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RESEARCH ARTICLE

Detection and Removal of Wood Pellets in Pneumatic Conveying Pipelines Using Robot

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Abstract– This paper presents a novel instrumentation system for detection of wood pellets in pneumatic conveying pipelines and removing them using robot. The objective of this project is to remove the wood pellets to increase the combustion efficiency which increases the power generation. This project is a human controlled robot that gives an insight view about the pipeline. A blower is used for maintenance. The robot is operated through PC using wireless zigbee technology and using wireless camera we can get information about the pipeline.

Index Terms - Robot, Removing wood Pellets, Wireless Camera, Zigbee, Blower

I. Introduction

Electricity plays a major role in our day to day life. So, we are in need to produce large amount of electricity which is carried out by means of various renewable power generation system. 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, high pollution emission, slagging and fouling.

Currently, the detection of wood pellets in dust flow is realized through regular inspection of pipelines manually. Initially, on-line particle size measurement is done [6]. Many of the techniques have been introduced to detect wood pellets in pneumatic conveying pipelines. In laser diffraction system, particle size distribution is determined using Mie theory [7]. In digital imaging technique, the charge coupled CMOS camera is used to

capture the image of the particle by laser beam and then the particle size is determined through image processing [8]. In Piezoelectric sensing technique, an impact probe is inserted in to the pipeline and the particle size is determined by collision between the particle and the probe [9]. In [10] wood pellets are detected using vibration and acoustic sensors where the system captures the vibration and sound generated by the collisions between biomass particles and the pipe wall.

The above techniques are all used only to detect 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. It can also be used for inspection, maintenance and cleaning. Inspection of pipes may relevant from increasing security and efficiency in industrial plant.

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 [4].

Thus pellet production [5] 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.

In [7], particle size distribution is determined by applying Mie theory of light scattering. It has the drawbacks of high cost, complexity and requirements for skilled personnel to operate.

In [8], 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 [9], 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.

In [10] , wood pellets are detected using vibration and acoustic sensor. This system 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.

In [11], capacitive electrode topologies are used for moisture determination in wood pellets to avoid effect on corrosion and decomposition of materials. A test box designed with planar and parallel plate setup where frequency in narrow bandwidth is analysed.

In [12], design of a robot to rescue of a child in a borehole is described. 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 Method

In this proposed work, 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 robot and arm movement.

At the time of detection of wood pellets robotic arm is functioned using servo motor to remove them. A blower is also used for removing wood pellets and 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.

3.1 Block Diagram

It consist of temperature 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

Block diagram 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.

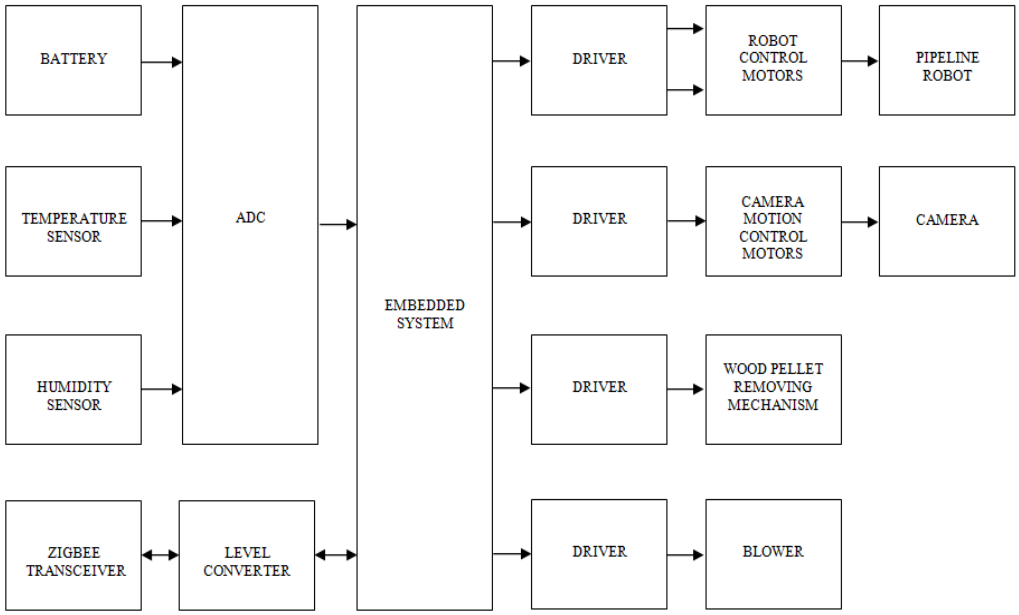

Fig. 1: Block diagram for robo section

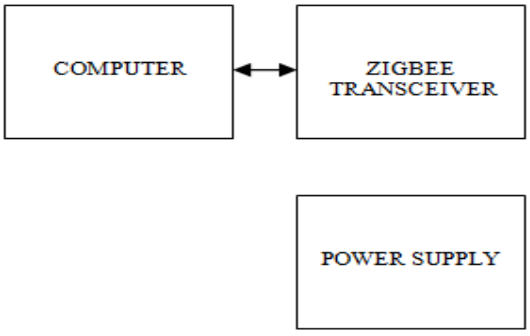

Fig. 2: Block diagram for control section

3.2 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 ° 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.

