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Hydraulic Study, Design & Analysis of Different Geometries of Drip Irrigation Emitter Labyrinth

Sachin S Patil, P T Nimbalkar, Abhijit Joshi

Abstract- ***In order to solve the problem of water shortage in agriculture, it's necessary to develop water-saving irrigation. Drip Irrigation is a method of applying uniform and precise amount of water directly to the root zone of the plants as per the requirement, through emitters at frequent intervals over a long period of time, via pressure pipe network. As the key device in drip irrigation systems, the emitter is to drip the pressured water in the pipeline to the root of the crops evenly and steadily, so as to guarantee the water demand for crop growth. The quality of the emitter has an important effect on the reliability, life span of the drip irrigation system and irrigation quality. Usually, the structure of the emitter channel is very complex with a dimension. Emitter's intricate inner channel makes the flow of water have turbulent behavior. In the design of emitter structure, we use 3D parametric CAD software SolidWorks 2012 to design labyrinth emitter. According to emitter's hydraulic performance and its requirement for anti-clogging, we can design new channel structures by changing those dimensions. The irrigation quality of drip irrigation system is verified by emitter's hydraulic performance. In the high-pressure pipeline, the water energy may dissipate after flowing through the labyrinth channel and the flow rate can be controlled to meet the water need of the crops. To ensure the emitter's hydraulic performance, before the fabrication of emitter, computational fluid dynamics (CFD) is used to predict emitter's flow rate and analyze its hydraulic performance under various water pressures.***

Keywords: anticlogging, discharge,drip irrigation, exponent, emitter.

I. INTRODUCTION

Water is becoming more and more a scarce and valuable resource as population and consumption rise. Evaluation of these factors, as well as technology and action to support healthy water supplies, is necessary to gain control of the situation. Agricultural use of water accounts for nearly 70% of the water used throughout the world, and the majority of this water is used for irrigation. A successful uniform application through drip irrigation system depends on the physical and hydraulic characteristics of the drip tubing (Al – Amoud, 1995). In surface drip irrigation systems, uniformity can be evaluated by direct measurement of emitter flow rates. The emission uniformity (EU) criterion is used largely to design micro irrigation laterals. The EU is affected by the variation of pressure head due to elevation changes and head losses along the lines, as well as by water temperature, manufacture's variation, grouping of emitters, clogging, variability in soil hydraulic characteristics, and emitter spacing (Wu, 1997).

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Introduction of emitters along a drip irrigation line modifies flow streamlines, inducing local turbulence that results in additional head losses friction losses and local losses due to the presence of emitters in the pipe are must be considered (Bagarello and Pumo, 1992; Al Amoud, 1995; Provenzano*et al.*, 2003).

India occupies about 329 million hectare (Mha) geographical area, which forms only 2.3 per cent of the world's land area and supports over 15 per cent of the world's population. Thus, India supports about 1/6th of world population with 1/5th of world's land and 1/25th of world's water resources. India has a livestock population of 500 million, which is about 20 per cent of the world's total livestock population. More than half of these are cattle, forming the backbone of Indian agriculture. The total utilizable water resources of the country are assessed as 1086 BCM. The largest consumer of the water is agriculture, which accounts for about 85 per cent of the total available fresh water. Therefore, to cope up with increasing demand for water in agriculture, it is necessary to utilize it efficiently and judiciously (Kumar *et al.*, 2005).

The relationship between the emitter flow rate and the static pressure of the pipe, which is called characteristic of emitters (COE), is very important to a drip irrigation system. This relationship is used

The most important properties in drip tubing irrigation systems are uniformity; anti-clogging unregulated dripper varies with inlet water pressurerather than friction losses along the laterals, both in designing the desired emitter flow path. Computational Fluid Dynamics (CFD) numerical technique was applied to investigate the flow, heat and mass transfer for many years. CFD technique has many advantages compared with other numerical calculation methods. The simulation can maintain a stable boundary condition while CFD modeling can be easily simulated with the change of the structure specification (Lee and Short, 2000). The numerical calculation results can help researcher analyze the hydraulic performance of the emitters and modify the geometries of the flow path, thus reducing time and cost for producing new emitter designs (P. Salvador et al, 2004).

II. STRUCTURE DESIGN AND FLOW RATE PREDICTION OF MICRO CHANNEL

The drip emitter is an important device in water-saving agriculture, and it characterizes all development of modern agriculture. The use of dripper emitter is fundamental in arid regions or where rain begins to decrease. The task of this component is to dissipate pressure and to deliver water at a constant rate by lowering the pressure energy.

