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PROCESS PRODUCTION OF FLUTED ROLL ON ROLL MILLS MACHINERY

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ABSTRACT

Wheat as raw material for flour is milled using a Fluted Roll in a Roll Mill machine. Fluted Rolls are made through a machining process that aims to obtain the desired shape, size, and level of surface roughness. This study aims to determine the material contained in Fluted Rolls and the process of making Fluted Rolls through machining processes, such as milling and scraping, as well as welding processes. The results of this study conclude the fluted roll machining process uses steel medium carbon, namely JIS S45C, and high alloy steel (High Alloy Steel) namely AISI 410, the milling process uses a vertical milling machine, and the scrap machining process uses a CNC (Computer Numerical Control) scrap machine in making flutes on the fluted roll surface. In the milling process using a blade diameter of 20 mm and the main spindle speed of 600 rpm, the machine's cutting speed is 37.68 mm/minute. The welding process on the fluted roll aims to connect the milled shaft with the roller mill using TIG (Tungsten Inert Gas). In the scrap machining process, the feeding speed used is 9000 mm/minute and the chisel return speed to point 0 is 27132 mm/minute, resulting in a one-time feeding time of 14.24 seconds. The total time for working on fluted rolls with B3f specifications is the total flute 550, diameter 250 mm, length 1250 mm, and the slope of the flutes that form a spiral is 10% for 2 hours 10 minutes 53 seconds.

Keywords: *Machining, Welding, Roll Mill*

INTRODUCTION

The machining process is important in the manufacturing industry, especially for the manufacture of metal machine components. This process aims to obtain the desired shape, size, and level of surface roughness.

Stainless steel is alloy steel with a high alloy content (High Alloy Steel), where there is a chromium alloy in the iron and carbon alloy system. This type of steel alloy has high corrosion resistance properties. One type of stainless steel is AISI 410, which is a martensitic material that is widely used in the food and health industries. This material has excellent corrosion resistance but low hardness value compared to other martensitic stainless steels. An example of the application of AISI 410 in the food industry is as the main material in the Fluted Roll machining process on a Roll Mill machine or wheat grinding machine.

A rolling mill is used to grind wheat as raw material for making flour. Therefore, the purpose of this scientific writing is to know the material and process of making Fluted Roll as the main part of the Roll Mill grinding machine in producing wheat flour.

BASIC THEORY

Machining is a production process using machine tools by utilizing the relative motion between the tool and the workpiece to produce a product according to the desired geometry [1][2]. Machining processes can be classified into two broad classifications, namely machining processes to form cylindrical or conical workpieces with a rotating workpiece or tool, and machining processes to form flat surface workpieces without rotating the workpiece [2]. The first classification includes the lathe process and variations of the process carried out using a lathe, drilling machine, milling machine, and grinding machine. The second classification includes the shaping process, the slot process, the sawing process, and the gear-cutting process.

A milling machine is one of the conventional machines that are capable of working on a workpiece on a flat, wide, upright, inclined surface, and even gear grooves. This machine tool works or completes a workpiece using a milling knife (cutter). With this, a machine tool that works on the workpiece using a knife or milling chisel rotates on the main axis of the machine and the workpiece is delivered to the knife, either horizontally, transversely, or vertically.

Milling machines can do several jobs. The following jobs can be done with a milling machine, among others:

1. Surface milling
2. Multilevel milling
3. Angle mill
4. Groove mill
5. Gear mill

The cutting speed of the machine produces the length of the incision per minute using the calculation formula:
Kecepatan potong mesin menghasilkan panjang sayatan tiap menitnya dengan menggunakan rumus perhitungan:

$$Cs = \frac{\pi . d . n}{1000} = \cdot\cdot$$

Where :
Cs = Cutting Speed (mm/minute)
n = Main spindle rotation (rpm)
d = Cutting blade diameter (mm)

Shaping

A scrap machine (shaping machine) is also called a planer or shaver machine. This machine is used to work on planes that are flat, convex, concave, grooved, etc., in a horizontal, upright, or inclined position. A scraping machine is a machine tool with a straight main movement back and forth vertically or horizontally [3].

