*Journal of Advanced Mechanical Sciences (JAMS)*
*ISSN: 2583-3790 (Online)*
*"J. Adv. Mech. Sci., vol. 1, no. 1, pp. 14-20, March 2022"*

# Studies on Venturi Scrubber Performance and Efficiency - A Review

M. Avinasilingam[a]* S. Gopalsamy[b]

[a]*R&D Department, Saint-Gobain, Chennai, Tamil Nadu, India.*
[b]*R&D Department, Quest Global, Bengaluru, Karnataka, India.*
**Corresponding Author Email and Phone Number: avinasilingam165@gmail.com, +91994979815*

*Article received: 05/02/2022, Article Revised: 14/03/2022, Article Accepted: 15/03/2022*
*Doi: 10.5281/zenodo.6482122*



***Abstract***

*The Venturi scrubbers are utilized to separate the fine particulate matters escaped from the furnace during casting process. The Venturi scrubber has large pressure drop. Therefore, it consume large amount of power, and increases the functioning cost of the plant. The effectiveness of the scrubber was affected due to its large pressure drop. In past decades, many researchers attempted to find the suitable parameters and methodologies to reduce the pressure drop. In this study, a literature study was conducted related to pressure drop, efficiency of scrubber, turbulence models applied and alteration in geometrical parameters in previous studies. In addition, a summary was provided related to performance Venturi scrubber.*

***Keywords:*** *Venturi scrubber, Pressure drop, CFD, Mathematical model.*

## 1. INTRODUCTION

Nowadays society and peoples are expecting dustless environment and clean products and also foundries are also looking clean environment in casting process. In foundry, while undergoing casting, forging process many dust particles and gases are formed. It causes more harmful to the surrounding. To avoid that type of harmful gases, many dust controlling process are involved. This study presents about the Venturi scrubbers. For dust cleaning, Venturi scrubber is used for getting better efficiency. So that scrubbers are mostly used for dust collecting purposes. The efficiency of scrubber is reduced due to maximum pressure drop. Due to this reason, many researchers are research about the scrubber to reduce the pressure drop for getting maximum efficiency by changing the suitable geometries with the help of computational fluid dynamics and suitable optimization techniques. Venturi scrubber is used for cleaning the dust particles. Since there are many Venturi scrubbers present, our suggestion is mainly based on the flow of the liquid inside the Venture scrubber. Basically they use to flow the water in throat and on the walls. For our convenient we had made that the

flow of the liquid is passed through throat section of the Venturi scrubber. By using Venturi scrubber we reduce the dust particles.

Though the dust particles were in minute size, they affect the human health .The dust particles are mainly caused from the exhaust of the vehicles. The main parts of the Venturi scrubber are convergent unit, throat and diffuser unit. The dust particles are collected in the convergent section and the water is sprayed in the throat area of the scrubber. If the water is scattered to the dust particles, the weight will be increased and settled down at the bottom. At last, the pure air is discharged from the Venturi scrubber to the environment

Air pollution is the major causes in industry. To control those air pollution several concerns have been performed. By using the cleaning equipment we can analyze the pressure drop, if it is of more, then the efficiency gets decreased. Hence pressure drop plays a vital role in the scrubber. The performance is totally based on the pressure drop.

## 2. EARLIER STUDY OF VENTURI SCRUBBERS

Rahimi et al. [1] here he clearly explains about the mathematical relation of pressure drop with the mass and heat transmission through the scrubber. And also he states that the competence of the scrubber will be very low only because of the pressure drop. The pressure drop gets reduced when the heat and mass transfer takes place. Even though the undeniable effects can be neglected, it may lead to large errors. This large errors results in liquid, higher gas temperature and gas flow rates and the humidity is neglected. Mi and Yu [2] analyzed and created a novel for Venturi scrubber which is totally depends upon the structure of the Venturi scrubber. As per his analysis, he said that the efficiency and the performance is based on the pressure drop.

From previous study droplet size of the Peace- Anthony, jet and gas velocity are the major parameters required for the Venturi scrubber. Guerra et al. [3] experimentally investigated about the liquid droplets present inside the core region and also about the liquid deposition. They carried out various experiments such as variation in jet penetration. The result is totally based on the dimensionless number

Ahmadv and Talaie [4] based on foreign author approach, the two dimensional model was created to analyze the pressure drop in the scrubber. Based on the turbulence model the gas velocity can be determined and also the velocity distribution of the droplets also yet to be determined. By using various techniques and operations the diameter of the droplets are also analyzed. The pressure drop is the main parameter for the determination of the liquid

droplets. For further verification, the performance can be done by using the scale cylindrical Venturi scrubber with vertical liquid flow.