Features of LM35

- Calibrated directly in ° Celsius (Centigrade).
- Linear + 10.0 mV/°C scale factor.
- 0.5°C accuracy guarantee able (at +25°C).
- Rated for full −55° to +150°C range.
- Suitable for remote applications.
- Low cost due to wafer-level trimming.
- Operates from 4 to 30 volts.
- Less than 60 μA current drain.

3.3 Humidity Sensor

Humidity Refers to the water vapour content in air or other gases. Humidity measurements can be stated in a variety of terms and units.

The three commonly used terms are absolute humidity, dew point, and relative humidity (RH). It is based on an interdigitated or bifilar winding. After deposition of a hydroscopic polymer coating, their resistance changes inversely with humidity. The impedance change is typically an inverse exponential relationship to humidity. Resistive humidity sensors usually consist of noble metal electrodes either deposited on a substrate by photo resist 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.

3.4 ADC

The ADC in general converts the analog signal into digital signal .The most commonly used type is Successive Approximation Register .ADC0801, ADC0802, ADC0803, ADC0804 and ADC0805 are CMOS 8-bit successive approximation A/D. These operations with the NSC800 and INS8080A derivative control bus with TRI-STATE output latches directly driving the data bus. These A/Ds appear like memory locations or I/O ports to the microprocessor and no interfacing logic is needed. Differential analog voltage inputs allow increasing the common-mode rejection and offsetting the analog zero input voltage value. In addition, the voltage reference input can be adjusted to allow encoding any smaller analog voltage span to the full 8 bits of resolution.

Features of ADC

- Compatible with 8080 μP derivatives no interfacing logic needed access time 135 ns.
- Easy interface to all microprocessors, or operates "stand alone".
- Differential analog voltage inputs.
- Logic inputs and outputs meet both MOS and TTL voltage level specifications.
- Works with 2.5V (LM336) voltage reference

3.5 PIC 16F887

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "**Peripheral Interface Controller**". PICs are popular with developers due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming capability.

The PIC architecture is distinctively minimalist. It is characterized by the following features:

- Separate code and data spaces (Harvard architecture)
- A small number of fixed length instructions
- Most instructions are single cycle execution (4 clock cycles), with single delay cycles upon branches and skips
- A single accumulator (W), the use of which (as source operand) is implied (i.e. is not encoded in the opcode)
- All RAM locations function as registers as both source and/or destination of math and other functions.
- A hardware stack for storing return addresses
- A fairly small amount of addressable data space (typically 256 bytes), extended through banking
- Data space mapped CPU, port, and peripheral registers

3.6 Zigbee Transceiver

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.

ZigBee protocol features:

- Low duty cycle - Provides long battery life
- Low latency
- Support for multiple network topologies: Static, dynamic, star and mesh
- Direct Sequence Spread Spectrum (DSSS)
- Up to 65,000 nodes on a network
- Collision avoidance
- Link quality indication
- Clear channel assessment

3.7 Level Converter

The RS232 is not compatible with today's microprocessors and microcontrollers; we need a line driver (voltage convertor) to convert the RS232's signals to the TTLvoltage levels that will be acceptable to the 8051's TxD and RxD pins. The MAX232 converts from RS232 voltage levels to TTL voltage levels, and vice versa. One advantage of the MAX232 chip is that it uses a +5 V power source which is the same as the source voltage for the 8051. In other words, with a single +5 V power supply we can power both the 8051 and MAX232, with no need for the dual power supplies that are common in many older system.

