OPTIMIZATION OF RAPPING SYSTEM TO IMPROVE THE DUST COLLECTION EFFICIENCY OF ELECTROSTATIC PRECIPITATOR

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ABSTRACT

Electrostatic precipitator (ESP) is the device used for dominant for air pollution. This can be used for boiler cleansing method gases. Process gases contain suspended mud particles. This mud particles square measure collected on collection electrodes. The effectiveness of Electrostatic Precipitators is littered with numerous factors. Continuous cleansing of collection system plays a serious role. Mud gets deposited on collection electrodes and is extracted by vibrations made by the collection electrodes. For immense volume of method gas the scale of ESP will be massive. Since there is a restriction in the area, the final word resolution can to travel vertically i.e. increase the peak and consequently the gathering space. Since the peak is inflated recent strategies of rapping are ineffective and thus the new strategies introduced to extend the vibration. Time is another major constraint for checking of such continuous enhancements. Therefore simulation and additional physical calculations are to be performed. This project presents FEA idea of modelling with analysis of collection electrodes of an ESP by Implicit Transient Dynamic Analysis.

Key words: Electrodes, mud particles, vibrations made by collecting electrodes

1. INTRODUCTION

Mechanical process gases contain earth particles. This is regularly a goliath disadvantage of air contamination and ought to be controlled. There square measure various contamination prevailing types of gear offered inside the market like power Electrostatic precipitator (ESP), Bag filters, Cyclones, Mechanical dust Collector and so on. Except for this, ESP is one in everything about first across the board and at times utilized gadget to dispose of the dust from gases. The adequacy of ESP relies upon parameters like gas stream condition, electric field generation and geometric parameters. An opportunity to time cleanup might be a noteworthy action also rather the cause for dust collection. So we propose a dust particle collecting system using the ESP.

Process gases contain suspended residue particles. These residue particles are gathered on gathering anodes. The viability of ESP is influenced by different variables. Intermittent cleaning of gathering framework assumes a noteworthy part. Residue gets kept on gathering anodes and removed by methods for vibrations of gathering cathodes. For enormous volume of process gas the measure of ESP will likewise be vast. Since space is significant limitations a definitive arrangement will to go vertically i.e. increment the stature and likewise the gathering region. Since the peak is expanded old strategies for rapping will be inadequate. **T**his experimental approach has major drawbacks of higher time lines and cost involved in physical testing.

2. LITERATURE SURVEY

The paper explored are alluded and utilized specifically or in a roundabout way to complete this work. The present undertaking work is in view of the investigations did by different specialists on ESP and vibration execution assessment of gathering anode. These papers are. Andrzej N[6]. The paper shows a numerical model for mimicking the vibration of gathering cathodes in an electrostatic precipitator. The limited components (FEM) technique was utilized to portray the shell components of the gathering anodes. The rest of the components of the framework were demonstrated with the use of the inflexible limited components strategy (RFEM). Estimating approval and testing counts results are exhibited. The vibro ESP count programming is utilized. The exhibited FEM show was reached out by presenting RFEM models of suspension and iron block pillars, furthermore, executed into vibro ESP figuring programming. The outcomes are validated by contrasting the consequences of numerical reproductions with estimations performed on a test stand worked by a maker of electrostatic precipitators. Andrzej N. what's more, Wojciech S[7]. Presents the aftereffects of investigation into changes in vibrations of gathering terminals are exhibited in the paper. The progressions originate from the streamlining of geometric and dynamic parameters of the shaking down framework in electrostatic precipitators (ESP). The computational check was done utilizing the limited component technique on the MSC NASTRAN bundle. Vibrations and increasing velocities of the gathering cathodes were estimated. The outcomes were utilized in the near investigation and the examination of unearthly thickness of increasing speed control. Iwona An., et al[8]. Introduced two new strategies in displaying the gathering anodes which empower us to dissect vibrations of the ESP framework. The principal strategy called a cross breed limited component technique which joins the inflexible limited component strategy and the limited component technique. The model includes a substantial number of degrees of flexibility which influences the required computation time. Since geometrical properties don't change along the length of the gathering cathode, the second model is detailed utilizing a semi-logical process the limited strip strategy. Neundorfer M.,[9] exhibited strategies for enhancing electrostatic precipitator execution by expanding anode excitation level amid rapping and by upgrading rapping control. Outline alteration can decrease mechanical impedance to vibration transmission amid rapping. These same changes can kill regions of high pressure fixation where weakness disappointment regularly happens. Rapping framework control parameters are exhibited as they identify with varieties in field accumulation and shedding rates. Strategies for enhancing field rapping rehash rates utilizing accessible murkiness, cinder draw, and precipitator control data are talked about. Manyin H. et al[10]. Introduced that the ordinary task of the vibration gear and the residue expelling hardware of ESP is a critical factor to guarantee ESP in a sheltered, steady and productive running and impacts the proficiency of ESP and the working existence of the related supplies. Kim S. what's more, Lee K[11] have done test investigation of electrostatic precipitator execution. They have outlined, constructed what's more, worked a research center scale single-arrange electrostatic precipitator (ESP) in a breeze burrow.

