ANALYSIS OF HYDRAULIC POWER REQUIREMENTS OF CONTINUOUS *COLORING LINE AREA EXIT MACHINE*

Rohman Rohman[1*], **Ade Kristian**[2], **Jatira**[3], **Yadi Heryadi**[4]
[1]Teknik Mesin, STT Wastukancana, Purwakarta, 41118
**Email Corresponding Author* : rohman@wastukancana.ac.id

ABSTRAK

Dalam industri pengolahan logam, sistem hidrolik memegang peranan penting dalam mendukung operasi mesin produksi seperti *cut shear*, *mandrel*, dan *coil cart*. Ketiga mesin ini bergantung pada daya hidrolik agar dapat berfungsi secara *efisien* dan andal. Penelitian ini bertujuan untuk *menganalisis* dan menghitung kebutuhan tekanan serta daya hidrolik optimal yang dibutuhkan oleh masing – masing mesin pada area *exit Continuous Coloring Line* (CCL). Metode yang digunakan meliputi pengukuran tekanan hidrolik *aktual* berdasarkan *variasi* ketebalan *plat* dan lebar *plat galvalume* serta berat *coil*, yang kemudian d*ianalisis* secara *deskriptif kunatitatif*. Hasil Penelitian menunjukan bahwa tekanan hidrolik yang dibutuhkan oleh mesin *cut shear bervariasi* dari 58,1 (bar) hingga 139,62 (bar), tergantung pada ketebalan dan lebar *plat galvalume*. Mesin *mandrel* memerlukan tekanan antara 15,93 (bar) hingga 28,93 (bar) tergantung pada berat *coil*, sedangkan mesin *coil cart* membutuhkan tekanan antara 21,30 (bar) hinga 38,70 (bar) tergantung berat *coil*. Tekanan tertinggi tercatat sebesar 207,25 (bar) saat seluruh mesin bekerja dengan beban *maksimum*, mendekati batas *kapasitas* pompa sebesar 210 (bar). Hal ini menunjukan bahwa sistem bekerja dalam kondisi *optimal* namun mendekati batas aman, sehingga perlu perhatian teknis untuk menjaga keandalan sistem.

Kata kunci : Sistem hidrolik, tekanan kerja, *cut shear*,*mandrel*, *coil cart*, daya *optimal*.

ABSTRACT

In the metal processing industry, hydraulic system play a crucial role in supporting the operation of production machines such as cut shear, mandrel, and coil cart. These machines rely on hydraulic power to function efficiently and reliably. This study aims to analyze and calculate the pressure and optimal hydraulic power required for each machine in the exit area of the continuos coloring line (CCL). The methodology includes measuring actual hydraulic pressure based on variations in the thickness nada width of galvalume sheets as coil weights, followed by quantitative descriptive analysis. The result show that the hydraulic pressure required by the cut shear machine varies from 58,1 bar to 139,62 bar depending on sheet galvalume dimensions. The mandrel machine pressure ranging from 15,93 bar to 28,93 bar depending to weight coil,, while the coil cart needs between 21,30 bar and 38,70 bar depending to weight coil. The highest recorded pressure reached 207,25 bar when all machine operated simultaneously under maximum load, approaching the pump is maximum capacity of 210 bar. This indicates that the system operates at near-optimal levels but closes to its safety threshold, thus requiring technical attention to maintain system reliability.

Keywords : Hydraulic system; working pressure; cut shear; mandrel, coil cart.

PENDAHULUAN

Hydraulic is a technology that uses fluid to produce *mechanical* movements. The history of hydraulics began in ancient times, around 3000 BC, when the Egyptian and Mesopothonian civilizations first used water to power sluices and irrigation. Further development of hydraulics began in the 17th century when Blaise Pascal, a French scientist, developed Pascal's law describing the basic principles of hydraulics. In ancient Roman times, hydraulics were developed for the provision of general water, windmills, and hydraulic mining.

The modern manufacturing industry increasingly demands *efficiency*, precision, and reliability in every production process. One of the important aspects in meeting these demands is the application of an effective power system to drive production machines. Among the various power systems used, hydraulic systems are the main choice in a wide range of industrial applications due to their ability to generate large forces with a relatively *compact design*, as well as *precise control*.

