Design of pneumatic press machine for 250 page bundle book based on microcontroller arduino uno

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Design of pneumatic press machine for 250 page bundle book based on microcontroller arduino uno

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Abstrak. Book is a collection of recorded papers that were put together by binding technique. Several types of binding techniques are carried out in the book bundle suppression stage. In this research, designing and building a book bundle press machine. The design starts with the demand for printing, house of quality, determination of specifications, functions, morphology, concepts to produce the best variant selection. The book bundle suppression system used follows the needs of printing with a semi-automatic system. This Research, a pneumatic press system with 250 pages capacity was controlled by Arduino UNO. This study discusses the selection and counting of pneumatic components and their framework, the selection of control components, simulating the results of component selection and control. From the design results obtained component costs of IDR 2,565,500.

1. Introduction

The graphic industry is a company in the printing of books, tabloids, banners, notes, letters and others. According to the Ministry of Industry the growth of the graphics industry this year increased by 5.3%. Indonesia has become one of the countries of Asia whose graphic industry growth is very good.

There are now 1,317 publishers registered as members of the Indonesian Publisher Association . Among those publishers, 94% are listed as active publishers. Active publishers are centered in 24 provinces out of 33 provinces in Indonesia. Around 1,182 publishers are in Java.

This means that around 90% of publishers are concentrated in Java, especially DKI Jakarta, West Java, Central Java and East Java. 1 , The printing industry in Indonesia continues to experience growth until the end of 2012. The graphic printing industry, which rose 40% in 2011 to US $ 392 million compared to imports in 2010 which were only US $ 280 million. Thus industry competition not only attracts consumers to believe in low priced products..

2. Research Methodology

2.1 Research Flow Chart

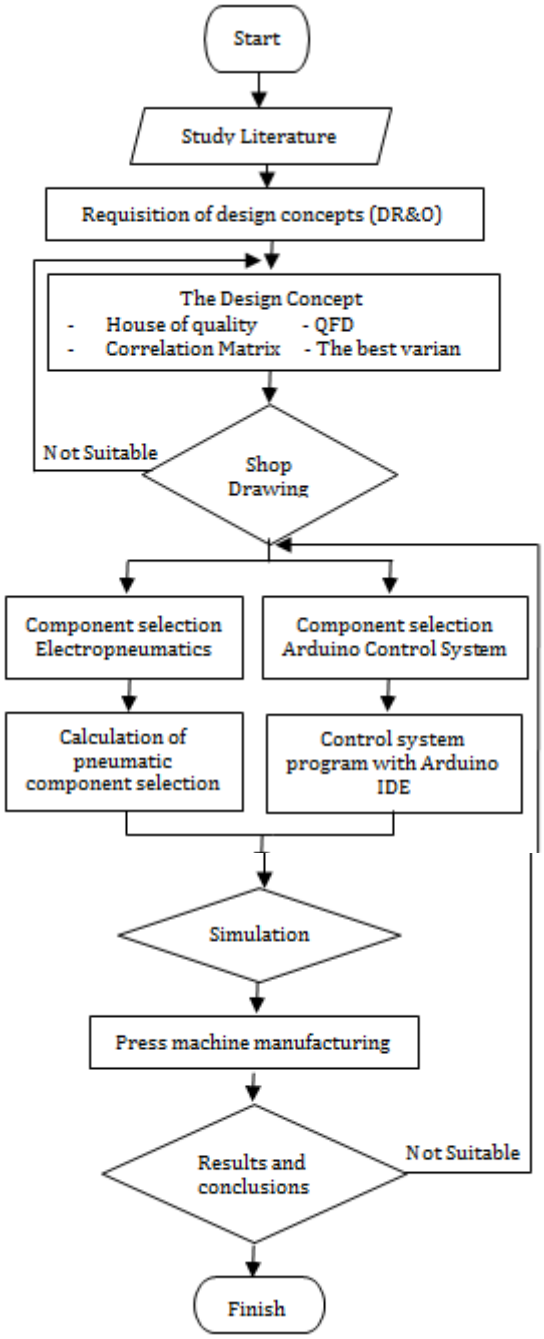

Figure 1. Research flow chart

2.2 Requirement list

Request for machine specifications was obtained from one of the printing companies in the city of Serang. Requests for specifications with interviews produced the following list of requests:

1. The price of production is smaller than the price of the machine on the market.
2. Semi-automatic tool system
3. The operator is as minimal as possible work
4. Does not damage paper

3. Results

3.1 Determination of the Best Variant

The best variant determination stage is the translation phase of variants that might be applied to this paper bundle press from function variants, shape variants, to physical variants taking into account the advantages and disadvantages of several variants.

