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Automation of Sand Reclamation System using Arduino mega-2560

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Abstract - *The objective of current automation is online monitoring and data acquisition for thermal sand reclamation system .The foundry sector has been showing an increased interest in reclamation of used sands. For better casting grain size, chemical and thermal properties must be uniform while molding the sand. Automation using an Arduino mega, thermal sensors, relay module, Wi-Fi, Wi-Fi module being remotely controlled by smart phone. As technology advancing the system is also getting smarter. Automated system is gradually shifting from conventional switches to centralized control system, involving online monitoring and data acquisition smart control system. Online monitoring and Data acquisition is the main purpose of the automation in which the data is stored in data sheet. Automation of Sand Reclamation System is for Labor-saving technology. It is the technology by which a process is performed with less human assistance.*

***Key Words*: Fluidized bed chamber, Sand cooler, Sand siever, Automation, Online monitoring, Arduino.**

1. INTRODUCTION

A foundry produces metal castings. Molten metal is used to make cast. Molten metal is poured in the mold and by removing mold material after it gets solidify when it cools. Parts of desired shapes and sizes can be formed. This sand used for molding is also called foundry sand. Foundries have become more and more interested in the possibilities of reduced costs in any way keeping their standard, they are well known about the conditions in the foundry sector. Recycling of materials is the only way to reduce cost. This used sand can be reused by Reclamation of Sand. There are number of types of reclamation. We have one of them is Thermal Reclamation system. Main purpose of the system is to modify used sand without lowering its original sand properties. Sand is costly as it does not available locally so recycling is a best solution for reducing cost. The current system is beneficial in all the way. So, considering objective of automation, it will also help us to reduce cost and saving of operational work of labor. [1][2]

1.1 Elements of Sand Reclamation System:

We are using Thermal sand reclamation system so most of the elements are mechanical elements.

a) Fluidized Bed Combustor (FBC):

1) The Fluidized Bed Combustor (FBC) is the main equipment of sand Reclamation System.
2) In FBC, sand is heated up to 700^0c.
3) Sand capacity of FBC is more, but usually 20kg sand is poured through hopper.
4) The FBC has cylindrical shape as shown in picture and it is made up of SS310 material.
5) The heat loss is prevented by insulation surrounding the FBC.
6) All the binders and other organic materials are removed from sand in FBC.

b) Heating Element:

1) The heating element is used to heat the sand in Fluidized Bed Chamber.
2) After pouring 20 kg sand through hopper in FBC the heating element is turned on.
3) The temperature kept increasing up to 700^0c.

c) Unloading valve mechanism:

1) It starts working when heating process of sand is done.
2) The unloading valve opens and the sand in FBC drop down into the sand cooler where cooling of the sand takes place.

d) Sand cooler:

1) After heating the sand in sand cooler is cooled. The temperature of the sand dropped to 30^0c.
2) The function of sand cooler is to reduce the temperature of the heated sand with the help of water pump and air.

e) Sand siever:

1) In sand siever, the sand coming from sand cooler separated by its grain size.

2) Separate motor is connected to siever. Siever vibrates when it starts so that sand gets separated by its grain size.

1.2 Working of Sand Reclamation System:

The system can perform operations like heating, cooling, unloading of sand. First, we have to pour 20kg foundry sand in the FBC. After pouring is done the heating coil and compressor should be switched ON. Heater will increase the temperature of FBC and sand. Direction control valve placed to control the air supply coming from compressor. Air is supplied to sand in FBC. Proper mixing of sand and temperature is done. This DC valve starts working when the temperature reaches at 300^0c. Temperature kept increasing till it reaches to 700^0c. At 700^0c keep constant heating for 15 minutes. Unloading valve opens after 15 minutes and coil switched OFF. Sand from FBC is dropped down into the sand cooler where the cooling process is done. A water pump is used to provide cooling water is circulated through the pipes in the cooler. The pump and DC valve of the sand cooler start simultaneously. Temperature of sand is reduced to 30^0c. This process of cooling is timed for 10 minutes. Once cooling is done sand id dropped in the sand siever bucket. Motor of the sand siever switched ON. It works like a vibrator. Sand is separated by grain size. [2]

