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PSE ROLLING MILL
EGR 450 - Manufacturing Controls
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1.0 Project Description

The goal of the project was to develop the controls for a rolling mill. The controls for the rolling mill will turn the rollers forward and backward, control the speed of the rollers, and provide the necessary safety features. The rolling mill is presently under design, the assumptions of its operation is as follows. The rolling mill will be a two-high roller bearing mill. Each roll will have a diameter of 76.2 mm and a length of 87.63 mm. The roll gap will range between zero and 12.7 mm. The maximum separating force between the two rollers will be 133.4 kN. A load indicator with a range of zero to 89.0 kN will be used to measure the separating force. The rolling mill will be powered by an electric motor. The speed of the rollers will be variable between zero and twenty revolutions per minute. The speed of the rollers will be outputted. The maximum temperature of the materials being rolled will be 1,093°C

2.0 Design Process

The rolling mill was designed to exist in one of three states. It will either be in an idle state, forward state or a reverse state. In the idle state the rolling mill is stopped. In the idle state the direction of the rolling mill and the speed of the mill can be selected. In the forward state the rolling mill is rolling in the forward direction. In the forward state the speed of the rolling mill can be increased or decreased and the speed of the roller is read. In the reverse state the speed of the rolling mill can be increased or decreased. The state diagram is shown in Figure 2.1.

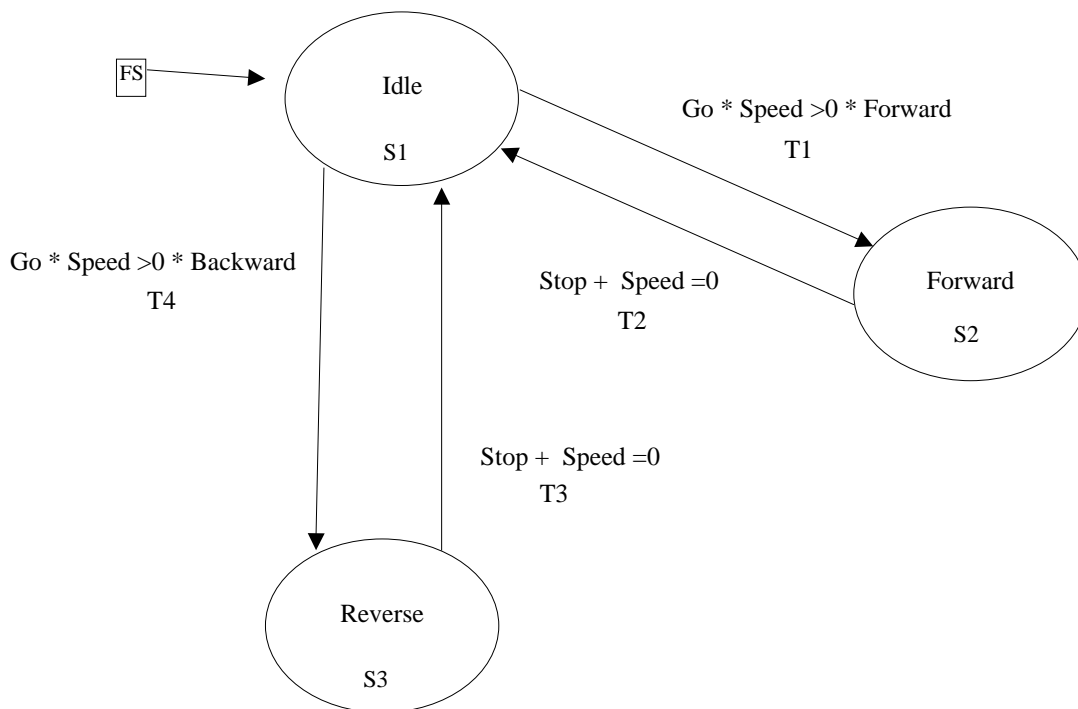


Figure 2.1: State Diagram

The transitions between the different states are listed below

T1 = Idle to Forward = Go * Speed>0 * Forward

T2 = Forward to Idle = Stop + Speed=0

T3 = Reverse to Idle = Stop + Speed=0

T4 = Idle to Reverse = Go * Speed>0 * Reverse

The transitions bit locations and formulas using bit locations are listed below

T1 = Idle to Forward = B3:3 = (B3:0*I:00/0*I:00/3)

T2 = Forward to Idle = B3:4 = (B3:1*I:00/4)

T3 = Reverse to Idle = B3:5 = (B3:2*I:00/4)

T4 = Idle to Reverse = B3:6 = (B3:0*I:00/0* \overline{I} :00/3)

The three states are defined below:

$Idle = S1 = B3:0 = (B3:0 + S2:1/15 + B3:4 + B3:5) * \overline{B3:0} + \overline{B3:8} * \overline{B3:6}$

$Forward = S2 = B3:1 = (B3:1 + B3:3) * \overline{B3:1} + \overline{B3:4}$

$Reverse = S3 = B3:2 = (B3:2 + B3:6) * \overline{B3:2} + \overline{B3:5}$

Inputs

I:00/0	Go
I:00/1	Speed Up
I:00/2	Speed Down
I:00/3	Direction: Forward/Reverse
I:00/4	Stop
I:00/5	Speed
A/IO	Force