In designing the hydraulic system of this paper bundle press machine, the following variants will be used in the table below:

Tabel 1. Variant of book press machine

No	Variant	A	B
1	Drive	fuel motor	Electric motor
2	Press Mechanism	Hydraulic	Pneumatic
3	Power transfer	Pulley & belt	Coupling
4	Control	PLC	Arduino

Of the several variants of this press machine design, to get the best variant then compare the functions of each variant.

From the results of the selection of the best variants, there are 2 best specifications, the choice of thinking about the working system tool. Then the variant was chosen with a pneumatic system, electric motor, clutch and Arduino. The use of hydraulics in addition to expensive component prices and the use of fluid or oil can damage the product.

3.2 Data Operations Press Book Bundle

3.2.1 Open side height and back of book

The first operation data is knowing the height of each bundle to determine the height of the frame and the length of the cylinder stroke with the desired bundle capacity.

Table 2. Tinggi sisi buka dan punggung bundel buku

NO	Number of page	Thick side open	Thick side back	Weight
1	50	5 mm	15 mm	25 Kg
2	100	10 mm	30 mm	50 kg
3	150	15 mm	45 mm	75 kg
4	200	20 mm	60 mm	100 kg
5	250	25 mm	75 mm	125 kg

3.2.2 Pressure Force

In the experiment to find the required compressive force using a sample of 50 sheets of paper under pressure from above. Below there are scales to indicate the amount of weight that is converted to a magnitude of force. The following is an illustration of paper press force taking data.

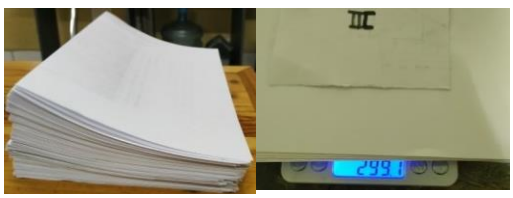

Figure 2. 250 page emphasis paper sample

In the suppression experiment with 50 sheets of paper 3 times the data was taken and calculated the average weight of the emphasis, on 50 pages of paper required weight of 25 kg of pressure. In the number of each bundle desired the straight comparison calculation is performed as follows:

$$x = 125\ kg$$

The calculation continues on the number of papers 100, 150 and 200 pages, the following results are obtained:

Press force 50 page = 25 kg x 9.86 m/s^2 = 246,5 N
Press force 100 page = 50 kg x 9.86 m/s^2 = 493 N
Press force 150 page = 75 kg x 9.86 m/s^2 = 739,5 N
Press force 200 page = 100 kg x 9.86 m/s^2 = 986 N
Press force 250 page = 125 kg x 9.86 m/s^2 = 1232,5 N

3.2.3 Pressure needed for each book bundle

The area of design pressure on the smallest size paper is A5. Emphasis on paper is desired with an area of paper length A5 = 210 mm and width from the back to the back side = 75 mm.

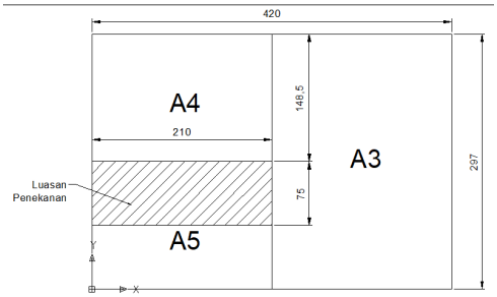

Figure 3. Extent of bundle suppression

With the equation P = F / A, where A = 0.075 m x 0.21 m = 0.01575 m^2. The resulting paper pressure is needed for each amount of paper as follows:

1. Pressure 50 page = $\frac{246,5\ \text{N}}{0.01575\ m^2} = 15.650\ N/m^2$
2. Pressure 100 page = $\frac{493\ \text{N}}{0.01575\ m^2} = 31.301\ N/m^2$
3. Pressure 150 page= $\frac{739,5\ \text{N}}{0.01575\ m^2} = 46.952\ N/m^2$
4. Pressure 200 page= $\frac{986\ \text{N}}{0.01575\ m^2} = 62.605\ N/m^2$
5. Pressure 250 page= $\frac{1232,5\ \text{N}}{0.01575\ m^2} = 78.253\ N/m^2$

3.3 Component Selection Pneumatic

3.3.1 Sylinder pneumatic

The need for compressive force with a number of 250 pages is 1232.5 N and a maximum pressure of 8 bar design with a double working cylinder type. Then the selection of a pneumatic cylinder can be determined by the following calculation:

$$A = 1{,}69x10^{-3}\ m$$

$$D = 0{,}0463\ m = 46\ mm$$

After the cylinder is selected, it calculates whether the cylinder can be used and the air capacity of the cylinder. The calculation of the force and capacity produced on the pneumatic system as follows:

1. The area of the cylinder steps down
$$A = 1{,}96x10^{-3}\ m^2$$
2. Cylinder working force steps down
$$F_{th} = 1570\ N$$
3. The force is able to work effectively the cylinder steps down
$$F_{eff} = 1413\ N$$
4. Extensive cylinder step up
$$A' = 1{,}64x10^{-3}\ m^2$$
5. Cylinder working force step up
$$F_{th} = 1.318{,}8\ N$$
6. The force is able to work effectively the cylinder steps down
$$F_{eff} = 1.187\ N$$
7. Position cylinder volume down
$$V_{ex} = 147\ cm^3$$
8. Position cylinder volume up
$$V_{re} = 1.230\ cm^3$$
9. Total volume
$$V_{ex} = 199{,}9\ cm^3$$

The resulting force of the selected cylinder is 1570 N and the demand force is 1232.5 N. then the selected cylinder can be used. In a working press system, there are a number of different pages for each bundle. In this case, the working pressure on each bundle is also different. Therefore, it is necessary to calculate the working pressure in each bundle with the following calculation:
Pressure for 30 pages (150 N)

$$P = 76.433{,}1\ Pa$$

With the same calculation, each bundle is known by the following table:

Table 3. Press on the number of pages in cm

No	Number of Page	Range sensor(cm)	Compressive weight (Kg)	Press force (N)	Pressure (Pa)
1	30	13	15	150	76.433,1
2	60	12	30	300	152.866,2
3	90	11	45	450	229.299,3
4	120	10	60	600	305.732,4
5	150	9	75	750	382.165,6
6	180	8	90	900	458.598,7
7	210	7	105	1050	535.031,8
8	240	6	120	1200	611.464,9
9	270	5	135	1350	687.898,0

3.3.2 Pneumatic Hose

To drain fluid from the compressor to the cylinder using a pressurized hose. The minimum diameter used in this design can be calculated as follows:

$$d = 2{,}5x10^{-3}\ m = 2{,}5\ mm$$

From the calculation results obtained a minimum internal diameter of 1.35 mm. from the hose selection results obtained hose with the following specifications:

- Internal diameter : 5 mm
- Outer diameter : 8 mm
- Max. pressure : 10 bar

Calculation of corrections to pressure drop

$$\Delta P = 158{,}8\ N/m^2\ < 5000\ N/m^2$$

then the diameter of the hose can be used.

3.3.3 Compressor Selection

In the selection of the compressor must weigh the flow rate, pressure and power needed in the design. The calculation of compressor power needed is as follows:

- Compressor discharge

$$Q_s = 3{,}14x10^{-5}\ m^3/2\ = 1{,}88\ l/min$$

- Power Compressor

$$N_s = 1{,}5\ KW$$

- Drive motor power

$$N_m = \ 1{,}435\ KW$$

3.4 Frame Material Selection

This material selection is intended for the type of material and profile iron that is right for the frame on the press.

