

# Design, Analysis (CFD) and Development of Fertilizers Injection System for Irrigation

K.S.Madhu<sup>1</sup>, Bheemarao Wadekar D<sup>2</sup>

Assistant Professor, Department of Mechanical Engineering, Rajarajeswari College of Engineering, Mysore road, Bangalore, India<sup>1</sup>

Assistant Professor, Department of Mechanical Engineering, Rajarajeswari College of Engineering, Mysore road, Bangalore, India<sup>2</sup>

**ABSTRACT:** We all know that in agriculture for better yield of crops fertilizers are very much essential. But, to distribute fertilizers to each crop with proper proportion will be a difficult task due to many reasons such as mixing of fertilizer with proper proportions, more man power required, paying wages for them, time span etc. which finally results in low yield of crop which is undesirable. To overcome this problem, we have come out with a solution in which the fertilizer is mixed with the water which is being distributed to the agriculture land with proper proportions and without any extra labor for that. It has less cost compared to the conventional method. There are many methods available to mix two fluids require external agency like human power, electric motor, for the purpose. Here we are going through a method which will reduce the external power requirement, by the means of a venturi-meter. The practical functioning of a venture-meter allows us to utilize the flow characteristic of liquid through venturi-meter as a carrier for the mixing of liquids. The results and analysis were done in three ways namely, theoretical, experimental and CFD analysis. Obtained results were compared, where results from all three calculations were in agreement to each other. Thus we concluded the project successfully.

**KEYWORDS:** water, Fertilizers, Venturimeter, Irrigation system, CFD analysis.

## I. INTRODUCTION

Day by day the requirements in agriculture are increasing for higher productivity of crops due to increasing population. In the agricultural field, for proper growth of the crop, it is necessary to provide it require nutrients & this nutrients are made available by the fertilizers. If we use Liquid fertilization it is better for plant growth & its productivity. So our aim is to maintain constant amount of flow for each & every crop or plant. In the agricultural field, for proper growth of the crop, it is necessary to provide it require nutrients & this nutrients are made available by the fertilizers. If we use Liquid fertilization it is better for plant growth & it's productivity. For this purpose liquid fertilizer must be provided in adequate amount. The application of fertilizer through irrigation systems is referred to as fertigation. Using fertigation, fertilizer can be directed towards the plant root zone with irrigation water. A liquid fertilizer solution is injected into the irrigation water at the desired rate. When injecting fertilizer into a properly designed micro-irrigation system the fertilizer will be carried to the plant root zone by the irrigation water.

For efficient fertilization of nutrient elements which plants require at each stage of their growth, this liquid fertilization is used. For healthy growth of any plants, a balance supply of trace elements such as Iron, Boron or Molybdenum is necessary in the water. Furthermore, Nitrogen, phosphorus and Potassium which are often called the three major (or macro) nutrients for plants, are also often found lacking in many plants which cannot give its usual productivity. It enables efficient supplement of nutrient elements to meet the requirements of all your aquatic plants which change in time. A full line of specially formulated supplements were developed also to target specific issues such as colour loss, stress after trimming, and algae resistance. This liquid fertilization proves better than ordinary one. Because all require nutrients of the plant are made available to it in terms, to dissolve in the farm and that are reaches to

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the stem of plant with the help of roots. Means for ordinary powder fertilizer, first it has to dissolve in the farm and then it will reach to the plant with the help of roots. Due to this productivity increases.

Chemigation is the process of injecting chemicals and fertilizers into an irrigation system. Using high-efficiency Venturi injectors, chemigation technology delivers a uniform distribution of chemicals and fertilizers within the irrigation water. With no moving parts, and often no supplemental pump system, Venturi injectors are the right choice.

## II. LITERATURE SURVEY

Once we were sure of what we have to do, our all intentions were towards collecting as many data and information as possible. We looked for all possible sources in form of websites, related projects, published journals etc. Almost two weeks of intensive works all round the corner in 2<sup>nd</sup> and 3<sup>rd</sup> week of January 2014 yielded sufficient materials for us in terms of our project.