Hydraulic systems are widely applied in a variety of industrial machinery, especially in processes that require large compressive or *linear* forces . An example is in the metal processing industry, which involves various stages such as cutting, winding, and moving high-weight materials. Machines such as *cut shears*, *mandrels*, and *coil carts* are an important part of the production line and rely entirely on hydraulic systems to perform their functions optimally. One of the advantages of this hydraulic system is that it is easy to control, *the linear* and *rotary movements* can be easily controlled with an electronic system. [1].

Cutshear *machines* are used to cut sheet metal to size, *mandrel machines serve as* coil *supports and winders*, while *coil cart machines* are in charge of moving the *coils* to the next process point. All three machines require an appropriate hydraulic power supply to be able to work properly without overloading the system. Power mismatches can cause *inefficiency*, system damage, and potential adverse production *downtime*. Therefore, it is important to analyze the hydraulic power needs of each machine. This study was conducted to calculate and *evaluate the* hydraulic power requirements of *cut shear*, *mandrel*, and *coil cart machines* in one integrated production system .

RESEARCH METHODS

This study uses a quantitative descriptive method with an experimental approach in the field. The research process began with the identification of hydraulic systems in cutshear, mandrel, and coilcart machines, followed by the collection of technical data, actual pressure measurement, data analysis, and evaluation of total hydraulic power requirements in the exit area of the continuous colouring line machine. The steps are as follows:

1. Knowing the power of the induction motor used
2. Knowing the pump power used
3. Looking for hydraulic pressure requirements in cutshear machine
4. Finding hydraulic pressure requirements in mandrel machines
5. Finding hydraulic pressure requirements on coilcart machines

RESULTS AND DISCUSSION

1. Knowing the power of the induction motor

Figure 1. Induction motors.

$$P=\sqrt{3} \times V \times I \times \cos\varphi \quad \text{Equation (1)}$$
$$P = \sqrt{3} \times 380(V) \times 96(A) \times 0{,}87(\%)$$
$$P = 54.908\ (w)$$

Then the power of the induction motor is 55 Kw

2. Knowing the power of the hydraulic pump

Figure 2. Hydraulic Pump.

$$P=\frac{P \times Q}{600}\{\text{kW}\} \quad \text{Equation (2)}$$
$$P = \frac{210\ \text{bar} \times 145\ \text{liter/menit}}{600}\{\text{kW}\}$$
$$P = 50{,}75\ \text{kW}$$

Then the power of the hydraulic pump is 50.75 kW

3. Finding the cross-sectional area of the cylinder of the cutshear machine

Figure 3. Cutshear Machine.

$$A = \pi . r^2 \quad \text{Equation (3)}$$
$$A = 3{,}14 \times 50^2 mm$$
$$A = 7850\ mm^2$$

Then the cross-sectional area of the cutshear cylinder is 0,00785 m^2

Looking for the force required by a cutshear machine to cut galvalume plates with a thickness of 0.45 $mm \times$ 914 mm

$$F = L \times T \times \tau \qquad \text{Equation} \quad (4)$$

$$F = 0{,}914m \times 0{,}00045m \times (200 \times 10^6)$$

$$F = 82.260\ N/m$$

Then the force required by the cutshear machine to cut the galvalume plate thickly 0.45 × 914 Was 82.260 N/m²

Finding the Pressure required by the cutshear machine to cut galvalume plates

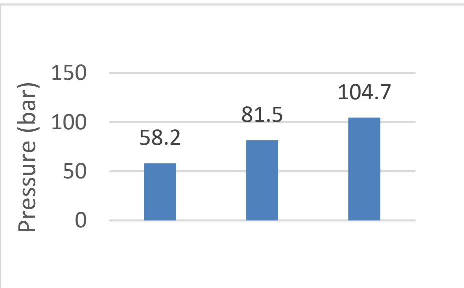
$$P = \frac{F}{A} \qquad \text{Equation} \quad (5)$$

$$P = \frac{82.260 N/m^2}{0{,}00785\ m^2}$$

So the pressure required by the cutshear machine to cut galvalume plates with a thickness of 0.45 mm x 914 mm is 104.7 bar

Table 1. Width 914 mm

No	*Size* (mm)	*Pressure* (bar)
1.	0,25 x 914	58,2
2.	0,35 x 914	81,5
3.	0,45 x 914	104,7



Graph 1. Pressure width 914 mm.

