

## Introduction of Product

# Hydrogen Gas Cutting System

Keiichi Taniguchi

*Under the present circumstances where companies are required to seriously tackle global environmental issues, hydrogen is drawing attention as clean energy. This report introduces the advanced safe cutting method using hydrogen. This cutting method can meet ecological (environment friendly) as well as economical requirements and is expected to become a dominant cutting method for steel in the future.*

**Key Words:** Hydrogen Gas Cutting, Environment Friendly.

## 1. Introduction

Recently, the introduction of advanced “Hydrogen Gas Cutting” was investigated but finally abandoned due to the problems of several accidents occurred, cost merit and safety. The facility is called “Hydrogen-Oxygen Mixture Gas Generation System” and stores the hydrogen detonating gas (when hydrogen and oxygen are mixed to 2:1 in volume ratio, the mixture gas violently explodes if ignited), so that it is susceptible to explosion accidents even with a small amount of static electricity, if occurs. In addition, because a large quantity of propane is mixed to avoid reaching the explosion limit, the system is less advantageous from the cost point of view and has a problem concerning safety. The hydrogen gas cutting system that we introduce in this report is of “hydrogen-oxygen full separation occurrence method” and therefore less susceptible to explosion, or safe. In addition, the new type torch that does not use propane at all makes high-speed cutting possible. It is the “new hydrogen gas cutting system” that incorporates new technologies to solve the problems of conventional systems. Besides, “The Kyoto Protocol” (global warming effect preventive measures) has taken effect, and Japan has been obliged to reduce the emission of greenhouse effect gas. In such circumstances, the new steel cutting system that uses “hydrogen”, or environment-friendly clean energy without “CO<sub>2</sub>” emission, has suddenly come to draw attention. Compared with conventional gas cutting systems that use fossil fuel, such as acetylene gas and propane gas, the new system has many advantages not only from the environmental point of view but also from the viewpoint of cost and productivity.

## 2. Advantages of the Hydrogen Gas Cutting System

- Environment friendly (reducing the emission of CO<sub>2</sub>)
- High quality of cut surface
- Reduction of man-hours for finishing after cutting
- Reduction of running cost
- High productivity by high-speed cutting

### (1) Clean, environment-friendly and safe cutting method

Safe and very clean cutting system because hydrogen and oxygen are generated by electrolyzing water and burned at the tip of cutting torch. Compared with conventional systems that use fossil fuel, the new system generates remarkably small amount of fume and emits no carbon dioxide. The generation of carbon dioxide, or one of the substances under industrial emission control to which importance is given from the viewpoint of global environmental issues, is theoretically zero. It is a next-generation cutting system (which improves the working environment).

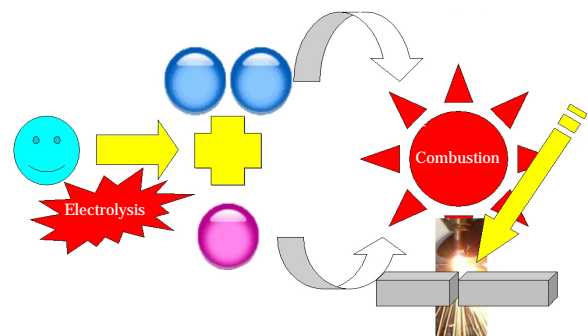


Fig. 1 An image of Hydrogen Gas Cutting

(2) High-quality high-precision cutting with low heat input

In principle, it is one kind of thermal cutting, the same as LP gas cutting. However, compared with LP gas cutting, the quantity of input heat during cutting is reduced to approx. 60%, so that the heat input to base metal is low, reducing thermal distortion to a large extent. Therefore, the new cutting system can produce high precision products.

In addition, cut surface is smooth and the corners of cut groove are sharp, which assures high precision cutting, or 1 mm or smaller deviation of cutout products, for example. When combined with our peculiar touch sensor, more precision cutting is possible with a cutting robot.

(3) Greatly relieved slag removal work after cutting

One of the greatest advantages of hydrogen gas cutting is easy separation of slag (dross). Like ordinary gas cutting, hydrogen gas cutting also generates slag, which, however, has high releasability and can easily be removed. Compared with LP gas cutting, slag can surprisingly easily be removed, so that time is hardly consumed for slag removal. As a result, the man-hours conventionally required for the finishing of cutout products can be reduced to a large extent, contributing to productivity improvement and cost reduction as well as improving product quality.



Fig. 2

(4) Reduction of running cost for cutting

Comparing the cost of propane and oxygen gases necessary for LP gas cutting and the cost of the oxygen gas and the electricity for generating hydrogen gas that are necessary for hydrogen gas cutting, it is possible to reduce cost by approximately 30%.

