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Modification and Testing System Control and Swing Model Excavator System

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ABSTRACT

One of the heavy equipment that play role in development projects is the excavator. An excavator can perform construction work such as digging, splitting, loading and so on. Laboratory of Hydraulics and Pneumatics Mechanical Engineering Faculty of Engineering, University of Riau has produced a model excavator using pneumatic system, support on a controller box, equipped with buttons setting and motion rotary swing 120^o. The research has modifications control system, remove the control box under the excavator and change to the remote system. The motion rotary swing system has changed from 120^o to 360^o. The purpose is all movements similar in general excavator. The result, excavator model using power 12V DC the control system and compressed air drive pneumatic system. The results of testing control system work to properly, the rotary motion of the swing system 360^o and use electric voltage 7,5V will have speed 13,598 rpm, so swing motion from the excavator model similar in general.

KEY WORDS: *Remote; Swing; Control; Excavator*

1.0 INTRODUCTION

Various activities in heavy equipment when a project the construction is done, whether it is the way, bridge, airport, waterworks, reservoir, dam, port, and buildings. Heavy equipment in a project building having a very important role in terms of the sustainability of the project [2].

Generally, excavator have machine for moving all components, using a hydraulic system, pressurized fluid flowed into actuator to move the arms as boom, stick and bucket, as the technology and found the system excavator to move using motorcycle hydraulic on wheels the chain [9].

Mechanical Engineering Laboratory Hydraulic and Pneumatic of University of Riau has produced a model of excavator [8], by using pneumatic system and taken advantage of pressurized air to move translation and rotation. Its movement is only an arm motion and maximum swing rotation in 120^0. All the movements of the excavator model are controlled by knobs control which is with the excavator. There are two ways to actuate the excavator. Firstly, the excavator moves single cycle where the operator is just depressing single button to actuate the excavator including all of arm components in order to be able in loading and unloading process load with sway motion 120^0 and moving back to original position. Secondly, the excavator is actuated manually by operator with existing control systems. The control system serves as control module to activate all of the components.

2.0 THEORY

2.1 Excavator Definition

The excavator is one of heavy equipment which is consist of components such as boom, arm, bucket, and hydraulic and electric system. The excavator is used in construction and mining area that are used in digging, trenching, loading and unloading operation. The main part of excavator consists of travelling unit and revolving unit as shown in figure 2.1.

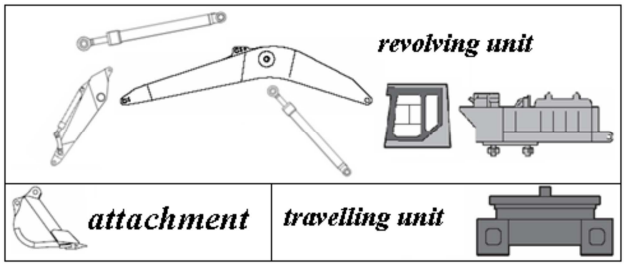


Figure 2.1: Parts of Excavator

2.2 Pneumatic
The Pneumatic is pressurized air which is used in the modern industry to serve a power which is used in remote controlling for a process. [5]. A pneumatic system controlled through with manual and automatic device to activate or to control some equipment.

2.3 Electrical Power
The electric power is associated with a complete electric circuit or circuit component which represent the rate of energy of the moving charges to some other form, e.g., heat, mechanical energy. This energy is stored in electric field or magnetic field. The power of DC Circuit is given by the product of applied voltage and electric current:

$$P = V.I \tag{2.1}$$

Where,
V = *Voltage* (Volt)
P = *Power* (Watt)
I = *Current* (Ampere)

2.3.1 Direct Current
The Direct Current is the unidirectional flow or movement of the electric charges. In general, the direction or movement stays the same time at all time [11].

2.3.2 Direct Current Motor
A Direct current motor represents the electromagnetic field where the electrical energy is converted to the mechanical energy. Furthermore, the mechanical energy is transferred to rotate a shaft.[14]. The rotational speed of the motor can be calculated as follows:

$$V_t = E_a + I_a R_a \tag{2.2}$$

$$E_a = Cn\Phi \tag{2.3}$$

$$\omega = \frac{V_t - I_a R_a}{C\Phi} \tag{2.4}$$

$$\omega = \frac{2\pi n}{60} \tag{2.5}$$

Where:

V_a = input voltage
R_a= Resistance of Winding armature
I_a = Current of armature
E_a= Power of electric in watt
Φ = Magnetic flux in Weber
ω = Angular velocity, Rad/Sec
C = Constanta
n = Revolution per minute (RPM)

2.4 Control System
A control system is sets of devices, which functioned to manage, command is used in the industrial equipment (Fig. 2.2). Physically, the control system is allowed to control the equipment automatically [12].

