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Development and Performance of Electro-Hydraulic Excavator

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ABSTRACT

The heavy earth moving machineries (HEMM) like hydraulic excavators play a major role in the construction and mining industries. In an industry of mining and construction, a hydraulic excavator plays a major role in action to perform a carry an heavy load. Employing the technology of automation, an alternative solution is made to replace the manual operation. By addressing the concept of automation in construction, the inevitable usage of embedded is accumulated to introduce in earthmovers. In a mass production or construction site, unplanned work would lead to time-consuming and fault. To overcome the major disadvantage of time-consuming, so implementation of automation is made on excavators. This could be made workers do other work sequentially with half monitoring the working process of excavator. This also favors the firm or industry to increase the work capability with an adequate number of laborers.

KEYWORDS: *Excavator, Embedded programme, solenoid valve, pneumatic actuators*

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I. INTRODUCTION

It is an era of automation where broadly defined as replacement of manual effort by mechanical power in all degree of automation. The operation remains an essential part of the system although with changing demands on physical inputs as the degree of mechanization is increased. Automation can be achieved through the evolving technology of embedded system, etc.., The main advantages of all hydraulic systems are economy and simplicity. Automation plays an important role in mass production to increase the work capability with unskilled labourers too. It also enables the firm or industry to yield satisfied profit with enhancing sequential work to the workers in the same time, on performing automated work by embedded installed excavator.

As we see in the excavator part in the JCB is operated by using manual lever mechanism with the help of hydraulic concept facing an issue of inefficiency in the system because of force reduction exerted on the system. The following(3) have done on research about to eliminate the difficulties of ground clearance and mechanical vibration of links. Through the LUCIE programme made to follow the organized robotics following with the concept of automation.(4)The concept of unmanned excavator made to offer facility for local workers to automated in the hazardous area using sensor and camera recording.(5)While on the eye of economy side especially coal mining industry, bucket wheel excavator plays an major role to increase the energy saving and with reduced amount of time.(6)To improve the productivity and safety of construction site an integration of AMC/G with a multi-agent system and the RTS. The use of RTS makes one to follow the correct procedure of safety and productivity and also by enhancing the transition of RTS through AMC/G causes an great change in productivity, site safety and project management.(7)In every mass production there should be an shop floor section to carried out a specific tasks to meet the production rate. Some of the shortcomings like unavailability of tools and sudden damage of tools and excess inventory control, between those above mentioned aspects. makes the operator weary to carry over the finished part from

that place to testing. It also causes intangible work load for operator. To eliminate this difficulties, the implementation of global boom makes sequential process of displacing the finished product into further section. This ideology has proceed through Value Stream Mapping which could causes high productivity rate and it meets the demand of customers.(8) On considering the lower pressure losses and lower energy consumption, the zonal hydraulics and automated mini electro hydraulic excavator enables us to control emission of CO2 from the excavator. This ideology can be directly implemented in the mechanical industries.(9) The three main machineries in construction sites are sawing machine, concrete and hoist mixer where it's peal load could be maintained by small sensor through embedded. It's main function is to monitor and if fault occurs, the error code is feedback to the encoder for further data analyzing.(10) The advancement of Programmable Hydraulic Control recovers the adversity of mobile electro-hydraulic which makes low energy efficiency and poor capability. The intro of independent actuators, integrated relay and intelligent embedded software control replaces all these difficulties.

II. MATERIALS AND METHODS

The aim of this chapter is to describe various materials used and methodology used to make different parts. The conceptualization, designing, analysis of links with their line diagrams are dealt in this chapter. Fabrication of CPC and heat pipe are also discussed. The characteristics of various components and their specifications along with their dimensions were taken into account.

Methodology

- Conceptual development of model
- Flow chart
- Collection of materials
- Fabrication

2.1. Conceptual design

The conceptual design of excavator done with the help of solid works as shown in fig.1

Fig.1

2.2. Components involved

The main components of a project are

- Frame
- Hydraulic cylinders
- Solenoid valve
- Rack and pinion
- PIC controller board
- Oil reservoir
- Bucket

2.3. Frame

A frame is often a structural system that supports other components of a physical construction and/or steel frame that limits the construction's extent. Frame has made up of mild steel with the dimensions 25×25×3.

