Volume 63 • Issue 2 • April 2014

Journal of Achievements in Materials and Manufacturing Engineering

International Scientific Journal published monthly by the World Academy of Materials and Manufacturing Engineering

Cost comparison between oxyfuel and plasma cutting low alloy steel

A. Rzeźnikiewicz
Welding Department, Faculty of Mechanical Engineering,
Silesian University of Technology, ul. Konarskiego 18a, 44-100 Gliwice, Poland
Corresponding e-mail address: agnieszka.rzeznikiewicz@polsl.pl

Received 29.01.2014; published in revised form 01.04.2014

ABSTRACT

Purpose of this paper: This paper presents a comparison of the oxyfuel flame cutting and plasma cutting in economic terms. The cutting method you can choose depends on the type, thickness and amount of metal you need to cut as well as the cut quality you require. The cost estimation is also critical. In order to obtain maximum of technical and economical efficiency, in these cases, very important is to estimate the production cost and the production rates. Knowledge of investment and operating cost represents a base for investment in cutting machine. For different cutting machines typical investment costs and operating costs depend from the power of the cutting machine and important. To determine the cost of cutting 1 m it should be specify the type of cutting material, cut quality and used parameters. In this paper economic analysis of the cutting processes has been performed for low alloy steels with thicknesses of 2, 5, 10, 15, 25 and 50 mm. In this economic analysis were calculated the direct costs (electric energy, gases, depreciation and consumables), without the labour cost. The analysis shows that the cheapest cutting process for 10-15 mm thick is plasma cutting, for a thicker plates more economical process is the oxyfuel flame cutting. Plasma cutting provides a good balance in terms of capital costs and a optimal mix of cut quality, productivity and operating cost. It offers a significant thickness range and material flexibility and provides the highest cutting speed.

Design/methodology/approach: Different measures of cost may be appropriate, depending upon the context in which the comparison is being made. In this paper used the most common measures (cost per unit time, cost per unit length)

Findings: In this economic analysis were calculated the direct costs (electric energy, gases, depreciation and consumables), without the labour cost. Cost estimation of cutting methods and assessment of the most cost effective process for a given type of parts manufacture is quite an involve process. It depends on many factors related with the quality that must be obtained.

Research limitations/implications: All cutting technologies have stable long term industrial application and differ distinctively by technological parameters, economics and quality of cut edges. Knowledge of a cutting system’s investment and operating costs should form the basis for evaluating its profitability. The investment and operating cost must be justified according to economic criteria with corresponding financial advantages.

Practical implications: In addition to the technical aspect, which has a significant impact on the choice of cutting technology is a very important to know the economic aspect. To see the competitiveness of the method, it is important to know the actual cost of cutting 1 meter in length. Comprehensive analysis of the technical and economic aspects of cutting technology allows to avoid wrong decisions.

Originality/value: In this paper economic analysis of the cutting processes has been performed for low alloy steels with thicknesses of 2, 5, 10, 15, 25 and 50 mm. In this economic analysis calculated the direct costs (electric energy, gases, depreciation and consumables), without the labour cost.

Keywords: Cutting cost comparison; Economical analysis; Plasma cutting; Oxyfuel flame cutting; HTPAC

Reference to this paper should be given in the following way:

A. Rzeźnikiewicz, Cost comparison between oxyfuel and plasma cutting low alloy steel, Journal of Achievements in Materials and Manufacturing Engineering 63/2 (2014) 81-85.

INDUSTRIAL MANAGEMENT AND ORGANISATION

1. Introduction

Virtually all steel products are cut at some stage during manufacture, fabrication and construction. The cutting method you can choose depends on the type, thickness and amount of metal you need to cut as well as the cut quality you require. The cost estimation is also critical. In order to obtain maximum of technical and economical efficiency, in these cases, very important is to estimate the production cost and the production rates. Knowledge of investment and operating cost represents a base for investment in cutting machine. For different cutting machines typical investment costs and operating costs depend from the power of the cutting machine and important system components. Knowledge of a cutting system's investment and operating costs should form the basis for evaluating its profitability. The investment and operating cost must be justified according to economic criteria with corresponding financial advantages [1-12].

The production plans made by the production managers are based on serious calculations, including operating cost and investment cost besides those related with the quality that must be obtained [1-8].

Today, there are many methods of cutting, but the most widely used in the industry are still oxyfuel and plasma cutting.