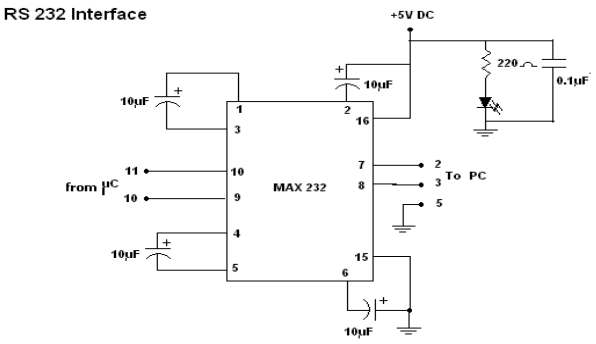

Fig. 3 : RS232 Level Converter

3.8 Driver Circuit

The driver circuit is enabled certain time duration only, such enable pulse is depended by delay programming of microcontroller, here darling circuit has been two transistors made connection of cascade network, if input is set to base of the first transistor, then that is turn on and emitter current of that turn the another one. Hereby the circuit is closed through the driven device and second transistor, now the energized driven device. The enabled signal is not essential after energized that driven device because transistor collector current maintains the transistors in saturation state continuously. The induction effect may be affect the indication components and another thing, so diode is connected across the coil which can prevents the chopping effect the inverse magnitude of magnetic field shorted across from driven device.

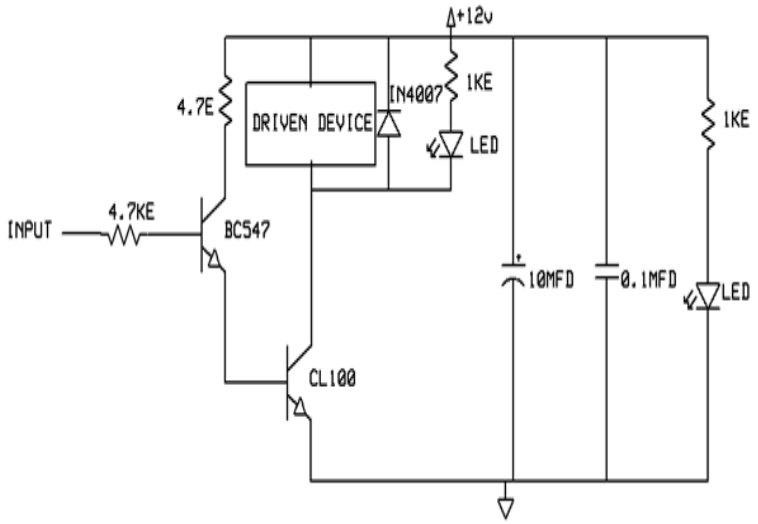

Fig 4: Driver

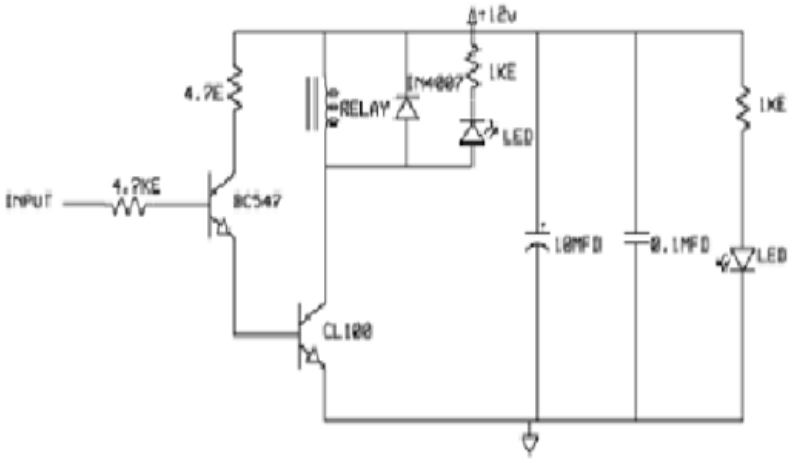

Fig 5: Relay Driver

3.9 Camera

Wireless security cameras are closed-circuit television (CCTV) cameras that transmit a video and audio signal to a wireless receiver through a radio band. Many wireless security cameras require at least one cable or wire for power; "wireless" refers to the transmission of video/audio. However, some wireless security cameras are battery-powered, making the cameras truly wireless from top to bottom.

Wireless cameras are proving very popular among modern security consumers due to their low installation costs (there is no need to run expensive video extension cables) and flexible mounting options; wireless cameras can be mounted/installed in locations previously unavailable to standard wired cameras

3.10 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

IV. Simulation

4.1 Software

LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a platform and development environment for a visual programming language from National Instruments.
LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various flavors of UNIX, Linux, and Mac OS.

The NI LabVIEW graphical system design platform is enabling new applications for industrial robots by integrating measurements, vision, robot control, and human machine interfaces (HMIs) into one, easy-to-use environment. By combining the capabilities of LabVIEW with add-ons provided by partners such as Imaging Lab, you can quickly interface to the robot controller of leading industrial arm manufacturers such as DENSO, KUKA, Epson, and Mitsubishi.

