Improving the Perfomance of Hydrocyclone filter for Microirrigation Systems

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Abstract— The hydrocyclone filter main problem is occurred that known as the corrosion and rusting problem. The main reason for this is when hydrocyclone filter filters water, the slurry or impurity or sand gets stored in storage tank. Ideally farmer should clean storage tank on regular basis but irregular maintenance of storage tank causes slurry to move upward and make their place in apex section. The slurry stored in apex section leads to severe corrosion. Secondary cause for wearing of apex section is turbulence of water. So avoid this problem, the modification in the design of an existing hydro cyclone filter is the core of efficiency improvement. We will make some important changes in the design of the current version. On detail analysis of the problems, one can conclude that farmers are equally responsible for decreased life and problems faced of the hydrocyclone filter. This given rise to a new idea where equipment cost will be less, the filter will be totally self-sufficient to be independent in fuel and will not need any external power to drive. This requirement will comprise a drain valve with automatic flushing of sand, existing energy use.

Keywords— corrosion, underflow, apex, power, responsible, etc.

I. INTRODUCTION

Hydrocyclone is a simple mechanical device, with no moving parts, where solid particles or immiscible liquids are separated from liquid which is usually water (hydro). Hydrocyclones are also known as sand separators, centrifugal filters or cyclone separators. A typical hydrocyclone consists of a cylindrical section, a conical section, an underflow cylinder section and a sand collection basket.

The device has an inlet (feed nozzle) to feed the unfiltered water and a cylindrical section where the flow is introduced tangentially to generate a swirling motion. Below the cylindrical section there is a conical section which helps in increasing the velocity of flow of water. It is a truncated cone with the tapered end facing the downward direction. It is followed by a cylindrical pipe called underflow section which is meant to empty the unwanted solid particles in the irrigation water into a collection basket which is connected at the other end. The overflow pipe extends back into the cylindrical portion of the hydrocyclone to the full length of the cylindrical portion plus another centimeter into the conical portion. This portion of pipe is called the vortex finder and it conveys the overflow water to irrigation system after elimination of larger sized solid particles.

Separation is based on density difference between the liquid and the matter to be separated. The separating force is normal acceleration motion to which the water is subjected while swirling through the conical section, with progressively increasing velocity. The cyclone utilizes the energy obtained from fluid pressure to create the rotational fluid motion. This rotational motion causes the material suspended in the fluid to separate from one another or from the fluid quickly, due to the centrifugal force.

Inlet water contains sand particle, when water passes at very high velocity through apex, sand particles in water falls on apex section causing wearing of the section.

So avoid this problem, the modification in the design of an existing hydro cyclone filter is the core of efficiency improvement. We will make some important changes in the design of the current version.

Objective:

- To avoid, leakage issue of the Hydrocyclone filters.
- To reduced severe corrosion of the Hydrocyclone filters.
- To improve the resistance of Hydrocyclone filter's Material getting wear out.
- To avoid, severe damage of the Hydrocyclone filter.
- To improve, proper filter platforms.

II. METHODS AND WORKING

A. Drain Valve concept

Drain valve is a simple mechanical device for which used to cleaning the storage tank of the hydrocyclone filter. So in this drain valve used a existing energy of the hydrocyclone filter. Means used an inlet pressure of the hydrocyclone filter.

This pressure is minimum 2.5 kg/cm^2 to provide the inlet. Then in this situation we are nothing used to any another energy and different systems for the valve. This is main benefit of the system. Basically this type of drain valve nothing used in previous systems and another different locations of the filter. It's purely used for the flushing conditions of the filter.

B. On filed procedure of Drain Valve

At time passes impurity gets stored in storage tank. After certain amount of time level the impurity increases at level where it impacts efficiency of system. At this point drain valve automatically clean up storage tank impurity.