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Shapes may vary with different shapes. Usually dimensions are very small, and the water flow crosses through micro-orifices like a labyrinth channels which make the pressure drop. Discharge rate is usually 1 to 8 L/h and is linked to the small width and depth of the flow path which is about 0.5 to 1.5 mm high.
Drippers are equally spaced inside irrigation lines which are laid on the ground or just few centimeters below the surface level. During pipe extrusion drippers are welded toward its inner surface. Pipe diameter is around 16 mm and its thickness varies between 0.12 and 1.5 mm. In agriculture many pipe-lines are used and the intake pressure is variable. In horizontals fields, nominal pressure is 1 bar, while in sloping fields pressure can reach even 4 bars in lower level areas.
There are two big families of drip emitters: the flat dripper and the round type. Each of them can be divided in two subfamilies: unregulated dripper and regulated dripper.
On the contrary, regulated emitter maintains a relatively constant flow rate at varying water pressure, within the limits specified by the manufacturer. Last ones show good performance in sloped fields where intake pressure is inevitably variable capacity and lifespan of all components. A well designed dripper device should maximize these aspects and ensure a good hydraulic performance.
Uniformity is the property of each dripper of a piping line to provide almost the same discharge rate in a range of ±10%. Anti-clogging capacity is the property of an emitter to reduce the precipitation of suspended particles. In fact, these devices can easily clog. Efficient turbulence can create some reverse whirlpools in low velocity zones and this effect prevents the sedimentation of suspended particles. Another method to reduce clogging is the introduction of a filter at water inlet section. This filter is often made of a grid which blocks particles larger than a third of the labyrinth smallest cross section.
Dripper life is linked to the plastic material used to produce this device. Many producers employ only thermoplastic materials. Most of them are made in high density polyethylene, because this choice is an important compromise between physical and molding properties.

III. HYDRAULICS IN DRIP IRRIGATION EMITTER:

Recently some researchers studied the fluid dynamics in the dentate path with many numerical and experimental methods. However, these studies are often pure computational fluid dynamics simulation of the flow inside the labyrinth channels. In fact, the main objective is the verification of the presence of a turbulent flow. On the other hand, there are not many research papers focusing on the behavior of the dentate path and the influence of the geometry on the discharge rate.
There is an important study around the Reynolds numbers inside the labyrinth. In fact, if the particular dentate geometry has not yet been analyzed, there is no actual knowledge of critical Reynolds number, that fixes the transition from laminar to turbulence flow. For Kamrmli the critical Reynolds is almost 2000. Maintaining fluid dynamics conditions over this value, the flow can be considered turbulent providing enrgy dissipation inside path and anti-clogging effect. The effects of reverse vortexes along the path where shown in the work. From an experimental point of view, it is pretty difficult to measure the effective Reynolds in a path almost 0.8 mm width. So, many authors rely only on CFD simulation results. Zhang [10] made an experimental setup to measure flow using a Laser Doppler Velocimetry device with magnified model in Plexiglas (dimensional ratio 15:1) according to the Reynolds number similarity method but we are usin9 IPM Scope High Megapixel Camera (40 x).

IV. HYDRAULIC DESIGN PROCESS OF EMITTER

The research is focused on drippers design and production. Companies define the exact shape of drippers on the base of specifications and then design and produce injection molds for their realization. Usually they sell the product, but sometimes only molds. Above all, they provide a specific dripper design service. Dripper production follows the mass customization paradigm, today highly diffused in the modern globalization. The dripper is not a standard product and customers are represented by pipe producers. These firms buy drippers which are inserted in the pipeline during the extrusion process. Every customer requires different specification based on the specific irrigation application and the technologies being used to manufacture the pipeline.
When a new order comes, it specifies some overall dimension requirement, a specific flow rate, a certain intake pressure, specific environmental working conditions and other functional requirements. All these variables lead to the necessity of a new design which often may be similar to a previous one. However this does not mean that the design process can be fully recovered. Small changes require the repetition of all the design, manufacturing and testing steps as pointed out as in fig. 1.
Currently the time for designing and realizing of the final prototype of a drip emitter is quite long (almost 3 months) and it includes four steps:
1. Design of the emitters,
2. RPD development & CFD analysis of emitters,
3. Assembling emitter on setup,
4. Experimental set-up of the emitters pipelines