Figure 2.2: Control System

2.4.1 On-Off Control
The control element has two positions either it is fully closed or fully open. The control system made for such controlling element, is known as on-off control theory.

2.5 Chain
A chain is a series of connected link which consists of one or two more links. The chain is used to transmit the power between two shafts. There are two styles of chain, according to their intended use, namely roll chain and gear chain.

2.5.1 Roll Chain Selection
The horsepower rating is transmitted through roll chain could be calculated as below:

$$HP\ Design = HP \times SF \tag{2.6}$$

where:
$HP\ Design$= Horse Power design
HP = Horse Power of motor
SF = Service Factor as show in table 2.1

Table 2.1: Service Factor

Class of Driven Load	Type of Input Power		
	Internal Combustion Engine with Hydraulic Drive	Electric Motor or Turbine	Internal Combustion Engine with Mechanical Drive
Uniform	1	1	1.2
Moderate	1.2	1.3	1.4
Heavy	1.4	1.5	1.7

Figure 2.3 is used to determine the selected chain number according to the drive sprocket revolution, the transmitted power and the number of chain that will be used.

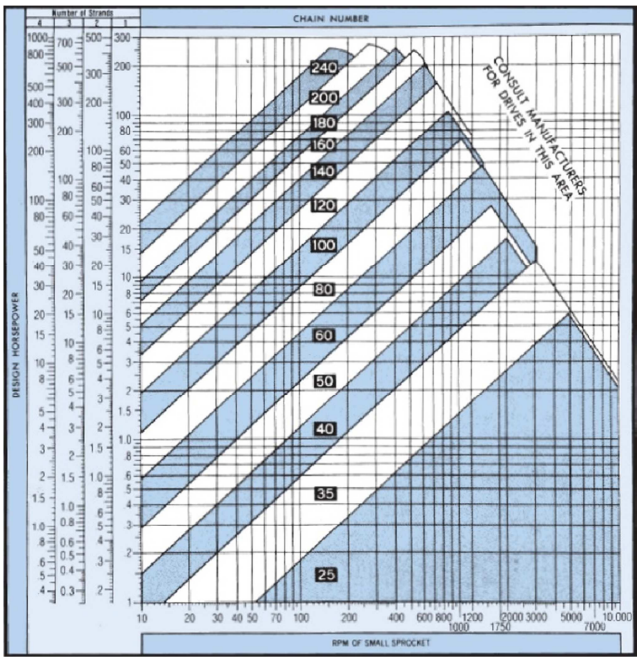


Figure 2.3: Quick Selector Chart

In order to determine the number of strand that will be used in this project, refer to table 2.2

Table 2.2: Number of Strand

No. of Strands	1	2	3	4	5	6
Factor	1	1.7	2.5	3.3	3.9	4.6

The specification of chain number is selected according to Figure 2.3 Standard ASME B29.1M-1993.

The sprocket rotation could be calculated by the equation (2.7) as below:

$$\frac{N_1}{N_2} = \frac{T_2}{T_1} \qquad (2.7)$$

Where,
N_1 = Drive sprocket rotation in rpm
N_2 = Driven sprocket rotation in rpm
T_2 = Number of teeth for drive sprocket
T_1 = Number of teeth for driven sprocket

The chain length is determined by the equation (2.8) as follows:

$$L = K.p \qquad (2.8)$$

Chain link, K is the number of links could be determined by the equation (2.9):

$$K = \frac{T_1+T_2}{2} + \frac{2x}{p} + \left(\frac{T_2-T_1}{2\pi}\right)^2 \frac{p}{x} \qquad (2.9)$$

The sprocket axis distance could be formulated by the equation (2.10) as follows:

$$x = \frac{2T_1+T_2}{6} \qquad (2.10)$$

Where:
L = Length of Chain (mm)
K = Chain Link
p = Pitch (mm)
x = Axis distance between sprockets (mm).

Therefore, the power could be transmitted to satisfy the equation as below:

$$P = \frac{T2\pi N}{60} \qquad (2.11)$$

3.0 METHODOLOGY

The research will be accomplished in three stages. First, Modification of system control. Second, Designing process and manufacturing of the swing system. Third, testing on control system and swing system.

3.1 Modification of System Control

This research is carried out to modify the control system by using the remote control to activate the prototype equipment.