Fig no. 01 Actual model of drain valve

After starting motor, the output pressure has been set to 2 – 3 kg/cm^2. Then water moves towards hydro cyclone filter. As per previous discussion about working of hydro cyclone filter, all heavy impure particle/slurry gets stored in storage tank. The duty of operator is to remove slurry collected in storage tank. To achieve this a mechanical drain valve is to be set up near storage tank outlet. Pure water from without slurry is passed through pipe to main line. After water passes through main line function of hydro cyclone filter is over and drain valve come in action. Now the process is continued till 7-8 hours. By the time impurity gets collected in storage tank. Now duty of operator is to clean/remove slurry in storage tank. To achieve this drain valve is used. The system is made in such a way that as soon as pump stops, drain valve starts cleaning storage tank. On cleaning impurity, pure water is made to pass to filter through channel. Ideally cleaning process should be carried once in a day. The main objective to mention this point is because in actual case farmers don't clean tank very frequently so to eliminate human error the drain valve is to be set for automated cleaning. Due to irregular cleaning of the storage tank, rusting of surface occurs which leads to decrease in efficiency of system and which further leads to fall in life. After cleaning storage time, most of times some amount of sand remains in tank. This remaining sand may create further issues. On next day when operator starts motor by the time motor attends actual working pressure drain valve cleans up the unwanted sand collected. This process doesn't need special attention as it is an automatic process. This may be evaluated as concept of 'Simple flush'.

C. Material of Drain Valve

Synthetic resin made from polymerization of Vinyl Chloride. Only the second quantity of polyethylene in the production and consumption of plastic, PVC is used in many categories of domestic and industrial products, from raincoats and shower screens, window frames and indoor plumbing. Lightweight, rigid plastic is also made in its pure form, form it flexible "plasticized".

Typical Properties of PVC Material:

Table no. 01 Mechanical Properties of Drain valve

Mechanical Properties	**PVC**
Tensile Strength	7500
Tensile Elongation	411000
Tensile Modulus	-
Flexural Strength	12800
Flexural Modulus	481000
Hardness	115
Density	1.41
Water Absorption	0

PVC is a very durable and long-term material that can be used in a variety of applications, rigid or flexible, wide or black and the wide variety of colors in it.
Therefore, all parts of this drain valve model have been developed by PVC material as it also has zero water absorption properties.

D. Design of Drain Valve parts

1. Cylindrical port

It is rounded section made up of PVC material. It consists of front port and back port. Front port is located near storage tank exit point where as back port has threads to open and close the port. Front port has ¾ inch standard BSP threads in the internal diameter of the cylindrical port. These threads help to make seal arrangement leak proof.
Back port is also having BSPT threads. This BSPT thread helps to join between cylindrical bush and cylindrical port. In addition to this it has O-ring which functions as leak-proof agent. Cylindrical port has inlet and outlet port. Pressurised water enters inlet port. Tube and inlet port are clamped with the help of ¼ inch standard BSP thread.

Fig. 02 Cylindrical Port of the Drain Valve

Processed the Draining water exit from outlet port through simple uniform cylindrical hole.

2. Cylindrical Bush

Cylindrical bush hexagonal handle, standard BSPT threads, cylindrical hole, Hole extrude cut and circular extrude cut. Standard BSPT thread is used for proper fitting of cylindrical bush with cylindrical port.

Fig. 03 Cylindrical Bush of the Drain Valve

During initial development, the hexagonal handle had round shape. But considering practical complications associated with the handle it has given hexagonal shape for easy and better grip. M5 allen is inserted into cylindrical hole. Allen inserted make arrangement concrete and avoids further fatigue.

M5 allen is inserted into cylindrical hole. Allen inserted make arrangement concrete and avoids further fatigue. On front side of cylindrical bush, a 5 mm deep ring hole is provided to insert spring. At the centre of cylindrical bush, 3 mm deep extrude cut has been provided. A guided strip is inserted into this 3 mm deep hole.

3. Piston port

Piston port works as leak-proof agent and auto manages pressurised water from inlet and drainage water from outlet. Piston port consists of Cylindrical ring, Standard O-rings, cylindrical extrude cut and Guided strip cut.

Fig. 04 Piston Port of the Drain Valve

Two standard O-rings have been designed with standard grooves that will fit to upper and lower section of the piston.

4. Guide strip

Guided strip is used to ensure proper clamping between Cylindrical bush and spring, Piston port and spring. Guided strip is a flat plate with an Elliptical shape.

Fig. 05 Guide Strip and Connecting Rod of the Drain Valve

Guided strip has two holes i.e. upper and lower. Upper hole is at top side of guided strip. A cylindrical rod is fitted on this upper hole. Lower extruded hole is at bottom side of strip. It is inserted between cylindrical bush and piston port of the deep hole.

5. Extension spring

An extension spring can absorb and store energy, as well as create resistance to a pulling force. Extension springs often have a loop or hook at the end for mounting the spring. An extension spring is in most cases mounted on other objects that are in motion. When these objects move, the extension spring attempts to bring the objects back to their start position.