2.4. Hydraulic cylinders

A hydraulic cylinder is a mechanical actuator that is used to give a unidirectional force through a unidirectional stroke. It has many applications, notably in construction equipment manufacturing machinery, and civil engineering. Four cylinders used with following dimensions 40mm inner dia, 150mm stroke length

2.5. Solenoid valve

Solenoid valves are electrically activated valves, typically used to control the flow or direction of air or liquid in fluid power systems. Used in both pneumatic and hydraulic fluid power functions, the spool or poppet design of most solenoid valves makes them perfect for various functions and applications.It is 5/2 electrically operated valve and pressure limit is 8kgf/cm^{2}The used valve is shown in fig.2.

Fig.2

2.6. Rack and Pinion

Rack and pinion, mechanical device consisting of a bar of rectangular cross section (the rack), having teeth on one side that mesh with teeth on a small gear (the pinion). The pinion may have straight teeth, as in the figure, or helical (twisted) teeth that mesh with teeth on the rack that are inclined to the pinion-shaft axis.

If the pinion rotates about a fixed axis, the rack will translate; i.e., move on a straight path. Some automobiles have rack-and-pinion drives on their steering mechanisms that operate in this way.

2.7. PIC microcontroller

PIC microcontrollers (Programmable Interface Controllers), are electronic circuits that can be programmed to carry out a vast range of tasks. They can be programmed to be timers or to control a production line and much more. They are found in most electronic devices such as alarm systems, computer control systems, phones, in fact almost any electronic device. Many types of PIC microcontrollers exist, although the best are probably found in the GENIE range of programmable microcontrollers. These are programmed and simulated by Circuit.

2.7.1. Input power supply

Initially input voltage of 230V power is supplied to PIC controller board.

2.7.2. Transformer

The transformer which incorporated in the board step downs the voltage to 15V.

2.7.3. Bridge rectifier

The four types of diode present in the board which is known to be bridge rectifier again step down to 5V. It converts AC to DC supply.