Looking for the force that the cutshear machine needs to cut galvalume plates thickly $0.45mm \times 1219mm$

$$F = L \times T \times \tau$$

$$F = 1.219m \times 0{,}00045m \times (200 \times 10^6)$$

$$F = 109.710 N/m^2$$

So the force required by the cutshear machine to cut the galvalume plate with the thickness 0.45 $mm \times 1219\ mm$ is 109.710 N/m².

Finding the pressure required by the cutshear machine to cut the galvalume plate to the thickness $0.45mm \times 1219mm$

$$P = \frac{F}{A}$$

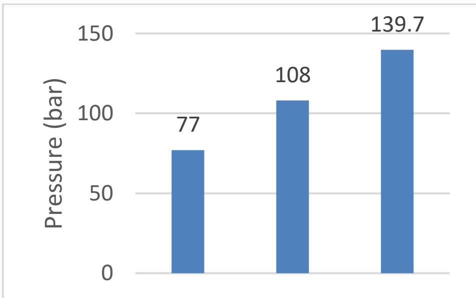
$$P = \frac{109.710\ N/m^2}{0{,}0785\ m}$$

$$P = 139{,}7\ bar$$

So the pressure required by the cutshear machine to cut the galvalume plate with the canopy $0.45mm \times 1219mm$ is 139,7 bar

Tabel 2. Lebar 1219 mm

No	*Size* (mm)	*Pressure* (bar)
1.	0,25 x 1219	77
2.	0,35 x 1219	108
3.	0,45 x 1219	139,7



Grafik 2. Width Pressure 1219.

4. Looking for the cross-section area of the mandrel machine cylinder

Figure 4 of the Mantrel Machine.

$$A = \frac{\pi}{4}(D^2 - d^2) \qquad \text{Equation} \quad (6)$$
$$A = \frac{3,14}{4}(\,160^2 mm - 80^2 mm)$$
$$A = 0,785\; mm \times 19.200 mm$$

Then the cross-sectional area of the mandrel cylinder is 0,015072 m²

Finding the force required for a mandrel machine to hold a coil coil

$$F = m \times g \qquad \text{Equation} \quad (7)$$

$$F = 4500 kg \times 9,81 m/s$$

$$F = 44.145\; N$$

Then the force required by the mandrel machine to hold the coil coil is 44.145 N.

Finding the pressure required by the mandrel machine to hold the coil coil

$$P = \frac{F}{A} \qquad \text{Equation} \quad (8)$$

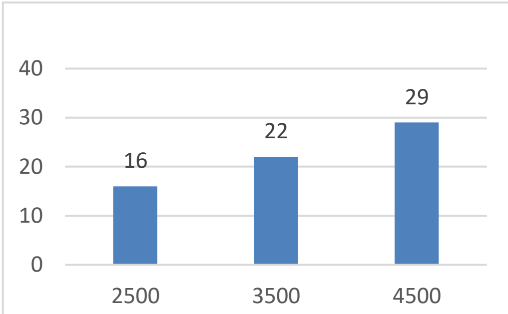
$$P = \frac{44.145 N}{0,015972\; m^2}$$

$$P = 29\; bar$$

So the pressure needed by the mandrel machine to hold a coil coil weighing 4500 kg is 29 bar.

Table 3. Pressure Mandrel Machine

No	Coil Weight (kg	Pressure (bar)
1.	2.500	16
2.	3.500	22
3.	4.500	29



Graph 3. Pressure Mandrel.

