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Predicting Vibration Performance of Collecting plates of Electrostatic Precipitators

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ABSTRACT

Electrostatic Precipitator is the device used for controlling air pollution. This is used for cleaning of boiler process gases. Boiler process gases contain suspended dust particles. These dust particles are collected on collecting electrodes. The effectiveness of Electrostatic Precipitators is affected by various factors. Periodic cleaning of collecting system plays a major role. Dust gets deposited on collecting electrodes and dislodged by means of vibrations of collecting electrodes. For huge volume of process gas the size of Electrostatic Precipitator will also be large. Since space is major constraints the ultimate solution will go vertically i.e. increase the height and accordingly the collection area. Since in old methods the height of collecting plate is increased due to this the rapping will be ineffective and hence the new methods introduced to increase the vibration. Time is another major constraint for checking of such continuous improvements. So simulation and further physical measurement is more practical method. This work will present FEA concept of modeling and analysis of collecting electrodes of an Electrostatic Precipitator by Implicit Transient Dynamic Analysis. Experimental testing will be done for validation. The results of FEA concept and physical measurements will be observed.

Keywords— **Electrostatic Precipitator,Experimental testing, FEA, Implicit Transient Dynamic Analysis.**

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I. INTRODUCTION

Industrial process gases contain dust particles. This is a big problem of industrial air pollution and has to be controlled. There arevarious air pollution controlling equipment's available in the market like Electrostatic Precipitator (ESP), Bag filters, Cyclones, Mechanical dust collector etc. Apart from this Electrostatic Precipitator (Fig.1) is one of the most popular and often used devices to remove the dust from process gases. The effectiveness of Electrostatic Precipitator depends on parameters like gas flow condition, electric field generation and geometric parameters.

The time to time cleaning is a major activity which is rather the cause of dust collection. The collecting electrodes are cleaned periodically on which dust is collected. Efficiency of ESP depends on the periodic cleaning of collecting electrodes. The dust is removed by introducing the vibrations of collecting plates by means of rapping .The rapping system generates the vibration of collecting plates and due to vibrations the dust layer available on collecting electrodes will get detached and further collected in dust hoppers.

The vibrations of collecting electrodes plays major role and improves the ESP effectiveness and performance. The vibrations created by means of gravity and electrically operated rapping system. The rapping system includes the rotating hammer mounted on the common shaft and arranged in such a way that the cleaning will be periodic. Thus effective working of rapping system plays important role in dust removal process.

Different accelerations are developed at different locations of the system. Accelerations are mainly depends on both energy of the hammer at the moment of impact and the way

in which the force is transferred to the collecting electrodes and also Geometrical features of the electrodes (shape, length, thickness). Impact force generated by the hammer have an essential influence on tangent and normal accelerations at different points of the plates, and thus on the effectiveness of the dust removal process.

The main objective of this study is by using the variousconfigurations of impact hammer produce constant vibrations in the collecting plates of Electrostatic Precipitator.

II. PROBLEM STATEMENT

ESP is widely used for industrial exhaust emission control purpose. The main requirement of the ESP is high performance, easy maintenance, longer life and robust construction. The major challenge in today is Air Pollution Control due to industries are increasing from day to day so it is very important concern to Reduce Air Pollutants emission from industries. ESP manufacturers are looking for innovative ways of modifying the existing ESP designs, thus complying with the industry standards and regulations.Maximization of Vibration Period of Collecting Plates in order to get better performance of the ESP. Hence increase in Vibration Period of Collecting plate will result in improving the ESP performance, handling and cost reduction.

III. LITERATURE SURVEY

The paper reviewed are referred and used directly or indirectly for completing this work. The present project work is based on the studies carried out by various researchers on ESP and Predicting Vibration Performance of Collecting plates of Electrostatic Precipitators.

Stephen L. Francis et.al.[1], discussed the results of research into changes in Electrostatic performance are presented in the paper. The changes come from the optimization of geometric and dynamic parameters of the shaking down system in electrostatic precipitators (ESP). Alstom Power Systems (APS) has developed a new technique to reduce the rapping losses from an ESP. The new Off-Flow Rapping System (OFRS) is introduced by Alstom in which perforated plates similar to the ones used in the inlet of the unit to help reduce or eliminate rapping losses from the ESP.