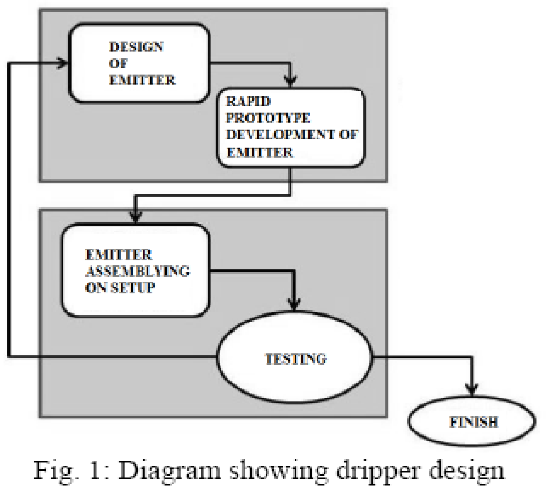

Fig. 1: Diagram showing dripper design

An initial wrong design could highly increment the cost of all the realization process. For instance, negative results from the experimental set-up require a product revision and the repetition of all the design and manufacturing steps. Moreover, drippers are usually designed and produced by a firm while they are assembled by pipe producers.

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That means the overall time for iteration is long and the all design process could span for months. The first design step is the most complex because engineers must considerate at least four fundamental aspects: fluid dynamics, geometrical and dimensional constraints, influence of geometry into molding process and the choice of materials. A new project begins with the analysis of the geometrical constraints. Overall dimensions depend on different extruding machines which include drippers in pipeline.

Each of them makes use of a particular track to convey the emitters: so it is not possible to standardize product geometrical limits. Secondly, the designer must fulfill customer fluid dynamics specifications. In particular, every dripper has its own characteristic discharge rate, linked to a particular agricultural application. This parameter is very critical. There are no rules or methods to analytically compute this value due to the complexity of the geometry.

CFD simulation may be employed but there are many parameters influencing the results. It is important to know them precisely in order to come out with good results. That means the designer usually bases his work only on experience. At first he fixes a possible labyrinth path. Then he works only varying the depth of the channel. In choosing the geometry he must take into account anticlogging properties, life-span of the parts and overall performance. A dentate design is usually preferred since it meets these two aspects. The profile is often triangular since it guarantees a turbulence flow to increase pressure dissipation and to prevent sedimentation of suspended grains. In addition, an intake filter is added to stop bigger particles.

After geometry definition, the molding process is designed. Main aspects are related to lines productivity and the correct and constant properties of the product. This is very important forth quality of dripper pipelines, because every dripper must emit almost the same water quantity to guarantee a balanced irrigation of any plant of the field. The discharge uniformity is a central parameter the designer must control in all the process. Besides, the realization of molds requires many types of machine tools, such as copper electrodes and mills with an accuracy of about 0.01 mm. The compromise between performance, cost and fast realization is hardly reachable and requires knowledge linked to the experience.

After a pilot batch has been obtained, the customer tests a first assembly-line to experimentally measure the effective discharge rate. Results are often not very good, so the first dripper model may need a deep revision and the repetition of all previous phases. This leads to a trial and- error loop which terminates only when the experimental results are sufficiently good. This loop spans in all production steps, so it is very expensive for the company which needs to employ many resources to realize changes to the first dripper design.

V. PARAMETERS FOR EMITTER DESIGN:

To test the introduced methodology, two different cases from the flat and the round dripper families have been analysed. The input parameters, which influence the performance of all the drippers, can be divided in geometric parameters, such as dentate path shape, path depth, pipe thickness; process parameters, such as molding pressure, molding temperature, assembly process temperature; dripper and pipe material properties; operating parameters

as water pressure, water temperature and clogging state. The output parameters can be mainly recognized in discharge rate and lifetime. All these parameters are numerous, heterogeneous and complexly linked. Here some hypotheses follow which where formulated to simplify the approach. The study was focused on geometric and on operating parameters. Factors linked to material and molding process where considered as constant. Material was fixed in high density polyethylene both for the dripper and pipe; operating temperature and clogging state where respectively fixed in about 23°C and in the absence of any clogging sediment. As output parameter, discharge rate was only taken into account while lifetime has been ignored since it mainly depends on chosen material and employing conditions. In the test cases a constant pressure of about 1 bar was fixed and the attention focused on geometrical parameters, such as the dentate path geometry and the path depth, which deeply influence the dripper performance.

Generally speaking, parameters are chosen out of convenience considerations. New design very often new design starts from an existing model which maintains most of the geometric choices such as structure, labyrinth shape, inlet position, and so on…. For that reason a new design is often based on a product family choice and then concentrates on parameters such as path depth, overall length and number of labyrinth bends which, conveniently varied, lead to desiderate performance.

Chosen dripper models were both experimentally and numerically analysed. Fluid dynamics aspects were simulated with a commercial CFD system, Fluent by Fluent Inc. All geometries were meshed with grids of 0.1 mm spacing leading to more than 1x105 cells. From the literature is clear how water flow into the emitter dentate path can be considered as turbulent.