Below are the mentioned few important resources that helped us throughout our project

- Developments in Venturi Meter Diagnostics for Dry and Wet Gas Flows , (South East Asia Flow Measurement Conference 6 – 8 March 2012 )

### FERTIGATION TIPS

- Be aware of the effects of storage time and temperature on fertilizer solutions. Many solutions may salt out at lower temperatures. For example urea-ammonium-nitrate solutions will salt out at about 60 EF.
- If injecting phosphorous and potassium make sure you use soluble forms. White phosphoric acid and potassium nitrate are soluble forms of these nutrients.
- Be aware that phosphate will react with calcium to form a precipitant (make sure you test before you inject!)
- Always inject all fertilizers and chemicals before (upstream of) your filtration system.
- Inject fertilizer toward the end of an irrigation cycle, but allow enough time for clear water to displace the fertilizer evenly.

## III. EXPERIMENTAL SETUP

### 3.1 DESIGN AND DEVELOPMENT

Various standards were studied for designing of our equipment. Following parameters were taken for venturi meter.

Inlet diameter: 5.08cm (2inch), Throat diameter: 3 cm, Overall length excluding threading: 31.5cms, Length of thread: 3.5cms, Diameter of projection between throat and hose: 2.54cms (1 inch), diverging angle: 3 degree, Converging angle: 45 degree

### 3D Model

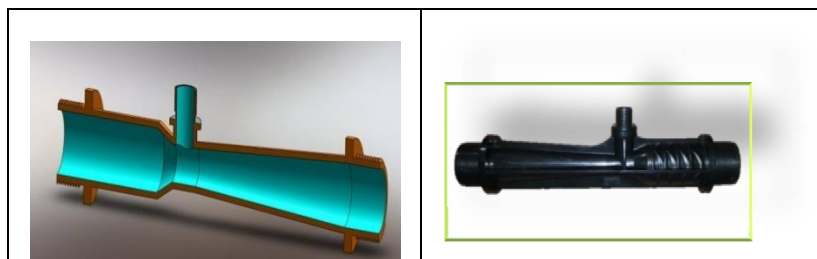


Fig. 1 Inner view of 3D model of venturi meter & b. fabricated venturi meter 3.3

### DEVELOPMENT

### 3.2 SPOT SURVEY

The spot survey as it says deals with the study and research of the field which we planned to set our system and implement the project. We needed to find out more about the land where we are going to implement the project. This

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land was located at Chintamani dist. 80kms form the Bangalore city. It measured about 5 acres with multiple plantations including mangoes, coconuts, lemons, chilies etc. It included 3 main pipe lines which carry water to various irrigation channels. The air view of the field is shown:



Fig 2. Google map view of field

The above map depicts the Google map view of the field. The locations of setup, pipelines and source of water are also represented. It included following observations: Area of land, Evaluating the characteristics of pump, No. of pipelines and irrigation channels, Types of cultivation

### 3.3SETUP

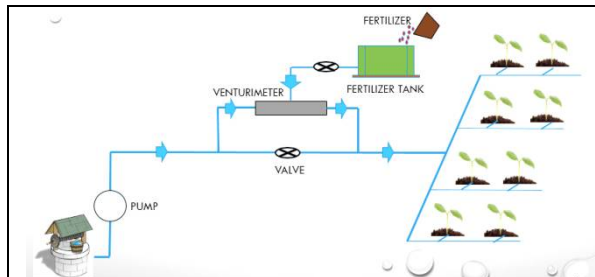


Fig 3 block diagram of the setup



Fig 4 Executed Setup

In the above diagram it explain how the liquid fertigation can be done with the help of venture injector. Injectors require differential pressure to create suction. The injector's outlet pressure (backpressure) must be sufficiently lower than the inlet pressure. So here we are using a venturi meter with certain dimension. That can develop a sufficient pressure difference in the throat and inlet. Pump is another component which should provide continuous flow of water to maintain the pressure difference. Pump may be centrifugal or positive displacement with sufficient arrangement to provide continuous flow of water. The amount of water and fertilizer given to the plants is in a controlled amount. The over or under supply of water, fertilizer or its mixture will damage or prevent the plants growth. Valve can be used to control the flow it. There are two valve used for controlling the water and fertilizer to get its right proposition mixture. Normally the fertilizer available in a solid form, so it have to get completely dissolved in the water. A tank with sufficient capacity is used for this purpose. Pipes and fittings are used to connect the motor, venturi injector, valve, filter, etc. and to deliver the liquid fertilizer to plants.