Fig. 06 Extension Spring of the Drain Valve

Extension springs, also known as a tension spring, are helical wound coils, wrapped tightly together to create tension. Extension springs usually have hooks, loops, or end coils that are pulled out and formed from each end of the body. The function of an extension spring is to provide extended force when the spring is pulled apart from its original length.

Spring Parameter

Select Assembly Dimensions Input: Length at Preload

- Safety Factor: 1
- Coil Direction: Right
- Coiling Process: Cold Coiled
- Hook Type: Open Loop

Material properties used for calculations

- Material: Cold Drawn Unalloyed Steel Wire - SL
- Modulus of Rigidity: 81370 MPa
- Density: 7850 Kg/m^3

Material properties applied to the model

Table no. 02 Extension Spring Design Parameters

Design Input	Inputs value (mm)
Spring Condition	With Initial Tension
Design Criteria	Design Spring at given Loads
Diameter Selection	Specify Outer Diameter
Output Parameters	Not applicable
Spring Dimensions	Not applicable
Design Method	Based on Spring Diameter
Diameter Constraints	Not applicable
Deflection Constraints	No

E. Assembly of drain valve

As shown in fig this is assembly of drain valve. All parts 3D model made by solid works 2019. First of all we used a spring becomes front end of the spring put into the piston port. After guide strip has deep into the hole of the piston port. This piston port hole has dimensioned as same as guide strip front end. Then guide strip and piston port connected with M5 allen bolt. It's important of stuffing point between the two parts. So another end of the spring connected with cylindrical bush, the guided strip also joint to the cylindrical bush. This is our basic arrangement of the spring, cylindrical bush and piston port. And connecting rob to be also place on the guided strip. The overall arrangement has associated with a cylindrical port. Cylindrical port of the back end has a thread to be design. So this thread contact with cylindrical bush male threads.

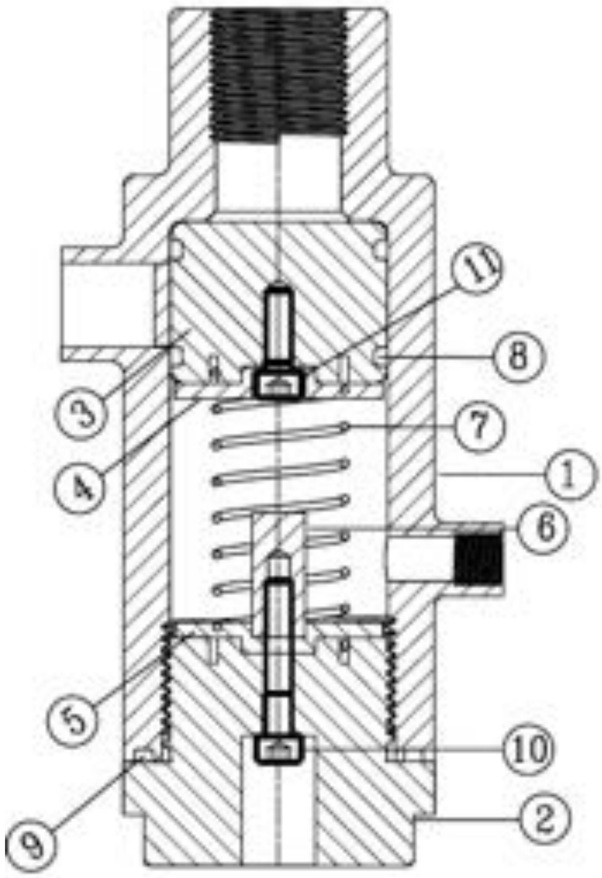

Fig. 07 Details view of assembly of the Drain Valve

As shown as dia. This is an assembly of drain valve, all different parts of the drain valve shown with a numbers.

Table no. 03 Bill of Material of Drain valve

Sr. No.	Part Name	Material	Quantity
1.	Cylindrical Port	PVC	1
2.	Cylindrical Bush	PVC	1
3.	Piston Port	PVC	1
4.	Guide strip 1	PVC	1
5.	Guide strip 2	PVC	1
6.	Cylindrical rod	PVC	1
7.	Spring	STD	1
8.	O" ring for piston	STD	2
9.	O" ring for bush	STD	1
10.	Allen screw 1	STD	1
11.	Allen screw 2	STD	1

III. CONSTRUCTION AND WORKING

A. Construction

As per previous discussion we are now aware about set up procedure of hydrcyclone filter. In newly developed set up there is addition of drain valve in an assembly. We will now discuss how to connect newly developed set up to an existing setup.

