

Improved Quality of Brake Pedal Welding Connection Using GMAW Process

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Abstract - Welded brake pedal component connection using GMAW process with CO₂ protective gas 100% contains *spatter weld defects, weld-bead ripple, undercut and porosity* at the level limit of 8.2%. By replacing 100% CO₂ protective gas with Ar 75% CO₂ protective blend gas 25%, welding defects are reduced to a level limit of 0.88% dominated by *spatters* while other welding defects are virtually non-existent. Defective *welding spatter* with protective gas CO₂100% shows a level of 2.77%. By using Ar 75% CO₂ protective mixed gas 25%, defective *welding spatters* decreased to the level of 1.11%. Therefore, the replacement of protective gases in the GMAW process led to a 150% improvement in the quality of brake pedal welding joints. This will have an impact on improving the competitiveness of the industrial brake pedal components of two-wheeled motor vehicles.

Keywords: brake pedal, *spatter*, GMAW welding process, CO₂ protective gas, Ar 75% CO₂ protective mix gas 25%.

I. INTRODUCTION

The development of national industries that are part of the industrialization process becomes a challenge for the industrial sector to compete closely, especially in the era of globalization. The development towards free trade will have an increasing impact on opportunities as well as threats to small and medium-sized industries in the country at the production level with guarantees of the quality of products to be marketed to be defended. In small industries the advantages and disadvantages vary greatly due to lack of knowledge of production technology, quality control and human resources improvement. The Small and Medium Industry of West Java is able to produce transportation equipment components to support the development of the auto industry- two-wheeled motor vehicle motifs, especially brake pedal products, but some of its products are still rejected because they do not meet customer specifications.

From the observation of visual test results of salt spray products brake pedal products at Bandung Technical Materials and Goods Hall found rusty products on their welding joints at exposures of 48 to 96 hours at rust levels of 1 to 20% [2].

Welding defects in the form of *ripple weld-bead, spatter, porosity and undercut* on the surface of the welding joint of the brake pedal components when the coating process is implemented the result is not perfect so it is easy to rust [3]. Therefore, this welding defect must be prevented so that the coating process can be directly good and the result is flat on the surface of the parent material as well as the welding joint.

A *spatter* (S) is a high-temperature metal filler jump from the electrode's flame arc to the surface of the welding joint and its surroundings. Called a defect because it can interfere with the coating process, the *spatter should be* cleaned. This defect grows when high current and *stickout filler wire* are high so that *the radiating liquid wire filler* breaks in the air touching the welding crater and a portion of the beam bouncing into the air usually *occurs in the transfer mode spray*[4]. Metal *spatter wasted* is a loss of weight loss wire *filler*.

Porosity (P) surfaces are holes individually or in groups growing on the surface of welding joints, these defects can be caused by moist, dirty, oil or *grease* parent material. The flow of protective gas from the *nozzle torch* as a protection area of liquid welding metal is not functioning properly, such as *unstable gas flow, turbulence, less gas flow pressure, or clogged torch nozzle* is the main cause of porosity failure.

Ripple weld-bead (RWB) welding joint surface is uneven; this defect can be grown by *unstable torch* movement or *high welding speed* giving rise to rough welding surfaces.

Undercut (UC) is a takikan between the parent material and welding metal is generally on the sides of the weld. This defect can be grown by high heat input and welding speed, the melting main material is not filled by a melting filler[4]. *The undercut* on the surface of the takikan-shaped welding joint will thicken the chrome & nickel layer unevenly the impact is easily corrosion so that the quality of the coating becomes low [3,4].

The use of CO₂ protective gas 100% as a reactive gas commonly used to weld carbon steel is not as good as inert gas tends to grow *spatter*, deep penetration, thick welding smoke, low deposit efficiency, uneven welding connection surface,

high ionization potential, high heat energy characteristics of conglomeration against fusion and penetration [5]. Those welding defects when they occur in the brake pedal welding joint will cause uneven chrome & nickel coating thickness [4] or low coating quality. Therefore, to improve the quality of the coating process on this brake pedal, the quality of the welding process must also be improved from CO₂ protective gas 100% replaced by a Ar75% CO₂ protective mixture gas 25%.

It is well known that the use of protective mixed gas Ar 75% CO₂ 25% can improve quality [5]. The failure rate or welding defects will drop significantly, therefore GMAW process experiments are carried out using Ar 75% CO₂ protective mixed gas 25% on welding brake pedal components. The purpose of this study is to observe differences in the quality of GMAW welding processes in the use of two types of protective gases that have different characteristics. First gmaW welding process protective gas CO₂100% as the beginning of research observation and secondly as an improvement of GMAW welding process the use of protective mixed gas Ar 75% CO₂ 25% for improved welding connection quality on motorcycle brake pedal components in small industry.