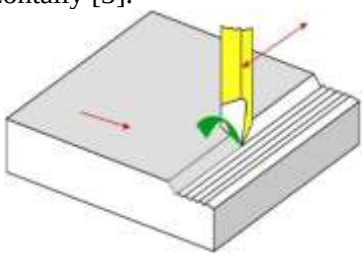

Figure 1. The Working Principle of the Scrap Machine [3]

In a scraping process (shaping), it takes time to process. To find out the total time in one scraping process (shaping), the formula used is:

$$FT = \frac{t \times N}{60\ menit}$$

Welding

Welding is one of the metal splicing techniques by melting some of the parent metal and filler metal with or without pressure and with or without additional metal and produces a continuous connection[6]. In this study, the welding theory used is the GTAW (Gas Tungsten Arc Welding) welding method, which is an electric arc welding process that uses an electrode that is not fed or does not melt [7].

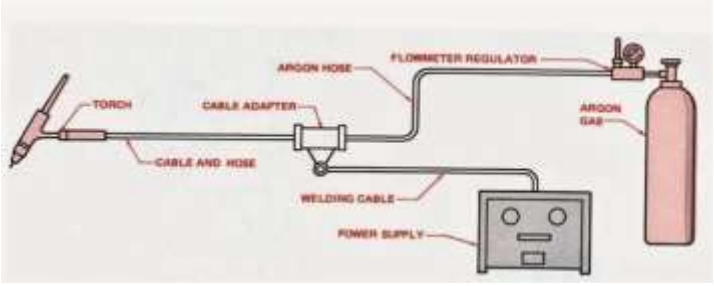

Figure 2. GTAW / TIG (Gas Tungsten Arc Welding) Welding Equipment.[6]

Table 1. Types of GTAW Tungsten Electrodes [6].

Electrode Colour Chart		
Welding Mode	**Tungsten Type**	**Colour**
AC	Pure Tungsten	Green
DC or AC/DC	Ceriated 2%	Grey
DC or AC/DC	Lanthanated 1%	Black
DC or AC/DC	Lanthanated 1.5%	Gold
DC or AC/DC	Lanthanated 2%	Blue
DC	Thoriated 1%	Yellow
DC	Thoriated 2%	Red
AC	Zirconiated 1%	White

Recommended Electrode Current Guide			
Tungsten Size	**DC-Electrode Negative**	**AC Symmetrical Wave**	**AC Un-symmetrical Wave**
1.0 mm	15-80A	10-80A	20-60A
1.6mm	70-150A	70-150A	60-120A
2.4mm	150-250A	140-225A	100-180A
3.2mm	250-400A	225-325A	160-250A
4.0mm	400-500A	300-400A	200-320A
6.0mm	750-1000A	500-630A	340-525A

In the welding process using the GTAW / TIG method, this method has advantages and disadvantages, including:

GTAW welding advantages:

1. Welding results do not need to be cleaned because it does not produce slag.
2. The flow of gas makes the area around the liquid metal not contain air to prevent contamination by nitrogen and oxygen, which can cause oxidation.
3. The result of the weld is stronger because it gets deep penetration and higher corrosion resistance.
4. Welding results are very clean.
5. The welding process can be observed easily because the smoke that arises is not much.
6. Deformation is rare because the heat center is very small.
7. Does not produce spatter or welding sparks so that the weld is cleaner.

GTAW Welding Disadvantages:

1. For low GTAW welding speed efficiency.
2. During the welding process, burnback may occur.
3. Welding defects of porosity or small holes often occur if the welding surface shielding gas cannot protect optimally.
4. Trapping of tungsten contaminants in the weld metal can occur (tungsten inclusions).

RESEARCH METHOD

In the Fluted Roll machining process, several steps need to be carried out as described in the chart below:

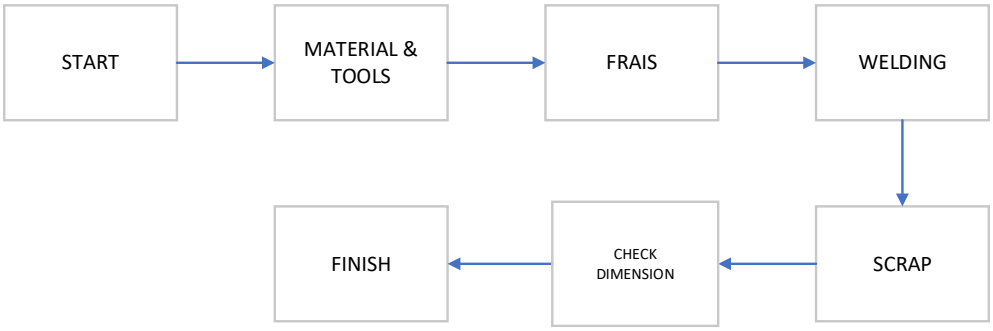

Figure 3. Chart of the fluted roll machining process

Material

The metal material used in this research is JIS S45C medium carbon steel which is a type of "Medium Carbon Steel" (steel with medium carbon content: 0.3-0.5%) which is classified as machinery steel[9]. S45C material is very often used because the price is cheaper than other machinery steels such as (AISI 4140, and AISI 4340. This medium carbon content, allows this steel to be hardened by heat treatment to form a hard martensite microstructure because it has a hardness of 160-220 HB (Brinell Hardness) and can be hardened again. The chemical composition of the JIS S45C carbon steel is shown in table 3.1 below:

Table 2. Chemical Composition of JIS S45C. Medium Carbon Steel [10]

Kandungan	Komposisi (%)
C	0,42 – 0,50
Si	0,04
Mn	0,50 – 0,80
S	0,035
P	0,035

Table 3. Mechanical Properties of JIS S45C. Medium Carbon Steel [10]

Density (Kg/m^3)	7700 – 8030
Young's Modulus (Gpa)	0190 – 210
Tensile Strength (Mpa)	569 (*Standard*), 686 (*Quenching, Tempering*)
Yield Strength (Mpa)	343 (*Standard*), 490 (*Quenching, Tempering*)
Poisson's Ratio	0,27 – 0,30
Melting Point	~1520 °C

The metal used next is High Alloy Steel which contains chromium alloy in the iron and carbon alloy system, namely AISI 410 which is a martensitic stainless steel material that is widely used in the food and health industries [11]. The chemical composition of AISI 410 stainless steel is shown in table 3. below:

Table 4. Chemical Composition of AISI 410. Stainless Steel [12]

Kandungan	Min. (%)	Maks. (%)
C	-	0,15
Mn	-	1
Si	-	1
P	-	0,04
S	-	0,03
Cr	11,5	13,5
Ni	0,75	0,75

AISI 410 stainless steel has a chromium content of more than 10%, therefore this steel is a type of steel that is strong enough to resist corrosion or rust [12]. The American Iron and Steel Institute (AISI) sets a limit for the type of stainless steel alloy when the chromium content in the alloy exceeds 10-13%. Meanwhile, the mechanical properties of AISI 410 stainless steel are shown in table 3.2 below:

Table 5. Mechanical Properties of Stainless Steel AISI 410. [12]

Suhu *Tempering* (°C)	Beban Tekan (MPa)	Beban Luluh 0.2% *Proof* (MPa)	Pemanjangan (% in 50 mm)	*Hardness Brinell* (HB)	*Impact Charpy* V (J)
Annealed*	480 mnt	275 mnt	16 mnt	-	-
204	1475	1005	11	400	30
316	1470	961	18	400	36
427	1340	920	18,5	405	#
538	985	730	16	321	#
593	870	675	20	255	39
650	300	270	29,5	225	80

Milling

The dimensions of the incision to be made on the specimen are:

Incision width = 20 mm,
Incision length = 132.6 mm,
Depth = 5.2 mm.

The specimen to be processed is a shaft made of medium carbon steel JIS S45C which has a diameter of 64.8 mm on a fluted roll as a lock when operating on a roll mill machine.

Figure 4. Workpieces that have been milled

When the feeding process takes place, the cutting speed of the machine produces the length of the incision every minute by using the calculation formula:

$$Cs = \frac{\pi . d . n}{1000}$$

$$= \frac{3{,}14 \,.\, 20\ mm \,.\, 600\ rpm}{1000}$$

$$= \frac{37680}{1000}$$

$$= 37{,}68\ mm/menit.$$

From the results of the calculations that have been carried out, the cutting speed of the milling machine on the specimen is 37.68 mm/minute.

Welding

The welding method used is TIG Welding (Tungsten Inert Gas Welding) which is a welding process using tungsten electrodes (non consumable tungsten) [7]. The weld area is protected (covered) by a covering made of gas (usually argon/helium gas or a combination of both). Argon is more often used in welding because it is heavier than air and can provide a better coverage area for welding.