The flow inside the emitters could be considerate as a viscous steady uncompressible flow described by these fundamental equations:

Continuity equation:

$$\frac{\partial u_i}{\partial x_i} = 0$$

Navier-Stokes equation:

$$\rho \frac{\partial u_i u_j}{\partial x_i} = -\frac{\partial P}{\partial x_j} + \frac{\partial}{\partial x_i}\left[\mu_e\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)\right]$$

procedures, an experimental setup was designed and installed at Jain Plastic Park, Jain Irrigation Systems Pvt. Ltd., Jalgaon (Maharashtra, India).

Gravity and surface roughness effects were neglected. In the simulation standard boundary conditions about flow inlets and outlets were set. Relative pressure at inlets was set to 1 bar, corresponding to normal emitters working pressure, while at the outlets pressure was fixed to zero.

VI. MATHEMATICAL EMITTER DESIGN MODEL:

A mathematical model derivation of emitter discharge depending on the geometric parameters on the basis of numerical simulation of water flow movement in emitter labyrinth channel (Ref : 11th National Congress on Theoretical and Applied Mechanics, 2-5 Sept. 2009, Borovets, Bulgaria; A mathematical model of drip emitter discharge depending on the geometric parameters of labyrinth channel – Nina Philipova, Nikola Nikolov).

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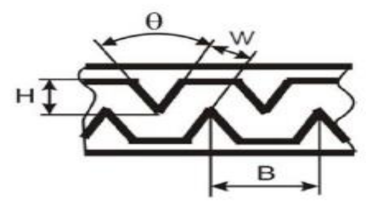

Fig.: Geometric parameters of the labyrinth channel: θ- dentation angle, H-dentation height

$$q^{mod} = 3.445064 + 0.02224\theta + 0.699B + 0.3606H - 0.004775\theta B + 0.0053\theta H - 0.0373BH - 0.08564\theta^2 - 0.02424B^2 + 0.05429H^2$$

the next conclusions could be drawn about the influence of the dentition angle θ, the dentation spacing B and the dentation height H on the emitter discharge. The self-depended increases of three parameters lead to increasing emitter discharge. Most important influence on the emitter discharge has the increase of dentation spacing *B* followed by this one of the hight*H* and angle θ. The simultaneous increase of *B* together with *H* has a negative influence on the emitter discharge whereas the simultaneous increase of θ together with *H* has a positive influence on it. The comparison between the model and the experimental data can be done.

VII. EXPERIMENTAL SETUP

For achieving the required experimental and the experimental setup included one water tank, pump to lift the water, filters, Pressure regulator valves, digital pressure gauges, and different types of procedures, an experimental setup was designed and installed at Jain Plastic Park, Jain Irrigation Systems Pvt. Ltd., Jalgaon (Maharashtra, India) as shown in fig. and the experimental setup included one water tank, pump to lift the water, filters, Pressure regulator valves, digital pressure gauges, and different types of experimental emitters.

7.1 Flow Testing of Prototypes:

Flow testing is one of primary test to check our Prototype. Whatever calculations which we did earlier to prepare prototype we can check by taking readings at different pressure. For a standard emitter development we must have to check Average discharge, Standard Deviation and Coefficient of Variation (CV). Confirm these readings with IS 13488 – 2008.

The experimental phase was consisted in the design of the molds and in the realization of the different flat and round drippers discussed above. Then tests were carried out to measure output parameters. The data were gathered in two different ways: with a standard discharge rate measurement of some extruded emitter piping and by means of an innovative test machine. Since the discharge depends on the type of pipe, the second test was designed to simulate the tube interference effect. Basically, a silicon cylinder encloses the dripper and let the water flow into the labyrinth.

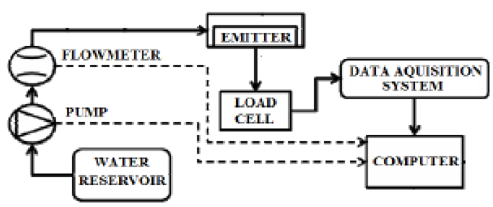

Fig.: Schematic diagram of experimental setupused

7.1.1 Estimation of discharge from the emitter

Despite the large number of emission devices available, and emission devices all regulate water flow by dissipating energy through friction resistance. Emission devices generally operate according to the flow formula (Michael, 2008):

$q = kP^x$Where,

q = discharge of dripper, (m^3/s)

P = operating pressure head, (m)

k = flow coefficient

x = flow exponent

The value of flow coefficient k is related to the physical dimensions of the water passage. The flow exponent x may range from zero to one, depending upon the emission device. The value of x is important because it plays a major role in the uniformity of water application. The lower the value of x, the more pressure compensating the device is. Thus, in the case of fully pressure compensating emitters, x equals to zero, the flow rate is constant within the specified range of operating pressure, and the uniformity of the system will theoretically be perfect. In the case of non-pressure compensating emitters, the value of x depends upon whether the emitter flow rate is fully turbulent, fully laminar, or somewhere between turbulent and laminar. When x approaches 1, the dripper is long path or laminar flow type one. Because discharge and operating pressure are linearly related, the discharge of these emitters is sensitive to variation in operating pressure. Further, the discharge can be very sensitive to the temperature of water, as the theoretical value of k is a function of viscosity of water.