Fig. 08 Drain Valve Set up

In existing setup mark a hole exactly below pressure gauge. Join Adaptor to the marked hole. Take 1/8-inch polytube. Join one end of polytube to adaptor and another end to drain valve inlet. Add round shape filter net. Join drain valve front end to the storage tank outlet.

B. *Working of Drain Valve*

First, start motor. Now water from will lifted from. Water is made to pass through polytube which further passed to drain valve inlet. As water pressure increase quantity of water coming to drain valve also increase. Due to increased water pressure spring at inlet of drain valve gets extension power. This spring is connected to piston. Due to extension of spring, piston further slides. Sliding piston causes blocking of water flow at inlet. This is initial stage of setup. After 7-8 hours, switch off motor. This causes decrease in water pressure. Now pressure spring losses it's extension power. This causes piston to move backward. Now water bypasses through hole as no piston force is acting on it.

IV. TESTING AND RESULTS

A. *Drain Valve Leakage Problem Test*

At the section, O-ring gets important role play on the piston port section. We gets test the drain valve can be operated on O-ring. This O-ring joins with a piston port. Then sometimes on the operating time or working time, to test the drain valve with different pressure and flow check the leakage problem of that valve. Different pressure such as 1 kg/cm^2, 2 kg/cm^2, 2.5 kg/cm^2, 3 kg/cm^2, 4 kg/cm^2 and flows are 15 m^3/hr, 25 m^3/hr, 40 m^3/hr, 50 m^3/hr, 60 m^3/hr. To connect the all set up firstly, check without O- ring drain valve and another testing to join the O-ring to the piston poet of the drain valve.

Table no. 04 Drain valve outlet leakage problem Test

Pressure (kg/cm^2)	**Flow** (m^3/hr.)	**Drain Valve Outlet Leakage Problem**	
		With O-ring	**Without Oring**
1	15	No Leakage	Leakage
2	25	No Leakage	Leakage
2.5	40	No Leakage	Leakage
3	50	No Leakage	Leakage
4	60	No Leakage	Leakage

B. *Drain valve piston port sliding test*

In this testing procedure check the piston port return and non-return test. When spring is inside the piston port then, definitely piston port will be return on its original position. But spring doesn't exist in the drain valve then to check under pressure the piston port will be get return or not. It's important to check the under pressure of the hydrocyclone filter. The main reason is that check also the sliding condition of the piston in inside surface of the drain valve.

Table no. 05 Drain valve of Piston port return test

Pressure (kg/cm²)	**Flow** (m³/hr.)	**Piston Port Return Test**	
		With spring	**Without spring**
1	15	Return	Non Return
2	25	Return	Non Return
2.5	40	Return	Non Return
3	50	Return	Non Return
4	60	Return	Non Return

At the same case, as compare to leakage problem of the drain valve

C. Clogging Test

In this test water made to pass through inlet with some amount of impurity. After water gets processed and collected at outlet. Quantity of impurity was checked in this outlet water. Collected impurity was dried and compared with initial impurity that was inserted along with water. Comparison report can be used as measure of impurity removal capacity of hydro cyclone filter.

Table no. 06 Drain Valve Mesh Test

Pressure (kg/cm²)	Flow (m³/hr.)	Mesh size(microns)			
		70		120	
		Inlet	Outlet	Inlet	Outlet
1	15	125	107.5	125	113.5
2	25	125	112	125	109.5
2.5	40	125	115	125	111
3	50	125	109	125	117
4	60	125	111	125	116

Two sizes of mesh particles have to be collecting for the testing purpose. Then in which to decide specific weight such 125 gm. Then collect 4 to 5 sample of the meshing. The mesh size is 70 and 120 microns to take for the test.

