A REVIEW ON PARAMETERS AFFECTING THE COLLECTION EFFICIENCY OF VENTURI SCRUBBER

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Abstract

The venturi scrubber has been used as air pollution controlling device. These scrubbers are promising device for cleaning the contaminated gases. It is found in the literature that the performance of venturi scrubber (i.e. collection efficiency), is significantly influenced by droplet distribution, pressure drop, disintegration of liquid, droplet sizes and injection methods. Effect of submergence height, multi-stage injection, position of the orifice, diameter of orifice, throat length and angle of convergence and divergence of venturi scrubber is found scarce and these parameters are affecting collection efficiency drastically. Therefore, it is necessary to study their effect to improve the performance of self-priming venturi scrubber. This article is the review of numerical and experimental study of the performance in venturi scrubber.

Keywords: Venturi Scrubber, Self-Priming, CFD Modelling, Collection efficiency.

I. Introduction

Now days the norms of pollution control agencies are getting more stringent. Due to these norms industries which are the primary sources of pollution must implement the new pollution control techniques. The venturi scrubbers is one of the best solution to these pollution sources viz, Nuclear Power Plant, Sugar factory, Steel Factory, Cement Plants, Oil Refineries. The release of these pollutants into the environment causes the health issues to human being and animals, Hazardous to plants and crops. To avoid inclusion of these pollutants into atmosphere the venturi scrubbers is very prominent solution. The venturi scrubber are the effective device to meet the todays industrial necessity.

Venturi Scrubber has three major parts as shown in Fig.1 convergent section, throat, divergent section. At the throat, no. of orifices is provided for injection of scrubbing liquid. When the contaminated gas flow enters through the convergent part it is accelerated to move at high velocities inside throat. At throat, scrubbing liquid enters by external force. The high gas flow rate of the contaminated gas at throat result in atomization of scrubbing liquid in to large number of droplets. The
contaminants in the gas are get adhere to those liquid droplets and get scrubbed with outflow of liquid from venturi scrubber. The primary scrubbing action takes place due the inertial impaction and diffusion mechanism [XXIII]. The venturi scrubber can be used to collect both particulate and gaseous pollutants.

![Venturi Scrubber](image)

**Fig. 1 Venturi Scrubber [XXXVIII]**

There is another working mode of venturi scrubber i.e. Self-priming venturi scrubber, as shown in Fig.2. This type of venturi scrubber works when it is submerged inside the scrubbing tank. The scrubbing liquid inside the tank get sucked due to the pressure difference inside and outside of the throat section [XXIV]. The high gas velocities at throat breaks this sucked scrubbing liquid into numerous droplets and rest of the working of cleaning of contaminated gas is same like forced feed venturi scrubber without any external source. The performance of both the mode i.e. Self-priming and Force feed venturi scrubbers measured by collection efficiency.

The present research article reviews the study of the hydrodynamic behavior of venturi scrubber and explains the Performance affecting parameters of venturi scrubber.

![Self-priming and Forced Feed Mode](image)

**Fig. 2 a) Forced Feed Mode b) Self Priming Mode [XXIV]**

### II. Literature Review

The performance of Venturi scrubber i.e. collection efficiency depends on many parameters viz. droplet distribution, pressure drop, liquid disintegration, droplet size and injection method [XXXIX]. The accurate estimation of these parameter is need of
the optimization of venturi scrubber. This article presents the review of the work of researcher for some of these parameters.

II.i Droplet Distribution:

Droplet distribution is a function of droplet size, liquid injection, the jet penetration, liquid atomization, eddy diffusivity & velocity of gas. Fathikalajahi and Talaie (1996) [XVII] had developed 3D dispersion model to study the particle removal process in VS. The obtained results from experimentation of Brick and Contain were compared with their model and found in good agreement. Also, they found that increase in removal efficiency depends on uniformity of droplets distribution as shown in fig 1. The uniformity of droplets increased with Increase in L/G ratio at constant gas flow rate, increase in nozzle diameter, Increase in penetration length. Perpendicular direction of liquid injection increased the uniformity of droplet.

![Fig. 2 (b) Effect of droplet diameter on removal efficiency [XVII]](image)

Fathikalajahi and Talaie (1997) [XVIII] investigated the effect of droplet diameter on the droplet distribution. They had developed 3D dispersion model to predict this effect. The results predicted from this model were validated with experimental results of Viswanathan and found good agreement. Goncalves et al. (2003) had developed the correlation for jet dynamic and validated with a small scale rectangular venturi scrubber. They were concluded that atomization of jet did not start at jet base. Also jet not getting atomize at single location, and it losses its mass travelling through trajectory of jet.