It will work as follows, when the water pump switch on it will start pumping the water continuously to the drip irrigation. After directing the flow of water to the venturi, a pressure drop will occur at the throat. The pressure drop at the throat helps to suck the liquid fertilizer through filter to the throat of the venturi at a controlled rate. Mixture of water and fertilizer will be the output of the venturi.

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## IV. ANALYSIS

Table 1: change of velocity and head of water to discharge

Discharge	Velocity	Velocity	Head difference
1	0.4933	1.4148	0.0896
2	0.9671	2.83	0.36
3	1.48	4.244	0.806
4	1.9735	5.204	1.4336
5	2.467	7.0735	2.24

Pressure and velocity variation throughout the length of the venturi meter

The pressure varies from inlet to exit of the Venturi meter due to the change in shape and losses. The pressure variation due to losses neglected here. By considering a flow rate of 4 l/s the pressure variation through length is funded out. For this total length is divided in to number of small length and diameter at each length calculated or found out by using design software, Corresponding area calculated, pressure difference between inlet and each area calculated and a graph plotted pressure versus the length of the venturi meter by taking inlet pressure as the reference.

Fig4.1 reveals the change in pressure head as the flow rate is increased. It is clearly visible from the graph that as the fluid flow rate is increased the change in pressure head also increases exponentially. This is because the more flow rate causes more pressure drops at the throat while inlet pressure remains constant. Hence the increase in pressure drops.

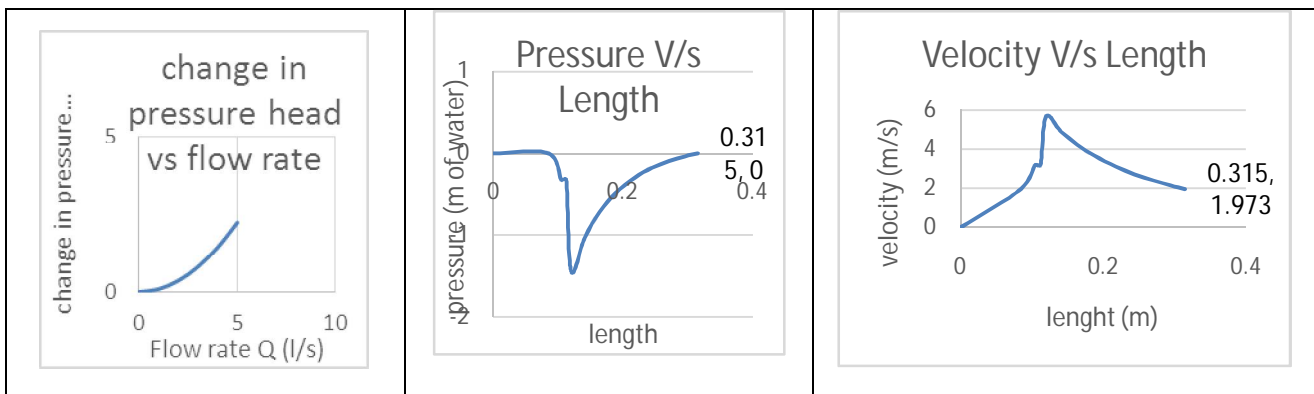


Fig 5 change in pressure head v/s flow rate in venturi meter

Fig 6 pressure variation along the length of venturi meter

Fig 7 velocity variation along the length of venturi meter

Fig 5 shows variation of pressure along the length of venturi meter. We can see from the graph that pressure drops deep at the throat section lesser than atmospheric pressure. Here we assumed no losses in the venturi meter so inlet and outlet pressure at same level. and Fig 4.3 shows velocity variation along the length of venturi meter. The velocity increases at throat due to reduction in area and so on because velocity and pressure are inversely proportional.

### 4.1. EXPERIMENTAL CALCULATIONS

The specification of the motor used for the experimentation is given below.