(5) High productivity

Hydrogen gas cutting is 10% to 30% higher in cutting speed than ordinary gas cutting. In addition, because pierce time can be reduced due to excellent heat concentration, total productivity is improved with hydrogen gas cutting. It is possible to cut steel plates (mild steel) with the thickness of 6 to 100 mm at the speed of 600 to 200 mm/min.

**2.1 Clean, environment-friendly and safe cutting method**

Hydrogen gas cutting is a cutting method that has the following merits and is friendly to global environment and safe for working environment.

- “Zero” emission of carbon dioxide
- Generation of fume is very small and therefore is favorable for working environment

- Low oxygen consumption
- Slag can be removed very easily, releasing workers from hard work.
- Use safe hydrogen gas for cutting

As shown in the following comparison table, hydrogen gas has lower specific gravity and higher ignition point and explosion limit and therefore is safer than propane and acetylene gases.

**Table 1** Comparison of gas properties

Gas	Formula	Specific gravity	Ignition point( )	Explosion limit ( air )
				( volume% )
Hydrogen	H <sub>2</sub>	0.07	585	4 ~
Acetylene	C <sub>2</sub> H <sub>2</sub>	0.88	335	2.5 ~
Propane	C <sub>3</sub> H <sub>8</sub>	1.567	467	2.2 ~

**2.2 Low heat input and high quality and cutting accuracy**

Groove cutting was performed with hydrogen gas cutting and LP gas cutting systems under the following conditions. The resultant cut surface, heat input and thermal strain are compared below.

For the quantity of input heat, according to the temperatures measured at various points, it is supposed that the ratio of hydrogen gas cutting to LP gas cutting is 3:5. Namely, the quantity of input heat is lower with hydrogen gas cutting. (Fig. 3)

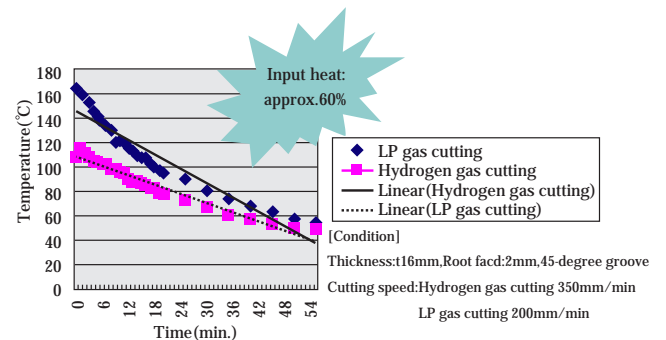


Fig. 3 Temperature change

Temperature was measured at points shown in Fig. 4

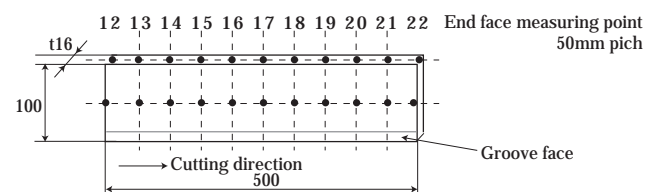


Fig. 4 Measuring point

Then distortion by input heat was measured. As a result, 0.9 mm of maximum distortion occurred with LP gas cutting, which is reduced to 0.5 mm with hydrogen gas cutting.

This means that because heat input is lower with hydrogen gas cutting, and distortion is lowered to approximately half. (Fig. 5)

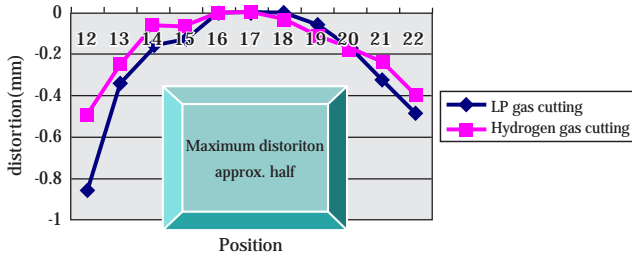


Fig. 5 Comparison of distortion

The photos show that sharp corners are obtained with hydrogen gas cutting, compared with LP gas cutting. (Fig. 6)