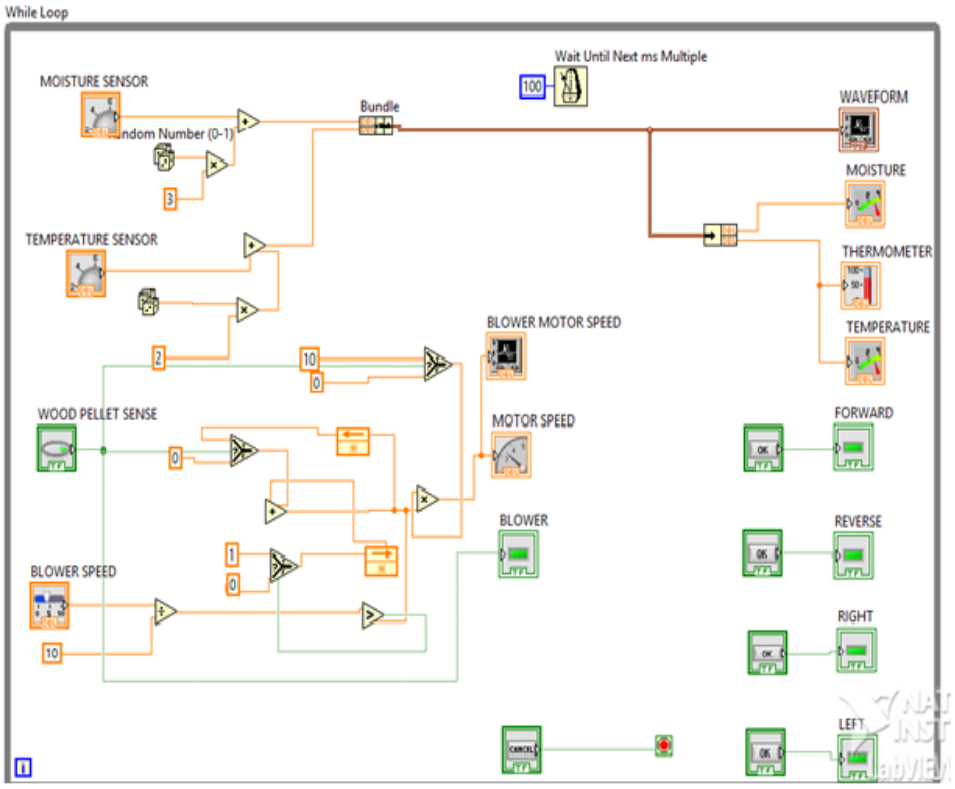

Fig 6: Block panel of simulation

V. Result

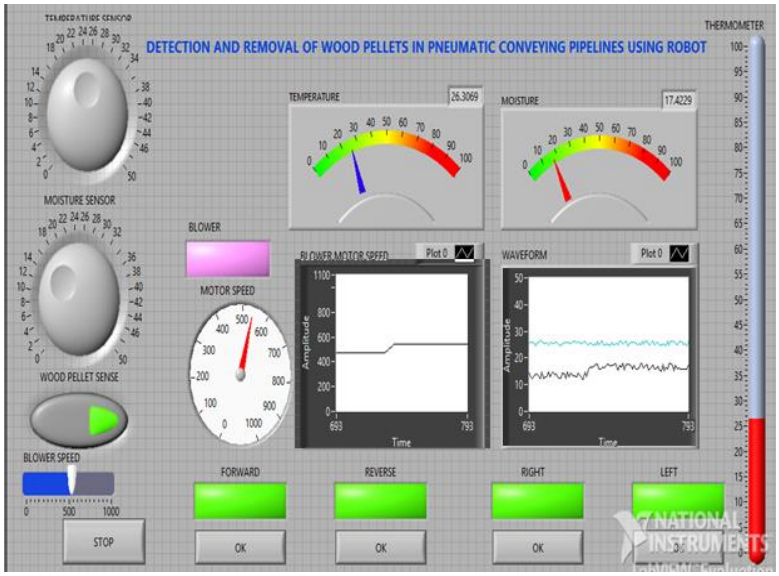

Fig 7: Simulation Result (front panel)

VI. Conclusion

In this paper, we have proposed a novel instrumentation system for detecting and removing of wood pellets in pneumatic pipeline using robot. It increases the combustion efficiency which increases the power generation. It is designed to remove the human factor which can also be used for inspection, maintenance and cleaning the pipelines.

- Less manpower
- Highly safety
- Accurate operation
- Low cost automation
- Wireless Communication

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