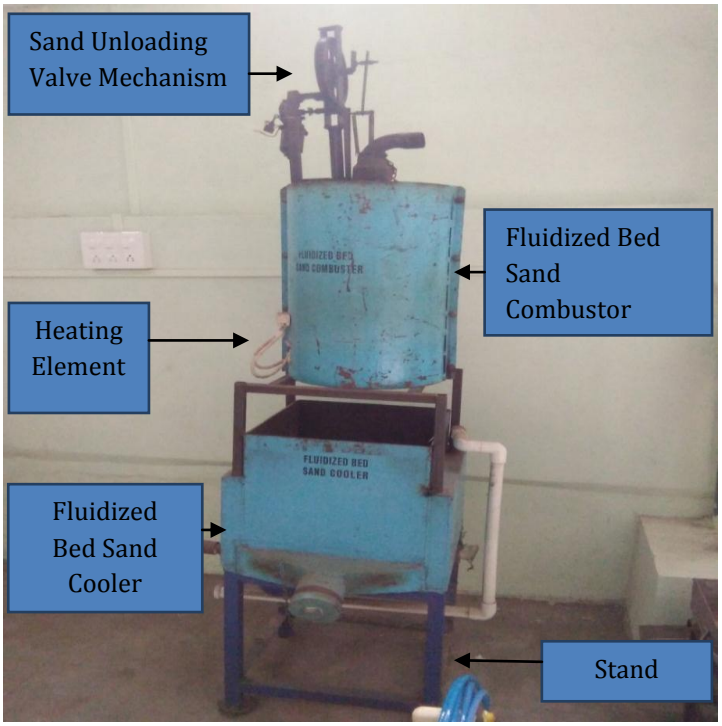

Fig 1.1: Sand Reclamation System

2. AUTOMATION

Automation is the technology by which process is performed with less human assistance. It has wide range of applications like machinery, factory processes, heat treatment, switching, air craft, etc. Automation is a solution for Sand Reclamation System to give better results regarding operating considerations. The only way to detect the physical errors, network problems is Automation. Automation regarding reclamation system is to make system easy to handle, to store data, to reduce labor work and to increase Safety of the labor. The whole system is controlled via smart phone app. This is the only way to reduce the cost and getting better results. [13][20]

2.1 Need of Automation:

1) The existing system contains variety of operations and it performs separately.

2) So there should be an operator to handle the system which makes the system separate and complex.

3) The time taken by the existing system due to gap between the operation is more so it need to be operate in less time and this can be problem can be minimize with the help of automation.

4) Precision is also one factor that matters in this system.

5) The automation can provide more clean and steady look to the Sand Reclamation System.

2.2Hardwares used for Automation:

For the automation of system we are using following hardware:

a) Arduino
b) K-type thermal sensor
c) DC valve: 5/2 pneumatic valve
d) Relay module
e) Wi-Fi module
a) Arduino :

Arduino is a microcontroller which can be easily programmed, erased and reprogrammed. It is introduced in 2005. Arduino is inexpensive and easy to learn about its programming for anyone. We can use arduino in any way to do automations. Also sensors, different actuators can be operated using this microcontroller. It is a source of computing platform that is used for programming electronic devices. It is also capable to control mechanical devices also. The main advantage of the Arduino is, you can directly make a program and test it without using the main devices. It allows the program to store in its memory storage which is very useful. The arduino uses software called IDE using C or C++ for programming. For this particular automation we are using arduino mega AT2560.[3][15]

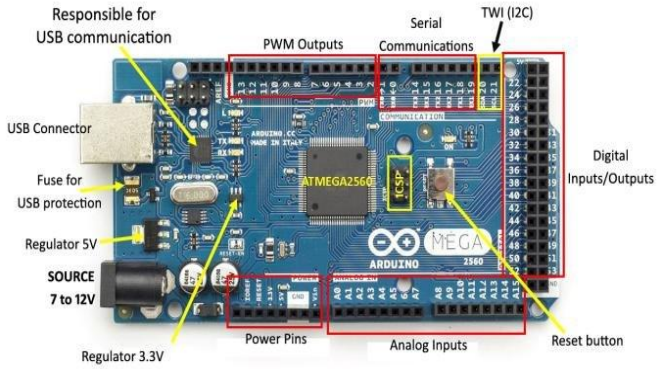

fig.2.1 Arduino mega AT2560

Features of arduino mega AT2560:

- Input voltage - 7-12V.
- 54 digital I/O pins.
- 16 analog input pins.
- 256k Flash Memory.
- 16 MHz Clock Speed.