II. MATERIALS AND METHODS

Metal materials used for experiments in research on improving the quality of brake pedal welding joints in gmaW process protective gas CO₂100% and gas protective mixture (Ar 75% CO₂ 25%) is a low carbon steel plate and pipe material jis specification G 3131 SPMC P-Q, STKM 13-AC jis standard G3445 [6]. These metal materials are made brake pedal components consisting of: 1. *Brake shoe* (brake footing) material SPCC, 2. *Arm* (brake arm) material STKM 11C, 3. *Bosh* material STKM, 4. *Rod* material SPHC, 5. *Rub spring* material SPHC, 6. *Return spring* material SPHC [7]. The shape of the brake pedal component is shown in Figure 1 to Figure 3.



Figure 1: Brake Pedal Components Before Welded



Figure 2: Brake Pedal After Welded



Figure 3: Brake Pedal After Coating



Figure 4: Brake Pedal Weld Connection Surface



Figure 5: GMAW Welding Process

The process of forming brake pedal components involves *embossing the manufacture of cartel grooves on the brake shoe, blanking pembuatan rod making, piercing hole making on rod and arm, bending the manufacture of arm arches and cutting for cutting the end of the arm from a material 4.5 mm thick. The process of making brake pedals starts from preparing raw materials to becoming finished products with the following stages of operation: cutting-forming- piercing- embossing- welding-plating* [7]. Brake pedal components (*brake shoes, arm, bosh, rod, hub spring and return spring*) through assembly, welding (Figure 5) and electroplating stages. The research method uses GMAW welding protective gas CO₂100% and GMAW welding gas protective mixture Ar 75% CO₂ 25%. With the following parameters: 1 welding machine used *gmau semiautomatic process technology*, 2 brands Varstroj, 3 *welding current 70-280 amper*, 4 *voltage operation 20–30 Volt*, 5 *open-circuit voltage machine 50 volts*, 6 *polarity DCEP*. Heat input welding (J/cm) based on formula $60 EI/V$ is 4.5 to 6 kJ/min. Where E (volt), I (current) and V (welding speed) cm/min [5]. The optimal heat energy parameters used must be sufficient to the need for heat energy for the melting of wire *fillers and parent metals*.

Before welding the brake pedal, the GMAW welding machine to be used must be ready-made. The inspection is focused on the parts associated with the gas flow line from the tube to the *nozzle torch, the flow rate instrument regulator* attached to the right side of the gas canister is enabled to regulate the flow of the gas outlet *pressure, the tube pressure regulator* to measure the volume of gas in the tube. GMAW repaired welding machines include: *regulator replacement* and torch gun *nozzle* cleaning for smooth flow of protective gas to prevent product failure. Two types of protective gas used are: type A protective gas CO₂ flow rate (flow rate): 20-30 l/min and type B is a protective gas mixture Ar 75% CO₂ 25% with flow rate: 25-30 l/min.

Welding Procedure Preparation

To produce a welding connection that complies with the acceptable *standard is made welding procedure specification (WPS)* semiautomatic GMAW *welding process* [8]. Metal

materials used carbon steel plates and carbon steel pipes for the manufacture of brake pedals. Type of welding *joint welding joint, sequare bevel, Partial Joint Penetration connection type, welding position flate*, protective gas CO₂100%, and protective alloy gas Ar 75% CO₂ 25%, *wire filler A 5.18 (E70S.6)*, the surface of the joint to be welded is assured clean of fat, corrosion and or other dirty. Welding parameters: 1) current 120–145A, 2) voltage $V = 0.05I + 20$ (I current used) 20 to 26 V, 3) *flow rate* of protective gas use CO₂100% 20-30 l/min called type A, 4) *flow rate* of protective mixed gas Ar75% CO₂ 25% 25-30 l/min called type B, 5) DCEP polarity, 6) stringer technique, 7) *wire feeder type spray mode transfer* towards *globular mode transfer*. During the welding process the *flow rate* of protective gas and *stick-out* wire *fillers* should be controlled in a stable condition so that welding defects can be avoided.