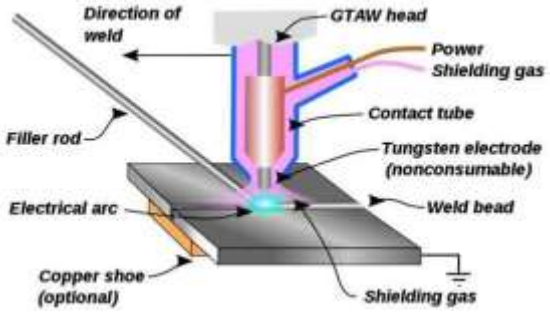

Figure 5. Simple TIG Welding Scheme [6]

The devices used in TIG Welding are:
1. Welding transformer.
2. Protective gas cylinder.
3. Shielded gas regulator.
4. Flowmeter for gas.
5. Gas hose and fittings.
6. Electrode cable and hose.
7. Handlebar welding (welding torch).
8. Tungsten Electrode

The welding transformer used is Multi Pro TIG 220AD M-JB with the following specifications:

Table 6. Specifications of Multi-Pro TIG 220AD M-JB. Welding Transformer

Input Voltage	3-Phase, AC 220V 50/60Hz
Rated Input Current	28 A
Output Current	10-220 A (TiG) / 10 - 160 A (MMA)
Rated Duty Voltage	18 V (TiG) / 26.4 V
Rated Output	200 A / 28 V
Pulse Frequency	0.5 – 5 Hz
Pulse Width	10 - 90 %
Welding Current	10-200 A
No-load Voltage	56 V
AC Balance	20-18 %
Rated Duty Cycle	60 %
Efficiency	80 %
Dimension	498mm x 328mm x 302mm
Weight	20 Kg

Figure 6. TIG Welding Results on Roll

Shaping

In the scraping process for fluted rolls, namely making teeth on the surface of the roll. The specimen used is a roll with a surface made of AISI 410 stainless steel with a diameter of 250 mm. The machine used is a CNC (Computer Numerical Control) scrap machine. The chisel used in the scraping process is the HSS (High-Speed Steel) chisel.

The size of the tool is larger and has a different hardness level than the HSS type tool that is commonly used in conventional lathes. The HSS tool contains 18% tungsten and 5.5% chromium. The composition of HSS usually consists of an alloy of iron with carbon, tungsten, molybdenum, chromium, and vanadium, sometimes with the addition of cobalt.

Figure 7. High-Speed Steel (HSS) Chisel Used in the Fluted Roll Scrap Process

Figure 8. Roller Mill to be Processed Scrap

In its manufacture, fluted rolls have different specifications, depending on the placement of the roll mill machine for grinding wheat and also how the standards have been determined in the following table:

Table 7. Fluted Roll Specifications

No	Roller	Length (mm)	Total Fluted	Angle / Degree	Spiral	f / (cm)	Land (mm)	Location
1	B1	1250	275	35 / 65	6	3,5	0,2	KL, MNO, C
2	B2	1250	375	35 / 65	6	4,77	0,2	KL, MNO, C
3	B3g	1250	450	35 / 65	6	5,73	0,2	KL, MNO, C
4	B3f	1250	550	35 / 65	10	7,00	0,1	KL, MNO, C
5	B4g	1250	625	45 / 65	8	7,96	0,1	KL, MNO, C
6	B4f	1250	675	45 / 65	8	8,59	0,1	KL, MNO, C
7	B5g	1250	800	45 / 65	8	10,19	0,1	KL, MNO, C
8	B5f	1250	850	45 / 65	8	10,82	0,1	KL, MNO, C
9	C6	1000	900	45 / 65	8	11,46	0,1	C
10	C10	1000	900	45 / 65	8	11,46	0,1	KL
11	B2gA	1000	800	35 / 65	8	5,73	0,1	C
12	B2gB	1000	850	35 / 65	8	7,00	0,1	C
13	B2fA	1000	625	45 / 65	8	7,96	0,1	C
14	B2fB	1000	675	45 / 65	8	8,59	0,1	C
15	B5g	1250	800	45 / 65	8	10,19	0,1	C
16	B5f	1250	850	45 / 65	8	10,82	0,1	C
17	C9	1250	900	45 / 65	8	11,46	0,1	MNO
18	D4	1250	850	55 / 70	10	8,59	0,1	MNO

The research was conducted on the manufacture of fluted roll B3f with 550 flutes or teeth, with a feeding speed of 9000 mm/min, a roll diameter of 250 mm, and a slope of the flutes that forms a spiral of 10%.

The things that must be done in the scrap process on the roller mill are as follows:

1. Prepare equipment.
2. Place the specimen on the machine using a pulley, because the weight of the specimen is very heavy.
3. Set the specimen feeding speed to 9000 mm/min.
4. Finding the zero point and setting the turning speed of the tool after feeding the specimen to 27132 mm/minute.
5. Adjust the slope of the flutes that form a spiral on the roll surface by 10%.
6. Set the number of flutes on the roll to be shaping at 550.
7. Determine the starting point and ending point on the roll.
8. Set the roll diameter to 250 mm.
9. Perform the scraping process (shaping).
10. Record processing time.