Advantages:

1) It is inexpensive and easily available.
2) Simple and clear programming environment.
3) Open source and extensible software.
4) The arduino software (IDE) runs on Windows, Linux, and Macintosh OSX operating system. This is extra benefit of the arduino.

b) K-type thermal sensor:

Most sensitive thermal sensor and widely used in industrial purposes is K-type thermocouple. It has sensitivity of 41V/^{0}C. Also it is highly reliable. It can be used in wide range of temperature up to 1100^{0}C-1200^{0}C. K-type thermocouple has wide range of applications and is available in cheap rates in markets. It is not as stable as other metal sensors that are commonly used. Because of relative radiation hardness it is also used in nuclear applications. It is difficult to achieve error which is almost less than one degree celcius. We are using K-type thermal sensor for measuring temperature of FBC, sand cooler, cooled sand which is essential for our data. Also it is reliable at high temperature range that we needed. [6][16]

Fig.2.2 K-type thermal sensor and module

C) Direction control valve:

Direction control valve are designed to provide direct air flow from compressor cylinder. Most of the nominal ports are of 1/2" and 1/8". The valve mechanism directs the compressed air supply, through the valve body to the selected output ports or stops the air from passing through the valve. The valve mechanism can be moved by the direct mechanical action, a spring, an electrical solenoid.

- 5/2 pneumatic valve:

5-way 2-position pneumatic solenoid valve, the two-position means that ON and OFF positions, can controlled. The five-way means five ports used for air flow, namely one inlet, one positive-action outlet and one reverse-action inlet, one positive-action exhaust vent and one reverse-action exhaust. The 5/2-way pneumatic solenoid has a valve coil which operates the valve position and ways. Voltage grade for this coil is DC12 V, DC 24V, AC 110V, and AC 220V.

Working principle of 5/2-way pneumatic double solenoid valve:

We are using double solenoid valve for the automation of sand reclamation system. This valve is operated using relay module connected to the arduino. When it gets power supply the positive means the first valve switched ON. Air supply starts. We are using only three ports of the valve, one is inlet and other two are outlets for air circulation. Air coming from the compressor through inlet is given to another solenoid valve. Then is further passed and circulated to FBC and Sand Cooler. It is actuated using relay and arduino. We have given temperature conditions to operate the solenoid valve. [8]

Fig.2.3 5/2 pneumatic solenoid valve

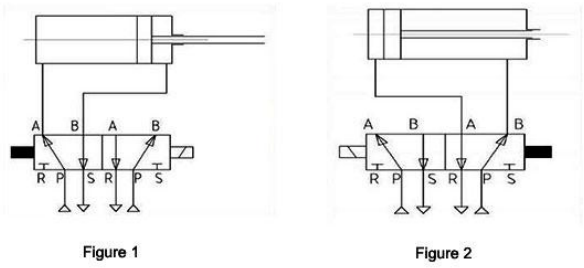

Fig.2.4 valve position symbol

d) Relay module:

We know that most of the industrial application devices are controlled using relays effective working. Relays are operated both ways electrically and mechanically. Relays consist of an electromagnet which helps to connect and disconnect using voltage. Relays are used to switching purposes. Relays are different for industrial and home applications. For low as well as high power places relays are used. We can control actuators using relays. The high end applications relays are called contactor. We are using 8 channel relay module as shown in figure. In the particular system work we need to control coil ON/OFF voltage, motor switching, DC valve. So we choose 8 module board. There are two fixed contacts, NO and NC. When the coil is not energized NO that is normally open; relay is OFF in condition and the NC that is normally closed; relay turned ON when power supply is given. Using this mechanism relays are controlled with the help of arduino programming.[7]

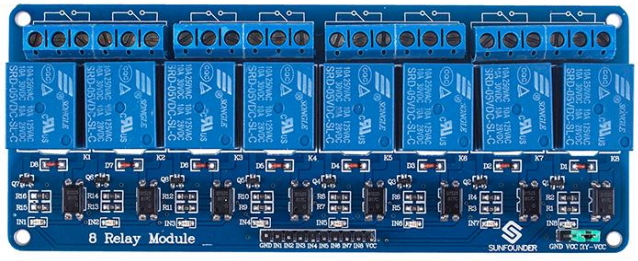

fig.2.5 8 channel relay module

- Features of relay module:

1) 5V-8 channel relay interface board.

2) Support to control 10A-30V DC and 10A-250V AC signals.

3) Easy to connect and control the connected devices.