To estimate emitter exponent, following formula is derived from the above equation,

$q = kP^x$

$k = \dfrac{q}{P^x}$

Taking log on both sides,

$\log k = \dfrac{\log q}{x \log P}$

or $\log k = \log q - x \log P$

or K = $\log q - x \log P$ here, K = $\log k$

Consider regression analysis. In which, we have,

$a = \bar{Y} - b\bar{X}$

Where,

a = K

$\bar{Y} = \log q$

$\bar{X} = \log p$

b = x

In regression analysis,

$$b = \frac{\sum X_i Y_i - \frac{1}{n}(\sum X_i)(\sum Y_i)}{\sum X_i^2 - \frac{1}{n}(\sum X_i)^2}$$

Where,

P_i = operating pressure, (kg/cm^2)

q_i = mean of observations of discharge, (lph)

n = total number of operating pressure applied.

7.2 Clogging Tests:

Aim is to test the capability of emitters either to let pass or to prevent entry of solid particles of a given size, with a view to approach minimum size of internal aperture within emitter, and further help establish guidance for system filtration size.

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The test method has been developed for testing within a short period of time the capability of emitters either to let pass or to prevent entry of solid particles of a given size, with a view to approach minimum size of internal aperture within emitter, and possibly to further help establish guidance for system filtration size.

7.2.1 Clogging test with Clay as impurity:

Number of phases: 4 (Each phase divided in Part A & Part B)

For each phase the total load of impurity in test water is increased by adding a fraction of clay, silt & fine sand. Suspension of impurity in test water should be maintained constant by appropriate means as carefully as possible.

Phase Mix	Clogging Materials	Median Grain size (µm)
Phase 1	Clay 1	0 - 25
Phase 2	Clay 2	25 - 75
Phase 3	Clay 3	75 - 150
Phase 4	Clay 4	150 - 225

Table : Grain sizes in the phase mixes to be prepared

7.2.2 Clogging test with Aluminum Oxide as impurity:

Requirements for the clogging material: particle size and relevant test methods:

Number of phases: 11

Phase	Impurity	Conc. (ppm)
Phase 1	Filtered Water only	-
Phase 2	Water + 240	31.25
Phase 3	Water + 240+220	31.25
Phase 4	Water + 240+220+180	31.25
Phase 5	Water+240+220+180+ 150	31.25
Phase 6	Water+240+220+180+ 150+120	31.25
Phase 7	Water+240+220+180+ 150+120+100	31.25
Phase 8	Water+240+220+180+ 150+120+100+80	31.25
Phase 9	Water+240+220+180+ 150+120+100+80+70	31.25
Phase 10	Off/On	-
Phase 11	Fresh Water	-
	Total:	250

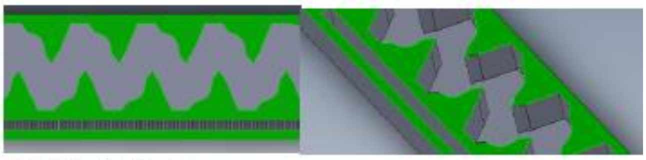
Table: Grain sizes in phase mixes

VIII. RESULTS AND DISCUSSION:

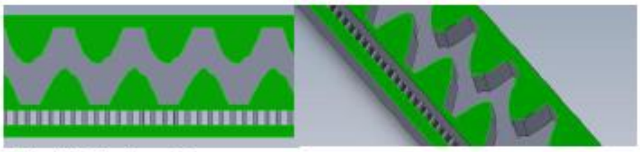
This chapter deals with the results obtained from the experimental studies carried out on different types of geometries, emitter prototypes at various operating pressure head. Firstly different emitter geometries are prepared and analysed in software (SolidWorks 2012 / 2008). Then selected emitter prototypes were prepared for experimental analysis.