III. RESULTS AND DISCUSSIONS

Observations were made of 10 examples from a population of 200 brake pedals (Table 1). Brake pedal welding using CO₂ protective gas 100% and protective mixed gas Ar 75% CO₂ 25%, welding is done by welder A. From visual observation of the welding connection of brake pedal products against the brilliance and dexterity of penetration indications there is little difference. On the observation of indications of welding penetration, the difference is not significant. Welding using protective gas CO₂100% tends to be deep while welding me-use gas protective mixture Ar 75% CO₂ 25% penetration is sufficient, *welding bead* appears more prominent to the surface, impressed high welding deposit. Visual observation of the surface of the gas welding joint protective mixture Ar 75% CO₂ 25% finer than the surface of the protective gas welding CO₂100%. From the *spatter observation*, using CO₂ protective gas 100% obtained 7 *spatter defects that can still be cleaned* using steel brush with acceptable category (Acc). Only 1 piece is difficult to clean with rejected category (Rjc). To be acceptable it usually has to be grinded smoothly but the product becomes defective. Welding using Ar75% CO₂ protective mixed gas protector 25% did not obtain failed product.

Table 1: Brake Pedal Receiving Visual Test

No Example	Protective gas CO ₂ 100%					Protective mixed gas Ar75%+CO ₂ 25%				
	S	P	WBR	UC	Welding surface	S	P	WBK	UC	Welding surface
1	Acc	Acc	Acc	Acc	Concave	Acc	Acc	Acc	Acc	Flat
2	Acc	Acc	Acc	Acc	Flat	Acc	Acc	Acc	Acc	Flat
3	Acc	Acc	Acc	Acc	Flat	Acc	Acc	Acc	Acc	Convex
4	Acc	Acc	Acc	Acc	Flat	Acc	Acc	Acc	Acc	Flat
5	Acc	Acc	Acc	Acc	Concave	Acc	Acc	Acc	Acc	Flat

6	Acc	Acc	Acc	Acc	Concave	Acc	Acc	Acc	Acc	Flat
7	Rje	Acc	Acc	Acc	Flat	Acc	Acc	Acc	Acc	Flat
8	Acc	Acc	Acc	Acc	Concave	Acc	Acc	Acc	Acc	Flat
9	Acc	Acc	Acc	Acc	Flat	Acc	Acc	Acc	Acc	Flat
10	Acc	Acc	Acc	Acc	Flat	Acc	Acc	Acc	Acc	Flat

Observations of 5 examples derived from a population of 200 brake pedals conducted by welder A, turned out to be welding using protective gas CO₂100% generally *spatter-shaped welding defects*, while other *defects undercut* 1 mm and 2 mm. By welding using mixed protective gas- an Ar 75% CO₂ 25% of it, no *spatter defects* were found as shown in Table 2.

Table 2: Visual Brake Pedal Defect

Example number	S	P	UC	RWB	Indication of penetration
Protective gas CO ₂					
1	5 points	None	2 mm	Enough	Deep penetration
2	3 points	None	None	Are	Deep penetration
3	None	None	None	Enough	Deep penetration
4	2 dots	None	1 mm	Good	Deep penetration
5	2 dots	None	None	Good	Deep penetration
Ar75%CO ₂ 25% mixed protective gas 2					
1	None	None	None	Good	Sufficient penetration
2	None	None	None	Good	Sufficient penetration
3	None	None	None	Good	Sufficient penetration
4	None	None	None	Good	Sufficient penetration
5	None	None	None	Good	Sufficient penetration

Observation of welding defects on 1,135 brake pedals using GMAW welding technology and CO₂ protectivegas100%, apparently *dominated by spatter defects* of 76 pieces (6.70%), porosity defects 2 pieces (0.18%), *undercut* 10 (0.9%), 27 *rigi-rigi* defects (2.37%). The total number of defects was 93 (8.2%). Welding defects caused by the weakness of the protective gas flow of *semiautomatic* GMAW welding machines that are less able to withstand the pressure of strong wind bursts from the side defects, occur as many as 2 pieces [5]. The *end of the wire filler* is arced between the parent metal and the tip tip contact forms a molten metal, followed by freezing the welding crater and protected by a protective gas that serves to avoid porosity-shaped welding defects. Because CO₂ protective gas is100% reactive gas so it will form a *spatter defect that dominates* the welding defect in the welding joint. CO₂ gas protector 100%in the form of transfer mode spray results in *good* enough to weld thick plates because the welding current can be adjusted to the material, while the brake pedal is designed of thin metal so it is not suitable for welding current settings because it easily forms a *spatter* defect [5,8].