3. PROPOSED SYSTEM

The proposed system is represented in simple in the block diagram representation as shown in the fig.1.

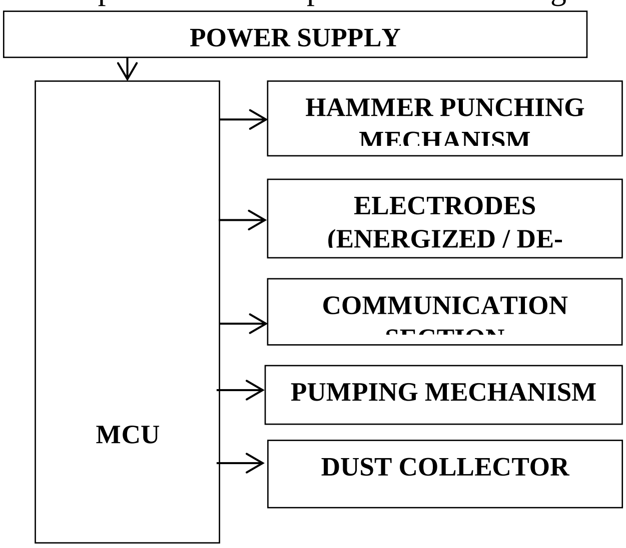

Figure: 1 Block Diagram of Proposed System

The ESP is arranged to the point that the gathering plates are kept parallel. The gathering plates are kept in hanging condition. The top end is associated with Top Hangers and base is with Bottom Hanger. Dusty gas is permitted to go through this section of gathering plates. The anvil is amassed at one side at base and center of gathering plates. Rotting hammer is arranged to the point that the rapping ought to be consistent, exchange and intermittent. The sledges are mounted on turning shaft which is associated with electric equipped motor. The vertical planes are gathering plates with anvil at base. Hammers are assembled to the point that rapping will be consistent however at elective gathering plates.

3(a).HAMMER PUNCHING MECHANISM

The ESP is arranged to the point that the gathering plates are kept parallel. The gathering plates are kept in hanging condition. The best side is associated with Top Hangers and base is with Bottom Hanger. Dusty gas is permitted to go through this entry of gathering plates. The blacksmith's iron is amassed at one side at base and center of gathering plates. Spoiling pound is arranged to the point that the rapping ought to be standard, interchange and intermittent.