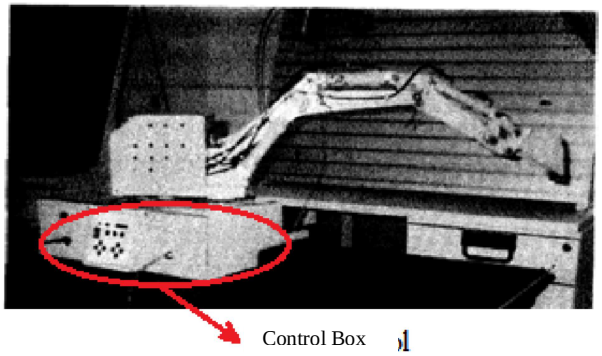


Figure 3.1: Model Excavtor

The flow chart of this research as follows:

No. of Strands	1	2	3	4	5	6

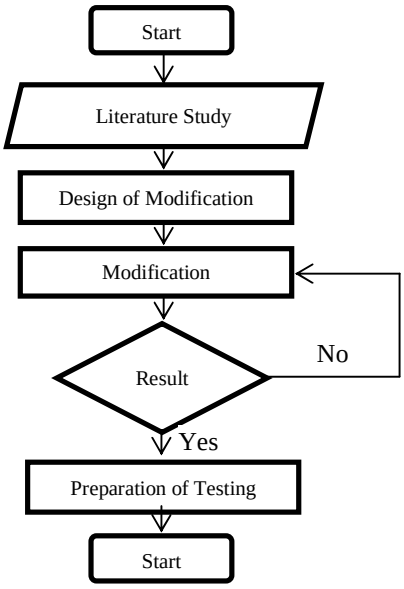


Figure 3.2: Flowchart of Control System Modification

3.1.1 Design of Control System

Design of control system could be seen in figure 3.3

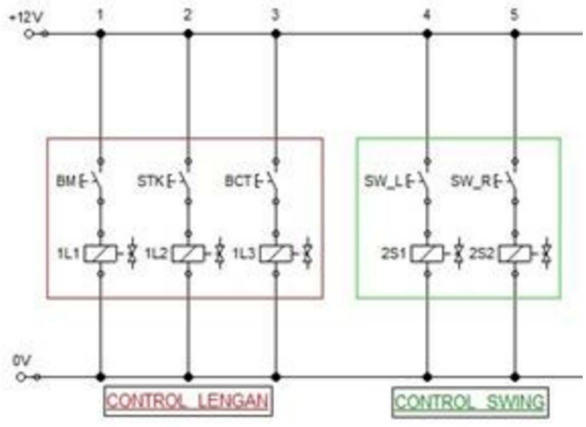


Figure 3.3: Design of electro pneumatic control system

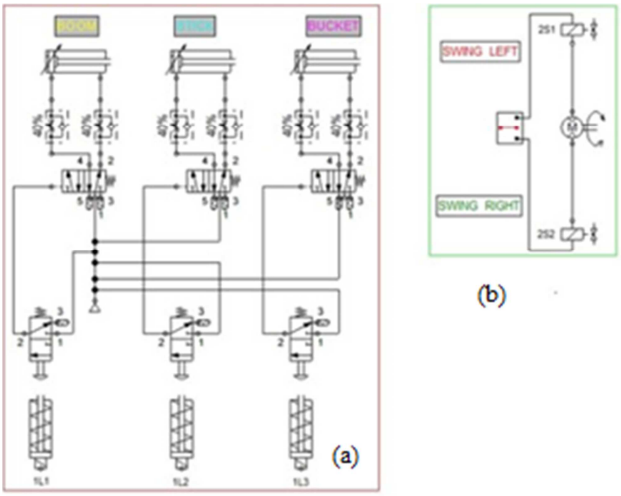


Figure 3.4: Circuit of pneumatic control (a) and circuit of swing (b) from model of excavator

In the circuit consists of pneumatic control system (boom, arm and bucket) and swing control system. Some label in Figure 3.3 and Figure 3.4 is explained as shown in table 3.1

Tabel 3.1: Description of Circuit Control

Label	Description
BM	Button to activate boom
SKT	Button to activate stick
BCT	Button to activate bucket
SW_L	Button to activate swing motor with CW rotation
SW_R	Button to activate swing motor with CCW rotation
1L1	Boom connector socket to Panel Control
1L2	Stick connector socket to panel control
1L3	Bucket connector socket to control panel
2S1	Swing motor connector socket with CW rotation
2S2	Swing motor connector socket with CCW rotation
0V	Input of Power Supply
+12V	Input of Power Supply

3.1.2 Build and Assembly Remote Control

The remote control comprises the several of part component which need to be assembled and joined with electrical cable to transmit the electrical voltage that used to activate all of part of excavator model.

Result of all of the control system can be seen in Figure 3.4 as below.