Goncalves et al. (2004) [XX] Validated their mathematical correlation for droplet dispersion experimentally and theoretically. They were ignored the effect of gravity and assumed drag force acting on jet. The uniform droplet distribution inside the throat of VS is important for high performance of it.

Ahmadvand and Talaie (2010) [XII] developed CFD model to study the gas diffusivity for droplet distribution by the use of k-ε turbulence & Eulerian model. They were used cylindrical venturi scrubber. Boll (1973) correlation was used to determine mean droplet diameter, Droplet distribution was predicted by Rosin-
Rammler model and Fathikalajahi and Talaie (1997) [XVIII] model for eddy diffusivity calculations. CFD model results agree with the experimental.

M. Lehner (1998) [XXIV] found that no difference in jet atomization in self-priming and forced feed venturi scrubber. For this study they were took pictures in self-priming venturi scrubber. But observed the jet penetration is most sensitive to the operating conditions.

Roberts and Hill (1981) [X] investigated and liquid disintegration process in different nozzles: straight, converging and orifice. They observed that air & water velocities are responsible for Jet breaks. The effect of jet diameter on the size of droplets has been observed.

Viswanathan et al. (1983) [XL] studied the jet penetration to get the uniform droplet distribution in the throat. Also, observed that collection efficiency increases with increase in L/G ratio, but it was affected due to film formation on the wall with further increases in L/G ratio.

Ananthanarayanan and Viswanathan (1999) [XXX] Developed a CFD model to study the effect of nozzle arrangement on liquid distribution in a Pease-Anthony VS. They found that the distance between nozzles exceeds 10% it forms non uniformity in liquid distribution.

Viswanathan et al. (1984) [XLVII] observed that when L/G ratio was in the range of 7 to 9, the droplet distribution found to be uniform. Also, Liquid flux distribution is affected by L/G ratio and not affected by gas velocity at constant L/G ratio. Particle-In-Cell approach was used to validate this model.

Rahimi et al. (2006) [I] Developed 2D semi empirical correlation to predict droplet distribution and liquid film formation.

Guerra etc. al. (2008) [XLVIII] Studied the effect of multiple orifice injection on the performance of venturi scrubber. Observed that as increases in no. of injection orifice the droplet diameter increases as shown in Fig 1. Also, increase in gas velocity for constant L/G ratio drop diameter decreases.

Fig. 2 (c) Droplet diameter as a function of L/G and no. orifices [XLVIII]
Guerra etc. al.(2009) [XLIX] Observed from the experimental results that liquid disintegration does not occur at single point. High gas velocities caused the flattering of jet penetration due high drag force. Increase in liquid flow rate increases the jet penetration.

Vadila. Guerra et. al. (2012) [XVI] Used the CFD code to study the liquid distribution in the venturi scrubber. The VOF Multiphase model was used to produce jet curve. The pressure drop for the same liquid flow rate the no. of injection orifices do not influence on the pressure drop. Liquid distribution depends on jet penetration and the configuration of injection orifices.

Fig.3 Effect of throat length and gas velocity on drop diameter [II]

Moharana et. al. (2017) [II] Developed 3 Phase computational model to understand the self-priming venturi scrubber. There were used Euler-Lagrangian approach to track the droplet and aerosols. The CFD and experimental results of Haller etc. Al (1989) [XIV] agreed well. Concluded that higher jet penetration can be achieved by higher L/G ratio and larger orifice diameter. Found that droplet size is greatly influenced by gas velocity Fig. 2 and smaller droplet size gave high collection efficiency.

II.i.a Findings Form the Review of Droplet Distribution:

1) As the uniformity of droplet distribution results in increase of the collection efficiency.

2) Uniformity of droplet distribution increases with:
   a) Increase in L/G ratio at constant gas flow rate.
   b) Increase in nozzle diameter
   c) Increase in penetration length
   d) Direction of liquid injection should be Perpendicular.

3) Droplet distribution depends on the distance between the nozzle not on the arrangement of nozzle.

4) In CFD modelling Droplet distribution predicted very well by Rosin-Rammler model.

5) Liquid distribution depends on jet penetration and jet diameter.
6) No difference in jet atomization found in self-priming and forced feed venturi scrubbers.

