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REVIEW ON INSPECTION ROBOT FOR THERMAL POWER PLANTS

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Abstract

This paper is an overview of various researches on boiler maintenance and a robot that can be equipped for many kinds of operations is proposed. This robot helps to reduce man power and it will be operated easily with live feedback. It is compact in size and can be used to do work for ASH cleaning, SLAG purging, boiler tubes cleaning, superheater tube cleaning, and will be able to find acidic parameters inside boiler tubes. These overall maintenances of the boilers can be done in one work cycle. The robot can move smoothly on the tube wall using a double magnetic tracked mechanism which is designed specially. The system will be able to drive up inside the tube wall with the cleaning or inspection application integrated. The inspection can be done by using a camera with flash technology for finding boilers parameters and for showing the boilers tube inside the scenario. The system consists of two electro-magnets track drivers connected by a frame for the movement of the robot. The structure of the robot, method of operation and devices, self-protection mechanisms and control system are described and the idea of the design is given.

Keywords: Inspection, Robot, Boiler, Boiler Tubes, Soot, Sludge

Introduction

Power plant boilers are elements of thermal power plants used to convert the chemical energy of the (fossil) fuel first into thermal energy by combustion and subsequently transferring the thermal energy of the combustion gases into thermal energy of highly pressurized water. The water flows inside armed pipes arranged at the inside walls of the boiler chamber. The boiler chambers can measure up to 35m x 35m x 50m. As an effect of the continuous combustion process, the pipes are more and more covered by a layer of combustion residues. These pipes need to be inspected regularly, mainly for wall thickness. Before a reliable inspection can take place, the residue layer has to be removed. As of today, this task is done manually using the dry blasting method. The cleaning and inspection method requires the installation of a scaffold inside the boiler in order to allow the person to access the wall. To reduce the cleaning and inspection time and to make this service task safer, a system is being developed to execute the working steps without scaffolding. The aim is to reduce the processing time significantly down to a few hours or days. Also, the new system allows for recording the inspection data to make it available offline for further analysis

The traditional system uses manpower and some primitive equipment for cleaning the boilers and boilers tubes. In the existing technique, a man goes inside the boiler tube via the entry window present and manually inspects the boiler from inside and according to that, he cleans the fly ash residue and any chemical deposition present on the surrounding walls of boilers. But in the case of boiler tubes, the inspection cannot be done manually due to the presence of fly ash particles inside, which creates very low vision distance and also for cleaning purpose the man has to be inside the dusty condition. To solve this problem this is developing.

Literature Reviews

1. **M. A. A. Shah et al. (2015)** This paper presents the design and development of a small boiler tube inspection robot that is capable of operating in boiler tube with nominal diameter of 1 inch and capable to move in 90° elbow tube. The developed prototype consists of two modules; one for the camera to perform visual inspection and one for the locomotion. Magnetic wheels are adopted to allow vertical movement inside the pipes. Analysis had been done before fabrication and assembly. The final dimensions for the developed inspection robot are 70mm in length, 15mm in height 21mm in width. The total weight of inspection robot is 18g. Different types of tests have been conducted to test the developed prototype. The results obtained show that the inspection robot is fully functional and met the objectives. The prototype is able to move horizontally

and vertically steadily. It is also capable to move in 90° elbow tube. Some limitations observed were that the wire and cable attached to the inspection robot is not flexible enough, thus flexibility of the wire and cable needs to be improved. The camera body is not parallel with motor body and boiler surface after turning. This is due to the unavailability of support from camera's body and the length of the universal joint is too long. From the overall result obtained from testing, it can be concluded that the inspection robot meets the design requirements and is fully functional.

2. **K. S. M. Sahari et al. (2012)** This paper discusses the development and actual site testing of an inspection robot designed for boiler header inspections in thermal power plants in Malaysia owned by Tenaga Nasional Berhad (TNB). The purpose of boiler headers are to tie up multiple boiler tubes together.It was found that the robotic inspection allowed consistent high quality images of the inner wall to be taken for the entire boiler header stretch. It is also observed that the rubber trackscan travel on top of the holes and can overcome all obstacles inside boiler header. Some areas are also identified for furtherimprovement of the robotic system such as a more reliable localization system and also the integration of the imageacquisition system with the main system. Based on the results of the site testing, it can be concludedthat the developed boiler header inspection robot prototype is fully functional. The prototype worked well during the site testing. However, based on observations and feedback from the power plant personnel, areas for further improvement on mechanical, electrical/electronic and graphical user interface(GUI) side have been identified.

