REVIEW ON FOULING REDUCTION MORPHOLOGY ANALYSIS IN WASTE HEAT RECOVERY

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Abstract— The particulate deposition on material on heat transfer surface is called fouling. Fouling of heat exchangers in industrial waste heat recovery is a problem which needs to be solved urgently. Fouling and corrosion problems occur in of the energy intensive industries including chemical, paper, glass, textile, cement and food industries. Fouling increases the overall thermal resistance and lowers the overall heat transfer coefficient of heat exchanger as well as impeding fluid flow, accelerating corrosion and increasing pressure drop across the heat exchanger. Development of fouling with time in heat exchanger may deteriorate to the extent that it must be repair or replaced from service. Because of this the preventive measures of fouling are highly encouraged. But some of the techniques used for mitigation of fouling are harmful to the environment.
There are different parameters studied to reduce fouling as well. Like defining flow velocity, particle size, and design of heat exchanger. In design of heat exchanger the parameter will be shape of the tube. So in this research the above mentioned parameters are going to be change for significant reduction of fouling, so as to increase heat transfer rate in the waste heat recovery unit.

Index Terms— Heat transfer, Heat exchanger, and fouling, particulate deposition, waste heat recovery.

I. INTRODUCTION

Many industrial process drains off the heat to the surrounding. This heat is known as the waste heat. The total amount of energy losses is estimated to amount 39% of the total energy consumption [5]. Waste heat is the heat which is generated in the process of fuel combustion, and dumped to atmosphere though it has still some potential amount to be reused in process. According to Pritchard and Thackery, about 15% of the maintenance costs of a process plant is attributed to heat exchanger and boilers, and of this half is probably caused by fouling [8]. The method of how to recover this waste heat is partly depends on the temperature and economic involved. Different types of Heat exchangers are applied in waste heat recovery systems to recover energy from different kinds of process streams. Depending on the conditions in heat exchanger, an insulating layer can form on the heat transfer surface. This process is known as fouling [5]. The fouling problem originates when fuel is combusted in a fired combustion chamber. Depending on the nature of fuel and the specific combustion process involved, these combustion gases will contain a variety of condensable and non-condensable gaseous components, as well as some liquid or solid particulate matter. The combustion gases characterization deals with the properties of particulate matter in gases a function of temperature. Fuel composition, combustion conditions, and any process contamination after the combustion of fuel leads to influence gas characteristics. Geometry of heat transfer equipment is also a major factor in deciding the fouling factor which needs to be addressed properly. The waste heat recovered potential is investigated by its quality and quantity. Current investigation shows that maximum waste heat recovery is carried out from clean, high temperature waste heat sources in large capacity systems. So opportunities are available in developing technologies for dust laden exhaust gases and recovering from low temperature losses.

Figure: Fouling of Heat exchanger

Heat transfer rates in heat exchangers are dependent on the composition and phase of waste heat streams, as well as influenced by deposition of any fouling substances on the heat exchanger. For addressing fouling issue different methods have been used like filtering contaminated streams, constructing the exchanger with advanced materials, increasing heat transfer surface area, and designing the heat exchanger for easy access and cleaning. But still problem of fouling is a big challenge in waste heat recovery units. The present study is going to focus on developing the solution to this challenge to enhance heat transfer rate.

II. LITERATURE REVIEW

Muller et al. [12] reported that by inserting turbulence promoters inside tubes or by using tube corrugations, the heat transfer coefficient can be increased by a factor of 2 to 15 by reducing the thickness of average thermal boundary layer. Turbulence promoters may reduce both the crystallization and reaction fouling. Muller et al. [12] informed that particulate fouling will be enhanced if particulate or fibrous material

already exists in the solution. In [1] Tang et al. research work they developed a discrete phase model for numerical simulation of fly-ash deposition and removal process in tube bundle heat exchanger of waste heat recovery unit. They did simulation at different particle sizes and flue gas velocity, which shows fouling rate increases with smaller particle and decreases with increase of flue gas velocity. Tang et al.[2], has developed the combined discrete phase model and dynamic mesh method, to predict the fouling morphology. Results obtained shows that staggered elliptical tube bundle with small relative transverse and longitudinal pitches can reduce the fouling mass compared to circular tube bundle. Naess et al.[3], did experimental investigation of particulate fouling from real industrial gas stream on bare and finned tubes in cross flow. The results obtained shows that the net fouling rates decreases with increasing flow velocity, and the annular fin tube experienced the slightly higher fouling rate than the unfinned tube. Visual observations of the deposit showed the major part of the particle deposition was on downstream side of the tubes. Fu et al. [6] did the numerical investigation of ash fouling characteristics, to propose effect of flow parameters and geometry parameters on fouling rate. Results shows that elliptical shape tube is recommended for fouling reduction of heat exchanger, while the arrangement of bundles depends on the typical diameter of fly ash to soothe ash fouling. In [7] Kazi, has explained the fouling and fouling mitigation on heat exchanger surface. Review study by kazi has explained how the particle velocity, surface temperature and bulk temperature, surface material, geometry of tube in heat exchanger influencing the fouling. In [9] the researchers has developed CFD model using finite volume discretization to evaluate the performance circular and non-circular tube arrangement in cross flow heat exchanger. In [10] the researchers has developed an experimental setup of double pipe heat exchanger fouling test rig to investigate the mineral scale deposition on different heat exchanger pipe surfaces. The calcium carbonate deposition rates on five different metal surfaces (SS316, brass, Al, carbon steel) were investigated. It was shown that fouling deposition increases with the increase of temperature and concentration due to enhanced potential whereas reduces due to increase of velocity which enhances shear stress.

III. RESEARCH OBJECTIVES AND APPROACH

- Analyzing the fouling characteristics of dust laden gases for removal mechanism.
- Removal of tars and organic vapors from the exhaust gases without dropping their temperature.
- Design waste heat recovery exchangers for fast startup, low thermal stresses, low cost and compact size.
- Validate the result of numerical simulation with Experimental result.

IV. METHODOLOGY

- Design of Experimentation
- Design and Fabrication of Experimental Setup
- Trial Experimentation
- Main Experimentation
- Data Analysis
- Correlation of parameters
- Result and Discussion

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