# ZIGBEE Based Robot for Detection and Removal of Wood Pellets in Pipelines

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*Abstract*— This paper deals with a design of a robot for detection and removal of wood pellets in pipelines. The objective of designing this robot is to remove the human factor from dangerous work and also to act in inaccessible environment. The goal of this paper is to remove the wood pellets to increase the combustion efficiency which increases the power generation. The robot is controlled by zigbee through which we can make our robot communicate from a distance. It is a human controlled robot that gives an insight view about the pipeline. It can sense temperature and humidity of the place and hence immediately send information to the controller. The robot is operated through PC using wireless zigbee technology and using wireless camera we can get information about the pipeline. Robot has number of advantages and application such as inspection, maintenance and cleaning purpose as well.

***Key words:*** Robot, Removing wood Pellets, Wireless Camera, Zigbee

## I. INTRODUCTION

Now a day the usage of electricity is increased due to human needs. For industrial side usage of electricity gradually increases and all domestic equipments and appliances are working in electricity. Hence, the power production is not sufficient. So we have to increase power production. Usage of fossil fuels and nuclear energy causes harmful to the environment and serious environmental hazards. So we have walk to renewable energy sources or also called green energy. All the countries are trying move on to renewable energy sources like hydro energy, wind energy and solar energy etc. Among them Biomass has become one of the most commonly used renewable energy sources for power generation because of its Co2 neutral properties [1]. Handling of biomass requires an elutriation process which is nothing but separation of larger and the smaller particles using compressed air. The small particles like dust are conveyed to temporary storage tank and then to furnace, while the large particles such as wood pellets are conveyed to grinding mill for pulverization before combustion. Due to some difficulties in maintaining the elutriator, wood pellets may present in dust flow. Direct combustion of wood pellets leads to many issues such as low combustion efficiency.

Currently, the detection of wood pellets in dust flow is realized through regular inspection of pipelines manually. Many of the techniques have been introduced to detect wood pellets [7, 8] in pneumatic conveying pipelines. But all the techniques are used only to detect the presence of wood pellets. This may leads to operational issues such as low combustion efficiency, high pollution emission. The present technique avoids the difficulties by removing those wood pellets in dust flow using robot. Robot involves mechanical, usually computer controlled devices to perform tasks that require hazardous work by people. The presented robot control system can be used for detecting and removing the wood pellets present in dust flow. Thus it increases the combustion efficiency which increases the power generation. It is designed to remove human factor. A lot of troubles caused by piping networks like aging, corrosion, cracks, and mechanical damages. So, continuous activities for inspection, maintenance and repair are strongly demanded.

## II. SURVEY OF THE RELATED WORK

In [1] [2], this describes about biomass. Biomass encompasses a large variety of materials, including wood from various sources, agricultural residues, and animal and human waste. [3] Biomass can be converted into electric power through several methods. The most common is direct combustion of biomass material, such as agricultural waste or woody materials. The pellet production [4] includes the process of grinding the wood pellets and these saw dusts are conveyed to the combustion chamber for heat or electricity. While direct combustion of wood pellets will give rise to problem in power generation. Thus different techniques have been developed to detect the presence of wood pellets such as those based on laser diffraction, digital imaging, piezoelectric sensing, vibration and acoustic sensor.

Particle size distribution is determined by applying Mie theory of light scattering [5]. It has the drawbacks of high cost, complexity and requirements for skilled personnel to operate. In [6] CMOS camera is used to capture 2D images of particles that are illuminated by external laser beams and then drives the particle size distribution through image processing. It is cost effective but requires regular maintenance. In [7], an impact probe is inserted in to the particle flow and drives the particle size from the piezoelectric signal due to collisions between the probe and the particles.

Wood pellets are detected using vibration and acoustic sensor. This system [8] captures the vibration and sound generated by the collisions between biomass particle and the pipe wall. Time frequency analysis technique is used to eliminate the environmental noise from the signal, extract information about collision and detect the presence of wood pellets. It fails to remove external noise as because it removes the noise only when the environmental noise is below cutoff frequency.

It [9] deals with design issues of in pipe inspection robots. Further, robots are classified on the basis of structure and method of locomotion. This paper can be utilised as a guideline while designing IPIR for a particular application.

The design of a robot to rescue a child in a borehole is described in [10]. It is a human controlled robot that gives insight view of rescuing baby safely. Robot moves inside the pipe according to user commands given from PC.

