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Biogas simulation with mixed gas free on metal cutting

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Abstract

This study aimed to study the biogas simulation with mixed gas free on metal cutting by using oxy-fuel to cut AISI 1045 metal size 50 mm. X 50 mm. X 6 mm. with automatic cutter model KT 5 NX. In general biogas was composed of methane, carbon dioxide, hydrogen sulfide and oxygen. However, this study employed only 67% methane and 26.3% carbon dioxide using Biogas 5000 as a measuring instrument. The results showed that the average surface roughness was 4.94 micrometer measured by Mitutoyo SURFTEST SJ-301 with the heat measured by SEM JS-5410 LV at 1000 magnification. The cut was divided into 4 sections i.e. the highest flame-cutting part, unequal heat radiation parts and less heat part. Heat was analyzed qualitatively by EDS Link ISIS300 to find changed elements. From 4 areas there were 9 elements, among these iron, carbon and manganese were necessary elements. After cutting, average carbon was higher at 0:42-00:50 while normal was 0.73%. Iron was below average at 76.35% from 98.51-98.98 whereas manganese was 0.58% which was similar to normal at 0.60-0.90%.

Keywords: Cutting, Oxy - fuel, Cutting process, Flame cutting

1. Introduction

There are many processes of preparation work in industry such as machining, milling, drilling and cutting. Besides, there are other processes such as laser and oxy-fuel cutting. Cutting process includes hand and automatic machine cutting called CNC. Both cuttings use flame to melt the metal and oxygen is released to blow out the melted metal so the metal separates. CNC provides very efficient and accurate preparation of the components of work pieces and it employs oxy-fuel to cut metal with flame rapidly. Therefore, this is better than hand cutting because of its accuracy and dimension.

The oxy-fuel cutting process is used as an efficient alternative cutting process in metal-manufacturing industries. The process begins by heating a small area on the surface of the metal to an ignition temperature of 760 to 8700C with an oxy-fuel gas flame. On reaching the ignition temperature, a cutting oxygen stream is then directed at the preheated spot, causing rapid oxidation of the heated metal and generating large amounts of heat. Also, when the properties and dimensional accuracy of a gas-cut plate are acceptable, oxy-fuel cutting can replace a costly machining operation when done under specific cutting variables and where very good roughness (Ra) can be achieved [1].

Regarding the consumption and cost of the fuels used in oxy-fuel gas cutting, many workers have arrived at the same conclusion; the use of propane gas is very economical. At present in developed countries in America and Europe, the main gas used in different thermal cutting processes is propane, although each country is looking for a gas that can be substituted for acetylene, because it is explosive, contains contaminates, and is harmful to the operators [2].

The oxy-fuel process is the most widely applied industrial thermal cutting process because it can cut thicknesses from 0.5mm to 250mm, the equipment is low cost and can be used manually or mechanized. There are several fuel gas and nozzle design options that can significantly enhance performance in terms of cut quality and cutting speed [3].

In studying various researches on oxy-fuel metal cutting process, most researches were conducted with oxy-fuel mixed with other gases such as acetylene, or liquid petroleum. Consequently, this study attempted to simulate biogas mixed with methane and carbon dioxide to find out the efficiency of biogas simulation on metal cutting. This can be used as a guideline for applying alternative energy in industry i.e. biogas obtained from residue. Implementing BIOGAS 5000 to measure pig's residue, 67% of methane, 26.3% carbon dioxide, 0.2% oxygen and 2,313 ppm. hydrogen sulfide were found. Then simulate biogas including 67% of methane and 26.3 of carbon dioxide. The gas obtained is used in the next cutting process

Objectives

1. To study the simulation of biogas with mixed gas free on metal cutting process.

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2. To investigate the efficiency of biogas simulation on metal cutting

2. Materials and methods

2.1 Materials

Work piece for metal cutting was AISI 1045 work piece, carbon steel 50 mm. X 50 mm. X 6 mm. (6 mm. thick) were used for experiment.

