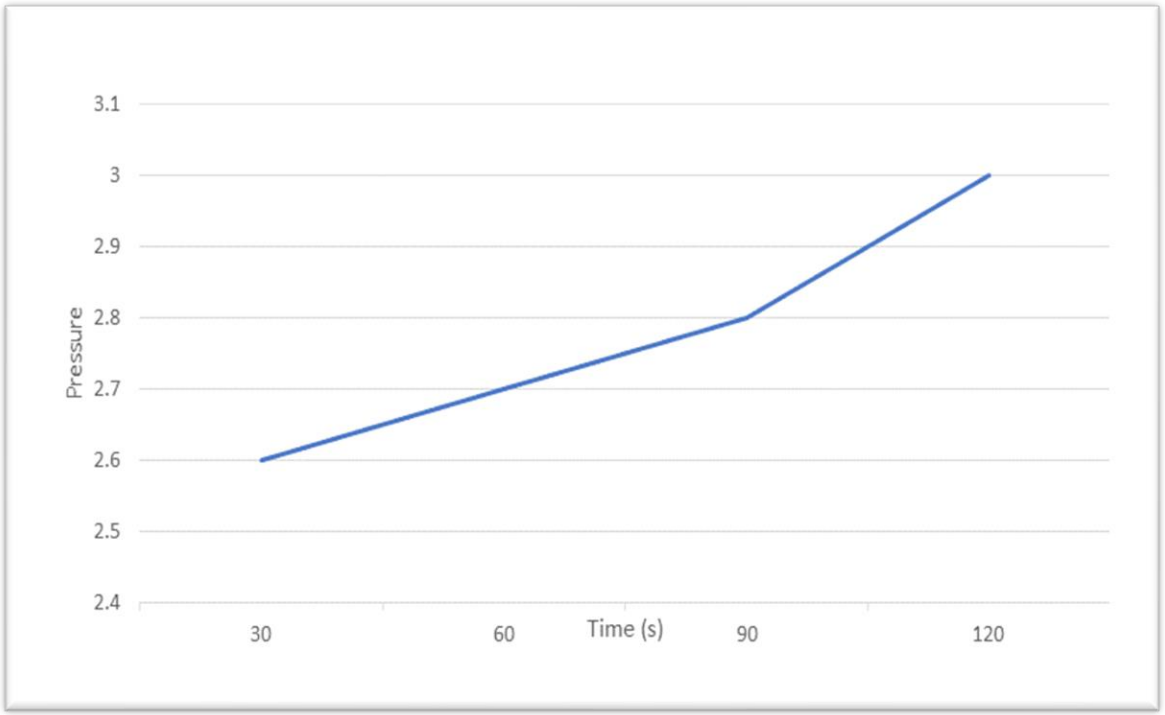

Fig 14. Timevs Pressure (Outlet).

The above graph **Fig 14** is plotted between time(sec) and pressure(gauge). In X axis time is denoted similarly in Y axis pressure is denoted. The above time denotes the cleaning process duration. When the time of cleaning increases the outlet pressure also increases.

Table 2. Cost of disc filter cleaning system

S. No	Pipe Size (inch)	Disc filter	Solenoid valve(4 in No's)	Tee joint (3 in No's)	L-Bow (2 in No's)	Total
1	2'1/2	9000/-	5400/-	90/-	70/-	31010/-
2	3	13000/-	6000/-	125/-	90/-	37555/-

From **Table 2** the cost of reverse flow system for three inch pipe but when it comes to the automatic filter in the market is 250,000/-. It is more cost efficient when compared to others.

VI. POWER SUPPLY

Table 3. Power supply calculation

S. No	Device	Voltage (V)	Current (A)	Power (W)	No. of Device	Total Power (W)
1	Solenoid Valve	12	0.35	4.2	4	16.8
2	Node MCU	5	0.75	3.75	1	3.75
3	Relay	5	0.1	0.5	4	2

Total power consumed by the circuit during the cleaning process of the disc filter is 22.25 (W) and input voltage is 5(v). **Table 3** shows the power supply calculation.

VII. CONCLUSION

Thus by using MIT app inventor the application developed for controlling the valves using relay. The application has been validated using a prototype. 1. Thus two different types of flow were created through the filter namely forward flow and reverse flow using four solenoids. During the normal flow the odd valves V1&V2 are kept open. 2. During the reverse flow process the even valves V2&V4 are kept open. The reverse flow process has been investigated in the field by passing the water in the reverse direction into the disc & inspected for clogging using the pressure gauge. 3. There are extra relays and solenoid valves to control the motor power on/off and water to all separate fields. 4. The application has been investigated by using an experimental set up where the MIT app Inventor developed successfully transmits water in two types of flow. 5. Thus MIT APP inventor assisted with reverse flow process forms an economic method in cleaning the drip irrigation disc filter.

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