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MANUAL OPERATION ADJUSTABLE ROBOT FOR SOOT REMOVER FOR COAL FIRED BOILERS IN THERMAL POWER PLANT

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***Abstract*— A boiler maintenance robot which is equipped for many kinds of operation devices is proposed. This robot has compact size and can be use to do work for ash cleaning, slag purging, boiler tubes cleaning, super heater tubes cleaning, and are 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 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 camera with flash technology for finding boilers parameter and showing the boilers tube inside scenario. The system consists of two electromagnets track drivers connected by a frame for movement of the robot. The structure of robot, method of operation and devices, self protection mechanism and control are described in detail and the idea of the design is given.**

Keywords- boiler tube, climbing robot, microcontroller, lifting mechanism, visual inspection.

I. INTRODUCTION

The robotic applications for pipe inspection are widely utilized in various fields ranging from oil and gas industry to sewage system. As in power plant industry, the sustainability of electric generation and supply to the end user involves periodical maintenance and monitoring of all physical structure and system. One of the major concerns in the thermal power plant of the boiler headers and tubes. This boiler headers and tubes operate under high pressure and thermo-mechanical loading. Thus, it is very important to inspect the overall condition especially the inner surface to avoid unplanned shutdown due to failures caused by degradation, creep, corrosion and others. Until a recent date, the boiler headers and tubes inspection routines at THERMAL power plant have been performed manually by inserting borescope or fiber optic camera attached to PVC pipe. This method is very tedious, time consuming and difficult. The operator is unable to acquire consistent image quality, full coverage of the inner wall and location of the failures or crack. Traditionally system uses man power for cleaning of boilers tubes which is hazardous to there health during inhalation of slag inside the boiler tubes which may leads to the certain danger disease like cancer, asthma or certain inhalation problems. In case of this the robot can be used in certain conditions for cleaning of boilers tubes and for finding defective parameters inside the boiler tube. These robot having the cylindrical assembly and having two electro-magnets for movement of the robot. The robot having the motor and wheel assembly for scraping the slag or ash inside the tube.

An arrangement of chemical spraying is also done in these robot in case if there is any acidic or alkaline chemicals formation had been occur inside the boilers tube. There can be various type of communication system which can be used for cleaning and inspections depending upon boilers parameter which are Camera/Radio Frequency/Bluetooth etc. The system is semi autonomus battery powered, driver based. Specifically Designed for removal of soot in coal fired boilers in thermal power plant .

The assessment and evaluation of surface conditions of boiler headers and tubes are solely depend on the image provided by the camera. Therefore, the inspection robot with integrated image acquisition system offers advantages in term of reliability, robustness and ease of operation compared to manual inspection methods practiced at thermal power plant.

II. BLOCK DIAGRAM

The manual operation adjustable robot for soot remover for coal fired boilers in thermal power plant is used for data inspection of various parameter inside the boiler tubes. Whenever the fault occurs inside the boiler tubes the robot helps for collecting the precise data for finding the various parameters such corrosion, foaming, sludge formation, degradation of tube, ash collection etc.

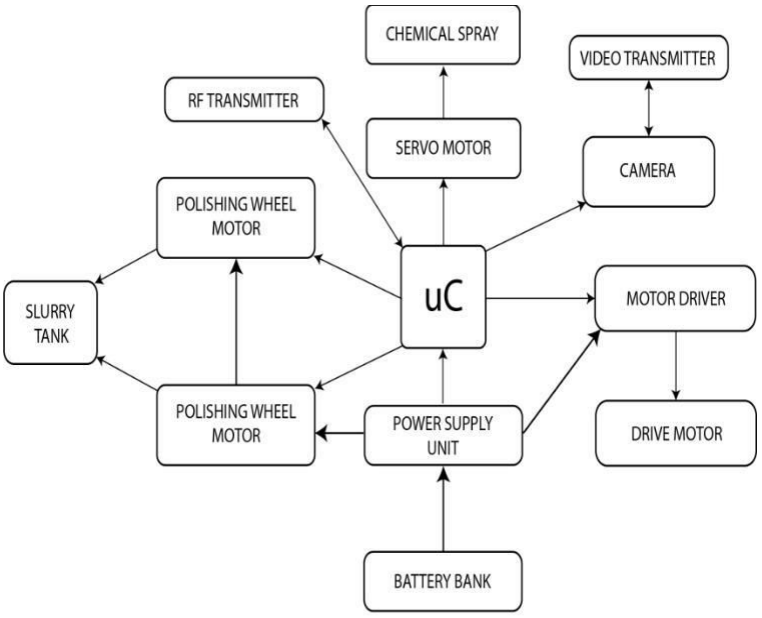

Fig. 1 : Block diagram of manual operation adjustable robot

The main components of the robot are battery bank, power supply unit, microcontroller, motor driver, drive controller, polishing wheel motor, slurry tank, chemical spray, radio frequency module, camera. Fig. 1 shows the block diagram of manual operation adjustable robot for soot remover for coal fired boiler in thermal power plant.

The proposed system is connected to the battery bank of lithium ion battery which delivers power to the power supply unit. The power supply unit delivers power separately to the motor driver unit and to the polishing wheel motor unit. The power control unit is used to control the power required for the different component which requires different rated voltage for different components of the system.

The microcontroller works on dc supply and hence for its working it needs constant 5v dc supply provided by lithium ion battery. The microcontroller will gives command to motor driver unit for the movement of the robot by make use of radio frequency module. After receiving command from the micro controller the servomotor, BLDC motor, high torque dc motor perform the specific task given by microcontroller. For performing the chemical treatment a chemical sprayer arrangement is used by microcontroller.