Pannkaaj More et.al.[2] discussed the FEA approach for modeling and analysis of collecting electrodes in an electrostatic precipitator using Implicit transient dynamic analysis approach. Gives information about vibration excitation of collecting electrodes which is mainly depends upon impact force and system geometry. Maximum displacement is occurring at middle of the collecting electrode and minimum at the bottom discussed effect of different geometrical parameters such as collecting plate profile, plate thickness and rapping location of the system on its vibrations. Experimental testing is done for validation of results.

Manyin H [3] discussed Vibration Period Optimization of Electrostatic Precipitator .The normal operation of the vibration equipment and the dust removing equipment of ESP is an important factor to ensure ESP in a safe, stable and efficient running and has a direct influence on the efficiency of ESP and the working life of the related equipment's. The vibration periods of each electric field were analysed by researching the rule of ash-deposition; the influence of boiler load, fly ash coefficient, carbon content in fly ash and dust content consistency in flue gas on vibration period was analysed by calculating with vibration period calculation formula; giving an example to show the EP at a coal-fired boiler, the vibration periods of each electric field which were calculated theoretically based on the coal and the evaporation capacity were compared with the actual vibration periods to ensure and adjust vibration periods.

SaeedAdibNazariet.al. [4] discussed the numerical model for simulating Fatigue Durability of Collecting Rapping System in an electrostatic precipitator. discussed the numerical and experimental results considering fatigue damage growth and vibration acceleration in the collecting system because of the successive impact of rapping hammers. Shown microscopic examination of the fracture surface due to rapping hammer, beach marks obviously show typical fatigue failure in the rapping hammer arm. The finite elements (FEM) method was used to describe the fatigue failure of the Hammer in Collecting Rapping System. Measuring validation and testing calculations results are presented.

Kim S. and Lee K et.al. [5] have done experimental study of electrostatic precipitator performance. They have designed, built and operated a laboratory-scale single-stage electrostatic precipitator (ESP) in a wind tunnel. As a first step, a series of experiments were conducted to seek the operating conditions for increasing the particle collection efficiency by varying basic operating parameters including the wire-to-plate spacing, the wire radius, the air velocity, the turbulence intensity and the applied voltage. As the diameter of the discharging wires and the wire-to plate spacing are set smaller, the higher collection efficiency has been obtained.

Andrzej N [6] discussed the numerical model for simulating the vibration of collecting electrodes in an electrostatic precipitator. The finite elements method (FEM) was used to describe the shell elements of the collectingelectrodes. The remaining elements of the system were modeled with the application of the rigid finite elements method (RFEM). Measuring validation and testing calculations results are presented. The Vibro ESP calculation software is used. The presented FEM model was extended by introducing RFEM models of suspension and anvil beams, and implemented into Vibro ESP calculation software. The results are validated by comparing the results of numerical simulations with measurements performed on a test stand built by a producer of electrostatic precipitators.

IV. MODEL OF EXISTING RAPPING SYSTEM

An important step towards increasing efficiency of ESP begins with the study of the existing model of the ESP rapping system. The Typical ESP top rapping System consists of rows of collecting electrodes mounted parallels and hanging between top and bottom hangers. Top hangers are mounted on support channel, which are hanging through roof bolts. Anvil is mounted on top hangers on which rapper rod is placed. Electromagnetically operated plunger is placed on top of rapper rod which lifts and falls on it periodically. Due to this impact collecting electrode gets vibrated. These periodic vibrations are responsible for removal of dust from collecting electrodes.