 

## III. PROPOSED SYSTEM HARDWARE

The proposed system consist of sensor, humidity sensor, embedded system, robot control motors, camera motion control motors, wood pellets removing mechanism, blower, and separate driver mechanism to control these sections, pipeline robot, camera, zigbee transceivers, a personal computer, power supply and a battery. It is a novel method of detecting and removing of wood pellets presented in pneumatic conveying pipelines using robot. A robot is designed which is operated through PC using wireless zigbee technology and using wireless camera we can get insight view of the pipeline. A temperature and humidity sensor is carried out by the robot, where it gives information about temperature and moisture level inside the pipeline, thus it helps to avoid flaws in the pipeline. It is a low cost robot used to monitor throughout the pipeline and gives information about the presence of wood pellets and the flaws in the pipes.

Robot is placed inside the pipeline. Zigbee transceiver is interfaced between microcontroller and PC. The controlling device of the whole system is a microcontroller. Whenever the user presses a button from the keyboard of the PC, the data related to that particular button is sent through zigbee module interfaced to PC. This data will be received by the zigbee module in the robot system and fed this to microcontroller which judges relevant task to the information received and act accordingly on the robot. At the time of detection of wood pellets by means of cameras input signal, the pipeline robot are activated to move inside the pipe and by removing mechanism wood pellets are removed. A blower is also for cleaning purpose. The live images from the camera in the robot system can be sent to monitor. The microcontrollers used in this project are programmed using embedded C language. Hardware design of robo section and control section for detection and removal of wood pellets in pneumatic conveying pipelines using robot is shown in figure1 and figure 2.

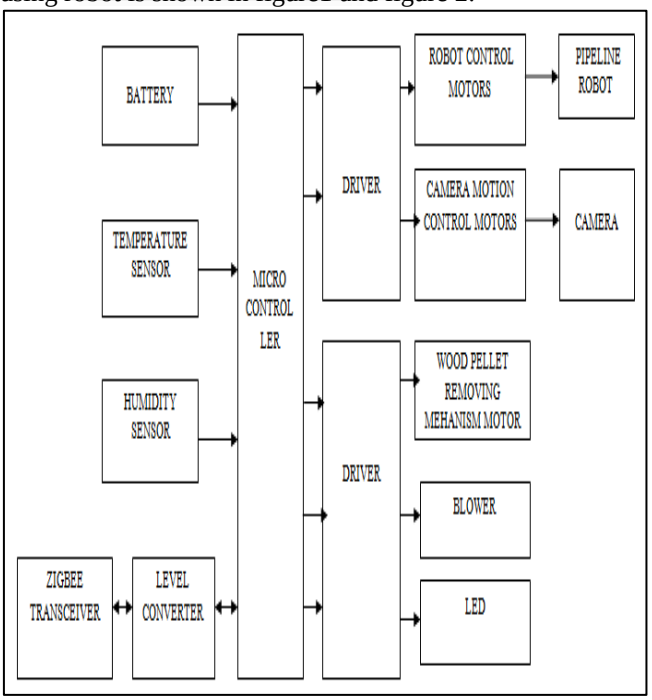


Fig. 1: Hardware Design of Robo Section

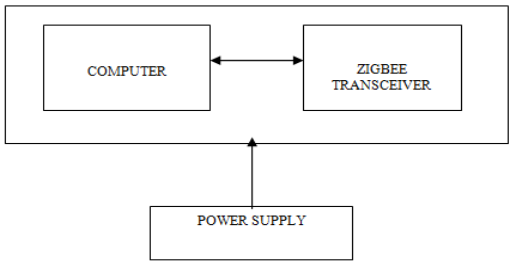


Fig. 2: Hardware Design of Control Section

### A. *Micro Controller:*

The microcontroller that is been used is the PIC 16F887A controller. PICs are popular with both industrial developers and hobbyists alike due to their cheap, easily available, large user base, easy to program according to application, free development & low cost tools availability, and serial programming and re-programming with flash memory capability. The microcontroller is used to gather the data from the sensor unit in real time and compare it with the set point safer level of temp and transfer the corresponding information data to the CPU of control room. It also receives commands from the CPU and transfers it to the robot unit for its movement. The microcontroller is the core of the surveillance robot.

PIC 167887 includes high-performance RISC CPU. Its wide operating voltage range is from 2.5V to 5.5V.Low-power, high-speed CMOS EPROM/EEPROM technology. It includes Up to 8K x 14 words of Flash Program Memory and 256 x 8 bytes of EEPROM data memory. It includes direct, indirect, and relative addressing modes. Programmable code-protection, Power saving SLEEP mode, Processor read/write access to program memory are some other features of PIC16F887.

### B. *Temperature Sensor:*

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in degree Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies.