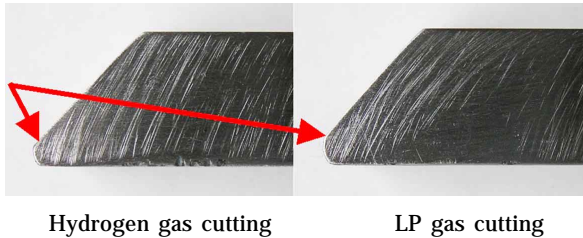


Fig. 6

**2.2.1 Example cutting of thick plate**

Komatsu Engineering corp. is marketing steel frame welding systems, where there is a demand for groove cutting of column steel in the upstream process of welding. Because high quality cutting is possible using our cutting know-how and experience, we are planning to merchandise a system for this purpose. (Fig. 7)



Fig. 7 Example cutting of column steel

**2.2.2 Improving the precision of cutting system**

Hydrogen gas cutting is a cutting method with low heat input and low distortion by input heat. Combining it with Komatsu's peculiar touch sensor (Photo 5) to make up a cutting robot, it is possible to further improve the cutting accuracy of whole work. (Fig. 8)

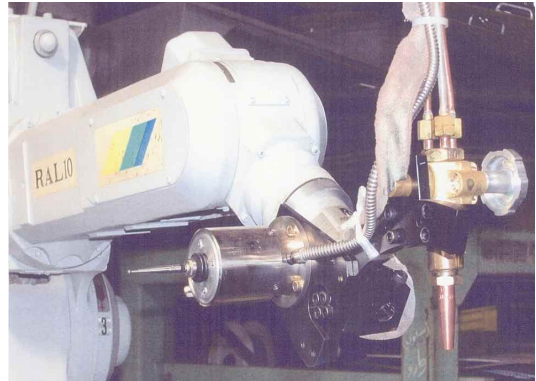


Fig. 8 Touch sensor

The function of the touch sensor is to accurately detect the actual position of work before cutting (total accuracy: 0.3 mm or less), correct, by shifting coordinates, the cutting data for basic position of work, which is programmed in the robot, so as to match the actual position of work, and start cutting operation. With this function, it is possible to highly accurately cut grooves that require especially high accuracy. (Fig. 9)

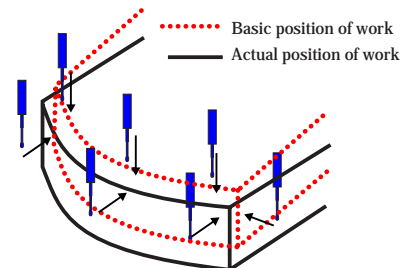


Fig. 9 Touch sensor motion for detection

**2.3 Greatly reduced secondary work after cutting**

The slag sticking to LP gas cut surface is hard to remove and, in many cases, needs to be removed and finished by secondary work using a grinder, etc. On the other hand, the slag that is generated by hydrogen gas cutting is sponge-like and can surprisingly easily be removed after cutting, compared with ordinary gas cutting. Therefore, it hardly consumes time for slag removal, and the man-hours required for care and cleaning can be reduced to a large extent. In addition, hydrogen gas cutting provide very smooth cut surface, or approximately 30 μm in surface roughness. (Fig. 10)(Fig. 11)

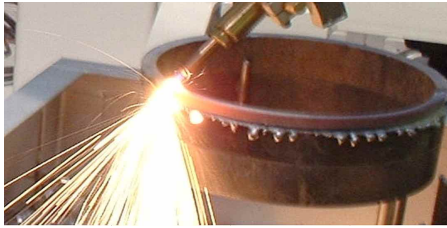


Fig. 10 Slag of hydrogen gas cutting

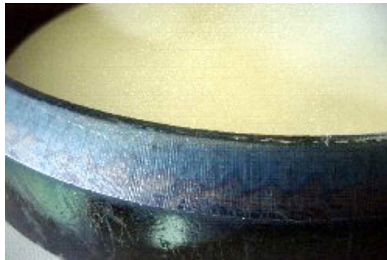


Fig. 11 After slag is removed

**2.4 Reduction of running cost for cutting**

Hydrogen gas cutting system also uses high-pressure oxygen gas, but the consumption is very low, compared with ordinary gas cutting systems. In addition, no propane (acetylene) gas is used for preheating flame, so that the cost of gas is basically low. In addition, because of high cutting speed, the cost of unit cut length can be reduced.

Table 2 shows the reaction formula for preheating flame with hydrogen gas cutting and acetylene and propane gas cutting. With hydrogen gas cutting, the oxygen consumption for preheating is reduced to 1/5 or less, and it is experienced that the total oxygen consumption including cutting operation is reduced by approximately 20%. Thus the cost of gas can be reduced.