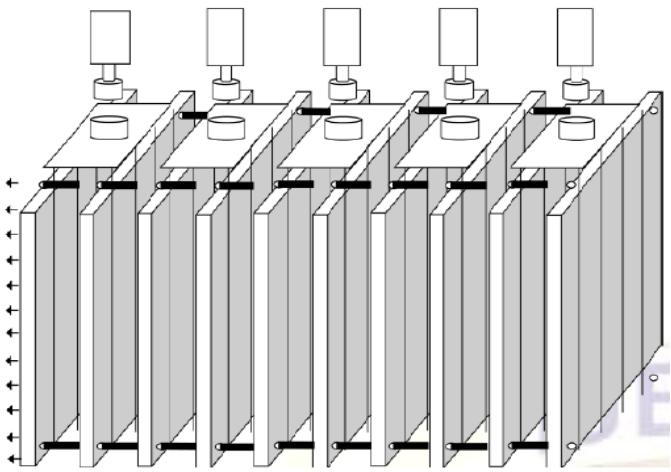


Fig.1 Typical assembly of top rapping system of ESP

V. DETAILS OF EXISTING TOP RAPPING MODEL OF RAPPING SYSTEM

Due to complicated geometry and large size of dimensions use of FEA method for modeling and analysis of vibrations of collecting electrodes is much suitable option. For finite element analysis subassembly of two parallel collecting plates is considered. The commercial software packages are used for modeling, meshing and analysis of the system. In this collecting plates and top & bottom hangers are modeled using shell63 element. Discretization of the solid components like rapper rod, anvil & bolt is done using solid45 element. Collecting plate to hanger bolt connection is modeled using rigid element. Connections of top hanger to support channel and rapper rod to anvil plate are considered as fixed connections. Analysis is done by using ANSYS package.

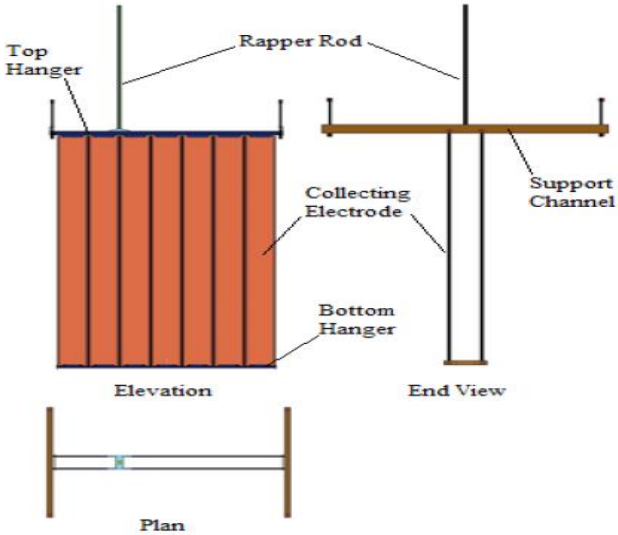


Fig.2 Subassembly of top rapping system of ESP

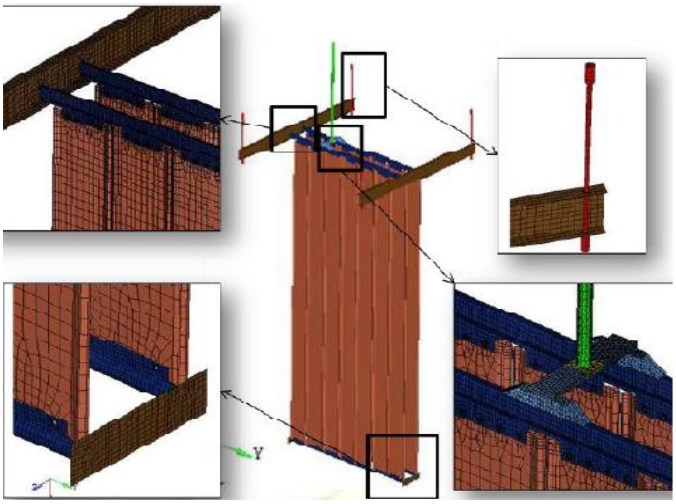
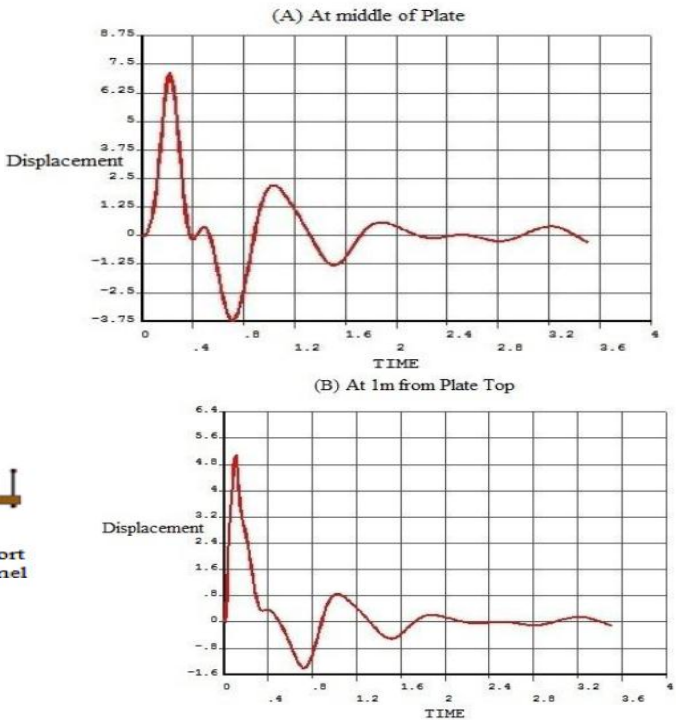