Fig. 3: LM35 Temperature Sensor

*C. Humidity Sensor:*

Resistive humidity sensors shown in figure 4 measure the change in electrical impedance of a hygroscopic medium such as a conductive polymer, salt, or treated substrate. The impedance change is typically an inverse exponential relationship to humidity Resistive sensors usually consist of noble metal electrodes either deposited on a substrate by photoresist techniques or wire-wound electrodes on a plastic or glass cylinder. The substrate is coated with a salt or conductive polymer. When it is dissolved or suspended in a liquid binder it functions as a vehicle to evenly coat the sensor. Alternatively, the substrate may be treated with activating chemicals such as acid. The sensor absorbs the water vapour and ionic functional groups are dissociated, resulting in an increase in electrical conductivity. The response time for most resistive sensors ranges from 10 to 30 s for a 63% step change. The impedance range of typical resistive elements varies from 1 kΩ to 100 MΩ.Most resistive sensors use symmetrical AC excitation voltage with no DC bias to prevent polarization of the sensor. The resulting current flow is converted and rectified to a DC voltage signal for additional scaling, amplification, linearization, or A/DR conversion.

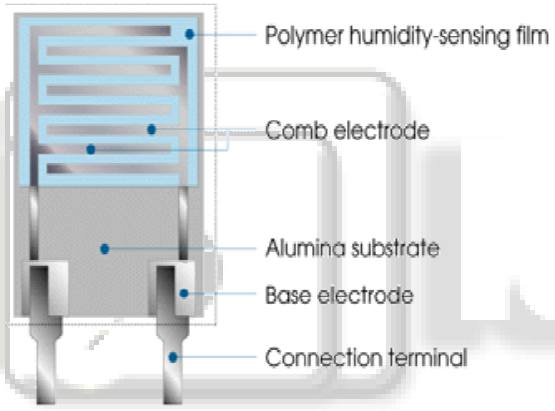


Fig. 4: Resistive Humidity Sensor

*D. Zigbee:*

ZigBee is an established set of specifications for wireless personal area networking (WPAN), i.e. digital radio connections between computers and related devices. WPAN Low Rate or ZigBee provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life. ZigBee makes possible completely networked homes where all devices are able to communicate and be controlled by a single unit. The Figure5 shows the CC2500 ZigBee module. CC2500 ZIGBEE Module is a transreceiver module which provides easy to use ZIGBEE communication at 2.4 GHz. It can be used to transmit and receive data at 9600 baud rates from any standard CMOS/TTL source. This module is a direct line in replacement for your serial communication it requires no extra hardware and no extra coding works in Half Duplex mode i.e. it provides communication in both directions, but only one direction at same time.

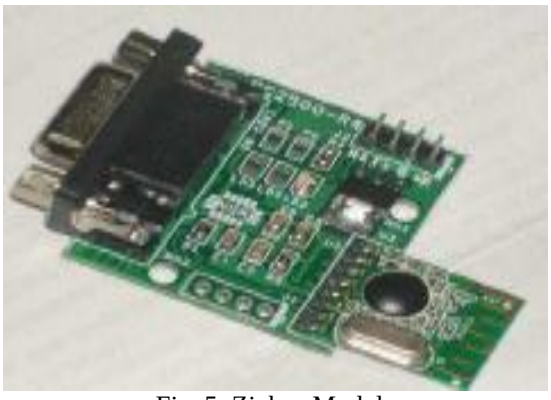

Fig. 5: Zigbee Module

*E. Gear DC Motor:*

It can be defined as an extension of DC motor. A geared DC motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and it is termed as RPM. The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reductions.

Fig. 6: Gear Motor

*F. Wireless AV Cam:*

Wireless security cameras are closed-circuit television (CCTV) cameras that transmit a video and audio signal to a wireless receiver through a radio band. Wireless cameras are proving very popular among modern security consumers due to their low installation costs and flexible mounting options, wireless cameras can be mounted/installed in locations where previously unavailable to standard wired cameras

Fig. 7: Wireless AV Camera

*G. Blower:*

Air blowers generally use centrifugal force to propel air forward. Inside a centrifugal air blower is a wheel with small blades on the circumference and a casing to direct the flow of air into the center of the wheel and out toward the edge. The design of the blades will affect how the air is

 

propelled and how efficient the air blower is. Blade designs in air blowers are classified as forward-curved, backward-inclined, backward-curved, radial and airfoil

Fig. 8: Blower

## IV. SOFTWARE IMPLEMENTATION

LabVIEW is a short form of Laboratory Virtual Instrumentation Engineering Workbench. It is a platform and development environment for a visual programming language from National Instruments. LABVIEW software is used for detection and removal of wood pellets in pipeline. The simulation result for block panel and front panel is shown in figure9 and figure10.