All of them have stable long term industrial application and differ distinctively by technological parameters, economics and quality of cut edges. Oxyfuel flame cutting is still the only one process allowing to thermal cut very thick steel up to 200-300 mm but using special oxygen-propane torches it is possible to cut steel elements up to 1000-2000 mm thick. Oxyfuel has the lowest capital investment and can be a good choice if there is not too many parts to cut. Disadvantages of oxygen cutting process is the ability to cut only the low-carbon and low-alloy steel, HAZ is very wide and sensitive to cracking initiation and strong distortion of cut plates [1,4,9,10,12].

Plasma arc allows to cut almost all known engineering materials. The disadvantages of plasma cutting are beveled cut, noise, and a lot of gases and fumes generated during cutting. Plasma cutting can be used for cutting thinner plates than oxygen cutting, but provides highest cutting speeds which increase the cutting efficiency[1-4, 9, 12].

To increase quality and speed of plasma arc cutting of thin steel sheets and to compete with laser cutting or water jet cutting new torches were designed – HTPAC (High Tolerance Plasma Arc Cutting). The basic deference between conventional torches and HTPAC torches lay in the shape and dimension of plasma jet. HTPAC arc has very small diameter and column-like shape similar to laser beam. Power density of plasma jet is in the range 40-90 A/mm^2 and the kerf is 50% narrower than for conventional plasma arc cutting torches. Plasma gas is swirl oxygen or nitrogen and shielding gas is supplied in bottom part of the torch which can be additionally constricted by magnetic field. For cutting mild steels parts that will be welded or where good fit up is important, most fabricators today elect to use precision cut system and oxygen as the plasma gas [5].

Both conventional cut and precision cut automated plasma system offer the flexibility to use different plasma and shield gases to improve cut quality, eliminate dross and further increase consumables life [5].

In addition to the technical aspect, which has a significant impact on the choice of cutting technology is a very important to know the economic aspect. To see the competitiveness of the method, it is important to know the actual cost of cutting 1 meter in length. Comprehensive analysis of the technical and economic aspects of cutting technology allows to avoid wrong decisions [1-8, 11].

This paper presents a comparison of the oxyfuel flame cutting and plasma cutting in economic terms.

2. Characteristic of cutting cost

To cut quality and productivity, you should to consider the operating cost of each method. Many factors – consumables, power, gas and the cost associated with replacement parts and maintenance – have impact the overall operating cost. Consumables make up the largest portion of operating costs when cutting with plasma. These costs vary widely depending not only on the cost of the parts but on the performance and life of the parts, which is dependent on many factors. Consumable and plasma torch life varies with application, operating parameters, duration of cuts, number of pierces, operator skill [2,6].

Three main categories make the cost of arc cutting: depreciations cost of initial investment, operating cost and labour cost, [2]. Thus the arc cutting cost per hour can be calculated through the following equation:

$$C_{total} = C_d + C_{op} + C_l \text{ , Euro/h} \quad (1)$$

where:
C_{total} – total arc cutting cost per hour, Euro/h,
C_d – depreciation cost of initial investment, Euro/h,
C_{op} – operating cost, Euro/h,
C_l – labour cost, Euro/h.

Depreciation cost is associated with equipment purchase. It is the initial price of the equipment amortized over a specific amount of time. While the investment cost of cutting machines may seams high, improved productivity and product quality often make a system economical, especially for companies that produce a wide range of parts. The depreciation cost of initial investment can be calculated through the following equation:

$$C_d = \frac{I}{P_a \times T_U} \text{ , Euro/h} \quad (2)$$

where:
C_d – depreciation cost of initial investment, Euro/h,
I – capital investment cost of cutting machine, Euro,
P_a – the depreciation period, year,
T_u – the machine utilization, h/year.

The **operating cost** is associated with operating the process, including electric energy consumption, gas consumption, wear parts consumption, maintenance and repair. This cost occur only when the machine is operating. The operating cost depends from the method of cutting. It does not include labour, lease of depreciation, facilities or other overhead cost.

The **labour cost** is associated with running the machine, including the time to handle raw-material, finished parts and remnants and attending the machinery while it's running. To place a value on these cost, it must know the hourly cost of operator, the amount of time it takes to run a part of machine, the percentage of time allotted for machine setup and the percentage of time while an operator actually attends the machine.

3. Economic analysis

Different measures of cost may be appropriate, depending upon the context in which the comparison is being made. The most common measures and their suitability are:

- cost per unit time – appropriate measure for financial planning purposes,
- cost per unit length – appropriate measure for process optimization purposes (e.g. study of the effect of use of different process gases)

To determine the cost of cutting 1 m it should be specify the type of cutting material, cut quality and used parameters.