Fig.3 Finite Element Model of ESP Top Rapping Sub System

VI. RESULTS AND DISCUSSION OF EXISTING TOP RAPPING SYSTEM



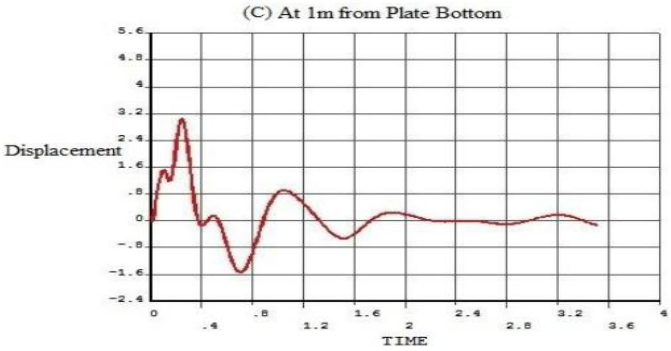


Fig.4 Displacement vs. time plots measured at, (A) At Middle of plate, (B) At 1m from top, (C) At 1m from plate bottom

The variation of Displacement for three different positions on the collecting plate is plotted with respect totime as shown in Fig.4. It is distinguished that in first position that is at the middle of collecting plate vibration or displacement is maximum. In second position that is at 1 m from top of collecting plate vibration or displacement produced in the plate vanishes within small interval of time. In the third position that is at the 1 m from bottom of collecting plate vibrations produced are very small. Hence as distance of plate is going to increase vibrations are reaching to opposite side of rapping.

VI. CONCLUSION

The main sources of air pollution are Industrial process gases contain dust particles. Electrostatic precipitator is one of the pollution control equipment available in the market. The aim of this project is to increase the vibrations of collecting plate of electrostatic precipitator in order to enhance the efficiency of electrostatic precipitator. Design of collecting plate for test is almost completed and validation of collecting plate assembly is done by using ANSYS. Now fabrication collecting plate is focused.After that design of Rapping System of Electrostatic precipitator and experimentation for vibration measurement will be completed.The results top rapping and bottom rapping will be compared by considering vibration parameters.

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REFERENCES

1. Stephen L. Francis , Andreas Back ,Reduction of Rapping Losses to Improve ESP Performance , Alstom Power Inc., 1409 Centerpoint Blvd., Knoxville, TN 37932, USA, pp.45-49.
2. PannkaajMore, D.H.Burande ,Vibrationperformance Evaluation of Collecting plates of Electrostatic Precipitators Using FEA Approach, International Journal of Engineering Research and Applications (IJERA),. 3(4), 2013, pp. 442-446.
3. Manyin H., Yujing L.,Zhong L., Xianglin G., “Research on Vibration Period Optimization of Electrostatic Precipitator”, 11th International Conference on Electrostatic Precipitation, 2007, pp. 94-97.
4. Ali Akbar LotfiNeyestanak, SaeedAdibNazari, Fatigue Durability Analysis of Collecting Rapping System in Electrostatic Precipitators under Impact Loading, Department of Mechanical and Aerospace Engineering, Science and Research Branch, Islamic Azad University, Tehran 14778 93855, Iran, January 2014, pp. 01-09.
5. Kim S., Lee K., Experimental study of electrostatic precipitator performance and comparison with existing theoretical prediction models , Journal of Electrostatics, 1999 pp. 3-25.
6. Andrzej Nowak, Vibration of collecting electrodes in electrostatic precipitators - Modeling measurements and simulation tests, Journal of Electrostatics 70 (2012), pp. 327-332.
7. Nowak Andrzej, WojciechStanisław, Optimisation and experimental verification of a dust-removal beater for the electrodes of electrostatic precipitators, Computers and Structures 82 (2004), pp. 1785–1792.