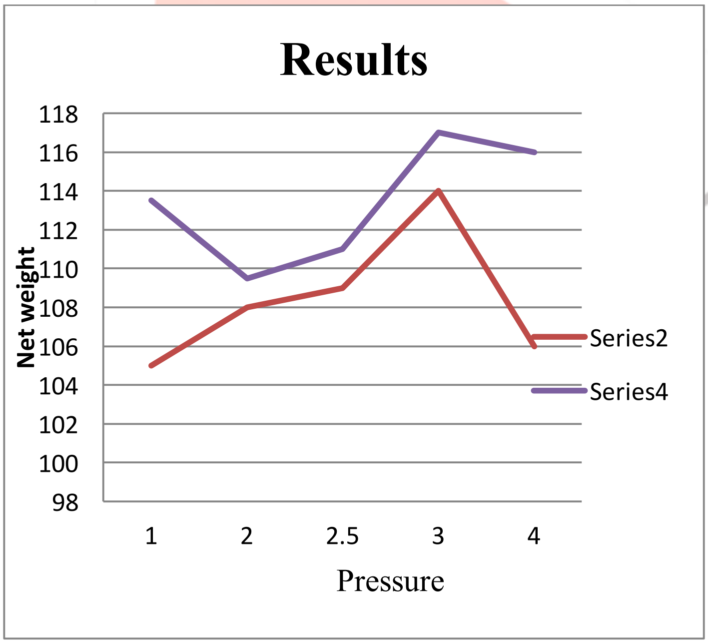

Fig. 09 Experimental results of the clogging test.

V. CONCLUSION

This type drain valve is economical for every condition. one can conclude that farmers are equally responsible for decreased life and problems faced of the hydrocyclone filter. This given rise to a new idea where equipment cost will be less, the filter will be totally self-sufficient to be independent in fuel and will not need any external power to drive. This requirement will comprise a drain valve with automatic flushing of sand, existing energy use.

REFERENCES

[1] Development of Hydrocyclones for Use in Plastic Recycling. *A Summary Report of Research Sponsored by the American Plastics Council*. MBA Polymers, Richmond, July, pp.1-42.

[2] Krebs gMAX cyclones – For finer separations with larger diameter cyclones. *Krebs Super Cyclone*, pp.1-7.

[3] Case Study 9 – Hydrocyclone. Solid Separation Systems for the Pig Industry. *FSA Environmental*. April, pp.9-1 to 9-12.

[4] Derrick 10" Hydrocyclone- Good Solids Control Starts with Efficient Removal of Fine Drill Cuttings. *Derrick Corporation,* Texas. www.DerrickEquipment.com

[5] Hydrocyclones. Helsinki University of Technology. Laboratory of Chemical Engineering and Plant Design. pp.1-17.

[6] Krebs Engineers-Products. www.krebs.com ANONYMOUS, 2005c, Product description-Hydrocyclone filter. *Dynamic Engineering Company, New Delhi.* www.easy2source.com

[7] Hydrocyclone assembly. United States Patent 4208270. http://www.freepatentsonline.com/index.html ARTERBURN, R.A., 1976, The Sizing and Selection of Hydrocyclones. *Krebs Engineers*. pp. 1-19. *www.krebs.com*

[8] The Hydrocyclone. *Pergamon Press.* BUCKS, D.A., NAKAYAMA, F.S. AND GILBERT, R.G., 1979, Trickle irrigation, water quality and prevention maintenance. *Agril. water manag.* **2:** 149-162.

[9] BUTTLER BARRY M., 1996, Hydrocyclones for separating solids from liquids and for separating immiscible liquids in process and wastewater streams: case study. *Krebs Engineers. www.krebs.com*

[10] COLUMBUS, E.P., 1993, Series cyclone arrangements to reduce gin emissions. *Trans. of ASAE*, **36**(2):545-550.

[11] DITRIA J.C. AND HOYACK, M.E., 1994, The separation of solids and liquids with hydrocyclone based technology for water treatment and crude processing. SPE Asia Pacific Oil & Gas Conference, Melbourne, Australia, 7-10 November.

[12] OLSON, T.J., AND TURNER, P.A., 2002, Hydrocyclone Selection for Plant Design. pp. 1-14.

[13] Mailapalli, D. R., Marques, P. A. A., & Thomas, K. J. (2007). Performance evaluation of hydrocyclone filter for microirrigation. Engineering Agricultural, Jaboticabal, 27(2), 373–382.

[14] Martinez, L. F., Lavin, A. G., Mahamud, M. M., & Bueno, J. L. (2008). Vortex finder optimum length in hydrocyclone separation. Chemical Engineering and Processing, 47(2), 192–199. doi:10.1016/j.cep.2007.03.003.