KIRLOSKAR BROTHERS LTD, DEWAS 455001 (INDIA), Type KDS-1.522+Imp dia. 134mm

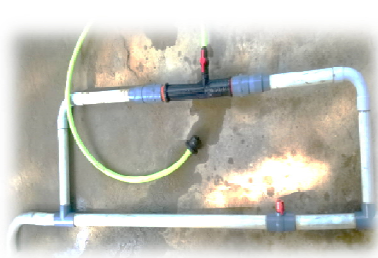
Capacity Range 2.5-5 (4 l/s), Head Range 12-20.5 (17 m), IPKW 1.1-1.5 (1.35), the flow rate of the water pump is experimentally calculated as shown below

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Table no 2: Tabulated readings in experimentation



Trial No:	Liter of water collected	Time taken to collect it in s
1	13.5	3.3
2	15.5	3.9
3	12	3.1

Table 2 contains values to measure flow rate in experimentation. It included three trials and time taken was calculated. The obtained average was 4 lit/s.--Liter per second =  $(13.5+15.5+12) / (3.3+3.9+3.1) = 3.98$  l/s can be taken as 4 l/s

Table 3: observations made during experimentation

Trial No:	Amount of water collected (l)	Time took to collect the water (s)	Fertilizer consumed (l)	Time took to consume the fertilizer(s)
1	5.5	4	4	19
2	9	5.2	5.5	27.23
3	11	3.9	2.5	14.54

Here the flow rate of water increases leads to decrease in the fertilizer consumption because the flow of water through the venturi decreases as the valve get opened means more water will flow directly to the exit not through the venturi. After complete closing of the valve the only way the water pass is venturi so it leads higher fertilizer consumption. So we can say that when the flow rate through the venturi increases more fertilizer will get mix with water

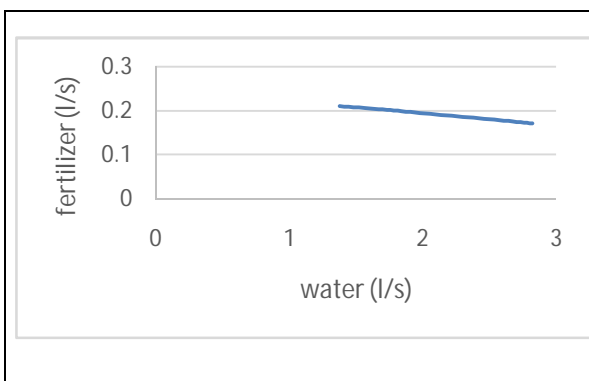


Fig 8 fertilizer v/s water flow rate

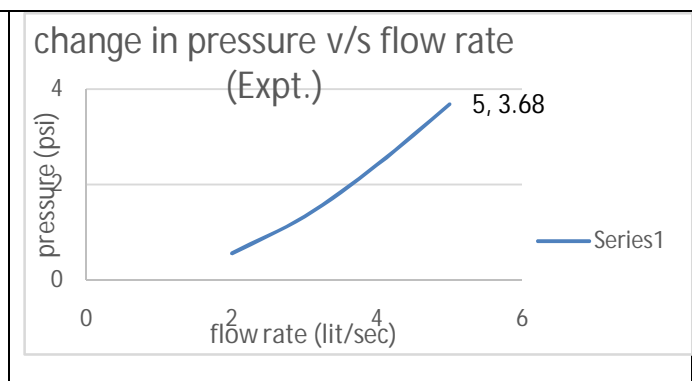


Fig 9: change in pressure v/s flow rate experimentally

Fig 5.3 shows experimental results for pressure variation along the length of venturi meter

## 4.2 CFD ANALYSIS

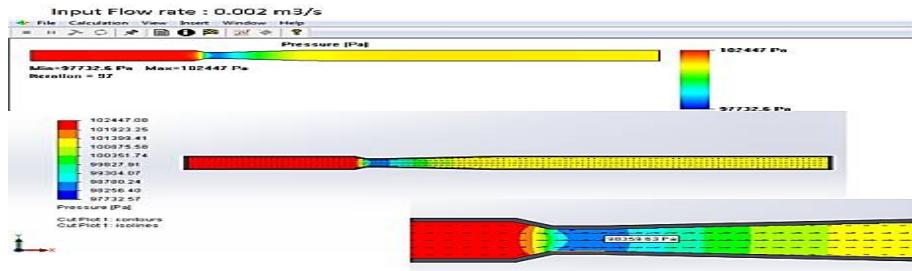


Fig 10 shows CFD analysis of venturi meter for flow rate of 0.002 m<sup>3</sup>/s.

