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Studies and Research on Cyclone Separators: A Review

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ABSTRACT

Sustainable development is most commonly used term nowadays. The industrial growth is essential part of global economy. The chemical manufacturing sector is always under scanner of pollution control authorities and organizations because of emission of water and air pollutants. Removal of gases and particulate matter is necessary from social and regulatory point of view. The gases are normally removed by absorption or adsorption. The removal of particulate matter is often carried out by using electrostatic precipitator or cyclone separator. The cost involved for treatment is driving force for optimization and research on pollution control equipments. The present review summarizes research and studies on cyclone separators.

Keywords: Particulate Matter, Separators, Collection Efficiency, Operational Parameters

I. INTRODUCTION

Air pollution control is gaining increasing importance because of various diseases caused because of them. Air pollutants are classified as particulate matters and gases. Various industries emit different gases like hydrogen sulfide, carbon dioxide, sulphur dioxide, oxides of nitrogen and many other gases. Oxides of sulphur and carbon are commonly observed gases because of presence of carbon and sulphur in fuel. Also particulate matter emitting from chimneys of these industries is major environmental problem.

The gases like sulphur dioxide, hydrogen sulphide and carbon dioxide can be treated by absorption in suitable solvent [1, 2,]. Biofiltration is also interesting option [3, 4]. Flue gas treatment of gases is carried out for removal of the gases formed during combustion. Various methods like absorption, adsorption are used for removal of these gases [5, 6, 7]. The particulate matter removal can be carried out by using fabric filters, electrostatic precipitator, inertial separators etc.[8,9,10]. Cyclone separator is one of the important devices for removal of particulate matter. The present review summarizes research and studies carried out on cyclone separator.

II. RESEARCH AND STUDIES ON CYCLONE SEPARATORS : A REVIEW

Pandey and Ray carried out studies on hydrodynamics of a cyclone separator as element of a re-circulating fluidized bed circuit [11]. They investigated effect of the operating conditions on the suspension density in the cyclone and downcomer. They also studied suspension density profiles along the downcomer and riser height. They observed that the suspension density attains its maximum at the cyclone inlet. Also the suspension density decreases along cyclone axis in down ward direction and becomes minimum at cone region. It again increases in downward direction. Vekteris et.al. presented a novel concept of cyclone separator, where sound waves are used to agglomerate fine particles[12]. They presented results of numerical simulation of air flows inside conventional and acoustic cyclone separators. During investigation they observed that the average separation efficiency of conventional cyclone separator reaches 87.2% only, while separation efficiency of acoustic cyclone separator is approximately 97.5%.They proved that air flow inside cyclone separator can be investigated numerically. Qian et.al. carried out numerical study of gas-liquid micro-cyclone separator flow field[13]. They presented the distribution

of gas tangential velocity of the inside flow field and its effects on the movement of liquid droplets. They found that tangential velocity plays an important role in the three dimensional gas-liquid movement of the micro-cyclone separator. They concluded that the tangential degree in micro-cyclone separator basically line with the combination vortex motion. They also observed that from axis to wall, the tangential velocity first increased rapidly to nearly twice of the inlet flow rate, then decreased slowly near the wall.CFD modeling of cyclone separators was carried out by Brennan et.al.[14]. In their work they presented results from CFD simulations of an industrial classification hydrocyclone. They used the measurements like the feed pressure vs. feed flow rate and recovery to underflow vs. feed flow rate for validation.Verma et.al. Carried out investigation on design of cyclone separator under collection efficiency and air density effect [15]. They used rotational effects and gravity to separate mixtures of solids and fluids. According to them, the cyclone is probably the most widely used dust collector in industry because of its simplicity and low operating cost. They characterized cyclone performance as affected by design and operational parameters. With increasing particle mean diameter and density, increasing gas tangential velocity, collection efficiency increased.Gopani and Bhargava carried out studies on cyclone separator aimed at designing of high efficiency cyclone by using stairmand method for a tiny cement plant[16].According to them cyclone separator was reasonable option as it is cheaper and has low operating cost. They designed cyclone separator for 90 percent efficiency.