II.ii. Size of Droplet

The liquid droplet is active medium of cleaning in the venturi scrubber. The removal efficiency of contaminant is dependent on the droplet size. Thus, size of droplet is the essential parameter in the scrub action.

Following are the sources of measurement of droplet size in venturi scrubber given in Table 1:

| Source               | Convergence Angle | Diffuser Angle | Throat Section | Liquid injection method | Method of Measurement |
|----------------------|-------------------|----------------|----------------|-------------------------|-----------------------|
| Alonso et. al. (2001) | 36                | 10             | 0.019          | Spray/film              | Laser diffraction     |
| Gamisans et. al. (2002) | n/a             | n/a            | 0.150;0.1      | Spray                   | Photography           |
| Costa et. al. (2004)  | n/a               | n/a            | 0.035×0.024    | Spray                   | Laser diffraction     |
| Viswanathan et. al. (2005) | 30          | 5,7,9          | 0.076×0.267    | Spray                   | PDA                   |
| Silva et. al. (2008)  | 31                | 10             | 0.1225         | Spray/film              | Laser diffraction     |

Roberts and Hill (1981) [X] Investigated the VS in which scrubbing liquid injected through three types of nozzles; converging, straight and orifice. They were used Nukiyama and Tanasawa equation to predict droplet size by use of photography. They found that droplet size were similar in all three types of nozzles.

Alonso et al. (2001) [XL] Observed from the experiment that droplet size got influenced by gas velocity, and very less of effect of L/G ratio observed on the droplet size. Laser diffraction method was adopted to estimate the droplet size in acylindrical small scale VS. SMD of droplet was well predicted by the Boll (1973) [XXXVI] models as compare to Nukiyama and Tanasawa. Rosin-Rammler function gives satisfactory results for droplet size dispersion. Identical drop size was found for both the film and jet injection method.

Gamisan et al. (2002) [LI] observed that increase in the liquid flow rate and atomization angle of atomizer Sauter mean diameter of the droplet decreased.

Costa et al. (2004) [XXV] Investigated the rectangular VS for the measurement of droplet size by the using LD Method. They found that droplet size was affected by L/G ratio, Gas velocity, Liquid injection point. Drop size decreased as the gas velocity increased. As the distance from liquid injection point increased droplet size also increased. Either Nukiyama Tanasawa or Boll (1973) correlation not gave satisfactory results.
Fig. 4 Effect of L/G ratio and Gas velocity on Droplet size [XXV]

Silva et al. (2009a) [V] Investigated droplet size in large scale venturi scrubber by using laser diffraction. Measurement of droplet size carried out three different sections of VS. The predicted results from Nukiyama Tanasawa and Boll (1973) correlation were not in agreement with experimental results. It was found that breakup and coalescence was the controlling parameter for droplet size. Also, found that the droplet size was decreased along the length of throat Fig. 5.

Fig. 5. Droplet diameter as function of length of venturi scrubber [V]

Guerra etc. al. (2011) [L] Presented the experimental study for droplet size and film fraction by using laser diffraction method for Pease Anthony VS. It was
concluded that increased in jet velocity and gas velocity caused reduction in droplet size. As the No. of injection orifices increased droplet size also increased.

Pak & Chang (2006) [XLI] Developed 3 Phase computational model to estimate the performance of circular Pease-Anthony VS. Euler-Lagrangian approach was adopted to solve this model by using KIVA CFD code. It was concluded that droplet size was the very important parameter to predict the performance of the VS. Also, collision between the droplets affects the size of droplet.

Shaifi etc. al. (2013) [IV] Modelled the CFD model by combining Population balance model in ANSYS CFX tool. Observed that the droplet diameter decreased as the distance from the injection point increased. Also, increased in gas velocity resulted in decreased in droplet size at low L/G ratio.

Moharana etc. al. (2017) [II] Developed 3 Phase computational model to understand the self-priming venturi scrubber. There were used Euler-Lagrangian approach to track the droplet and aerosols. The computed results from CFD model validated with the experimental results of Haller et. Al ( 1989)[XIV]. Found that droplet size is greatly influenced by gas velocity and smaller droplet size gave high collection efficiency.

II.iia  Findings Form the Review of Droplet Size :

1) The Droplet size varies with following parameters:  
   a) Decreases with increase in Gas velocity  
   b) Increases with increasing L/G ratio  
   c) Decreases with increase in distance from liquid injection point  
   d) Decreases with increase in Jet velocity  
   e) Increases with increase in no. of injection orifices  

2) Size of the Droplet found identical for different types of nozzle.  
3) Identical drop size found in film and jet injection.  
4) High gas velocities caused the flattering of jet penetration due high drag force.  
5) Increase in liquid flow rate increases the jet penetration.