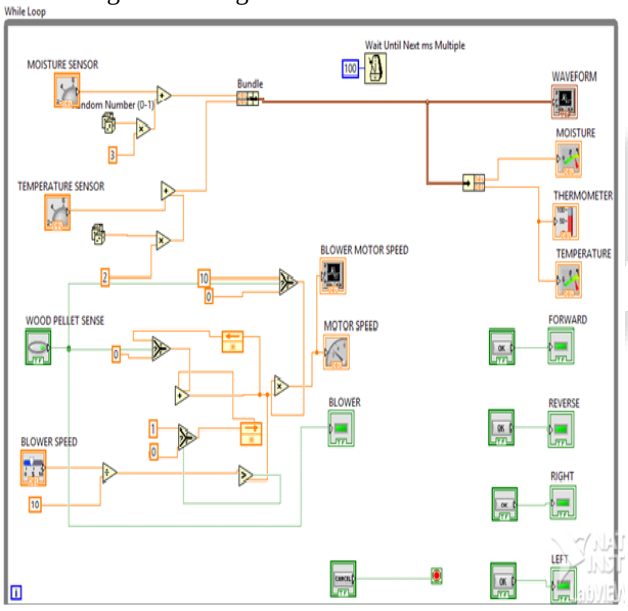


Fig. 9: Block Panel

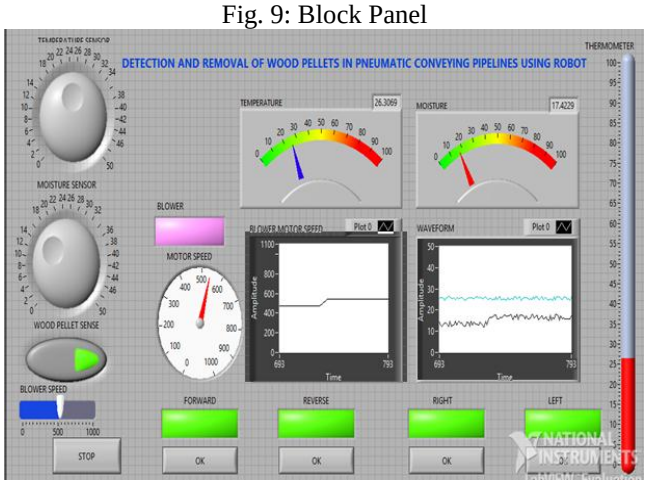


Fig. 10: Front Panel

## V. RESULT AND DISCUSSION

Figure 11 shows the robot module with hardware assembly and figure 12 shows mobile robot inside the pipeline.

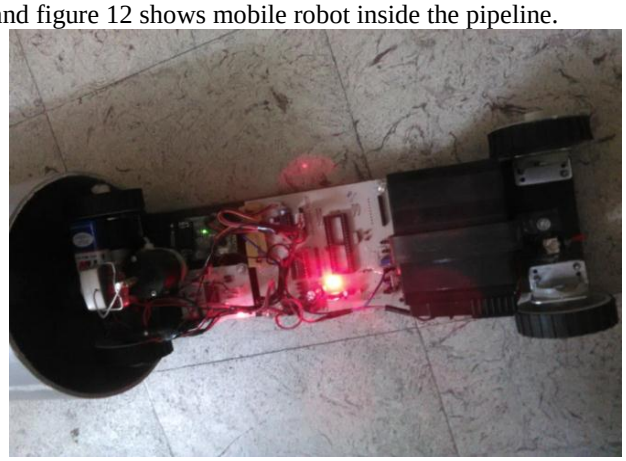

Fig. 11: Robot Module

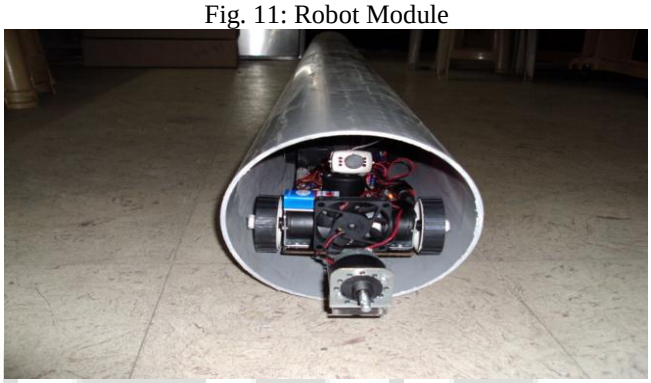

Fig. 12: Mobile Robot inside Pipeline

## VI. CONCLUSION

Robotics is one of the fastest growing engineering fields of today. This project develops the robot for detection and removal of wood pellets in the pipeline. This project describes the mechanism of robot that provides good mobility throughout the pipeline which is used for inspection. In this project, the robot was implemented by using PIC16F887 micro controller, a wireless security camera, LM35 temperature and humidity sensor and ZigBee module for communication. The robot module simulation was designed with the help of LABVIEW. The implemented robot can use for inspecting the pipeline and also used for maintenance purpose. Thus by removing the wood pellets in the pipelines by the robot will give rise to combustion efficiency which increases the power generation. The motion of robot was successfully controlled by ZigBee communication.

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