Jadhav et.al. carried out studies on design development of cyclone based on CFD[17]. They also carried out experimental trials. They carried out experimentation on the performance of flour mill cyclone for different flow rates. They designed cyclone with two symmetrical tangential inlets and a single tangential outlet at the barrel top area where impeller is mounted. Their results indicated that these new designs can improve the cyclone performance parameters significantly. Very interesting details were found on cyclone fluid dynamics properties. In their investigation, Ficici et.al. designed three cylinder-shaped vortex finders with diameters of 80, 120 and 160 mm[18]. They obtained a critical diameter of vortex finder in their investigation. They observed that there was a linear relationship between length of vortex finder and pressure loss. In this investigation, the theoretical argument of critical vortex finder was experimentally proved. Tapkir and Kamble presented analytical and computational fluid dynamics calculation to predict and to evaluate the effects of change in dimensions on static pressure and collection efficiency[19]. They studied velocities, pressures, collection efficiency and the pressure drops according to change in inlet parameters. CFD method was used to generate the pressures and collection efficiency. They used three standard models for carrying out studies, namely Lapple Model, Swift Model and Starmand Model. They formulated a model, which indicated effect of change of cone dimensions along with proportionate change in inlet dimensions. They observed that the value of pressure and collection efficiency increased with the change in dimensions of inlet parameters. Shah carried out a review on gas solid cyclone separator parametric analysis [20]. Their review indicated various reasons for increasing the collection efficiency. Increase in particle size, density, speed of rotation, cyclone length and decreasing the diameter are reasons for that. They also observed that pressure drop and separation efficiency are affected by factors like solid loading ratio, gas inlet velocity flow field parameter. Funk and Baker conducted literature review on dust cyclone seperators[21]. Their emphasis was on cyclone seperators in cotton ginning industry. This industry faces stringent pollution control norms. The cost associated for the dust removal motivates more and more research for improving the efficiency and reducing cost. They reviewed various techniques used in other industries which can be beneficial for ginning industry.This review summarized dust cyclone designs, algebraic and computer models and recent experiments. They concluded that the energy consumption of control devices and not just stack total emissions needs to be considered in the implementation plan as producing electricity to operate control devices results in pollution where that electricity is generated.

Kouba and Shoham presented review on gas-liquid cylindrical cyclone (glcc) technology (22). They presented the status of the development of the the state-of-the-art GLCC, with respect to modeling the GLCC, and discussed current installations and potential applications. The lack of proven performance prediction tools which are valid over a wide range of conditions is

the single biggest impediment to the wide-spread implementation of the GLCC. According to their studies, CFD simulations can capture much detail of local hydrodynamics but are too computationally intensive, time consuming and complicated to apply to large systems. They concluded that the combination of CFD and mechanistic modeling provide a realistic approach to obtaining useful tools for design and performance predictions for the GLCC. The performance of oil-gas cyclone separators in oil injected compressor systems was studied by Gao et.al.[23]. They consider the breakup of oil droplets in oil-gas cyclone while carrying out simulation and experimental studies. They observed that the breakup of oil droplets, especially for the high inlet velocity has significant effect on the separation efficiency.

III. CONCLUSION

From the review of various investigations on cyclone separators, following conclusions can be highlighted – Tangential velocity plays an important role in the three dimensional gas-liquid movement of the micro-cyclone separator. The cyclone is probably the most widely used dust collector in industry because of its simplicity and low operating cost. With increasing particle mean diameter and density, increasing gas tangential velocity, collection efficiency increased. Pressure drop and separation efficiency are affected by factors like solid loading ratio, gas inlet velocity flow field parameter. The lack of proven performance prediction tools which are valid over a wide range of conditions is the single biggest impediment to the wide-spread implementation of the gas-liquid cylindrical cyclone, GLCC. The combination of CFD and mechanistic modeling provide a realistic approach to obtaining useful tools for design and performance predictions for the GLCC.

IV. REFERENCES

[1] Sunil J. Kulkarni, Nilesh L. Shinde(2014), A Review On Hydrogen Sulphide Removal From Waste Gases, International Journal Of Advanced Research In Science, Engineering And Technology 1(4), 187-189.

[2] Sunil Jayant Kulkarni, Ajaygiri Kamalgiri Goswami(2014), Adsorption For Waste Gas Treatment: A Short Review, International Journal For Research In Applied Science & Engineering Technology (Ijraset), 2(12), 513-514.

[3] Veena Ramachandran,Tanmay Uttam Gound , Sunil Kulkarni(2014), Biofilteration For Waste Gas Treatment- A Review, International Journal Of Ethics In Engineering & Management Education,1(4) ,8-13.

[4] Tanmay Uttam Gound, Veena Ramachandran, Sunil Kulkarni(2014),Various Methods To Reduce SO2 Emission- A Review, International Journal Of Ethics In Engineering & Management Education 1(1), 1-6.

[5] Sunil Jayant Kulkarni, Ajaygiri Kamalgiri Goswami & Nilesh Shinde(2015), Treatment and Recovery for Flue Gases: a Review, International Journal of Research (IJR), 2(6), 515-519.