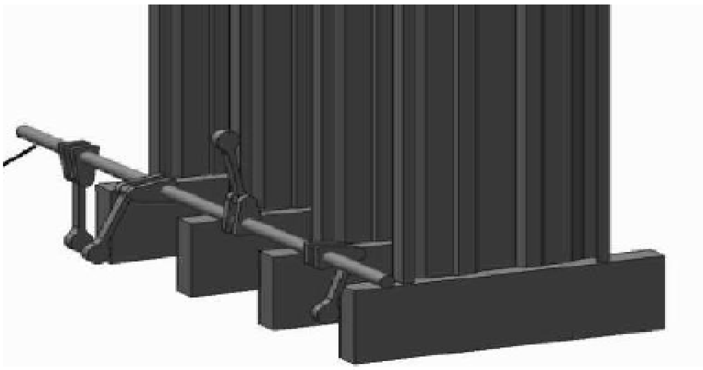

Figure: 2 hammer Punching Mechanism

Figure 2 demonstrates the run of the mill course of action of the gathering plates and decaying hammer. The mallets are mounted on pivoting shaft which is associated with electric equipped engine. The vertical boards are gathering plates with iron block at base. Mallets are assembled to the point that rapping will be ceaseless yet at elective gathering plates.

3(b). PUMPING MECHANISM

The heat pump system with electrostatic Precipitator is connected to the rear of the indoor unit of the ducted heat pump which consists of blower and heat exchanger. The air is blowed from the front end of the indoor unit, passes through the indoor unit, passes through the ESP module, and flows into the room. The model to describe the collection efficiency of the electrostatic precipitator is based on Deutsch-Anderson equation [11] as following:

$$\eta = 1 - \exp(-VA/Q) \qquad (1)$$

where V is migration velocity induced by electrostatic field(m/s), A effective collection plate area(m2), Q airflow velocity(m/s) and V is defined as following equation:

$$V = (neECc\ )/(3phd) \qquad (2)$$

where n is number of charge on single particle, e elementary charge (C), E electric field strength (V/m), Cc Cunningham correction factor, h air viscosity (kg/(m·s)), d particle diameter (m). The equation is modified in several ways [12]. From equation (1), V and A increase and Q decrease to improve dust collection efficiency. In order to increase V, E must be increased except for environmental conditions that cannot be controlled. Therefore, it can be seen that the dust collection efficiency is mainly controlled by E, Q, and A, respectively. If the size of the product is fixed in a given installation environment, the dust collection efficiency is affected by E and Q. Therefore, in this study, the applied voltage of the load and dust collector and air flow rate were selected as the main parameters and the effect and characteristics of the applied voltage and the air flow rate were examined.

3(c). DUST COLLECTOR

Cleaning the collected materials from the plates often is accomplished intermittently or continuously by rapping the plates severely with automatic hammers or pistons, usually along their top edges, except in the case of wet ESPs that use water. Rapping dislodges the material, which then falls down the length of the plate until it lands in a dust hopper. The dust characteristics, rapping intensity, and rapping frequency determine how much of the material is restrained and how much reaches the hopper permanently. For wet ESPs, consideration must be given to handling waste waters. For simple systems with innocuous dusts, water with particles collected by the ESP may be discharged from the ESP system to a solids-removing clarifier (either dedicated to the ESP or part of the plant waste water treatment system) and then to final disposal. More complex systems may require skimming and sludge removal, clarification in dedicated equipment, pH adjustment, and/or treatment to remove dissolved-solids. Spray water from the ESP preconditioner may be treated separately from the water used to flood the ESP collecting plates, so that the cleaner of the two treated waters may be returned to the ESP. Recirculation of treated water to the ESP may approach 100 percent. The hopper should be designed so that all the material in it slides to the very bottom, where it can be evacuated periodically, as the hopper becomes full. Dust is removed through a valve into a dust-handling system, such as a pneumatic conveyor. Hoppers often are supplied with auxiliary heat to prevent the formation of lumps or cakes and the subsequent blockage of the dust handling system.

3(d). COMMUNICATION

Wireless communication involves the transmission of information over a distance without the help of wires, cables or any other forms of electrical conductors.

Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices. Wireless communication involves transfer of information without any physical connection between two or more points. Because of this absence of any 'physical infrastructure', wireless communication has certain advantages. This would often include collapsing distance or space.The Asynchronous Receiving and Transmitting Protocol A synchronous transmission allows data to be transmitted without the sender having to send a clock signal to the receiver. In this case, the sender and receiver must agree on timing parameters (Baud Rate) prior transmission and special bits are added to each word to synchronize the sending and receiving units. In asynchronous transmission, the sender sends a Start bit, 5 to 8data bits (LSB first), an optional Parity bit, and then 1, 1.5 or 2 Stop bits. When a word is passed to the UART for asynchronous transmissions, the Start bit is added at beginning of the word. The Start bit is used to inform the receiver that a word of data is about to be send, thereby forcing the clock in the receiver to be in sync with the clock in the transmitter.

Basic UART packet format: 1 Start bit, 8 data bits, 1 Parity bit and 1 Stop bit every operation of the UART hardware is controlled by a clock signal which runs at much faster rate than the baud rate. For example, the popular 16450 UART has an internal clock that runs 16 times faster than the baud rate. This allows the UART receiver to sample the incoming data with granularity of 1/16 the baud-rate period and has greater immunity towards baud rate error.

MICROCONTROLLER

All the functions required on a single chip. A microcontroller differs from a microprocessor, which is a general-purpose chip that is used to create a multi-function computer or device and requires multiple chips to handle various tasks. A microcontroller is meant to be more self-contained and independent, and functions as a tiny, dedicated computer.

They are typically designed using CMOS (complementary metal oxide semiconductor) technology, an efficient fabrication technique that uses less power and is more immune to power spikes than other techniques. There are also multiple architectures A microcontroller is an integrated chip that is often part of an embedded system. The microcontroller includes a CPU, RAM, ROM, I/O ports, and timers like a standard computer, but because they are designed to execute only a single specific task to control a single system, they are much smaller and simplified so that they can include used, but the predominant architecture is CISC (Complex Instruction Set Computer), which allows the microcontroller to contain multiple control instructions that can be executed with a single macro instruction. Some use a RISC (Reduced Instruction Set Computer) architecture, which implements fewer instructions, but delivers greater simplicity and lower power consumption.

Early controllers were typically built from logic components and were usually quite large. Later, microprocessors were used, and controllers were able to fit onto a circuit board. Microcontrollers now place all of the needed components onto a single chip. Because they control a single function, some complex devices contain multiple microprocessors.

Microcontrollers have become common in many areas, and can be found in home appliances, computer equipment, and instrumentation. They are often used in automobiles, and have many industrial uses as well, and have become a central part of industrial robotics. Because they are usually used to control a single process and execute simple instructions, microcontrollers do not require significant processing power.

Products like CD players, hi-fi equipment, video games, washing machines, cookers and so on fit into this category. The communications market, automotive market, and the military share the rest of the application areas. Microcontrollers have traditionally been programmed using the assembly language of the target microcontroller. Different microcontrollers from different manufacturers have different assembly languages.

Assembly language consists of short mnemonic descriptions of the instruction sets. These mnemonics are difficult to remember and the programs developed for one microcontroller cannot be used for other types of microcontrollers. The most common complaint about microcontroller programming is that the assembly language is somewhat difficult to work with, especially during the development of complex projects.

The solution to this problem is to use high-level languages. This makes the programming a much simpler task and the programs are usually more readable, portable, and easier to maintain. There are various forms of BASIC and C compilers available for most microcontrollers. BASIC compilers are usually in the form of interpreters and the code produced is usually slow.

First, microcontrollers were developed in the mid-1970s. These were basically calculator-based processors with small ROM program memories, very limited RAM data memories, and a handful of input/output ports. As silicon technology developed, more powerful, 8-bit microcontrollers were produced. In addition to their improved instruction sets, these microcontrollers included on-chip counter/timers, interrupt facilities, and improved I/O handling. On-chip memory capacity was still small and was not adequate for many applications. One of the most significant developments at this time was the availability of on-chip ultraviolet erasable EPROM memory. This simplified the product development time considerably and, for the first time, also allowed the use of microcontrollers in low-volume applications.

PIC16F877A

The term PIC, or Peripheral Interface Controller, is the name given by Microchip Technologies to its single – chip microcontrollers. PIC micros have grown to become the most widely used microcontrollers in the 8- bit microcontroller segment.