Silva et al. [5] analyzed the fluid flow rate, the amount of liquid flow through the system are the major causes for scrubber pressure drop. By using boundary layer concept we can analyze the divergent unit pressure drop. Finally the experimental data was compared with theoretical model developed by Cruz and Azzopardi.

In this study to forecast the pressure drop, ANN was implemented by Nasseh et al. [6]. In earlier days it was difficult to find the parameters, so they need some correlations to predict. Certain genetic algorithm has been developed to increase the efficiency of the neural network. He has aimed to increase the efficiency of the Venturi scrubber. Finally he modified Viswanathan's model equated with the models for analyzing the scrubber pressure drop.

Taheri and Mohebbi [7] to analyze the separation effectiveness of the scrubber certain new algorithms are founded based on neural network. To create an algorithm for neural networking few parameters are required such as diameter of the particle, the gas rate at the throat area, ratio of gas to liquid flow rate, fluid diameter and the efficiency of the scrubber. And also the velocity, pressure drop, efficiency, ratio values are to be determined.

Nasseh et al. [8] the new way is found to control the pressure drop based upon the neural networks. The main causes for pressure drop is gas velocity, axial distance and ratio of liquid to gas flow rate of scrubber. These parameters are mostly affecting the pressure drop. Three –phase flow has been dispersed from venture scrubber such as gas, dust and liquid. Interaction between phases and the liquid jet by atomization creates a big effect on the performance. Pak and Chang [9] to predict the performance three flow model has been developed. The Lagrangian method in the mathematical relation is used to solve the model and also the velocity of the gas flow can be solved by using the Stokes equation. Previously Basset described about the motion of dust particles, liquid droplets and later it is solved by Lagrangian approach. Simulation of Venturi scrubber by Anthony, with this new model.

Goncalves et al. [10] theoretically and experimentally pressure drop can be analyzed by rectangular Peace-Anthony .The main function of the Venturi scrubber is the distribution of the dewdrop. The recital of the scrubber can be enhanced by minimizing the liquid. In this experiment, throat unit of Venturi was 24mm×40 mm, and the length of the throat altered from 63 to160 mm. On the throat wall orifice is used to inject the liquid (2.0 mm diameter).

This arrangement helps to know about the pressure distribution. At throat region the gas velocity was 52.4 and 77.4 m/s and the flow rate of liquid was 279,562 and 849 ml/min.

Gamisans et al. [11] in this by the absorption of Sulphur dioxide and sodium hydroxide there is a changes in length and diameter of the throat section and the mass transfer can be studied. There are two types of atomized tests are involved. We can compare the experimental values with the prediction in the liquid phase. By boundary layer model the liquid phase can be split into two types, they are drop and flow. Finally it can be explained that the film of the liquid plays a major role in the heat and mass transfer.

Gamisans et al. [12] in this study a scale ejector-Venturi scrubber was investigated .In this based on his analysis he formulated the model which is according to the stable state macroscopic powered energy and also to get the basic questions for the design development purposes. Also the experiments can be done to evaluate the values of coefficients.

Sun and Azzopardi [13] annular flow model and the hydrodynamic model are the two parts of boundary layer model. To calculate the property of the film and the liquid flow ate annular flow rate is used. It is also described in May novels. The boundary layer and the growth modeling can be separated from the diffuser unit of the scrubber. We can compare the predicted values with the standard data over the wide range of system pressure.

Gamisans et al. [14] investigated the performance of the ejectors Venturi scrubbers. In this analysis, few parameter details can be obtained such as droplet size, axial pressure profiles and the pressure drop. Also he analyzed the length, diameter throat and the sprayed angle. The empirical models for the Venturi scrubber are to be tested. Azzopardi et al. 1991 model fully deals with the boundary layer growth which was adapt to the ejector Venturi systems. A study has been proposed based on the experimental thing describes the reliable correlations to calculate the diameter.

Gamisans et al. [15] in this investigation the flue gas contains Sulphur dioxide and ammonia which were absorbed into ammonium hydroxide and Sulphuric acid solutions, using scale ejector Venturi scrubber it has been studied. The performance of the Venturi scrubber can also be characterized by statistical relations and factors such as concentration, air flow rate can be performed. The construction of the Venturi scrubber can also be determined such as two-stage Venturi tube.