II.iii. Pressure Drop :

Pressure drop is the most significant parameter, which affects significantly the performance of VS. Numerous models are established and investigated, which are presented in literature for the estimate of pressure drop across the VS theoretically and experimentally. The best pressure drop predicting models are Calvert (1968) [XXXIX] and Boll (1973) [XXXVI]. The correlations for prediction of pressure drop by each researcher is different due to different assumptions. Some of these correlations for pressure drop in venturi scrubber are summarized here. Calvert (1970) [XLII] correlation is the simplest one due to inconsideration of geometry of venturi scrubber. The momentum change of droplets was only considered in pressure drop equation. Acceleration and frictional effects were neglected during modeling of correlations.
Boll (1973) [XXXVI] developed a model for pressure drop by considering acceleration of gas and droplet, and frictional loss. They assumed total disintegration of liquid.

Hesketh (1974) [XIII] developed mathematical model from the experimental data of different venturi scrubber.

Yung et al. (1977) [XLIII] had modified the Calvert’s correlation for pressure drop by assuming that the velocity of drop not equal to the gas velocity inside the throat section.

Allen et al. (1996) [XXXVII] Investigated the pressure drop in industrial Scale Venturi Scrubber for dry and wet condition. And compared the investigated data between two different venturi scrubbers.

Over camp & Bowen (1983) [XLVI] Presented the data for pressure drop in VS for different throat length and diffusers. Experimental results were compared with Boll and Calvert modified model for pressure drop. It was concluded that for long length of throat with small angle of divergence gave best pressure recovery. And short length of throat with large angle of divergence gave good pressure recovery. They observed that Calvert’s equation not suitable for small scale VS due to under prediction of frictional losses. Boll’s model worked satisfactorily except in wide angle diffuser due flow separation.

Goncalves et al. (2001) [XIX] Presented the evaluation of pressure drop prediction models. They had considered the different models viz. Yung, Calvert, Hesketh (1974), Leith, Boll, Azzopardi and Hollands and Goel and compared with the experimental results from a VS. The VS used were having different configurations. They were concluded that much attention to be paid while selecting pressure drop model.

Gamisan et al. (2002) [LI] Adopted Azzopardi (1991) model for prediction of pressure drop in the ejector type of venturi scrubber. Investigated the effect of throat diameter, throat length and spray angle on the pressure drop. It was concluded that increase in Gas and Liquid flow rate causes increase in pressure drop Fig. 6. The result obtained for convergent and throat part were in good agreement but not gives results for diffuser section.

Fig.6 Effect of gas velocity and liquid flow rate on pressure drop [XIX]
Sun et al. (2003) [XV] stretched his earlier work of boundary layer in divergent section to Full Boundary Layer Model to all the sections of a ventricle scrubber to get an exact pressure difference. The experimental results of Yung et al. (1978) and Sun et al. (2003), was used to validate their model. The FBL Mgives very good results of pressure drop in VS, particularly at high pressure.

Nasseh et al. (2007) [XXXVIII] used ANN software for prediction of the pressure drop in a VS, which does well than the other experimental correlations in literature. The ANN was trained from the data of five different venturi scrubbers. The results of these ANN networks were agreed with the experimental data.

Nasseh et al. (2009) [XLIV] They were improved their earlier study by using genetic algorithmm. The experimental data was extracted from seven different venturi scrubbers and two neural networks were designed to estimate the wet pressure drop and the dry pressure drop in venturi scrubbers. The first neural network evaluates the wet pressure drop with five input variables and dry pressure drop was evaluated in second neural network with four variables. The output variable for both neural networks was the pressure drop.

Silva et al. (2009) [III] used various injection systems to investigate the pressure drop in the large scale VS and studied effect of L/G ratio &gas throat velocity on it. It was found that slight difference in the values of pressure drop for both injection systems.

Rahimi et. al. (2011) [VIII] Developed a mathematical model to predict pressure drop by adding heat and mass transfer equations. The results obtained from model were compared with experimental data of Viswanathan (1985) and Silva et. al. (2009) and found to be in good agreement. Developed model useful when there is temperature difference between gas and injected liquid.