Figure 9. Feeding Speed in Scrap Process

Figure 10. Parameters Used in Scrap Process

a) **b)**

Figure 11. a)CNC Machine Used For Scrap Process, b)Roller Mill Scrap Process into Fluted Roll

Figure 12. Fluted Roll Surface After Passing Scraping Process

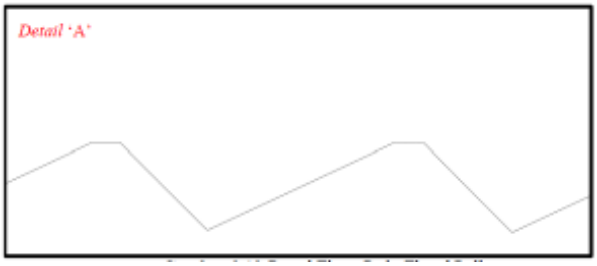

Figure 13. Details of Flutes on Fluted Roll

By using the feed speed data and the speed of the tool returning to point 0 in the scraping process, it is obtained that one feeding time is 14.24 seconds. To determine the total time of the shaping process on one fluted roll with a total of 550 flutes, then:

$$FT = \frac{t \times N}{60\ menit}$$

$$= \frac{t \times N}{60\ menit}$$

$$= \frac{14{,}24 \times 550}{60\ menit}$$

$$= \frac{7832}{60\ menit}$$

$$= 130{,}53$$

$$= 130\ menit\ 53\ detik.$$

From the results of the calculations that have been carried out, the time required for the CNC machine to perform the shaping process on a roll mill with a diameter of 250 mm with many flutes is 550, approximately 2 hours 10 minutes 53 seconds.

Quality Control (QC)

The next process is the Quality Control (QC) process. In this process, checking the results of the scrap process on the flutes using sensors on the machine

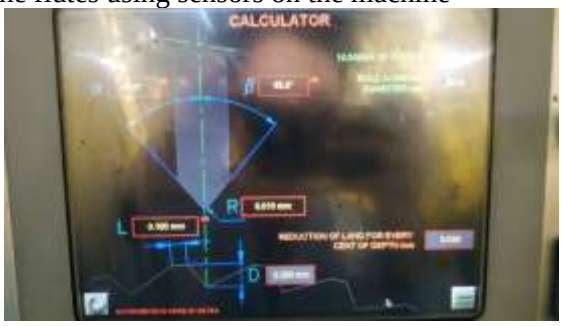

Figure 14. Standard Size Used For 250 mm Diameter Fluted Roll With 550 Flutes

Figure 17 Caption:

1. α is the slope of the first angle on the flutes by 45°.
2. β is the slope of the second angle on the flutes of 65°.
3. R is the angle in the flute surfaces forming an obtuse angle which has a radius of 0.010 mm, with a tolerance size of 0.008 mm.
4. L is the flute's surface width of 0.100 mm, with a tolerance of 0.080 mm.
5. D is the angular depth between the flutes of 0.290 mm, with a tolerance of 0.270 mm.
   If the size of the flutes on the Fluted Roll does not match the standard size and tolerance that has been determined, it will return to the shaping process or scrap.

CONCLUSION

Based on the results of the discussion that has been carried out in the previous chapter regarding the machining process in the manufacture of Fluted Roll, it can be concluded:

1. In the fluted roll machining process, it can be seen the processes, namely the preparation of materials, materials or metal materials used are medium carbon steel, namely JIS S45C and high alloy steel (High Alloy Steel), namely AISI 410, then the milling machining process used is using a vertical milling machine, then the welding process uses the GTAW welding

method with Argon shielding gas commonly called TIG (Tungsten Inert Gas), then the scrap machining process uses a CNC (Computer Numerical Control) scrap machine in making flutes on the fluted roll surface.

2. In the milling process using a cutting blade diameter of 20 mm and the main spindle speed of 600 rpm, the machine's cutting speed is 37.68 mm/minute.
3. The welding process on the fluted roll aims to connect the milled shaft with the roller mill. The welding is used in TIG (Tungsten Inert Gas) because the material used is fairly hard and requires deep penetration.
4. In the scrap machining process, the feeding speed used is 9000 mm/minute and the speed of returning the tool to point 0 is 27132 mm/minute, resulting in a one-time feeding time of 14.24 seconds. The total working time of the scraping process on fluted rolls with B3f specifications, namely a total of 550 flutes, 250 mm in diameter, 1250 mm in length, and a 10% slope of the flutes forming a spiral is 130 minutes 53 seconds, or approximately 2 hours 10 minutes 53 seconds.

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