2.7.4. IC circuit

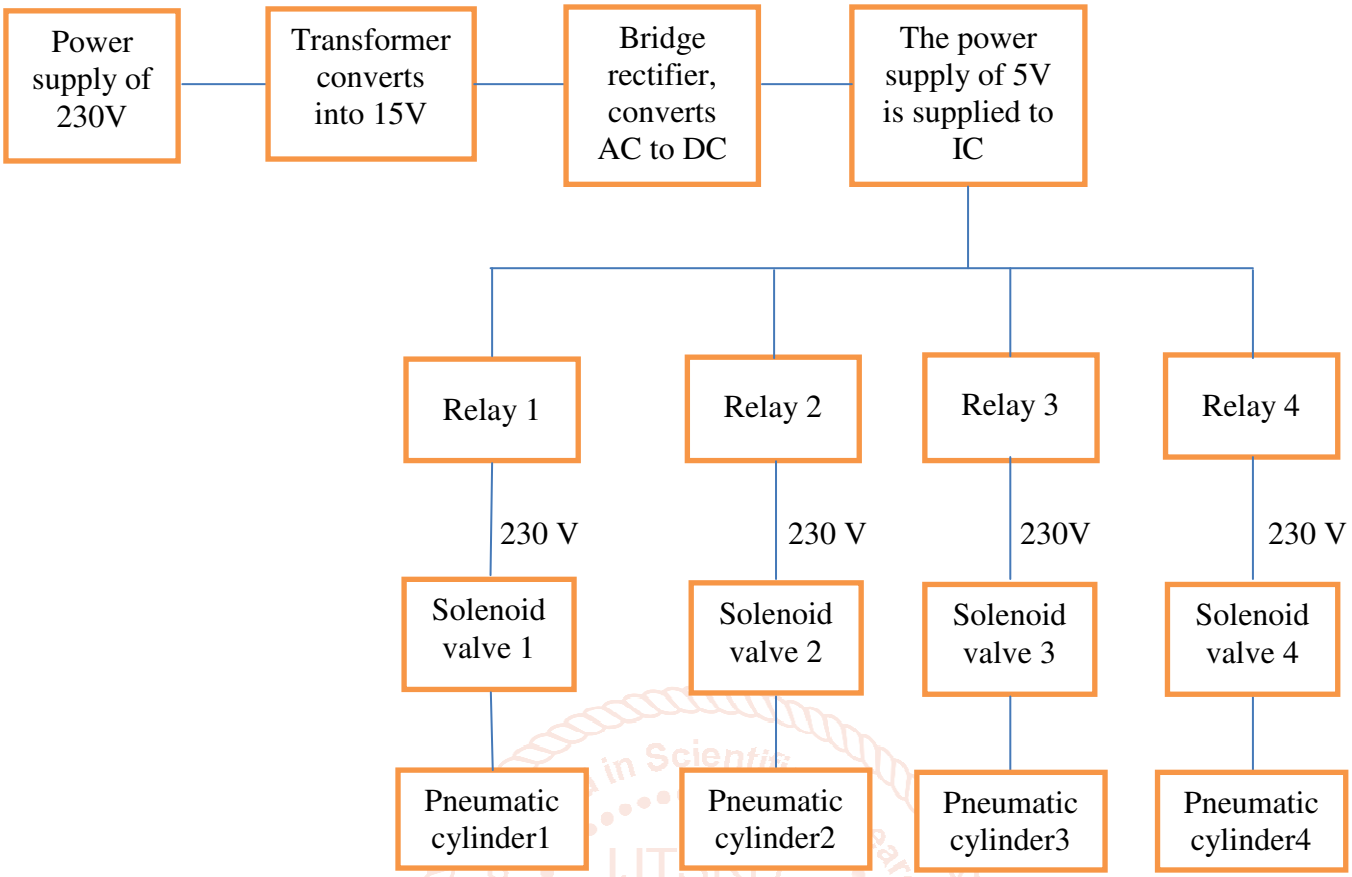
This 5V is being processed by PIC16f877a in which the instructions are stored. These instructions are send to relays for individual operations. Inside the IC chip, contains RAM and ROM. It has 32-bit memory.

2.7.5. Relay:

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof. The relay coil has Input voltage 15volts, output voltage 230volts and one input and two input terminals.

Finally the operating voltage of 230V is supplied to solenoid valve by the common supply unit from relay.

2.8. Flow chart



III. PERFORMANCE TESTING

The automation of excavator can be studied by using both the Fluidsimu software and embedded C software. TracePro is one of the most powerful and sophisticated fluid flow analysis and design software. The Electro-hydraulic excavator model designed in solidworks is imported to the Fluidsim software and the fluid flow were traced. The final result by the respective software shows that flow of fluid through the respective hydraulic cylinders and with the help of micro-controller makes it to study the sudden drop and time adjustment of fluid flow inside the cylinders. With the help the embedded C program helps to study the automation of excavator. The below figure 4.3 shown represent the input given in the Fluidsim software.

FluidSIM is a comprehensive software for the creation, simulation, instruction and study of electro pneumatic, electro hydraulic and digital circuits. You'll be able to create circuits easily by using drag&drop. You only have to place the items in the circuit as you want to view them and build the circuit intuitively. Simple and effective.