The maximum stress is observed at inlet while the minimum pressure is at throat. This holds true for all different flow rates as shown in following diagrams.

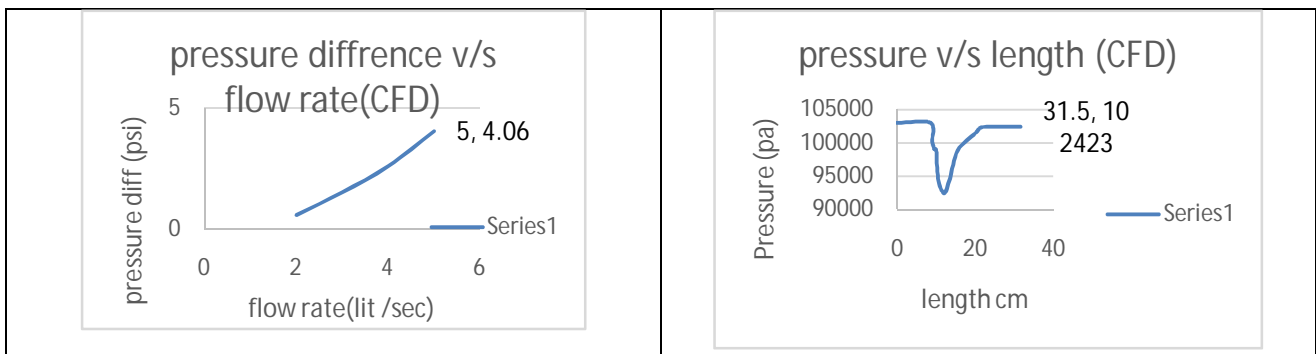


Fig 11 pressure variation along the flow rate of water via CFD

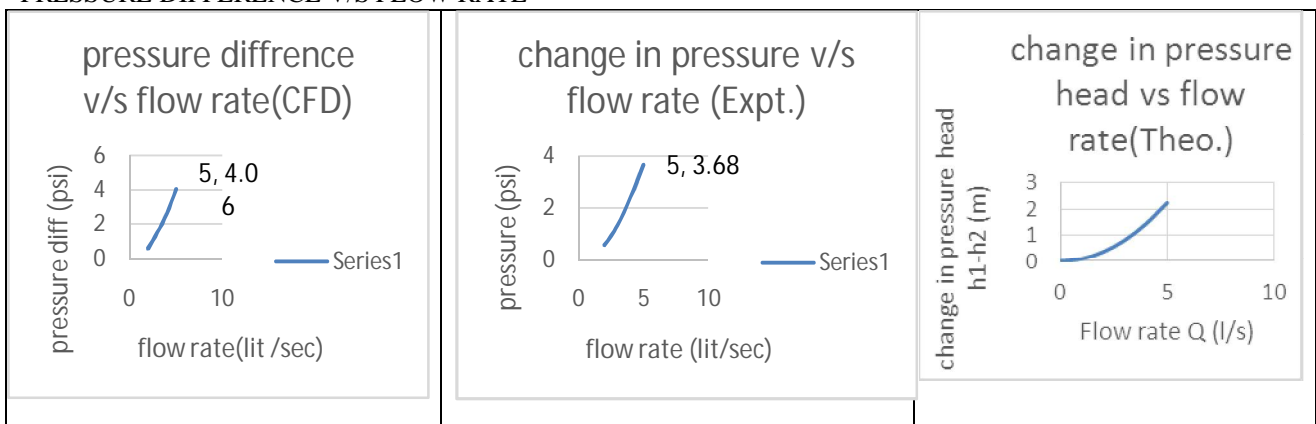
Fig 12 pressure variation along the length of venturi meter

Fig 11 shows the CFD results for the pressure difference as the flow rate is increased. It is more or less similar theoretical calculations and Fig 12 shows pressure variation along the length of venturi meter done in CFD.