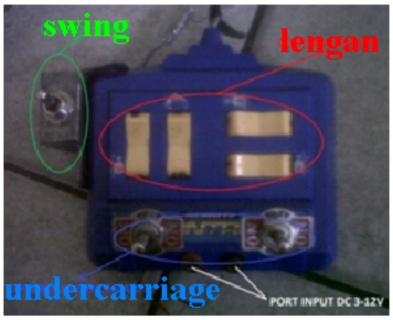


Figure 3.4 Remote Control Assembling

3.2 Swing modification

The old system [8] used in swing control is sliding shaft to rotate the swing (Fig. 3.5). In this study, the electric motor is applied to rotate the swing so the angular movement reach 360 ^{0}, as shown in Fig. 3.6.

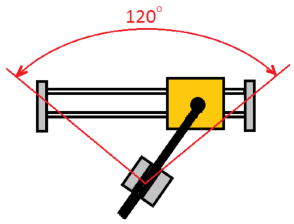


Figure 3.5 Mode swing at the old model

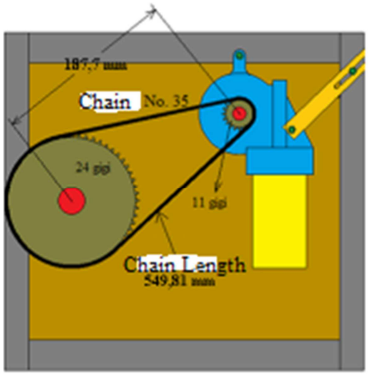
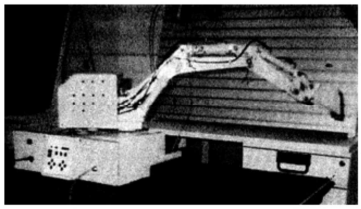


Figure 3.6 Chain and driving system on a new model

4. RESULT

Either of table and figure respectively are shown on Fig. 4.1 (a) and (b) as a final result that had been obtained after modification model of excavator [8].


(a). Before Modification


(b). After Modification

Table 4.1: Several state before/after modification

Before Modification	After Modification
Control system is on the box	Part of controlling was placed on a remote and used a wire to connect with system.
Excavator can't move cause have a controlling box under it.	Excavator can make a good travelling by undercarriage.
Old model can make a swing mode only 120^{o} by sliding beam.	New model can do a 360o swing mode was used electric motor and chain transmission.
Position of panel control at the box behind of arms	Panel control had been put at the small box beside an arms.
Serial of pneumatic have been placed on a test table	Serial of pneumatic have been placed behind an arms.

5. CONCLUSION

From step in this research such as design, manufacture and assembly several things are concluded;

1. This study continues previous work to make a remote and modification type of system control become an acting two position on or off.

2. Low voltage can reduce a power that make electric actuator weak. Consequently will be met a little bit time before pneumatic valve pushed a arm.

3. This study had been made a swing system using chain and bicycle sprocket that are driven by electric motor YB037001A from a car power window. The system rotate in 40.882 rpm in voltage 12 V.

4. Revolution on swing can be synchronize with the normally excavator while using 7.5 V and rotate in 13.598 rpm.

REFERENCE

1. Anonim. 2013. *Volvo Construction Equipment*. North America.
2. Ayu, W. Ade. 2007. *Peranan Penting Alat Berat pada Pembangunan JalanTol*. PoliteknikNegeriJakarta.
3. Norberg.C. B. 1993. Presision Power Transmission Roller Chains ASME B29.1M. NewYork, N.Y.
4. Dorf, R.C. 1983. *Sistem Pengaturan Edisi 3*. Jakarta: Erlangga.

5. Ebel F, 2002. *Electropneumatics Festo Didactic Vol 1*. Germany: Festo Didactic Industries.
6. Gustriansyah, Yogi. 2011. Hubungan AntaraTegangan dan RPM Pada Motor Listrik. TeknikElektro ITB.
7. Jeffrey, Renold. 2011. *Roller Drive Chain Selection*. America: Advancing Chain Technology Ltd.
8. Julianto, Nazarudin. 2004. *Perencanaan dan Pengujian Model Excavator*. Paper work. Mechanical Engineering.Universitas Riau.
9. Spotts.M. F. 1964. *Design of Machine Elements*. Northwestern University. Prentice-Hall.
10. Pakpahan, Sahat. 1988. *Kontrol Otomatik Teori dan Penerapan*. Jakarta.Erlangga.
11. Zuhal. 1991. *Dasar Tenaga Listrik dan Elektronika Daya*. Jakarta. PT. GramediaPustaka.