The PIC16F877A CMOS FLASH-based 8-bit microcontroller is upward compatible with the PIC16C5x, PIC12Cxxx and PIC16C7x devices. It features 200 ns instruction execution, 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire SPI or 2-wire I2C bus, a USART, and a Parallel Slave Port.

Special Microcontroller Features

- Flash Memory: 14.3 Kbytes (8192 words)
- Data SRAM: 368 bytes
- Data EEPROM: 256 bytes
- Self-reprogrammable under software control
- In-Circuit Serial Programming via two pins (5V)
- Watchdog Timer with on-chip RC oscillator
- Programmable code protection
- Power-saving Sleep mode
- In-Circuit Debug via two pins
- 10-bit, 8-channel A/D Converter
- Brown-Out Reset
- Analog Comparator module

Peripheral Features

- 33 I/O pins; 5 I/O ports
- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler
    - Can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
    - 16-bit Capture input; max resolution 12.5 ns
    - 16-bit Compare; max resolution 200 ns
    - 10-bit PWM
- Synchronous Serial Port with two modes:
    - SPI Master
    - I2C Master and Slave
- USART/SCI with 9-bit address detection
- Parallel Slave Port (PSP)
    - 8 bits wide with external RD, WR and CS controls
- Brown-out detection circuitry for Brown-Out Reset

The simplest microcontroller architecture consists of a microprocessor, memory, and input/output. The microprocessor consists of a central processing unit (CPU) and the control unit (CU).The CPU is the brain of a microprocessor and is where all of the arithmetic and logical operations are performed. The control unit controls the internal operations of the microprocessor and sends control signals to other parts of the microprocessor to carry out the required instructions. Memory is an important part of a microcomputer system. Depending upon the application we can classify memories into two groups: program memory and data memory. Program memory stores all the program code. This memory is usually a read-only memory (ROM). Other types of memories, e.g. EPROM and PEROM flash memories are used for low-volume applications and also during program development. Data memory is a read/write memory (RAM).

DC MOTOR

A DC motor is designed to run on DC electric power. Two examples of pure DC designs are Michael Faraday's homo-polar motor (which is uncommon), and the ball bearing motor, which is (so far) a novelty. By far the most common DC motor types are the brushed and brushless types, which use internal and external commutation respectively to create an oscillating AC current from the DC source—so they are not purely DC machines in a strict sense. We in our project are using brushed DC Motor, which will operate in the ratings of 12v DC 0.6A which will drive the flywheels in order to make the robot move.

DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor.

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

RELAY

A relay is an electrically operated switch. Electric current through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and there are double-throw (changeover) switches. It consists of a coil of wire surrounding a soft iron core, an iron yoke, which provides a low reluctance path for magnetic flux, a movable iron armature, and a set, or sets, of contacts. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. The P0_0, P0_1, P0_2 and P0_3 pin of controller is assumed as data transmit pins to the relay through relay driver ULN 2003. ULN 2003 is just like a current driver.

The ULN2003 is a monolithic high voltage and high current Darlington transistor arrays. It consists of seven NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diode for switching inductive loads. The collector-current rating of a single Darlington pair is 500mA. The Darlington pairs may be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED gas discharge), line drivers, and logic buffers.

The ULN2003 has a 2.7kW series base resistor for each Darlington pair for operation directly with TTL or 5V CMOS devices.