3. **W. Zesch et al. (2012)** The cleaning and inspection system being developed in collaboration with Alstom Switzerland, Alstom Inspection Robotics and Water jet Technologies is a compact and automated tool for cleaning and inspection of boiler water walls. The main benefits are the time saving due to omitting of scaffolding works and the increase of safe operation since no working at height is required. The deployment system is a mobile device able to drive across the boiler wall tubes. The system is controlled from a stationary controller by one operator. Different speed rates depending on the application are possible optimizing the installation, cleaning and inspection process time. The integrated cleaning system is based on a suspension cleaning technology resulting optimal cleaning quality and performance. Followed by the cleaning, the integrated ultrasound technology allows a reliable wall thickness measurement. The lab tests show promising results in terms of system reliability and cleaning performance.

4. **L. Xueqin et al. (2009)** This paper shows a design of climbing robot with magnetic wheels for the inspection of boiler tubes in fossil power plants, which can inspect the boiler tubes automatically. The climbing robot moves on the boiler tubes. The magnetic wheels of the robot can be moved on the tubes and the tubing can be inspected through the magnetic flux leakage sensor installed in the end of the front transverse slide arm. The moving mechanisms, inspecting device and inspection algorithm are introduced. The results show that this method can inspect the crack of the boiler tubes. Phenomenon and the detection bias is very small. The proposed controller assures its validity, effectiveness and its superiority to conventional sliding mode controller, smoothing the control actions and robustness against model parameter uncertainties for trajectory tracking of all similar robots. Further study will be placed on the produce of the real structure and intelligence of the climbing robot and on the improvement of detect ability of defect using EML sensor.