Table 3: Observation of Welding Defects Using Protective Gas CO₂ 100%

St.	Number of products	Process Las	Spatter		Porosity		Undercut		RWB		TOTAL	
			PCS	%	PCS	%	PCS	%	PCS	%	PCS	%
30	330	XC-281	10	3	0	0	2	0,6	3	0,9	15	4,5
30	130	XC-281	4	3,1	0	0	0	0	6	4,6	10	7,7
30	320	XC-281	18	5,6	1	0,3	3	0,9	7	2,2	29	9,1
30	210	XC-281	10	4,8	1	0,1	2	1	3	1,4	16	7,3
30	145*)	XC-281	8	5,1	0	0	3	2,1	8	5,5	19	13,0

*) welder berbeda

Visually defective observations (*spatter*, porosity, *undercut* and *ripple weld-bead*) were obtained in the GMAW process using Ar75% CO₂ protective mixed gas 25%. Of the 1145 products, 9 (0.79%) of the brake pedals were acquired. the highest, *ripple weld-bead defects* 1 piece (0.08%), the total number of defects 10 pieces (0.88%). Welding defects are down significantly compared to GMAW process welding with 100% CO₂ gas shielding. GMAW process welding technology using Ar75% CO₂ mixed protective gas is suitable for application to thin metals and welding results can be seen in Table 4.

Table 4: Observation defect Welding Gas Use Mixed Protector Ar75% CO₂ 25%

St	Amount	Process Las	Spatter		Porosity		Undercut		WBK		TOTAL	
			PCS	%	PCS	%	PCS	%	PCS	%	PCS	%
30	320	XC-281	3	0,93	0	0	0	0	1	0,31	4	1,24
30	150	XC-281	0	0	0	0	0	0	0	0	0	0
30	310	XC-281	2	0,64	0	0	0	0	0	0	2	0,64
30	195	XC-281	2	1,03	0	0	0	0	0	0	2	1,03
30	165	XC-281	2	1,2	0	0	0	0	0	0	2	1,2

On other conditions, there is a difference in output in the use of protective gas CO₂ 100%, which is 26 pieces or 2.77% while using protective gas mixture Ar75% CO₂ 25% output 11 pieces or 1.11%. The number of defects or percentage failures decreases. The decrease in the number of defects was caused by an increase in welder skills and the use of Ar75% CO₂ protective gas mixture 25%, thus improving the quality of brake pedal welding connections by up to 150%. In GMAW process semiautomatic use of protective gas CO₂ 100%, metal transfer mode transition from spray mode transfer to globular mode transfer does not occur, dropping metal transfer to smooth (metal filler displacement to small weld crater) as well as decreased current. Spatter more than the use of protective alloy gas Ar 75% CO₂ 25% spatter level down, also by setting the tip tip electrode and arc location at low capacity of the parent metal surface will lower the spatter [5,8].

Table 5: Special Observation Failed Spatter

Observation	Use CO ₂ 100%	Spatter Failure	Ar75% Usage CO ₂ 25%	Spatter Failure
1	300	11	330	2
2	320	8	130	4
3	320	7	320	2
4	--	--	210	3
Amount	940	26 (2,77%)	990	11 (1,11%)

CO₂ 100% gas protector is a reactive gas commonly used single in GMAW welding process, low welding deposit efficiency of spatter level and highest smoke compared to argon gas protection usage. The surface of the welding bead contains a lot of oxidation and the surface of the bead is less smooth [5].

The highest ionization potential in CO₂ 100% and characteristic of greater heat decomposition, high welding penetration. Protective gas CO₂ plus argon gas to improve stability, penetration is improving the flow characteristics of welding molten metal [8].

The highest heat conductivity in the use of CO₂ protective gas 100% by combining Argon gas will improve the transfer mode on the base metal by the inert properties of argon protective gas itself. Penetration of argon gas is quite low but

the distortion of base metals is very low especially base metals that have wide and thin gaps such as brake pedals.

IV. CONCLUSION

Based on the results of welding research on brake pedals using gmaw semiautomatic welding process technology with CO₂ protective gas 100% obtained spatter welding defects, uneven ripple weld-bead, undercut and porosity at the level limit of 8.2%. After being replaced with a protective mixture Ar75% CO₂ 25%, spatter type welding defects dropped to the limit of 0.88%, while the defects of undercut welding, porosity and welding rigi-rigi were almost non-existent.

GMAW welding process with CO₂ gas protector 100% produces spatter defects at a level limit of 2.77%. By using Ar75% CO₂ mixed protective gas 25% spatter type defects

dropped at the level limit of 1.11%. Thus gmaw process brake pedal welding connection with Ar75% CO₂protectivemixed gas 25% improves welding quality by up to 150%.

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