Analysis of ST-37 metal cutting with machine-cut tools using Oxy-LPG

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Abstract. This gas cutting machine is a ST-37 metal cutting tool in a semi-automatic way using LPG and Oxygen gas materials. LPG gas is used with a composition of propane 99.5% and Isobutan 5%. In the process of cutting metal must pay attention to several parameters, namely: metal thickness, oxygen gas pressure and LPG gas and cutting speed. Before cutting down the metal, the preparation stage is done by conditioning the test equipment and work equipment used to collect test data. The method used in this research is to select the type of metal and cutting equipment then do the recording and taking test data. Further analysis and examination are carried out as follows: visual inspection of the results of cutting and flame shape, a better composition results from testing in accordance with applicable rules such as pressure, plate thickness and time of cutting. 99.5% and 0.5% LPG gas composition at gas working pressure: 0.2 kg / cm²; oxygen pressure: 2.5 kg / cm², cutting distance of 2mm. The results of this test are overall in good condition and no defects occur.

1. Introduction
Gas cutting machine is one type of cutting machine that can cut steel plates with good accuracy. The principles of this cutting machine use oxyfuel welding. This machine has simple dimensions, application and maintenance.

The oxyfuel 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 [1].

The quality of cut depends mainly on parameters like cutting speed, oxygen pressure, type of nozzle selected. The increase in cutting speed decreases the quality of the cut resulting in rounding of the bottom edge to some extent and also undercuts the edge which destroys the flatness. As the oxygen pressure goes up, the diameter of the stream increases comparatively faster than the increase in oxygen flow. This increases the width of cut and provides less oxygen to oxidize the steel which results in loss of quality. Smaller nozzles can be used to cut heavier thickness with The quality of cut depends mainly on parameters like cutting speed, oxygen pressure, type of nozzle selected. The increase in cutting speed decreases the quality of the cut resulting in rounding of the bottom edge to some extent and also undercuts the edge which destroys the flatness. As the oxygen pressure goes up, the diameter of the stream increases comparatively faster than the increase in oxygen flow. This increases the width of cut.
and provides less oxygen to oxidize the steel which results in loss of quality. Smaller nozzles can be used to cut heavier thickness with dramatic reductions in speed with comparatively good quality [2-4].

A jet of pure oxygen is then directed into the preheated area instigating a vigorous exothermic chemical reaction between the oxygen and the metal to form iron oxide or slag. The oxygen jet blows away the slag enabling the jet to pierce through the material and continue to cut through the material. There are four basic requirements for oxy-fuel cutting [5]. A jet of pure oxygen is then directed into the preheated area. This triggers a vigorous exothermic chemical reaction between the oxygen and the metal to form Iron Oxide or slag. The oxygen jet blows away the slag enabling the jet to pierce through the material and continue to cut the material [6]. The effect of cutting parameters on the surface quality was implementing by the experimental results obtained from cutting a non-Galvanized steel plate ASTM BN 1323 in different cutting parameters (cutting speed, preheat time, and plate thickness) followed by nondestructive (hardness and roughness of a cutting surface) tests to investigate the quality control on the cut specimens [7].

1.1. Gas cutting machine

The Gas Cutting Machine machine unit uses motion from electric power which is supplied to the electric motor on the engine, this machine can move forward and backward on the rails used for the roadway so that the engine motion is straight and stable with an adjustable speed on the panel adjusting the speed according to Thickness of the plate to be cut. The plate that can be cut by this machine is 6 - 100 mm thick. Machine image can be seen in Figure 1.

| Type                          | CG1-30                                    |
|-------------------------------|-------------------------------------------|
| Cutting Speed                 | 50-750 mm/mnt                             |
| Cutting Thickness             | 5-100 mm                                  |
| Effective Cutting Diameter    | 200-2000 mm                               |
| Power source                  | AC 220V 50HZ                              |
| Weight                        | 16 kilogram                               |
| Machine dimension             | 435mmx210mmx240mm                         |
| Speed control                 | Silicon control                           |
| Groove angle                  | 0-45 degrees                              |
| Nozzle                        | G02 (acetylene) G03 (propane)             |
| Motor                         | DC 110V 50HZ 30W 4200r/min                |

Figure 1. Machine gas cutting. Semi-automatic [8].
1.2. Characteristics of St 37 Steel (AISI 1045)

St 37 steel is a medium carbon steel equivalent to AISI 1045, with a chemical composition Carbon: 0.5%, Manganese: 0.8%, Silicon: 0.3% plus other elements. With a hardness of 170 HB and a tensile strength of 650 - 800 N / mm² [9].

There is a wide variety of cutting tip styles and sizes available to suit various types of work. The thickness of the material to be cut generally governs the selection of the tip. The cutting oxygen pressure, cutting speed, and preheating intensity should be controlled to produce narrow, parallel sided kerfs. Cuts that are improperly made will produce ragged, irregular edges with adhering slag at the bottom of the plates. Table 1 display identifies cutting tip numbers, gas pressures, and hand-cutting speeds used for cutting mild steel up to 12 in. (304.8 mm) thickness.