5. Looking for the cross-sectional area of the cylinder of the coilcart machine

Figure 5. Coilcart Machine.

$$A = \pi . r^2 \qquad \text{Equation} \quad (9)$$
$$A = 3,14\; \times 60^2 mm$$
$$A = 0,011309\; m^2$$

Then the cross-sectional area of the cylinder of the coilcart machine is 0,011309 m²

Looking for the force that the coilcart machine needs to lift the coil coil

$$F = m \times g \qquad \text{Equation} \quad (11)$$
$$F = 4500\; kg \times 9,81\; m/s^2$$
$$F = 44.145\ \text{N}$$

Then the force required by the coilcart machine to lift the coil is 44.145 N

Finding the Pressure required by the coilcart machine to lift the coil coil

$$P = \frac{F}{A} \quad \text{Equation (12)}$$

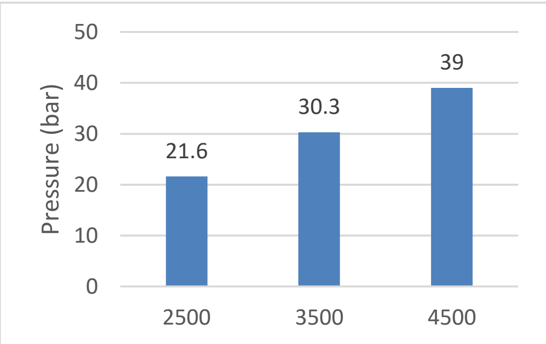
$$P = \frac{44.145\ N}{0{,}011309\ m^2}$$

$$P = 39\ bar$$

So the pressure needed by the coilcart machine to lift the coil coil with a weight of 4500 kg is 39 bar.

Tabel 4. Pressure Mesin Coilcart

No	Coil Weight (kg)	Pressure (bar)
1.	2.500	21,6
2.	3.500	30,3
3.	4.500	39



Grafik 4. Pressure Mesin Coilcart.

Finding the flow rate of the fluid

$$v = \frac{Q}{A} \quad \text{Equation 13}$$

$$v = \frac{0{,}0024167 \frac{m^3}{s}}{0{,}00785\ m^2}$$

$$v = 0{,}308\ m/s$$

Then the flow rate of the fluid is 0,308 m/s

Knowing the type of fluid flow rate in a pipeline installation

$$Re = \frac{\rho \times v \times D}{\mu} \quad \text{Equation 14}$$

$$Re = \frac{\rho \times v \times D}{\mu}$$

$$Re = \frac{870kg/m^3 \times 0{,}308m \times 0{,}0127m^2}{0{,}04002\ Pa}$$

$$Re = 85{,}03$$

Finding friction factors that occur in the pipeline installation

$$f = \frac{64}{Re} \quad \text{Equation 15}$$

$$f = \frac{64}{85}$$

$$f = 0{,}752$$

Looking for major headlosses that occur in pipeline installations

$$hf = f \times \frac{L}{D} \times \frac{v^2}{2.g} \quad \text{Equation 16}$$

$$hf = 0{,}752 \times \frac{3{,}3m}{0{,}0127m} \times \frac{0{,}308^2}{2.9{,}81m/s}$$

$$hf = 0{,}93\ m$$

So the major headloss that occurs in the pipe installation of the cutshear machine is 0,93m

Looking for minor headloss

$$hm = K \times \frac{v^2}{2.g} \quad \text{Equation 17}$$

$$hm = 0{,}9 \times \frac{0{,}308^2}{2.9{,}81m/s^2}$$

$$hm = 0{,}00432m$$

So the minor headloss that occurs is 0,00432m

Calculating total headloss

$$h\ total = hf + hm \quad \text{Equation 18}$$

$$h\ total = 0{,}93m + 0{,}00432m$$

$$h\ total = 0{,}93432m$$

looking for a direct impact on the pressure system and converted into a unit of pressure

$$\Delta P = \rho \times g \times h \quad \text{Equation 19}$$

$$\Delta P = 870kg/m^3 \times 9{,}81m/s^2 \times 0{,}93432m$$

$$\Delta P = 0{,}07974bar$$

Then the result of ΔP is 0,07974b bar

CONCLUSION

Experimental test research on hydraulic power requirements in *continuous coloring line* area exit machines, with *variations in* coil size *and weight*, resulted in the following findings :