3.1. Embedded C program

The embedded C program has the set of instructions to perform, monitor, automate the hydraulic excavator. The following set of program have one of the illustration for the working model of excavator. The working operation of excavator approximately runs for 23 secs with the extraction and retraction of every individual arms and excavators bucket with set of allocated time duration.

```
#include<pic.h>
#include"4 BIT LCD HEADER FILE.h"
#define X1_WHEEL RD0
#define X2_WHEEL RD1
#define Y1_WHEEL RD2
#define Y2_WHEEL RD3
#define Z1_WHEEL RC4

voidX_Forware()
{
        X1_WHEEL = 1;
        X2_WHEEL = 0;
}

voidX_Reverse()
{
        X1_WHEEL = 0;
        X2_WHEEL = 1;
}

voidY_Forware()
{
        Y1_WHEEL = 1;
        Y2_WHEEL = 0;
}
```

```
voidY_Reverse()
{
        Y1_WHEEL = 0;
        Y2_WHEEL = 1;
}
voidZ_Forware()
{
        Z1_WHEEL = 1;
}
voidZ_Reverse()
{
        Z1_WHEEL = 0;
}
voidAll_Stop()
{
        X1_WHEEL = 0;
        X2_WHEEL = 0;
        Y1_WHEEL = 0;
        Y2_WHEEL = 0;
        Z1_WHEEL = 0;
        __delay_ms(500);
}
voidX_F_Dip()
{
        X_Forware();
        __delay_ms(6000);
        All_Stop();

        Z_Forware();
        __delay_ms(3200);
        All_Stop();
}
voidY_F_Dip()
{
        Y_Forware();
        __delay_ms(6000);
        All_Stop();

        Z_Forware();
        __delay_ms(3200);
        All_Stop();
}
voidX_R_Dip()
{
        X_Reverse();
        __delay_ms(6000);
        All_Stop();

        Z_Forware();
        __delay_ms(3200);
        All_Stop();
}
voidY_R_Dip()
{
        Y_Reverse();
        __delay_ms(6000);
        All_Stop();

        Z_Forware();
        __delay_ms(3200);
        All_Stop();
}
void main()
{
        TRISD=0X00;
        PORTD=0X00;

        TRISC=0X00;
        PORTC=0X00;

        ADCON1=0X06;

        TRISB=0x00;
        PORTB=0X00;

        TRISE=0x00;
        PORTE=0X00;

        Lcd_Initialization();

        Lcd_String("hello",1,0);

        int a=3,b=1,c=3,d=1,e=3;

        while(1)
        {
                while(e)
                {
                        Lcd_Cursor(2,0);
                        Lcd_Data(e+48);

                        a=3,b=1,c=3,d=1;

                        while(a)
                        {
                                X_F_Dip();
                                a--;
                        }

                        while(b)
                        {
                                Y_F_Dip();
                                b--;
                        }
```

```
                while(c)
                {
                        X_R_Dip();
                        c--;
                }

                while(d)
                {
                        Y_F_Dip();
                        d--;
                }
                e--;
        }
        Y_Reverse();
        __delay_ms(6000);
        All_Stop();

        while(1);
    }
}
```

IV. RESULTS AND DISCUSSION

The hydraulic excavator was designed and fabricated as explained in chapter 3.1 to 3.12. Overall specifications with economic analysis, cost estimation of various components used in the CPC and test results found were dealt in this chapter. In addition, the comparison of results by varying different parameters also done.

4.1. Fabricated prototype

The design of the components was done using Solid works modelling software and fabricated. The evacuated tube, tanks, used were readily available in the market. The temperature indicator, light was also readily available in the market. The fabricated prototype have shown in fig.3.

Fig.3

4.2. Working

1. The working of the Electro-hydraulic excavator is described in this portion.
2. The voltage of 430V is supplied to the circuit of micro-controller.
3. The voltage is passed through the bridge rectifier to make the step-down the 430V-12V.
4. The voltage of 12V is passed to IC chip of PIC16f877a in which the instructions are stored to make the task performance of individual arm.
5. The four individual relay which acts as switch and ready to receive the 12V supply.
6. This relay could capable of acting swith, so it allows the further voltage supply to next stage by following the instructions stored in IC chip.
7. Among the four relay only one is capable to allow the supply for further stage and if one closes then another relay get opened the way for supply.
8. This relay converts the 12V to again 40V supply and then passed to the solenoid valve where the hydraulic cylinders have connected.
9. The compresser (4~7 bar) connected to the main unit of solenoid valve from that it is distributed to the individual valves.
10. When the signal is given to one of the valves, cylinders retraces with the help of oil filling through compressor.

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