Proposed Work

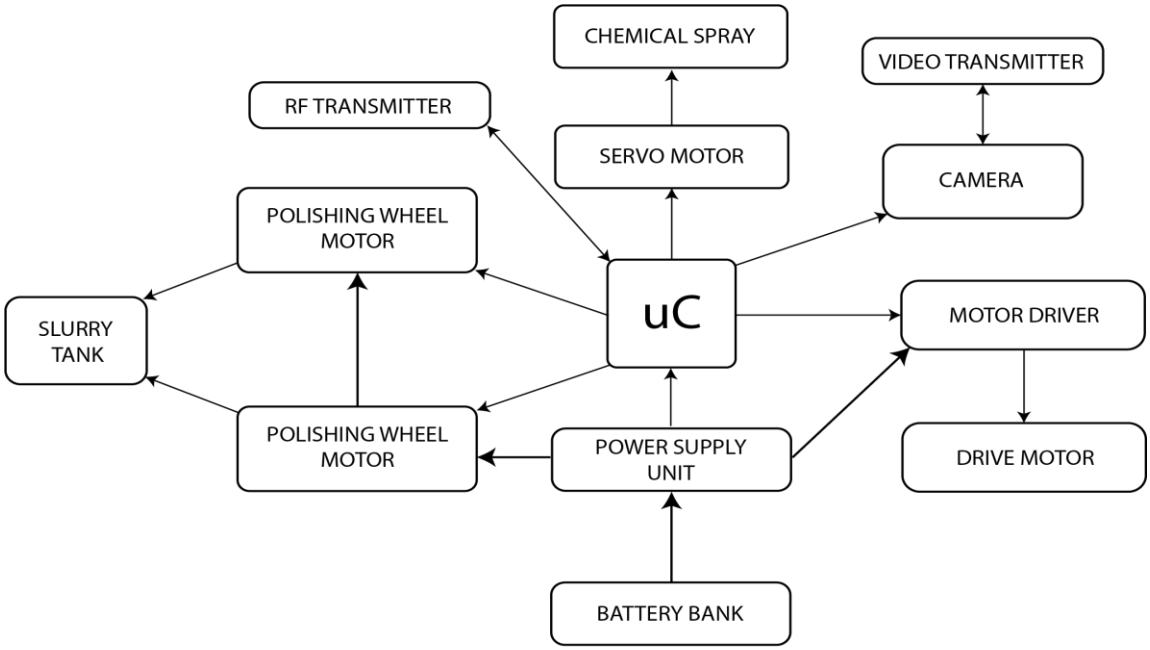

Fig.1 Block Diagram of Purpose System

The proposed robot will be in shape of a cylinder of adjustable diameter ranging from 6 to 8 inches as per the standard size of tubes in boiler, preheaters, and superheaters. The robot will also have a blower system to blow out the ash present in the tube through a mesh filter for clearing the tube air for better vision for live camera feedback. With all this the robot will also have two revolving wheels for cleaning purpose one will be used for scrapping and grinding purpose with bigger grain size for rough and coarse cleaning another one will be used with polishing compound for fine polishing and cleaning, both of them driven by a high-speed BLDC motor. For chemical treatment, a chemical nozzle will be provided with servo-based direction control to focus on a particular spot. The motion and movement of the robot are linear in nature via stationary and moving electromagnets capable of electromagnetic attraction up to 60Kg. The robot will have its own battery bank for power and supply and will be semiautonomous type control based on Arduinouno/mega. The end will have a container to store scraped fly ash and slurry extracted during chemical treatment.

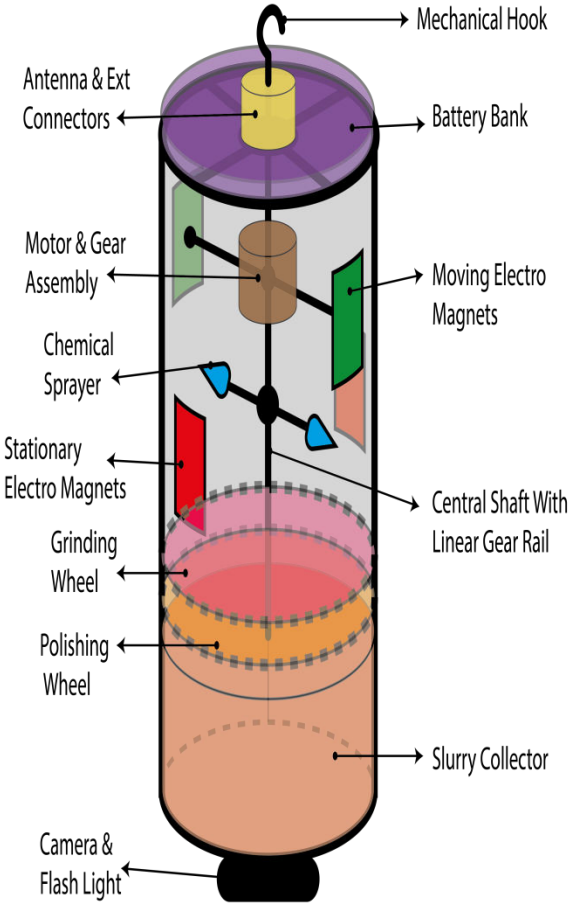

Fig.2 Design of Robot

Hardware Requirement

- Aluminium rods and angles
- ArduinoUno/Mega
- Servo Motor (0-360 degree, 9Kg/cm)
- Relay Module
- Camera 700TVL PAL
- Video Transmitter
- BLDC 2200kV, 3012 Stator
- 2X 5Ah Lead Acid Battery
- Electromagnet 30Kg Pull, 1Amp, 12V
- BLDC ESC 30Amp
- Linear Gear Rail
- High Torque 60Rpm, 12V, 3Amp, MG Box DC Brushed Motor
- Motor Driver H-Bridge 5Amp
- RF Tx/Rx Module

Conclusion

It has been seen that technology can help to solve the failures in a boiler during maintenance conditions, it requires lots of manpower, manual operating machines and harmful chemicals for preventing the surface of the boiler. It creates unsafety for the workers. To eliminate all these harmful operations which may cause a human accident, this project will be designing. The project is mainly based on solving the problem in one work cycle and enhance the safety of workers.

Above mentioned reviews have some unavailability of parts and facing problems while operating, mentioned research paper needs to add components or improving the attached component. Keeping all this in focus, this project will help to solve problems. This project will have a BLDC motor with a propeller which can move at any angle, implementing of a camera for getting information of live operation which is not used in the above-mentioned project, by using of flexible wire the robot will

move smoothly inside the boiler, using microcontroller all cleaning operations will be done automatically and implement slurry collector for storage and will not need to be removed manually. The major advantage of this project is that the operator will be able to see live conditions during the ongoing operations inside the boiler without entering inside it and get live feedback. This project will increase efficiency, improve worker's unsafety, collect slurry automatically in a bin, and increase the life and thermal conductivity of the boiler.

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