1. The hydraulic pressure required by the cut shear machine to cut plates of varying thicknesses 0,25 (mm) x 914 (mm), 0,35 (mm) x 914 (mm) and 0,45 (mm) x 914 (mm) is 58,1 (bar), 81,4 (bar), dan 104,6 (bar).
2. The hydraulic pressure required by the cut shear machine to cut plates of varying thicknesses 0,25 (mm) x 1219 (mm), 0,35 (mm) x 1219 (mm), and 0,45 (mm) x 1219 (mm) is 76,92 (bar), 107,92 (bar), dan 139,62 (bar).
3. The hydraulic pressure required by the mandrel machine to withstand coil loads with variations in coil weight 2500 (kg), 3500 (kg), dan 4500 (kg) is 15,93 (bar), 21,93 (bar), and 28,93 (bar).
4. The hydraulic pressure required by the coil cart machine to lift the load of the coil with variations in coil weight 2500 (kg), 3500 (kg), 4500 (kg) is 21,30 (bar), 30,00 (bar), and 38,70 (bar).
5. The optimal hydraulic pressure that occurs in the continuos colouring line area exit machine, is when the cut shear machine cuts the plate with the thickness 0,45 (mm) x 1219 (mm), Mandrel machine holds coil coil with weight 4500 (kg), and the coil cart machine lifts the coil with weight 4500 (kg) is as large as 207,25 (bar), with hydraulic pump capacity 210 (bar).

   Thus, the implementation of the hydraulic system on the continuous coloring line of the exit area has met the standard specifications of the induction motor, hydraulic pump, and hydraulic power requirements of the cut shear, mandrel, and coil cart machines.

DAFTAR PUSTAKA

[1] F. Anwar[1], D. Supriyatna[2], P. Vokasional, T. Mesin, U. Sultan, and A. Tirtayasa, “DASAR-DASAR SISTEM HIDROLIK”, [Online]. Available: https://ejournal.warunayama.org/kohesi

[2] A. Jannifar, “Analisa Partikel Kontaminasi Minyak Hidrolik Excavator Hitachi Pengusaha Galian C Di Aceh Utara,” 2016.

[3] D. Pembimbing, V. Suphandani, M. E. Jurusan, and T. Mesin, “Peracangan Pompa Sentrifugal Dengan Fluida Kerja Crude Oil Pada Central Processing Platform 2 Pt. Pertamina Hulu Energi West Madura Offshore Setya Mahendra Bayu Aji Nrp 2112 100 047.”

[4] B. Hondro, A. Waruwu, and J. Siburian, “Studi Perhitungan Pada S Is Tem Kerja Motor Induks I Tiga Phas A 380 Volt Dalam Trans Fer Air Pump Di Hotel Danau Toba Internas Ional Medan Studi Perhitungan Pada Sistem Kerja Motor Induksi Tiga Phasa 380 Volt Dalam Transfer Air Pump Di Hotel Danau Toba Internasional Medan.”

[5] “Rancang Bangun Mesin Press Hidrolik Berkapasitas 5 Ton (1)* Andrianus Andry, (2) Muhammad Ivanto, (3) Gita Suryani Lubis,” 2024.

[6] W. Umar, I. H. Abdullah, and B. Miliyawati, “Representasi Pola Penurunan Luas Lingkaran Dengan Menggunakan Figural-Geometris-Analitis”.

[7] J. Sialana *et al.*, “Analisa Sistem Hidrolik Pada Mesin Pemeras Buah Merah.”

[8] H. Alkindi, H. Santosa, and E. Sutoyo, “Analisis Head Losses Pada Circulating Fluida Air Dalam Dua Jenis Pipa,” 2023.

[9] E. Julianto and E. Sarwono, “Analisis Minor Losses Alat Uji Aliran Fluida Skala Laboratorium,” *Desember*, vol. 10, no. 2, pp. 7–19, [Online]. Available: https://talenta.usu.ac.id/jd

[10] W. Laksono and A. Roihatin, “Analisa Headloss dan Estimasi Umur Pipa Water Injection pada Sistem Pompa Finish Mill Industri Semen,” 2025. [Online]. Available: https://jurnal.polines.ac.id/index.php/rekayasa