Outputs

O:0/0	Stop (Normally Closed)
O:0/4	Reverse
O:0/5	Start (Normally Open)

Bit Memory Locations

B3:0	S1 Idle State
B3:1	S2 Forward State
B3:2	S3 Reverse State
B3:3	T1 Transition 1
B3:4	T2 Transition 2
B3:5	T3 Transition 3
B3:6	T4 Transition 4

Bit Memory Locations

ST20:0	Speed set:_
ST20:1	C5:0.acc
ST20:2	Speed set:_C5:0.acc
ST20:3	Speed:_
ST20:4	_RPM
ST20:5	N7:0
ST20:6	Speed set:_N7:0
ST20:7	Speed set:_N7:0_RPM
ST20:8	Torque
ST20:9	N7:1
ST20:10	set:_ft lb
ST20:11	Torque_N7:0
ST20:12	Torque_N7:0_ft lb

3.0 Components

The main component is the Micrologix 1000. It has 12 digital inputs and 8 digital outputs along with 4 analog inputs (2 voltage and 2 current) and one analog output. It was important that the plc contains an analog input and output to be able to control the speed of the motor. The motor controller also has specific requirements because it needs a minimum of 380 volts supplied to it. A complete parts list is shown in Table 3.1.

Table 3.1: Parts List

Part	Details	Cost	Location
PLC	Micrologix 1000 mfg# 1761-l20bwa-5a	650.00	Allen Bradley
Motor Controller	AB mfg# 160-AA03PSF1	425.50	stock
Motor	3/4 HP, 3 phase AC, Grainger # 3N042	124.99	Grainger
Display	Microview Operator interface, panel mount, mfg# 2707-mvp232	322.00	Allen Bradley
Display	Programming software, mfg# 2707-np2	114.00	Allen Bradley
RS-232 cable	From PLC to display, mfg# 2707-nc11	57.00	Allen Bradley
Force Sensor			Wait
Gear Box			Wait
Controls Panel	20x16x6, Grainger# 6C718	126.6	Grainger
Interior Panel	Grainger# 2W828	26.70	Grainger
MCR	700-HG power relay mfg# 700-HG42A1-99	26.10	stock
Conduit	5' 1"flexible conduit, terminator box connectors-2		stock
Power Cord	480 VAC power cord		stock
Mounting table	36x24 medium duty 12 gauge steel top, cat. # 46715T32	105.29	Wait
Master Power disconnect	30A, 3 HP, Grainger #1H247	40.90	Grainger
E-stop	mfg# 800FP-MT34	24.10	stock
Green Start	mfg# 800FP-F4	5.84	stock
Selector	mfg# 800FP-SL22	10.65	stock
Speed up push button	mfg# 800-FPF6	5.81	stock
Speed down PB	mfg# 800-FPF5	5.81	stock
Encoder	16 position, non-detent cat# CT3001-ND	2.58	stock

Total 2,073.87
Total to Order 1,462.19

4.0 Circuitry

The wiring diagram for the rolling mill is shown in Figure 4.1.