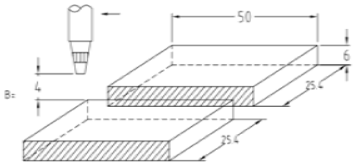


Figure 1 Cutting process and distance between work pieces

Methane mixed with carbon dioxide the same as the ratio of biogas from residue were used as fuel in the study, as shown in Figure 2. This was used with oxygen for cutting process.

Figure 2 Fuel certificate used in the experiment

Table 1 Chemical Composition [4]

Element	Content
Carbon,C	0.42-0.50 %
Iron,Fe	98.51-98.98 %
Manganese,Mn	0.60-0.90 %

2.2 Methods

Cutting process was shown in Figure 1. Basically, fuel gas used to heat metal is ignited the temperature below melting point. Oxygen flame controls the heated work piece. Chemical reaction between heat transfer and strength of the metal resulted in iron oxide or slag. Oxygen jet blows away the slag enabling the jet to cut through the material. There are four basic requirements for oxy-fuel cutting. [5-6]

Biogas used in oxy-fuel is not the cutting tool because it mixed thoroughly with fuel. Since there is no contact between cutting torch and metal, very small cutting forces are generated which is basis for metal cut process, value setting and operation process. Gas cutting process starts when flame preheats the work piece through ignition temperature. Then the lever is pressed to release high pressured oxygen to react with heated material. This oxygen blows away oxide and liquid from the cut. Moving torch with proper and regular speed causes the material to separate with smooth cut. Quality of the cut depends on the skillful of the cutter. Hence, the mechanism or torch is developed for good quality cut as shown in Figure 3.

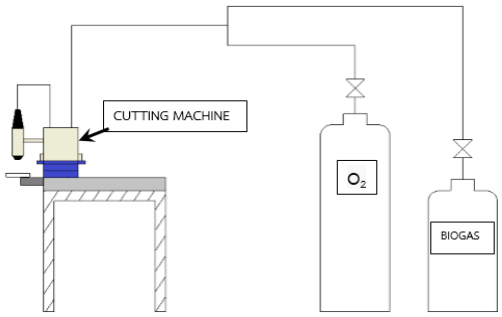


Figure 3 Oxy-Fuel in cutting process

The quality of the cut is checked by the cut surface to find out its roughness by Mitutoyo SURFTEST SJ 301. SEM JSM-5410 LV is used to measure the effect of heat while EDS Link ISIS300 analyzes how elements get different heat.

3. Results

This section presents the results of research in order to understand more easily be divided into three experimental results section below.

3.1 Surface roughness

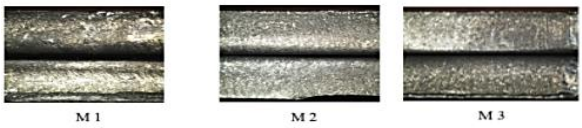


Figure 4 Work piece cut by methane gas

Table 2 Results from Mitutoyo SURFTEST SJ-301

Work piece	Ra (µm)
1.1	4.68
1.2	5.21
2.1	4.46
2.2	6.08
3.1	3.55
3.2	5.65

Each work piece was cut into 2 pieces, as shown in Figure 4. Each piece was measured for its average surface roughness or average roughness (Ra) by Mitutoyo SURFTEST SJ-3 0 1 , the result showed that the overall average was 4.94 micron shown in Table 2.

3.2 Heat affected zone

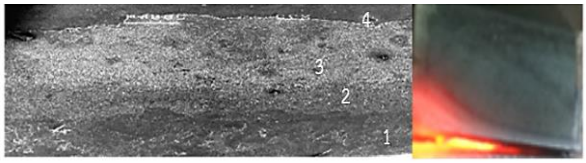
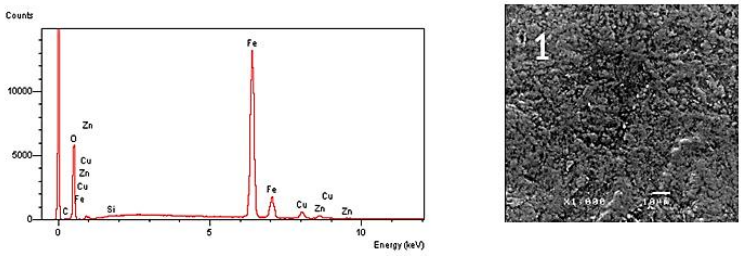
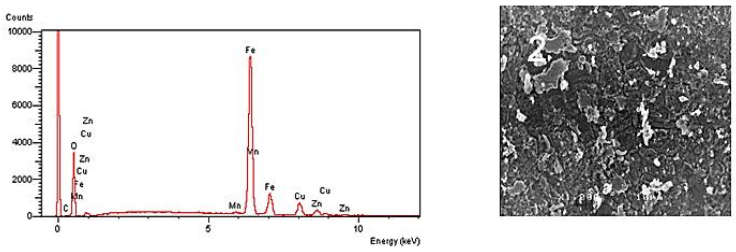