Function : Frame mesin press
Constrain : Yieldstrength min=78.253 N/m^2
Modulus of elasticity : 100 – 300 Gpa
Objective : Minimum cost
Free Variabel : Pemilihan material

From the screening results that match the specifications and the lowest price, low carbon steel material is obtained. The profile steel used as the frame is UNP 50 channel iron (50 mm x 38 mm x 5 mm). 2016 SP1 solidwork application simulation was carried out in order to produce a maximum working stress of 3.125 x $[\![10]\!]^7$ N / m ^{2} and yield strength of cast carbon steel material = 2,482 x $[\![10]\!]^8$ N / m ^{2}. Obtained safety factor (SF) = permit voltage divided by work voltage resulting in 7.9 Maximum displacement occurred = 0.12 mm. The following is a picture of the static frame simulation results.

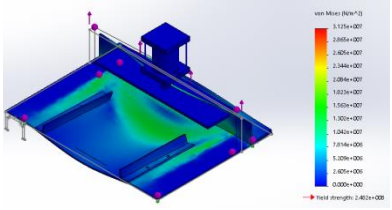

Figure 4. Static simulation of a pneumatic press frame with a force of 1232.5 N

3.5 Calculation of Welding Connection Strength

In the process of making the framework of this press machine using UNP 8 iron with the welding connection method. Calculation only on stems subject to large forces. As for the bars that counted bars 1,2 and 3 from the following image:

Welding uses type SMAW (shield metal arc welding) with AWS E6013 standard welding wires. Then the welding wire specifications are based on AWS standards namely;

$$F_{t1} = 330.947{,}2\ N$$

$$F_{t2} = 330.947{,}2\ N$$

$$F_{maks\ las} = 661.894{,}3\ N$$

$$F_{press} < F_{weld\ maks}$$

$$1232{,}5\ N < 661.894{,}3\ N \text{ (Safe)}$$

3.6 Calculation of Cylinder Thread Connection with Frame

Cylinder specifications use 10 bolt heads with M6 threads. The bolt eyes are 4 and are made of black steel with a tensile stress of 1600 kg/cm^2. Then the maximum tensile load capable of a cylindrical screw is:

$$P = 11.445\ N$$

Tensile load operation < Maximum screw tensile load

1232,5 N < 11.445 N (Safe)

3.7 Simulation Elektropenumatik

In this electrop pneumatic system there are 2 conditions as control inputs so that the working pressure adjusts the number of pages in a book bundle. Input 1 is to find out the number of pages to be pressed and pressure 2 input that has worked on the pneumatic system When the on / off button is pressed, the electrical circuit will flow current to the active inductive proximity due to the extended cylinder position, then flow to relay Y1 which activates the NO Y1 contactor. The pressure sensor will be active if the pressure is as desired, thus activating the Y3 relay to activate the NO S3 contactor.

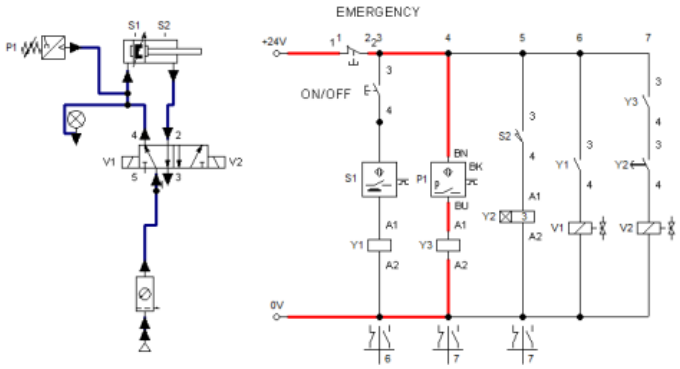

Figure 5. Pneumatic system and circuit extend condition

When the cylinder reaches the max stroke, the contactor Y2 will be active and the pressure sensor will detect whether the pressure has been reached. If it has been reached, the Y3 relay will be active and wait for a countdown of 3 seconds so that the Y2 solenoid valve will flow through. Then the direction valve will move to the left and the cylinder will extend.