Majid Ali et al. (2012a) [XXVI] Simulated the VS to study the pressure drop prediction by using the ANSYS CFX tool. Observed that pressure drop increased with increased in gas flow rate. Also, pressure drop increased with increased in static pressure at the liquid inlet, because it causes more liquid inlet as static pressure increased.

Fig. 7. Pressure drop for different static pressure [XXVI]
Majid Ali et al. (2012b) [VII] Observed from the ANSYS CFX CFD simulation that the throat pressure drop increased with increased in gas mass flow rate.

Toledo et al. (2014) [XXVIII] Presented the 3D 2Phase numerical simulation of circular venturi scrubber. The obtained numerical results were validated with the Silva et. Al. (2009) experimental results and found in good agreement. It concluded that Gas velocity had great influence on pressure drop as compared to liquid flow rate. The divergence angle had a more effect on the pressure drop than convergence angle due the pressure recovery at divergent section. The change in divergence and convergence angles not affected the maximum velocity of gas.

Zhou et. al. (2015) [LII] Presented the structure design to improve the injection performance of split type self-priming venturi scrubber. They found that Static pressure at the wall is greater than the center due to change in gas velocity near wall and center of VS. As the average gas velocity increased the pressure difference between wall and center found more obvious. But, above 230m/s gas velocity scenario got reversed static pressure increased with increased in gas velocity. It was concluded that as liquid flow rate increased the pressure at the throat increases due to the momentum exchange between gas and liquid. So, the influence of liquid channel area on the injection was found important and its increment was found to be effective for improving injection flow rate.

Horiguchi et al. (2016) [XXXII] Done the numerical simulation of Self priming venturi scrubber by using TPFIT tool. Predicted results were validated with experimental results of Horiguchi (2013) [XXXIII] and found in good agreement. It was concluded that self-priming occurs due the pressure difference at the outside and inside of the throat.

Manisha Bal & Bhim Charan (2017) [XXIX] Studied the hydrodynamics of VS by using the ANSYS Fluent CFD software. Predicted the effect of gas throat velocity, mass flow rate of liquid and L/G ratio on the pressure drop. As the throat gas velocity, mass flow rate of liquid and L/G ratio increased the pressure drop also increased. Higher pressure drop results into higher collection efficiency but it led to high pumping cost.

P. Goel et. al. (2017) [XXXIV] Demonstrated the pressure drop in self-priming venturi scrubber in submerged condition. It was concluded that pressure drop increased with increased in gas flow rate. Theoretical prediction of liquid flow rate slightly increased with increased in air flow rate.

Moharana et. al. (2017) [II] Developed 3 Phase computational model to understand the self-priming venturi scrubber. There were used Euler-Lagrangian approach to track the droplet and aerosols. The results obtained from the CFD model validated with the experimental results of Haller etc. Al (1989) [XIV]. Increased in pressure drop due to increase in L/G ratio observed.

P. Goel et. al. (2018) [XXXV] Performed experiment on Self-priming venturi scrubber submerged in the scrubber tank and studied the hydrodynamics of it. It was found that overall pressure drop increased with increase in gas flow rate. As increased
I. Submergence height caused increase in pressure drop at constant gas flow rate due to increase in liquid loading.

II.iii.a. Findings Form the Review of Pressure Drop:
1) While selecting the mathematical model to predict pressure drop attention to be paid on its assumptions. Every model works for some specific conditions. Boll and Calvert models are more significant models.
2) Pressure drop affected as follows:
   a) Pressure drop increase with increase in gas velocity
   b) Increases with increase in gas flow rate
   c) Increases with increase in liquid flow rate.
   d) Increase with increase in L/G ratio.
   e) Increases with increase in submergence height in the case of self-priming venturi scrubber.
3) The peak pressure drop in throat decrease with increase in throat length.
4) Static pressure near to the wall of throat is greater than center of throat due to low gas velocity near wall which causes increase in pressure near wall.
5) Static pressure difference inside and outside of the throat causes self-priming phenomena.
6) The predicted results from CFD models are in good agreement with theoretical and experimental results.

III. Collection Efficiency
The collection efficiency of a VS is affected by several different parameters like pressure drop, Droplet size, Mass flow rate of gas or liquid etc.

Calvert (1970) [XLII] developed a mathematical model to predict the removal efficiency of venturi scrubber by using the inertial impaction mechanism.

Boll (1973) [XXXVI] developed the equation for prediction of removal efficiency by considering the geometry and the drag coefficient in VS.