[6] S. Shanthakumar, D.N. Singh, R.C. Phadke(2011), Flue Gas Conditioning For Reducing Suspended Particulate Matter From Thermal PowerStations, dspace .library.Iitb.ac. In/xmlui/handle/10054/1374.

[7] Anil Sharma And Omprakash Sahu(2013), Modelling Of Air Pollution Equipment (Esp), Advanced Engineering And Applied Sciences: An International Journal, 3(2),21-23.

[8] Sunil J. Kulkarni, Pallavi M. Kherde(2015), Studies, Modification and Application of Electrostatic Precipitators - A Review,International Journal of Scientific Research in Science and Technology, 1(4), 1-5.

[9] H. Kawakami, A. Zukeran, K. Yasumoto, M. Kuboshima, Y. Ehara, And T. Yamamoto(2011), Diesel Exhaust Particle Reduction Using Electrostatic Precipitator, International Journal Of Plasma Environmental Science & Technology, 5(2), 179-183.

[10] Pannkaaj More, D.H. Burande(2013), Vibration Performance Evaluation Of Collecting Plates Of Electrostatic Precipitators Using Fea Approach, International Journal Of Engineering Research And Applications, 3(4), 442-446

[11] K. M. Pandey, M. Ray, Experimental Studies On Hydrodynamics Of A Cyclone Separator Employed In A Circulating Fluidized Bed, International Journal Of Chemical Engineering And Applications, 2010, 1(2), 123-132.

[12] Vladas Vekteris, Vytautas Strishka, Darius Ozarovskis, Vadim Mokshin(2015), Numerical

Simulation Of Air Flow Inside Acoustic Cyclone Separator, Aerosol And Air Quality Research, 15, 625–633.

[13] Peng Qian,Liang Ma, Yi Liu, Yanhong Zhang(2013) , Numerical Study Of Gas-Liquid Micro-Cyclone Separator Flow Field, The 2013 Aasri Winter International Conference On Engineering And Technology (Aasri-Wiet 2013),119-121.

[14] Matthew Brennan, Peter Holtham, Mangadoddy Narasimha(2009), CFD Modelling Of Cyclone Separators: Validation Against Plant Hydrodynamic Performance, Seventh International Conference On Cfd In The Minerals And Process Industries CSIRO, Melbourne, Australia 9-11 December 2009,1-6.

[15] Radhe Shyam Verma, Prakash Kumar Sen, Shailendra Kumar Bohidar(2015), Study Of Design Of Cyclone Separator Under Collection Efficiency And Air Density Effect, International Journal Of Advance Research In Science And Engineering, 4(1),44-52.

[16] Niki Gopani And Akshey Bhargava(2011), Design Of High Efficiency Cyclone For Tiny Cement Industry, International Journal Of Environmental Science And Development, 2(5), 350-354.

[17] Mahesh R Jadhav(2014), Design Of Cyclone And Study Of Its Performance Parameters, Int. J. Mech. Eng. & Rob. Res.,3(4), 147-152.

[18] Ferit Ficici, Vedat Ari And Murat Kapsiz(2010), The Effects Of Vortex Finder On The Pressure Drop In Cyclone Separators, International Journal Of The Physical Sciences, 5 (6), 804-813.

[19] Miss. Prajakta Tapkir1, Dr. Dinesh Kamble(2015), Analysis Of Cyclone Separator Using Empirical Models And CFD For Variation Of Dimensions, International Journal Of Research In Engineering & Advanced Technology, 2(6), 225-234.

[20] Shah Nikhil(2015), A Review On Gas Solid Cyclone Separator Parametric Analysis, International Journal For Scientific Research & Development, 3(04), 1204-1207.

[21] Paul A. Funk And Kevin D. Baker(2013), Engineering And Ginning Dust Cyclone Technology – A Literature Review, The Journal Of Cotton Science ,17,40–51.

[22] G. E. Kouba And O. Shoham, A Review Of Gas-Liquid Cylindrical Cyclone (Glcc) Technology(1996), Production Separation Systems" International Conference,Aberdeen, Uk, April 23 & 24, 1-25.

[23] Xiang Gao, Yaopeng Zhao, Jianmei Feng, Yunfeng Chang, Xueyuan Peng(2012), The Research On The Performance Of Oil-Gas Cyclone Separators In Oil Injected Compressor Systems With Considering The Breakup Of Oil Droplets, International Compressor Engineering Conference At Purdue University, Purdue, July 16-19, 1-11.