According to emitter's hydraulic performance and its requirement for anti-clogging, we can design new channel structures by changing those dimensions. The irrigation quality of drip irrigation system is verified by emitter's hydraulic performance. In the high-pressure pipeline, the water energy may dissipate after flowing through the labyrinth channel and the flow rate can be controlled to meet the water need of the crops. To ensure the emitter's hydraulic performance, before the fabrication of emitter, computational fluid dynamics (CFD) is used to predict emitter's flow rate and analyze its hydraulic performance under various water pressures. If the structure can meet the water flow's requirement very well, then rapid prototyping to fabricate the emitter, and also related experiments are performed. For each phase the total load of impurity in test water is increased by adding a fraction of Aluminum Oxide. Suspension of impurity in test water should be maintained constant by appropriate means as carefully as possible.

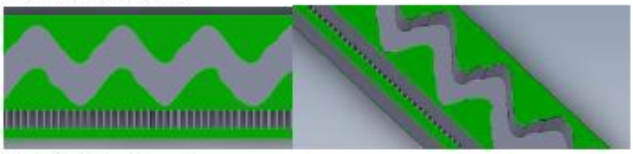
Model Emitter 1:



Model Emitter 2:



Model Emitter 3:



Model Emitter 4:

Model Emitter 5:

8.1 Pressure flow profile:

SolidWorks FloXpress is a first pass qualitative flow analysis tool which gives insight into water or air flow inside your SolidWorks model. To get more quantitative results like pressure drop, flow rate etc. you will have to use Flow Simulation. Please visit www.solidworks.com to learn more about the capabilities of Flow Simulation.

Boundary conditions:

Condition 1:		**Condition 2:**	
Faces	**Inlet Face**	**Faces**	**Outlet Face**
Value	Environment Pressure: 151325.00 Pa	Value	Environment Pressure: 101325.00 Pa
	Temperature: 293.20 K		Temperature: 293.20 K

Table: Boundary conditions for pressure flow profile

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Pressure flow profile results:

Sr. No.	Name	Max. Velocity (m/s)
1	Model Emitter 1	6.487
2	Model Emitter 2	8.07
3	Model Emitter 3	6.568
4	Model Emitter 4	6.839
5	Model Emitter 5	2.294

Table : Pressure flow profile results

Pressure flow profiles are as mentioned below:

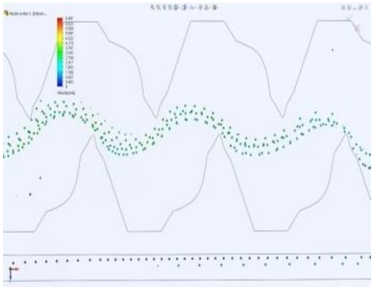

Fig.: Pressure flow profile for Model Emitter 1

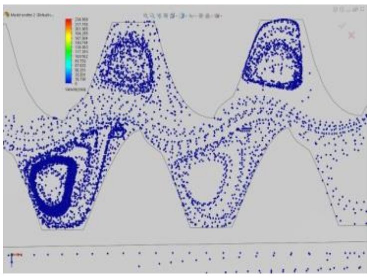

Fig.: Pressure flow profile for Model Emitter 2

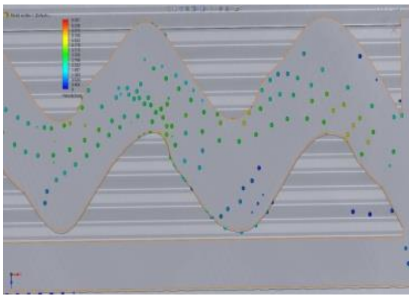

Fig. : Pressure flow profile for Model Emitter 3

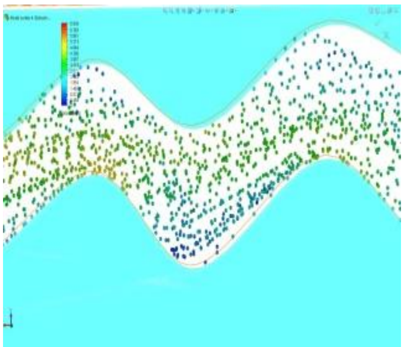

Fig. : Pressure flow profile for Model Emitter 4

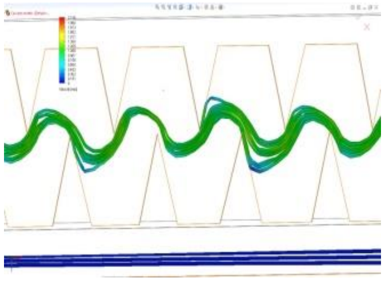

Fig.: Pressure flow profile for Model Emitter 5

8.2 Mass Flow Profile:

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Boundary conditions:

Boundary conditions:

Condition 1:		**Condition 2:**	
Faces	**Inlet Face**	**Faces**	**Outlet Face**
Value	Mass Flow Rate: 0.0400 kg/s Temperature: 293.20 K	Value	Environment Pressure:101325.00Pa Temperature:293.20 K