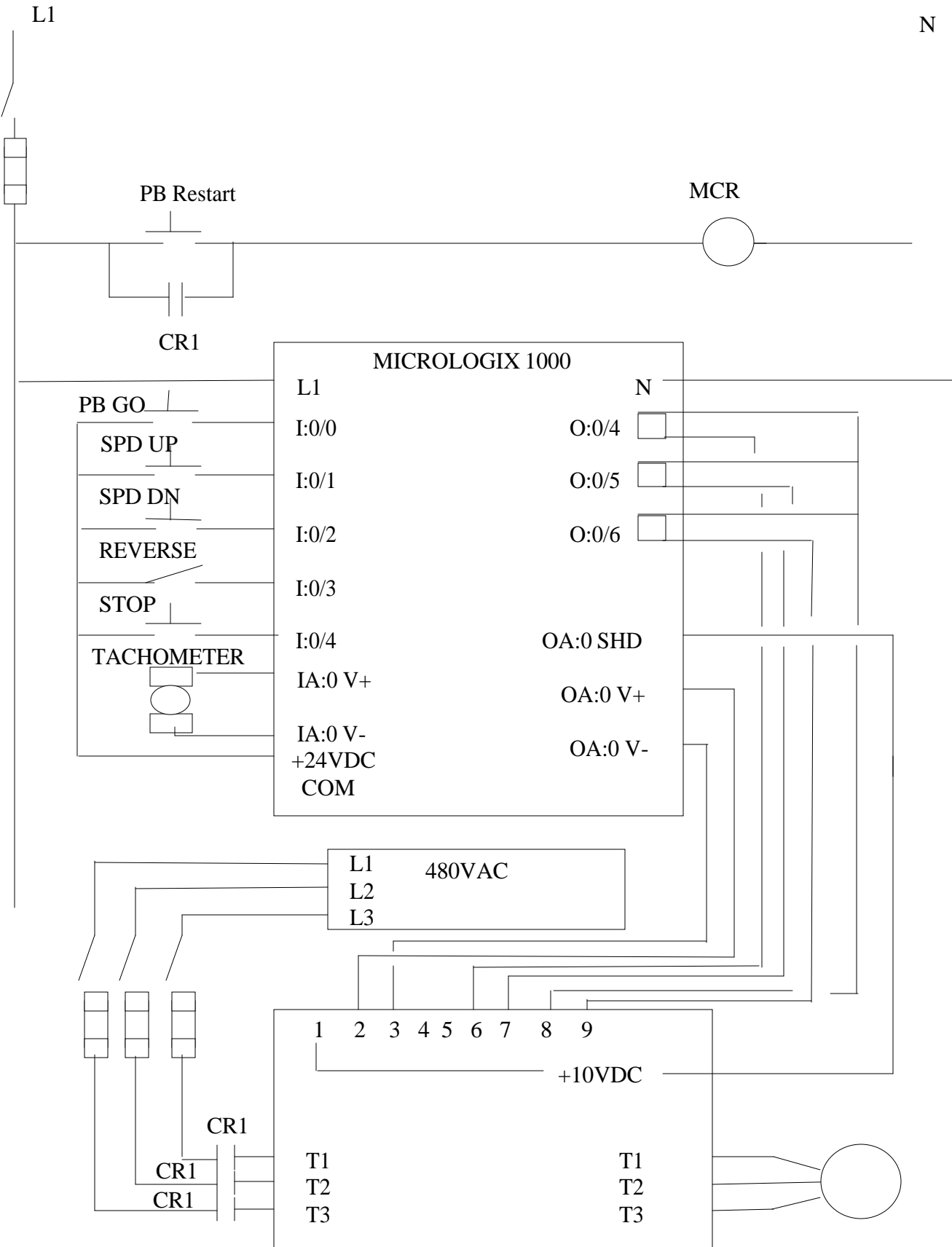


Figure 4.1: Wiring diagram

6.0 Operating Instructions

Operators Manual

This manual will describe how to properly run the metal rolling press. Figure 6.1 shows the front of the control panel.

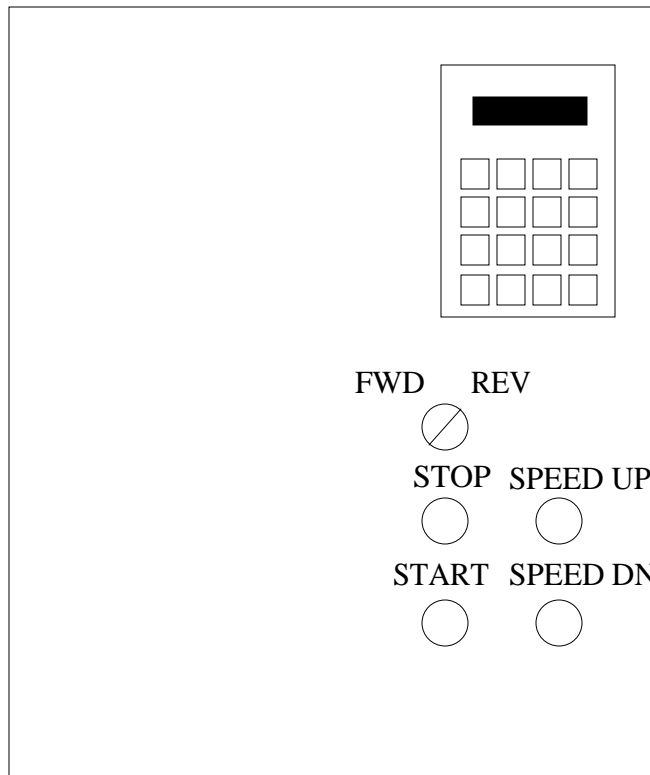


Figure 6.1: Control panel button layout

1. Setting the rolling speed

Either method can be used to change the speed with or without the mill running.

Method 1:

The rolling speed is adjustable from 0 to 20 RPM. This can be adjusted by pressing the speed up or speed down push-buttons on the control panel. Each time the button is pressed the speed will change by 1 RPM.

Method 2:

The speed can also be changed by pressing 1 when in the main menu on the display, entering the desired speed in RPM, and pressing enter.

2. Starting the mill

Once a speed has been chosen pressing the green start button will start the mill. If no speed is entered the mill will go into run mode, but will not turn until a speed is set. Each time the mill is started the speed must be set in order for the mill to run.

3. Reversing direction

The mill's direction of rotation can be set to draw material into the rollers or to back material out of the rollers. To back material out the machine must first be stopped, the direction switch moved to reverse and the start button pressed. The mill will start in the reverse direction at the set speed.

4. Emergency stop and Restart

If the emergency stop is used to stop the machine the button must be reset by pulling it out till a click, and the restart button pressed. The machine will default back to idle mode and the speed setting will be zero.

5. Display Instructions

To go to the main menu at any time press the menu button. From the main menu, press 1 to set the speed or 2 to view the roller speed and applied torque.