Table 2 Cutting gas and oxygen consumption for preheating

Gas	Reaction formula(preheating)	Oxygen consumption for preheating (When 10L gas is used)
Hydrogen	$2H_2+O_2 \rightarrow 2H_2O$	5L
Acetylene	$2C_2H_2+5O_2 \rightarrow 4CO_2+2H_2O$	25L
Propane	$C_3H_8+5O_2 \rightarrow 3CO_2+4H_2O$	50L

For hydrogen gas cutting, the oxygen generator as shown in Fig. 12 is installed at site to generate hydrogen and oxygen by water electrolysis and use them for preheating.

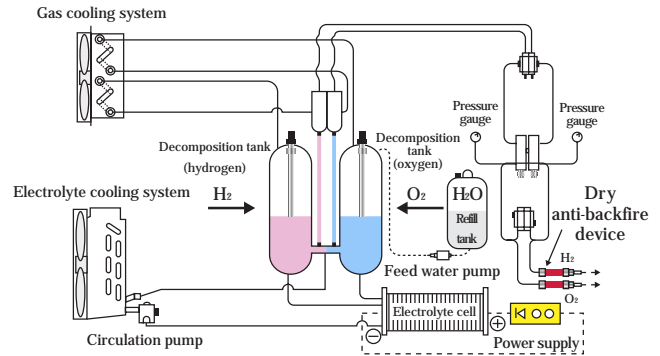


Fig. 12 Hydrogen gas generator

Table 3 shows the comparison of the total running cost for cutting operation between hydrogen gas cutting and LP gas cutting, based on actual result.

Table 3 Comparison of running cost for cutting

	Hydrogen	L P G	Difference
Oxygen	34	43	▲ 9
LPG	0	5	▲ 5
Power(facility driver)	12	12	0
Power(hydrogen gas generator)	4	0	4
Total	50	60	▲10

Hydrogen gas cutting can reduce approximately 15% of running cost for cutting operation compared with LP gas cutting.

**2.5 High-speed cutting**

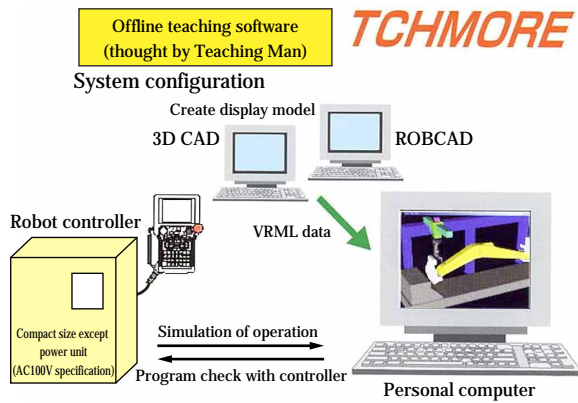
The cutting speed with 16 mm thick plate is as follows. Compared with ordinary gas cutting, hydrogen gas cutting can achieve 30% higher cutting speed.

Hydrogen gas cutting: 460 to 520 mm/min.

LP gas cutting: 380 mm/min

**3. Conclusion**

Komatsu Engineering Corp. provides a series of “manufacturing system”, from welding machine to cutting machine. We provide cutting and welding systems that meet customer needs (accuracy and productivity), including hydrogen gas cutting robot, plasma cutting robot and slide tandem welding robot. Especially the slide tandem welding system of quite new concept requires no large investment or space to improve productivity and yet shows excellent cost performance. In addition, the offline programming system “TCHMORE” (developed by Komatsu Manufacturing Engineering Development Center, see Fig. 13) is provided to cut the time required for setting up robots and thus further improve efficiency.

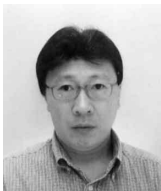


**Fig. 13** TCHMORE

In the future, we will collect more data of hydrogen gas cutting conditions and realize high-efficiency and high-accuracy cutting for a wide range of material, from thin plate through plank and column to ultra-thick plate. In addition, we will improve the peripheral devices and software of cutting robot to expand application fields as well as improve the completeness as high-value added cutting system.

Though it was pointed out that the flame of hydrogen gas is invisible and hard to adjust, we think there is no problem about this matter because operation is performed not manually but by robot and therefore no adjustment is necessary once conditions are determined. Besides, because a (digital) gas flow meter is equipped as standard, conditions can easily be adjusted.

#### Introduction of the writer



Keiichi Taniguchi  
Entered KOMATSU in 1978.  
Currently belongs to Komatsu Engineering Corp.

#### [A few words from the writer]

Though many people seem to have a prejudice about the safety of hydrogen (because of red bottle), it should be recognized that hydrogen is safer than other ordinary used gases, such as propane and acetylene.