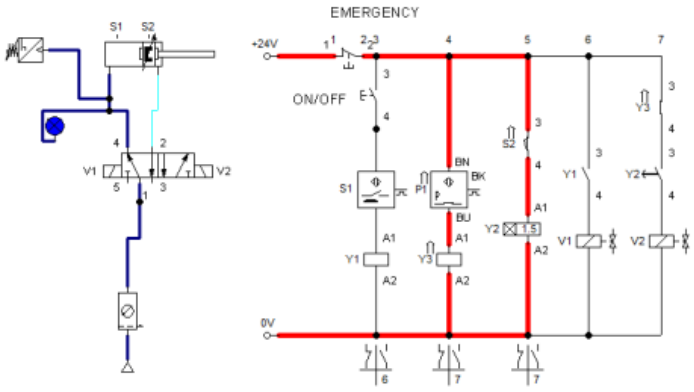

Figure 6. Pneumatic system and circuit condition reaction

3.8 Arduino Simulation of Pneumatic Control with Proteus

The position of the ultrasonic sensor is above the bundle of books you want to press. To determine the thickness of the book, it can be calculated the thickness of the book = 14 cm - the distance readable sensor. After obtaining the thickness of the book which is used as a reference for a large pressure that must be pressed. As for each sensor distance that is read on each book thickness from 0 to 250 pages for the control program follows table 4.2. This controller uses arduino with C. The logical function used is IF-ELSE. The logic statement used is "if the sensor read distance is smaller than 14 cm, it will flow through the current to relay Y1. Otherwise relay Y1 does not flow. In the presentation of the simulation using lights as an indicator of current flow or not.

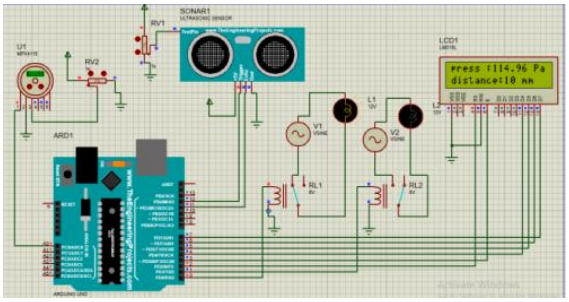

Figure 7. Control and coding diagram with arduino UNO Y1 relay active condition

If the conditions do not match the program it will activate relay Y2 (cylinder extend). The logic statement used is ". If the sensor distance is greater than 14 cm, the relay Y2 is active" and "if the distance is less than 14 cm (for example 13 cm) and the pressure is greater than 76,443.1 pa, then the Y2 relay is active"

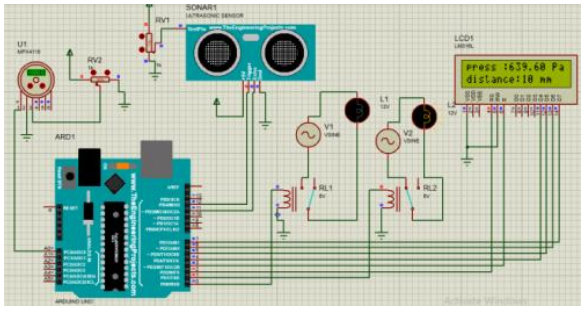

Figure 8. Control and coding diagram with arduino UNO Y2 relay condition active

4. Conclusion

From the results of the design selection and calculation of the design of a 250 page book pneumatic press machine capacity based on the Arduino UNO microcontroller, the following conclusions are obtained:

1. The design uses a 250-page Pneumatic system with an arduino control system. Hydraulic components used are:
   a. 8.75 MPa double acting pneumatic cylinder with 40 mm cylinder
   b. Compressors with 1.5 KW of power and minimum discharge of 1.88 L / min
   c. The framework uses UNP 8 with the dimensions attached
   d. Direction valve dengan seleniod 5/2 double seleniod AC 220 volt
2. The framework uses UNP 8 with the dimensions attached
3. The cost of components for producing pneumatic book bundle presses costs Rp. 2,565,500.

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