Hesketh (1974) [XIII] measured the removal efficiency consider in the jet penetration which is dependent on pressure drop, throat area and L/G ratio.

Goel and Hollands (1977a) [XXI] Developed the graphs to calculate the removal efficiency of venturi scrubber. Because removal efficiency dependent different variables.

Yung et al. (1978) [LIII] modified the Calvert’s collection efficiency equation by determining drag coefficient from Hollands model and validated with Ekman’s experimental results.

Cooper and Leith (1984) developed the model in terms of specific cleaning volume like a Boll’s model.

Costa et al. (2005) [XXVII] Developed a model to predict the performance of rectangular VS. Found that collection efficiency affected by throat gas velocity and liquid injection. Inertial impaction and diffusion were the collection mechanisms observed for the large particles and small particles respectively.
Pak and Chang (2006) [XLI] Investigated the venturi scrubber by developing CFD model by using Eulerian-Langrangian approach. Where gas phase had Euler approach and Droplet and Particles had Langrangian approach. The results got from the model validated with the experimental results and found in good agreement. It was concluded that collection efficiency increased with increased in L/G ratio. Suggested that for accurate prediction of VS performance accurate prediction of droplet size and consideration of liquid film needed.

Taheri and Mohebbi (2008) [XXII] Determined the effect of L/G ratio, Gas velocity and Particle diameter on collection efficiency by using Artificial Neural Network approach. It was concluded that ANN gave the better results as compared to Trial and Error method. The predicted collection efficiency well agreed with experimental results. It was observed that increased in gas velocity and L/G ratio the collection efficiency also increased.

Goniva etc al. (2009) [IX] Analyzed the performance of venturi scrubber in Open FOAM software. Eulerian-Langrangian approach was implemented to solve this model. The droplet breakup was modeled in a (TAB) model. The simulation results were found in good agreement with experimental results. It was concluded that as particle diameter increased the collection efficiency of VS increased.

M. Ali et. al. (2013) [VI] Simulated the spilt type venturi scrubber by using ANSYS CFX software to study the removal efficiency. It was concluded that dust removal efficiency increases with increase in gas flow rate. For droplet breakup CAB model were used.

Zhou etc. al. (2015) [LIV] Experimented on venturi scrubber to find out the effect of geometry on the collection efficiency and pressure drop. Experimental results found that venturi scrubber with large throat and small diffuser angle gave more collection efficiency for small size aerosols, but pressure drop increased due to this.

N. P. Gulhane et. al. (2015) [XXXI] Observed from the experiment performed on self-priming venturi scrubber that iodine removal efficiency of scrubber increase with increase in pH level of scrubbing liquid. The pressure drop results of
experiment well agreed with the theoretical results of Volgin’s Model as compared to Boll’s [XXXVI] and Hesketh Models [XIII].

Zhou et. al. (2016) [LV] Studied the iodine absorption in Self-Priming venturi Scrubber. Conclude that removal efficiency was the function of gas flow rate, Liquid flow rate and temperature. But, not affected by inlet concentration of iodide. Proposed a mathematical model for predictions of performance but it was applicable only for low gas flow rate and high liquid flow rates.

![Graph](image)

**Fig. 9. Effect of temperature on removal efficiency [LV]**

Sung Il Kim et. al. (2018) [XLV] Explained the test facility of the Aerosol Removal and Iodine Elimination which was composed of Self Priming venturi scrubber. Concluded with the experimental results for aerosol concentration measurement techniques ie. ELPI, CPC & OPC.

### IV. Conclusion

From the literature of different researcher this is concluded that the performance of venturi scrubber is measured by the collection efficiency which is dependent on the Droplet distribution, Size of droplet and Pressure drop across the venturi scrubber. These affecting parameters are influenced by gas flow rate, throat gas velocity, Liquid flow rate, L/G ratio, geometrical parameters, etc. This review process find that following are the areas under consideration for future work:

1. The study of the pressure drop, droplet size and distribution in self-priming VS is scarce.
2. The influence of no. of stages of injection, no. of nozzle, nozzle diameter, Submergence height and different convergence and divergence angle on pressure drop, droplet distribution and size need to study in self-priming mode.
3. CFD prediction for effect of submergence height and Pool swelling effect need to study. Also, accurate prediction of droplet size required to predict the collection efficiency accurately by CFD.
4. CFD model for prediction of droplet distribution by using another multiphase model can be studied to get more accurate results.

5. The influence of geometrical parameters of VS on pressure drop, droplet distribution and size need research.

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