4) Low level trigger equipped with indicator, easy to recognize working status.

e) Wi-Fi module:

The ESP8266 Wi-Fi Module mainly used for arduino applications. Another purpose of automation is to control system using smart app or smart phone. In which the system ON/OFF, process status and online data storage is mainly considered. It has wide range of temperature while using. Highly integrated chips are used to manufacture wi-fi module. Low power consumption is the benefit of this module. Wi-fi module and smart app need high speed network. We can use wireless network like routers. [19]

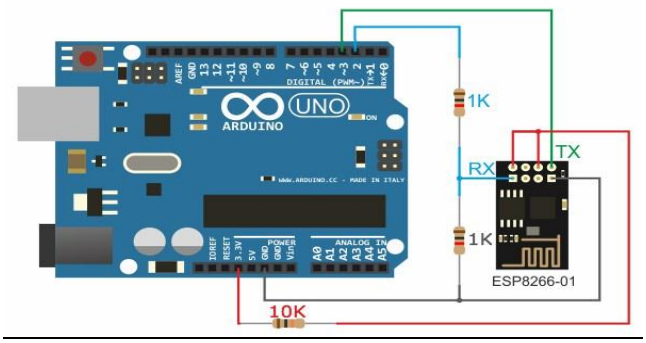

Fig.2.6 Wi-Fi module with arduino connections

3. WORKING ON PROGRAMMING AND CONNECTIONS:

All the programming is done with IDE software. In the beginning we studied the all hardwares and tested with their respective sample program. Then we collected data from all the sources given in reference and done a program for our reclamation system.[15]