Gonçalves et al. [16] in this study, the predictions about those models have been compared with the experimental one based upon the Venturi scrubber of various sizes,

structures, variables, and the arrangements of the liquid. It also says that models were applied with caution. The care was paid more for the assumptions occurred in the mathematical models. For predicting pressure drop of different types of models such as (i) The equations proposed by Calvert (1982) (ii) model developed by Yung et al. (1977) (iii) model developed by Leith (1980) (iv) correlation proposed by Hesketh (1974), (v) The model proposed by Boll (1973) (vi) The model proposed by Hollands and Goel (1975) (vii)The model proposed by Azzopardi and coworkers (1984) and (viii) model of Viswanathan (1985). These types of models were used in this study for predicting pressure drop.

Viswanathan et al. [17] in this investigation, characteristics of fluid flick in forecast of pressure drop in scrubber was scrutinized by gauging flow rate of film, thickness of film, and pressure drop by changing the velocity of throat gas, injection orifice diameter and the fluid packing in a pilot-scale part.

Viswanathan [18] investigated pilot-plant scales and variable of McInnis-Bischoff at the throat of the scrubber through mutable varieties which are generally encounters with industries. The examination includes the clear observation of the pressure drop which is a role of the different runny to gas ratio, the throat area and gas velocity at the throat.The expression for the competence of the Venturi scrubbers in relations of the pressure drop and dust collection proficiency. Pulley [19] used the model of Azzopardi in this model and previous model prediction for pressure drop and dust removal are compared to data for two different types of Venturi with either injecting liquid at the throat section or wetted approach. The results shows that the present model gives highly improved predictions than that of the model which is taken before over an extensive choice of sizes of Venturi and the operating conditions.

Fathikalajahi and Talaie [20] altered Venturi geometry to examine the dispersion of liquid. There was model considered in this process for determining the consequence of size spreading of the droplet on droplet scattering in scrubber. Allen and Santen [21] has investigated the changes that is occurred due to velocity at throat, flow rate, liquid to gas ratio, geometry, fouling surface, axial and radial spot alongside the surface of the Venturi to give detailed measurement of pressure drop. A function for extensive variety of working situations both wet and dry. In this investigation two different designs of Venturi scrubbers were examined, one is industrial prismatic unit and other is a classical design with long throat.

Azzopardi [22] developed a model which is used to determine the movement of the segment of fluid as a thin flick on the partition differs with gas and flow rate of the liquid and throat diameter. Also the model of Azzopardi et al. (1991), show the explanation of evolution and parting of the boundary layer and also gives the assumption of splitting of fluid among wall film and drips.

Azzopardi [23] conducted a test on status of progress and parting of gas limit layer in the unit of the diffuser of venture scrubbers has noticed. In this study, three Venturi of smaller size with varying diffuser angles are used to determine the pressure loss and growth of the boundary layer and separation.

## 3. CONCLUSION

As a result, from the literature review discussed above the different areas that will be covered in this study are as follows.

- Venturi's convergent region has an advantage that it increases the Venturi scrubber's efficiency and decreases pressure drop.
- Height of the Venturi also vital parameter to upsurge the performance of scrubber.
- Particle inlet velocity is based on inlet port size and shape of the inlet tube so this is also considered in this study as a main parameter.
- In this study, for measuring the flow field performance and pressure drop computational fluid dynamics technique is used.
- In CFD technique Reynolds stress turbulence model is used to predicting the flow field performance and pressure drop for different dimensions and shape of the above said seven parameters.

**Acknowledgement/Funding Acknowledgement**

The author(s) received no financial support for the research, authorship, and/or publication of this article.

**Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## REFERENCES

[1] Rahimi, A., Niksiar, A., & Mobasheri, M. (2011). Considering roles of heat and mass transfer for increasing the ability of pressure drop models in venturi scrubbers. *Chemical Engineering and Processing: Process Intensification*, *50*(1), 104-112.

[2] Mi, T., & Yu, X. M. (2012). Dust removal and desulphurization in a novel venturi scrubber. *Chemical*

*Engineering and Processing: Process Intensification*, *62*, 159-167.

[3] Guerra, V. G., Goncalves, J. A. S., & Coury, J. R. (2011). Experimental verification of the effect of liquid deposition on droplet size measured in a rectangular Venturi scrubber. *Chemical Engineering and Processing: Process Intensification*, *50*(11-12), 1137-1142.