UART

The Universal Asynchronous Receiver/Transmitter (UART) controller is the key component of the serial communications subsystem of a computer. UART is also a common integrated feature in most microcontrollers. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. Serial transmission of digital information (bits) through a single wire or other medium is much more cost effective than parallel transmission through multiple wires. Communication can be “full duplex” (both send and receive at the same time) or “half duplex” (devices take turn Transmitting and receiving).The Asynchronous Receiving and Transmitting Protocol Asynchronous transmission allows data to be transmitted without the sender having to send a clock signal to the receiver. In this case, the sender and receiver must agree on timing parameters (Baud Rate) prior transmission and special bits are added to each word to synchronize the sending and receiving units. In asynchronous transmission, the sender sends a Start bit, 5 to 8data bits (LSB first), an optional Parity bit, and then 1, 1.5 or 2 Stop bits. When a word is passed to the UART for asynchronous transmissions, the Start bit is added at beginning of the word. The Start bit is used to inform the receiver that a word of data is about to be send, thereby forcing the clock in the receiver to be in sync with the clock in the transmitter. Itis important to note that the frequency drift between these two clocks must not exceed 10%. In other words, both the transmitter and receiver must have identical baud rate. After the Start bit, the individual bits of the word of data are sent, beginning with the Least Significant Bit (LSB). When data is fully transmitted, an optional parity bit is sent to the transmitter. This bit is usually used by receiver to perform simple error checking. Lastly, Stop bit will be sent to indicate the end of transmission. When the receiver has received all of the bits in the data word, it may check for the Parity Bits(both sender and receiver must agree on whether a Parity Bit is to be used), and then the receiver searches for a Stop Bit. If the Stop Bit does not appear when it is supposed to, the UART considers the entire word to be garbled and will report a Framing Error to the host processor when the data word is read. Common reason for the occurrence of Framing Error is that the sender and receiver clocks were not running at the same speed, or that the signal was interrupted.

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CIRCUIT DIAGRAM:

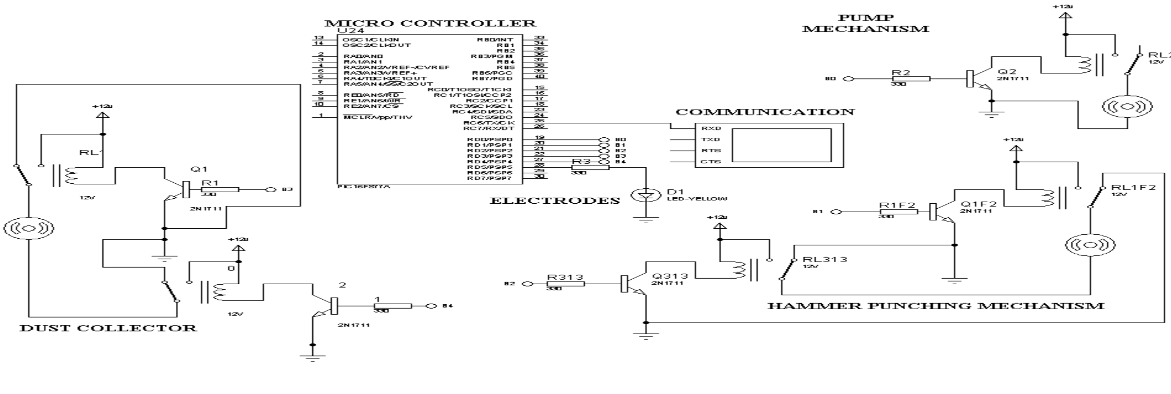

Figure:3 Circuit Diagram of ESP process

SIMULATED ESP PROCESS:

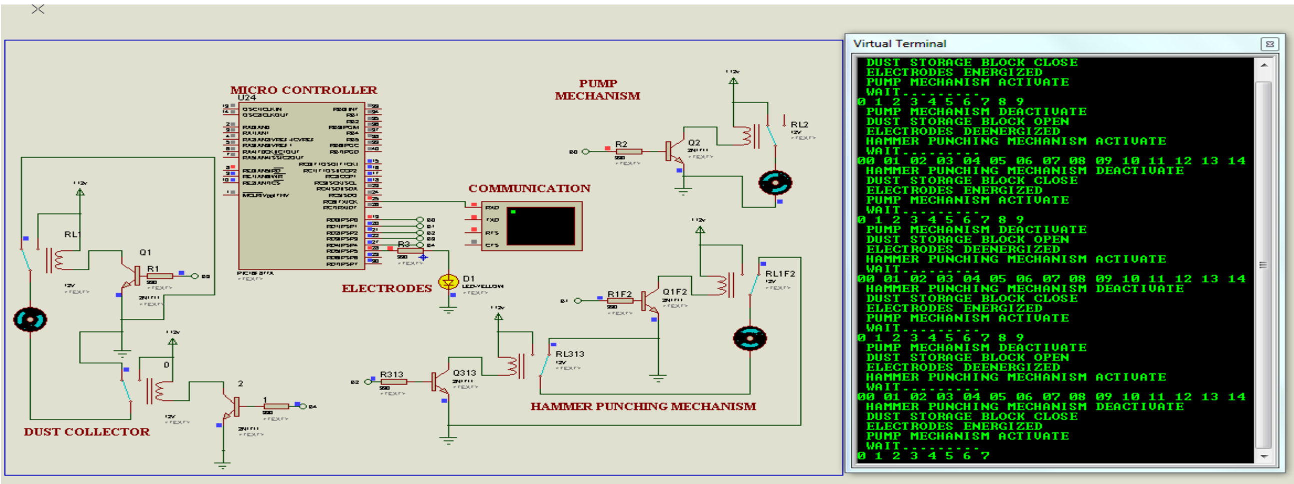

Figure: 4. Simulated Image of ESP process

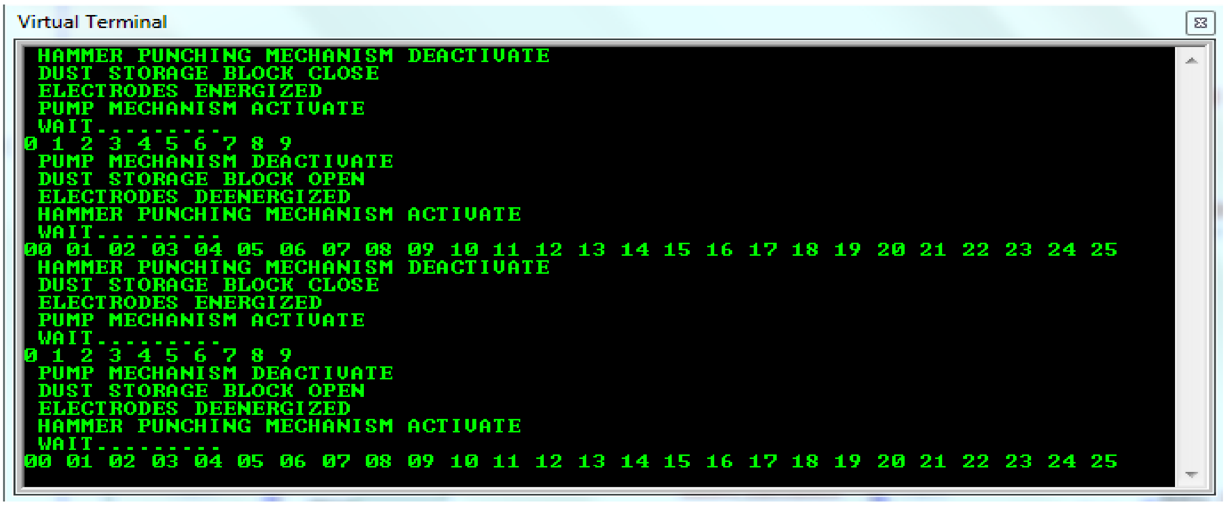

Figure: 5. Virtual Terminal of Simulated ESP process

CONCLUSION:

The present study was focused on simulation of ESP process such dust collection in electrostatic precipitator applied to ducted heat pump system. For experiment we have simulated process of dust collecting, hammering mechanism, pumping mechanism and electrode energized and de-energized. Three parameters – air flow rate, the applied voltages of the charging and collecting part, were selected as the main parameters in the given condition. The results showed that the order of contribution of each parameter on the dust collection efficiency is applied voltage in collecting part, air flow rate, applied voltage in charging part and the hammering respectively. The time consumed for whole three processes was around 30seconds. From the results, we can conclude that the future enhancement will be prototype designing and implementation of ESP which process with less time, with improved efficiency on dust collection.

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