4.3 COMPARISON: Here we are going to compare the data available from theoretical, analysis and experiment. Comparisons are made for the following parameters.

1. Pressure differences V/S flow rate
2. Pressure along the length of the venturi meter.

### PRESSURE DIFFERENCE V/S FLOW RATE



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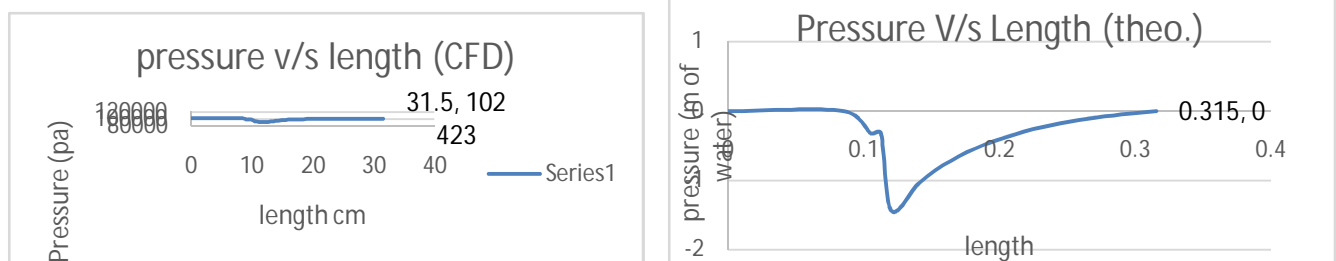
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Comparing the above 3 graphs it is clear that pressure head increases with increase in flow rate. And also we can say that the values of change in pressure head and flow rate corresponding to theoretical, experimental and analysis are similar. From this it is clear that our design is satisfactory.

### PRESSURE ALONG THE LENGTH OF VENTURIMETER

In this project we are concerned about pressure drop that is the pressure at the throat should be less than atmospheric pressure. So finding out the pressure variation along length of venturi following graph have been generated.



From the above graph it is clear that the pressure keeps decreasing from the inlet of the venturi till the throat and the pressure exactly at throat centre is less than the atmospheric pressure (1.10325 bar.) and again it gradually increases along the exit. By comparing the above two graphs we can say the pressure variation across the length is almost similar.

### V. CONCLUSION

We have done our best to show the usefulness of the project. Among the objectives our prime aim was to provide fertilizers to the crops without any external electrical power as well as man power. Our venturi meter model can be used for various discharge and various fertilizers proportions by varying the valve that connects the venture meter and the main flow line. For less proportion of fertilizers the water flow through the venturi meter should be less and it is achieved by opening valve. Similarly for more proportions of fertilizers the water flow through the venturi meter should be more and it is achieved by closing the valve. For various discharges that is for different pump capacity the same venturi meter can be used. From the experimentation, calculation and analysis we got successful results.

### VI. FUTURE RECOMMENDATIONS

Beside successful completion of our project only basic objectives were achieved. This makes it necessary for further research and development that can be done with respect to this project. Some of the prominent steps we would like to recommend are: Many new ideas can be implemented on the material type and design parameters. Apart from that this new technology shall be brought in to practical implementation in large numbers. Researchers can also go for the automation of the setup using typical micro controllers and integrated circuits.

- **Applicable to all kind of farms:** The project is suitable for all kind of farms as there is no question about the fertilization requirement of every plant and trees.
- **Modern farming technique like precision farming:** It is also favourable to farm with modern techniques like precision farming (a technique in which crops are grown in controlled environment and small area and parameters are controlled by microprocessors) or green house farming.
- **Single Crop, Multi-crop Farming and Mixed Farming:** Ideal for all types of farming including single or multi crop farming.
- **Regulated chemical injection:** The amount of fertilizer required can be easily regulated with the variation in flow of water, so it is not a concern as in where the setup can be established given the types of plantation is known.

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