3.1 Final Program:

```
#include <SPI.h>

#define temp1_CS  9          //sensor 1 CS Pin
#define temp1_SO  10         //sensor 1 SO Pin
#define temp1_SCK 8          //sensor 1 SCK Pin
#define temp2_CS  11         //sensor 2 CS Pin
#define temp2_SO  12         //sensor 2 SO Pin
```

```
#define temp2_SCK  13          //sensor 2 SCK Pin

int temp1;                      // variable for temperature
of sensor 1(Coil) value

int temp2;                     // variable for temperature of
sensor 2(sand siever) value

int tcount = 0;                 // time counter

#define relay1 22               // relay pins ↓

#define relay2 23

#define relay3 24

#define relay4 25

#define relay5 26

#define relay6 27

#define relay7 28

#define relay8 29

void setup() {

Serial.begin(9600);

pinMode(relay1,OUTPUT);

pinMode(relay2,OUTPUT);

pinMode(relay3,OUTPUT);

pinMode(relay4,OUTPUT);

pinMode(relay5,OUTPUT);

pinMode(relay6,OUTPUT);

pinMode(relay7,OUTPUT);

pinMode(relay8,OUTPUT);

}

void loop()

{

 digitalWrite(relay1,HIGH);

 digitalWrite(relay2,HIGH);

 digitalWrite(relay3, HIGH);

 digitalWrite(relay4,HIGH);

 digitalWrite(relay5, HIGH);

 digitalWrite(relay6,HIGH);

 digitalWrite(relay7,HIGH);

 digitalWrite(relay8,HIGH);

 delay(10000);              // 10seconds initial delay

 digitalWrite(relay1,LOW);  // Heating Coil - ON

 Serial.println("Heating Coil Turned On");

 digitalWrite(relay2,LOW);  // Solenoid 1 - ON

 Serial.println("Solenoid 1 Turned On");

 Serial.print("sensor 1  ");

 while(temp1 < 300)         // while temperature < 300 , it
will print sensor value

{

 temp1 = sen1reader();

 Serial.println(temp1);

 delay(1000);

}

Serial.println("Temperature reached 300");

digitalWrite(relay2,HIGH);   //solenoid 1 - OFF

Serial.println("Solenoid 1 Turned Off");

digitalWrite(relay3,LOW);   // solenoid 2 -ON

Serial.println("Solenoid 2 Turned On");

digitalWrite(relay4,LOW);    // solenoid 3 -ON

Serial.println("Solenoid 3 Turned On");

while(temp1 < 700)          // while temperature < 700 , it
will print sensor value

{

 temp1 = sen1reader();

 Serial.print(temp1);

 delay(1000);

 }

Serial.println("Temperature reached 700");

digitalWrite(relay1,HIGH);      // coil OFF
```

```
Serial.println("Coil turned off");
while(tcount < 900)            // If within 15 minutes ;
{                              // temperature decreases below 700, coil will turned on
 temp1 = sen1reader();         // temperature becomes 700, coil will turned off
 if(temp1 < 700)
 {
  digitalWrite(relay1,LOW);
  tcount++;
  delay(1000);
 }
 else
 {
  digitalWrite(relay1,HIGH);
  tcount++;
  delay(1000);
 }
 }
delay(5000);
digitalWrite(relay4,HIGH);      // solenoid 3 OFF
Serial.println("solenoid 3 turned off");
digitalWrite(relay5,LOW);      // unloading valve ON
Serial.println("unloading valve started");
delay(10000);                  // unloading 10 seconds   delay
digitalWrite(relay5,HIGH);     // unloading valve OFF
Serial.println("unloading valve offline");
digitalWrite(relay6,LOW);     // solenoid 4 ON
Serial.println("Solenoid 4 turned on");
digitalWrite(relay7,LOW);    // water pump ON
Serial.println("Water pump turned on");
Serial.print("sensor 2  ");
temp2 = sen2reader();
while(temp2 > 50)
{
 Serial.println(temp2);
 temp2 = sen2reader();
 delay(1000);
}
digitalWrite(relay7,HIGH);       // water pump OFF
Serial.println("water pump turned off");
delay(5000);
digitalWrite(relay8,LOW);       // Sand siever ON
Serial.println("Sand siever turned on");
delay(600000);                  // 10 minutes delay
Serial.println("Undergoing ShutDown Process");
digitalWrite(relay1,HIGH);    // System Reset
digitalWrite(relay2,HIGH);
digitalWrite(relay3,HIGH);
digitalWrite(relay4,HIGH);
digitalWrite(relay5,HIGH);
digitalWrite(relay6,HIGH);
digitalWrite(relay7,HIGH);
digitalWrite(relay8,HIGH);
delay(900000);
/*temp3 = sen3reader();
Serial.print("sensor 3  ");
Serial.println(temp3);
delay(1500);
}*/
}
 double sen1reader() {
 uint16_t v;
```

```
 pinMode(temp1_CS, OUTPUT);
 pinMode(temp1_SO, INPUT);
 pinMode(temp1_SCK, OUTPUT);
digitalWrite(temp1_CS, LOW);
delay(1);
// Read in 16 bits,
// 15    = 0 always
// 14..2 = 0.25 degree counts MSB First
// 2     = 1 if thermocouple is open circuit
// 1..0  = uninteresting status
 v = shiftIn(temp1_SO, temp1_SCK, MSBFIRST);
 v <<= 8;
 v |= shiftIn(temp1_SO, temp1_SCK, MSBFIRST);
digitalWrite(temp1_CS, HIGH);
 if (v & 0x4)
 {
 // Bit 2 indicates if the thermocouple is disconnected
   return NAN;
 }
// The lower three bits (0,1,2) are discarded status bits
 v >>= 3;
// The remaining bits are the number of 0.25 degree (C) counts
 return v*0.25;
}
double sen2reader() {
 uint16_t v;
 pinMode(temp2_CS, OUTPUT);
 pinMode(temp2_SO, INPUT);
 pinMode(temp2_SCK, OUTPUT);
 digitalWrite(temp2_CS, LOW);
 delay(1);
 // Read in 16 bits,
 // 15    = 0 always
 // 14..2 = 0.25 degree counts MSB First
 // 2     = 1 if thermocouple is open circuit
 /  1..0  = uninteresting status
 v = shiftIn(temp2_SO, temp2_SCK, MSBFIRST);
 v <<= 8;
 v |= shiftIn(temp2_SO, temp2_SCK, MSBFIRST);
digitalWrite(temp2_CS, HIGH);
 if (v & 0x4)
 {
  // Bit 2 indicates if the thermocouple is disconnected
   return NAN;
 }
 // The lower three bits (0,1,2) are discarded status bits
 v >>= 3;
 // The remaining bits are the number of 0.25 degree (C) counts
 return v*0.25;
}
```

4. CONCLUSION:

We found a result regarding the automation of sand reclamation system. The automation is mostly beneficial for the sand reclamation system as we can control the system in smart way. This automation has a prime importance of online monitoring. We are able to store data of the system in a single data sheet. Also automation reduces the cost of labor; once we start the program it does not to need to observe every time. Safety and life of the hardware and components of system increased due to automation. Labor safety has prime importance in our industry field. In automation labor safety is more than previous system. Cost is reduced due to less work with system. This automated system has certain disadvantages or limitations like power cut-off will restart the program.

Exceptionally SUV remains open due to lack of feedback system; limit switch can solve the problem.

5. ACKNOLEDGEMENT:

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