Table : Boundary conditions for mass flow profile

Mass flow profile results:

Sr. No.	Name	Max. Velocity (m/s)
1	Model Emitter 1	238.000
2	Model Emitter 2	247.782
3	Model Emitter 3	11.434
4	Model Emitter 4	163.910
5	Model Emitter 5	222.699

Table : Pressure flow profile results

Mass flow profiles are as mentioned below:

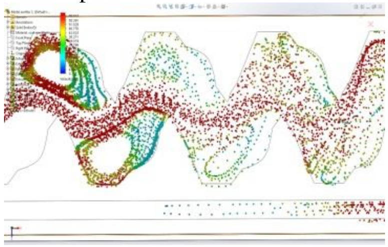

Fig.: Mass Flow Profile for Model Emitter 1

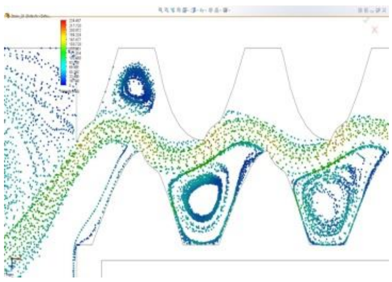

Fig.: Mass Flow Profile for Model Emitter 2

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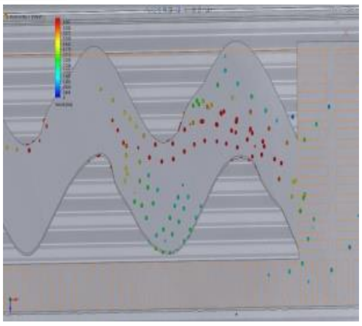


Fig.: Mass Flow Profile for Model Emitter 3

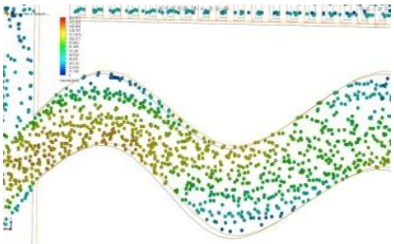


Fig.: Mass Flow Profile for Model Emitter 4

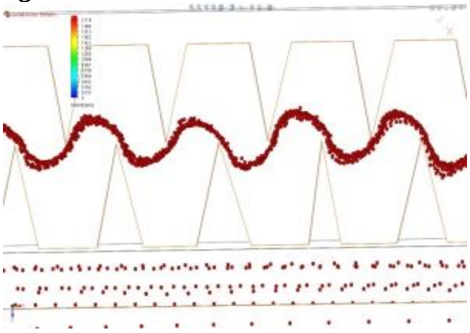


Fig.: Mass Flow Profile for Model Emitter 5

8.3 Experimental results:

The experimental phase was consisted in the design of the molds and in the realization of the different flat and round drippers discussed above. Then tests were carried out to measure output parameters. The data were gathered in two different ways: with a standard discharge rate measurement of some extruded emitter piping and by means of an innovative test machine. Since the discharge depends on the type of pipe, the second test was designed to simulate the tube interference effect. Basically, a silicon cylinder encloses the dripper and let the water flow into the labyrinth.

8.3.1 Flow Testing results:

Type	Discharge rate (lph)		Difference (%)
	CFD	Actual	
Model emitter1	1.2	1.11	7.5
Model emitter2	1.5	1.31	12.67
Model emitter3	1.5	1.34	10.67
Model emitter4	2.4	1.81	24.58
Model emitter5	0.9	0.86	4.44

Table: Experimental results for Model emitters

8.3.2 Clogging test results:

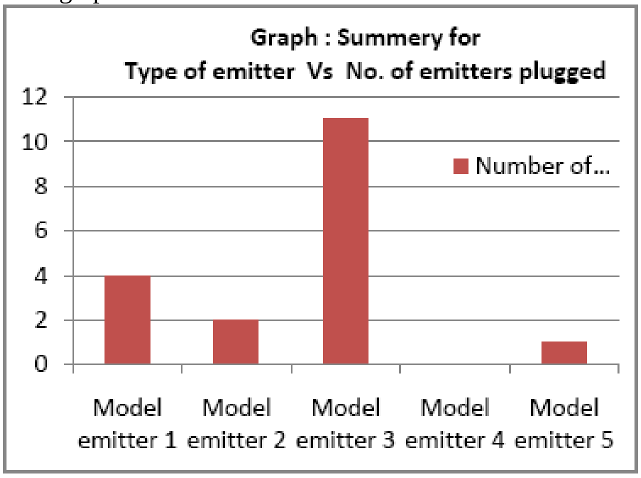
Conditions maintained while testing is:

Specifications		Unit	
Pressure maintained in tube		1	kg/cm^2
Velocity	Tube 1	1.130	m/s
	Tube 2	1.100	m/s
Tube ID		14.2	mm
Tube Wall thickness		0.78	mm
Volume of tank		150	liters

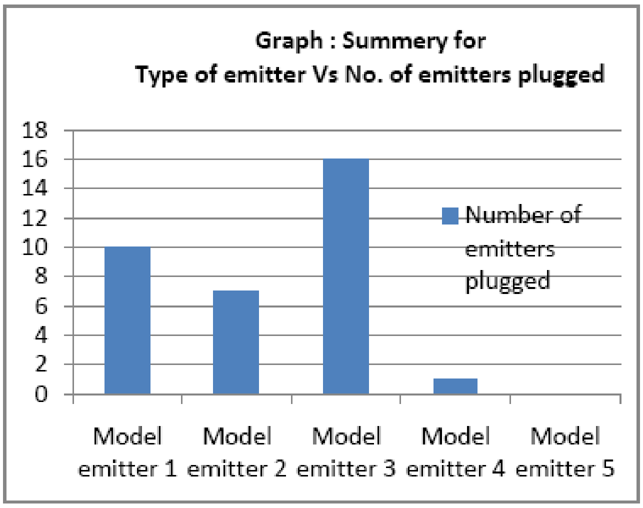
Table : Conditions for clogging test

8.3.2.1 Clogging test with Clay as impurity:

We observed that Model Emitter 4 & Model Emitter 5 have got good results as compared to others which is summarized in bar graph below:



8.3.2.2 Clogging test with Aluminum Oxide as impurity:



IX. SUMMARY AND CONCLUSION

By considering the above objective different emitter models were designed and analysed in computer based software (SolidWorks) as well as analysis did experimentally.

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The drip emitter is an important device in water-saving agriculture, and it characterizes all development of modern agriculture. The task of this component is to dissipate pressure and to deliver water at a constant rate by lowering the pressure energy. Shapes may vary with different shapes. Usually dimensions are very small, and the water flow crosses through micro-orifices like a labyrinth channels which make the pressure drop. The most important properties in drip tubing irrigation systems are uniformity, anti-clogging capacity and lifespan of all components. A well designed dripper device should maximize these aspects and ensure a good hydraulic performance.

Under different dentate structure, there were different intensities of turbulent whirlpools within the path. The flow resistance patterns and energy dissipation patterns were also different. This paper utilised the CFD technology to analyse the flow process within the flow path of emitter and revealed the correlation relationship between the dentate flow path structure and energy dissipation, meanwhile the anti-clogging analysis was conducted. The rear of dentations and dentate tip were the primary regions for energy dissipation. Selecting reasonable boundary structure could produce intensive turbulent whirlpools and increase the internal energy dissipation. The good hydraulic property could also improve the scouring effect along the boundary and the anti-clogging effect of emitters.

By considering anticlogging behaviour of drip irrigation emitter we have designed five different geometries in SolidWorks software. These models were analysed in the software. The CFD analysis shows that Emitter model 1, Emitter model 2, Emitter model 4 & Emitter model 5 shows better performance. But Emitter model 3 shows drastic change in velocity for mass flow profile even at higher rate of discharge from emitter, velocity of water is much lesser as compared to other emitter models.These Emitter model prototypes were

By considering anticlogging behaviour of drip irrigation emitter we have designed five different geometries in SolidWorks software. These models were analysed in the software. The CFD analysis shows that Emitter model 1, Emitter model 2, Emitter model 4 & Emitter model 5 shows better performance. But Emitter model 3 shows drastic change in velocity for mass flow profile even at higher rate of discharge from emitter, velocity of water is much lesser as compared to other emitter models.These Emitter model prototypes were prepared, firstly flow of emitter is checked for confirmation of design and then further samples were prepared. We observed more variation in Model emitter 4 which is calculated as 24.58% as compared to other emitter models.

This may happen because of either variable cross section labyrinth design or pipe material intrusion in emitter labyrinth while manufacturing. In Model emitter 5 variation is less (4.4 %) in comparison with proposed model. These emitter models were further tested for their behaviour of risk of clogging. In clogging test results we observed that Model emitter 4 & Model emitter 5 has better performance than other emitters.

By considering clogging test results we may propose Model emitter 4 or Model emitter 5 for use it in drip irrigation system. But by considering discharge variation in Model emitter 4 is more as compared to Model emitter 5. Even the discharge of emitter is less only one emitter is plugged in Clay clogging test, hence we propose Model emitter 5 has feasible drip irrigation emitter labyrinth.

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