MICROCONTROLLER:

The microcontroller is one of the main component of the system. Microcontroller is used to manually control the various parameters of robot. Figure 2 shows the diagram of a 32 pin microcontroller AtMega-328p. It is able to inspect the necessary parameters of the boiler tube and boiler and is cost efficient.

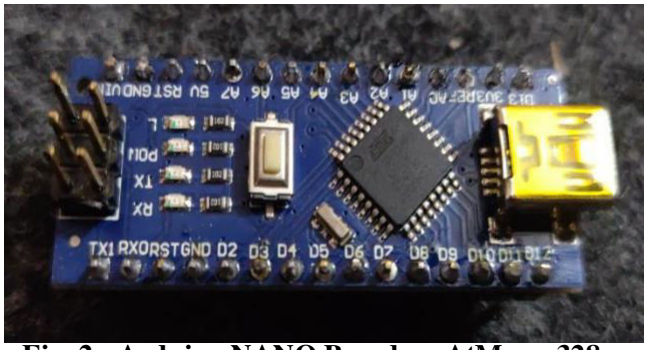

Fig. 2 : Arduino NANO Based on AtMega-328p

Specifications:

- Operation Voltage – 5 V
- Input Voltage – 7 V to 12 V
- I/O Pins – 22
- Digital Pins – 14
- Analog Pins - 8
- Power Consumption – 19 mA
- I/O Pins DC Current – 40 mA
- Flash Memory – 32 KB
- SRAM – 2 KB
- EEPROM – 1 KB
- CLK Speed – 16 MHz

III. ROBOT DESIGN

Considering real boiler tube arrangement and configuration, a prototype of our inspection robot is designed with a- pair of solenoids, screw rail, motor coupler for better traction and a camera. The manual operation adjustable robot (MOAR) is driven by solenoid motors. The robot must be able to transverse in ferromagnetic boiler tubes without any detached parts. The design of the model is given below in fig.3.

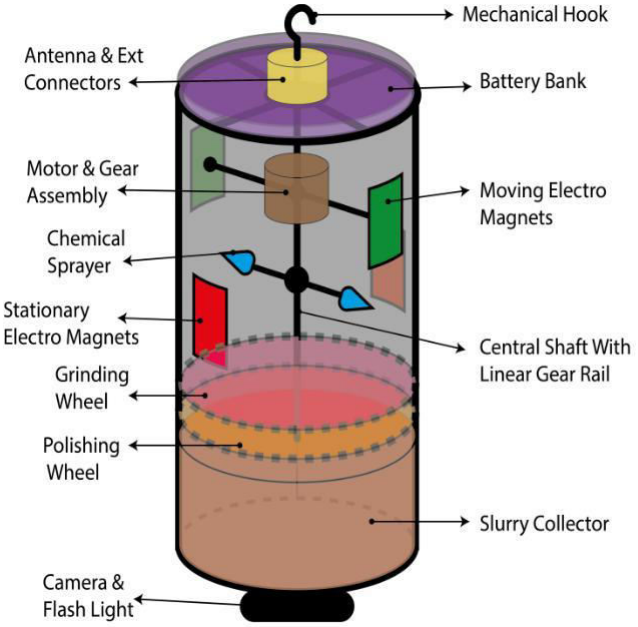

Fig. 3 : Design of climbing robot

A. Material Selection

Material selection is one of the important factors on designing MOAR so that each components and parts will not break or fail. Any parts that break or malfunction will cause the system fail to the inspection robot. Worst case scenario the fail system will disassemble and cause damage to the inner surface of the boiler tube. Properties that are important in material selection are mass, tensile strength, yield strength and stress. Selected material for camera body part and motor body part will be is shown in Table 1.

Table 1 . Material selected

Components	Material
Chasis	MS Rod Dimensions – 360mm X 640mm
Shaft	MS hard anodized 6mm
Solenoid	MILD STEEL MODEL – 12V KK-P40/25

B. Robot structure

The robot form is track-type with cyclindrical body (Figure 3). The dimension of the robot is 360mm x 640mm. This would allow the robot to enter through inspection nozzle of diameter 12inches=0.305meters. The material used for the robot is mainly MILD STEEL. A safety cable is attached to the robot in case of power or motor failure so that the robot can be manually retrieved.

C. Electronics and Control System

Microcontroller is used to control the movement of the robot through (radio frequency module). The microcontroller control layout is shown in Figure 2.after receiving the command from receiver the moving and stationary electromagnets (solenoids) gives the linear movement for robot. Which works by giving signal like an actuator. After the grinding task has been perform by the brushless dc motor (BLDC) by make use of its propeller. Then it goes for polishing by make use of high torque dc motor. For chemical treatment inside the boiler tube servo motor is used. It will rotate 360 degree wherever the chemical treatment is required.

D. Camera and Camera Holder

The system is using 1500 TVL PAL model-mini B19 orange type camera and visual display system during inspection for the current stage. The robot has a platform where the existing camera is to be mounted and secured. Due to the variation of entry and boiler tube diameter, this platform is designed to be collapsible during entry and fully expanded during inspection. The platform will enable the users to see areas that were not reachable before.

IV. CONCLUSION

This paper proposed a robot design that is able to operate inside the boiler tube. The objectives that need to be achieved are to design and develop boiler tube inspection robot that can operate and travel along the boiler tube with camera attached to the robot. Analyses on magnetic solenoid, motor selection and material selection have been conducted to ensure that the prototype is fully functional. Different type of testing has been carried out to inspect the functionality of the developed MOAR. From the overall result obtained from testing, it can be concluded that the inspection robot meets the design requirements and is fully functional although some limitations are observed during testing. These limitations will be addressed in the next version of the MOAR prototype.

V. ACKNOWLEDGEMENT

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