[4] Ahmadvand, F., & Talaie, M. R. (2010). CFD modeling of droplet dispersion in a Venturi scrubber. *Chemical Engineering Journal*, *160*(2), 423-431.

[5] Silva, A. M., Teixeira, J. C. F., & Teixeira, S. F. C. F. (2009). Experiments in a large-scale venturi scrubber: Part I: Pressure drop. *Chemical Engineering and Processing: Process Intensification*, *48*(1), 59-67.

[6] Nasseh, S., Mohebbi, A., Sarrafi, A., & Taheri, M. (2009). Estimation of pressure drop in venturi scrubbers based on annular two-phase flow model, artificial neural networks and genetic algorithm. *Chemical Engineering Journal*, *150*(1), 131-138.

[7] Taheri, M., & Mohebbi, A. (2008). Design of artificial neural networks using a genetic algorithm to predict collection efficiency in venturi scrubbers. *Journal of hazardous materials*, *157*(1), 122-129.

[8] Nasseh, S., Mohebbi, A., Jeirani, Z., & Sarrafi, A. (2007). Predicting pressure drop in venturi scrubbers with artificial neural networks. *Journal of hazardous materials*, *143*(1-2), 144-149.

[9] Pak, S. I., & Chang, K. S. (2006). Performance estimation of a Venturi scrubber using a computational model for capturing dust particles with liquid spray. *Journal of hazardous materials*, *138*(3), 560-573.

[10] Gonçalves, J. A. S., Costa, M. M., Henrique, P. R., & Coury, J. R. (2003). Atomization of liquids in a Pease-Anthony Venturi scrubber: Part I. Jet dynamics. *Journal of Hazardous Materials*, *97*(1-3), 267-279.

[11] Gamisans, X., Sarra, M., & Lafuente, F. J. (2004). The role of the liquid film on the mass transfer in venturi-based scrubbers. *Chemical Engineering Research and Design*, *82*(3), 372-380.

[12] Gamisans, X., Sarrà, M., & Lafuente, F. J. (2004). Fluid flow and pumping efficiency in an ejector-venturi scrubber. *Chemical Engineering and Processing: Process Intensification*, *43*(2), 127-136.

[13] Sun, H., & Azzopardi, B. J. (2003). Modelling gas–liquid flow in venturi scrubbers at high pressure. *Process Safety and Environmental Protection*, *81*(4), 250-256.

[14] Gamisans, X., Sarra, M., Lafuente, F. J., & Azzopardi, B. J. (2002). The hydrodynamics of ejector-Venturi scrubbers and their modelling by an annular flow/boundary layer model. *Chemical engineering science*, *57*(14), 2707-2718.

[15] Gamisans, X., Sarrà, M., & Lafuente, F. J. (2002). Gas pollutants removal in a single-and two-stage ejector–venturi scrubber. *Journal of hazardous materials*, *90*(3), 251-266.

[16] Gonçalves, J. A. S., Alonso, D. F., Costa, M. M., Azzopardi, B. J., & Coury, J. R. (2001). Evaluation of the models available for the prediction of pressure drop in venturi scrubbers. *Journal of Hazardous Materials*, *81*(1-2), 123-140.

[17] Viswanathan, S. (1998). Examination of liquid film characteristics in the prediction of pressure drop in a Venturi scrubber. *Chemical engineering science*, *53*(17), 3161-3175.

[18] Viswanathan, S. (1998). Development of a pressure drop model for a variable throat venturi scrubber. *Chemical Engineering Journal*, *71*(2), 153-160.

[19] Pulley, R.S. (1997). Modeling the performance of Venturi scrubbers. *Chemical Engineering Journal, 67*, 9-18.

[20] Fathikalajahi, J., & Talaie, M. R. (1997). The effect of droplet size distribution on liquid dispersion in a venturi scrubber. *Journal of Aerosol Science*, *28*, S291-S292.

[21] Allen, R. W. K., & Van Santen, A. (1996). Designing for pressure drop in Venturi scrubbers: the importance of dry pressure drop. *The Chemical Engineering Journal and the Biochemical Engineering Journal*, *61*(3), 203-211.

[22] Azzopardi, B. J. (1993). Liquid distribution in Venturi scrubbers: the importance of liquid films on the channel walls. *Chemical engineering science*, *48*(15), 2807-2813.

[23] Azzopardi, B. J. (1992). Gas-liquid flows in cylindrical venturi scrubbers: boundary layer separation in the diffuser section. *The Chemical Engineering Journal*, *49*(1), 55-64.