Table 2. Display identifies cutting tip numbers, gas pressures, and hand-cutting speeds used for cutting mild steel up to 12 in. (304.8 mm) thick.

| Plate thickness (inches) | Cutting tip (size number) | Oxygen (psi) | Fuel (psi) | Hand cutting speed (inches per minute) |
|--------------------------|---------------------------|--------------|------------|---------------------------------------|
| ¾                        | 0                         | 30           | 3          | 16 to 18                              |
| 3/8                      | 1                         | 30           | 3          | 14.5 to 16.5                          |
| ½                       | 1                         | 40           | 3          | 12 to 14.5                            |
| ¼                       | 2                         | 40           | 3          | 12 to 14.5                            |
| 1                        | 2                         | 50           | 3          | 8.5 to 11.5                           |
| 1½                      | 3                         | 45           | 3          | 6 to 7.5                              |
| 2                        | 4                         | 50           | 4          | 5.5 to 7                              |
| 3                        | 5                         | 45           | 4          | 5 to 6.5                              |
| 4                        | 5                         | 60           | 5          | 4 to 5                                |
| 5                        | 6                         | 50           | 5          | 3.5 to 4.5                            |
| 6                        | 6                         | 55           | 6          | 3 to 4                                |
| 8                        | 7                         | 60           | 6          | 2.5 to 3.5                            |
| 10                       | 7                         | 70           | 6          | 2 to 3                                |
| 12                       | 8                         | 70           | 6          | 1.5 to 2                              |

2. Methods

The method used in this research to the preparation stage is done by conditioning the test equipment and work equipment used to collect test data. The method used in this research is to select the type of metal and cutting equipment then do the recording and taking test data. Further analysis and examination are carried out as follows: visual inspection of the results of cutting, a better composition results from testing in accordance with applicable rules such as pressure, plate thickness and time of cutting [5,6].

This research was conducted at the Lab. Welding of Indorama Engineering Polytechnic Mechanical Engineering. Department The type of engine used is the CG-30 Gas Cutting Machine. Medium steel plate used is ST 37 steel. Dimensions of steel plate used are: 3 mm thick; Plate length of 40 mm, 9 mm thick; Template length of 50 mm, 12 mm thick; Plate length 65 mm. When the pressure of oxygen pressure = 2 kg / cm² and LPG pressure = 0.2 kg / cm². LPG with Composition of propane 99.5% and Isobutan 5% [8].

3. Results and discussion

3.1. Cutting speed to the thickness of sheet

Based on standard parameters of cutting tip, 106 HC standard tip for hand cutting and portable gas cutting for oxy-LPG gas certain graphs were plotted with the cutting thickness kept in the range of 0-100.
Figure 2. Torch cutting speed vs. thickness of sheet.

Figure 2 shows that when the thickness of sheet to be cut is increasing it cutting speed decreases.

1. The thicker the workpiece, the longer the cutting speed
2. The thinner the workpiece, the faster the cutting speed
3. The resulting gap caused by cutting is 2 mm at a standard speed
4. Adjusting speed can affect the distance of the cutting results if the adjusting speed is too slow on a thin plate then the distance resulting from cutting will be large.

3.2. Results of visual inspection of cutting

Figure 3. a) Cut thickness, b) Visual results piece.

From Figure 3. a, it appears that the resulting cutting groove is very neat and clean from slag and has a small width. Whereas in Figure 5. b looks a cross section of a cut steel plate where the result is a good cross-section surface and a very fine vertical lag line and at the top a little rounded. This result can be due.

There are several factors, namely:

- Proper cutting speed. In accordance with plate thickness and oxygen pressure and Propane gas that fits.
- Selection of a suitable nozzle size and clean nozzle conditions
- The cutting surface does not have a track on the workpiece with a thickness of 8 mm and above, but the track is still present if the plate used is very thin
- The resulting distance from cutting is 2 mm
- The condition of the mixture of fuel and oxygen is easily regulated.
- The flame condition is easy to ignite or the angle of fire is set
3.3. Pressure on plate thickness
From the test results with 4 variations in plate thickness can produce. The working pressure for oxygen the thicker the plate the greater the pressure needed while for the working pressure the propane gas is set constant at 0.2 kg / cm², more clearly.

Table 3. Oxy pressure and LPG pressure.

| No nozzle | Cutting Thicknees (mm) | Fill Pressure (kg/cm²) | Work Pressure (kg/cm²) | Propane (LPG) | Cutting Distance Width (mm) |
|-----------|------------------------|------------------------|------------------------|---------------|----------------------------|
| 1         | 3                      | 70                     | 10                     | 1,5           | 0,2                        | 2                           |
|           | 6                      | 70                     | 10                     | 2             | 0,2                        | 2                           |
|           | 8                      | 70                     | 10                     | 2,5           | 0,2                        | 2                           |
|           | 12                     | 70                     | 10                     | 2             | 0,2                        | 2                           |

Figure 4. Torch cutting pressure vs. thickness of sheet.

Figure 4. Conclude that as the thickness of the sheet to be increases pressure of oxygen gas increases almost while the pressure of LPG gas more or less remains same.

Working pressure on the mixture of fuel and oxygen affects the workpiece cutting results including:

- The thicker the workpiece that is cut, the pressure on the oxygen will increase, if the pressure is not. The thicaised, the surface of the cutting result will not be evenly melted, or the material will not be cut off.
- Propane gas working pressure on the 3mm, 6mm, 8mm and 12mm plate experiments, propane gas pressure remains the same and does not affect the cutting surface results.

4. Conclusions
From the results of the study and discussion several conclusions can be drawn including:

- All compositions can be used for plate cutting processes but the best composition between LPG (99.5% propane and % butane).
- The treatment of propane working pressure of 0.2 kg / cm²; oxygen working pressure 2.5 kg / cm²; propane content pressure of 70 kg / cm²; oxygen content pressure of 100 kg / cm²; cutting distance produced 2 mm.
- From the results of tests and analysis conducted using visual results of cutting, cutting speed, and LPG recommended as a substitute for gas asyteline can only be used for the cutting process.
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