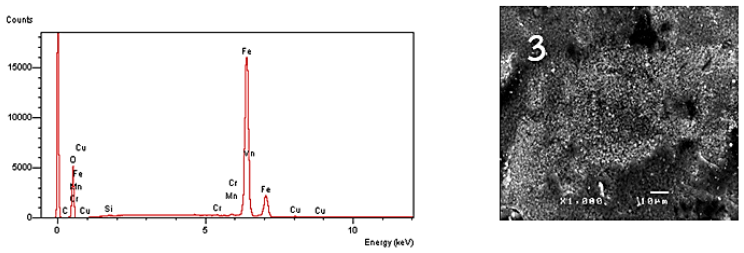
Figure 5 Heat affected Zone



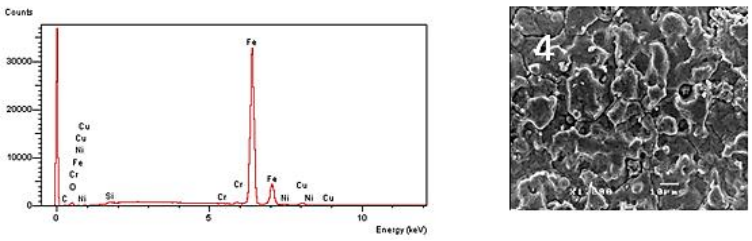
(a) Qualitative analysis and structure of section 1



(b) Qualitative analysis and structure of section 2



(c) Qualitative analysis and structure of section 3



(d) Qualitative analysis and structure of section 4

Figure 6 Graph showed Qualitative analysis and structure of pieces 1-4

In Figure 5 when analyzing heat affected by SEM JSM-5410 LV, area could be divided into 4 sections. Section 1 was the highest and the nearest heat. Sections 2, 3 and 4 affected heat respectively so they affected the structure differently

3.3 Qualitative analysis

Figure 6 showed qualitative analysis of 4 pieces including their components. 9 elements were found in cutting process. Table 1 indicated components of carbon, iron and manganese. After cutting, there was average carbon at 0.73% while average iron at 76.35% and average manganese was 0.58%.

This study focused on biogas simulation with mixed gas free on metal cutting intending to compare the efficiency of biogas from pig manure used in cutting process. Similarity or difference on metal cutting could be answered and also be alternative energy for industry.

4. Conclusions

This research aimed to study biogas simulation with mixed gas free and to find the efficiency of this simulation on metal cutting. Most biogas consisted of many gases such as methane, carbon dioxide, oxygen and hydrogen sulfide. In the experiment, only methane in biogas was mixed with carbon dioxide with the ratio of 67% methane, and 26.3% carbon dioxide. These 2 gases were mixed with oxygen for the metal cutting process. The results of surface roughness measured by Mitutoyo SURFTEST SJ-301 was 4.94 micron. Heat affected zone measured by SEM JSM-5410 LV with 1000 magnification included 4 sections. Section 1 referred

to the highest heat affected zone while sections 2 and 3 radiated heat differently measured by EDS Link ISIS 300 to find the components of elements. From 4 sections, there were 9 elements. The necessary elements were shown in Table 1 including carbon, iron and manganese. After cutting, carbon was higher at 0:42-00:50 while in normal was 0.73% whereas average iron was lower from the normal range of 98.51-98.98 to 76.35%. However, manganese was 0.58% which was similar to the normal at 0.60-0.90%. This study will be compared with biogas from pig manure in cutting process later.

5. Acknowledgements

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