In this paper economic analysis of the cutting process has been performed for low alloy steels with thicknesses of 2, 5, 10, 15, 25 and 50 mm. One meter cutting cost set for oxyfuel flame cutting (acetylene torch – Perun oxygen PC-216A) and plasma cutting (manual Powermax 85 and automated cutting system Ultra-Cut 150 Thermal Dynamics), Table 1. In this economic analysis were calculated the direct costs, without the labour cost. In Table 2 shows the detailed cutting cost of low alloy steel plate 10 mm thick.

Table 1.
Summary of oxyfuel flame and plasma cutting cost

Material	Thickness, mm	Oxyfuel cutting cost, zl/m	Manual plasma cutting cost, zl/m	Automated plasma cutting cost, zl/m
Low alloy steel	2	0.48	0.25	0.22
	5	0.68	0.32	0.53
	10	0.95	0.90	0.59
	15	1.18	1.42	0.84
	25	1.72	4.38	2.74
	50	3.54	-	7.44

Table 2.
Cutting costs of low alloy steel plate 10 mm thick

	Oxyfuel cutting cost	Manual plasma cutting cost	Automated plasma cutting cost
Electric energy cost, zl/h	-	3.24	6.60
Gases cost, zl/h	25.0	84.0	80.0
Depreciation cost and consumables cost, zl/h	0.70	4.40	18.70
Total cost, zl/h	25.70	91.64	105.30
Total cost, zl/m	0.95	0.90	0.59

The analysis shows that the cheapest cutting process for 10-15 mm thick is plasma cutting, for a thicker plates more economical process is the oxyfuel flame cutting Table 1. Lower cost of automated plasma cutting arise from the possibility to use higher cutting speed and much higher efficiency of this cutting technique. For example, 10 mm thick low-alloy steel plate could be cut in one hour in an automated way 178 m, manual plasma 100 m, and oxyfuel flame only 27 m. These differences are reduced with increasing the thickness of cutting material. For example, 25 mm thick low-alloy steel plate could be cut in one hour in an automated way 39 m, manual plasma and oxufuel flame 22 m.

The cutting cost of 1 m low alloy steel plate increases with increasing thickness of the cutting material.

The cutting cost structure of oxyfuel flame and plasma cutting of low alloy steel plate 10 mm thick is shown in Fig. 1. It is depends on the cutting method and cutting parameters. Gas consumption is the largest in oxyfuel flame cutting cost (approx. 97%). Little impact on the overall cost has a depreciation cost and consumable cost.

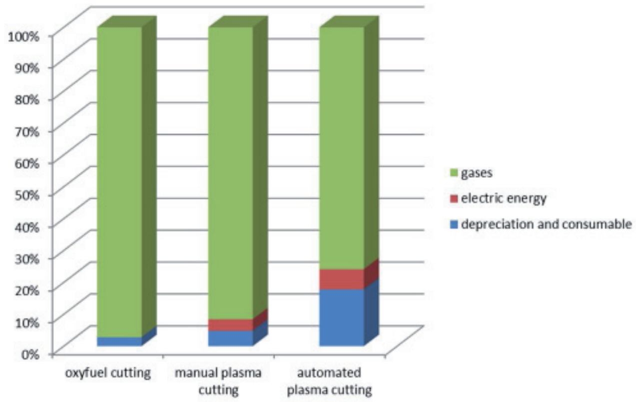

Fig 1. The cutting cost structure (%) of oxyfuel flame and plasma cutting of low alloy steel plate 10 mm thick

In manual plasma cutting the total cost of the cut consist of gases consumption cost (approx. 91%), electric energy consumption costs and consumable cost (approx. 9%). Automated plasma cutting system reduces costs of gas consumption (approx. 76%) but increases the cost of depreciation and consumables (about 18%). The cost of electric energy consumption is at 6%.

4. Conclusions

The technical aspect has a significant impact on the choice of cutting technology but it is also very important to know the economic aspect of cutting technology. Knowledge of competitive cutting methods and a comprehensive analysis of the technical aspects as well as economic aspects of cutting technology allows to avoid wrong decisions.

Oxyfuel flame cutting has the lowest capital investment cost. The cost of the oxygen torch with accessories is a several hundred zl so it can be a good choice if you don't have many parts to cut. The cost of manual plasma cutting stand is several thousand zl. The average cost of the automated plasma cutting system is tens of thousands zl. Plasma provides a good balance in terms of capital costs and optimal mix of cut quality, productivity and operating cost. It offers a significant thickness range and material flexibility and provides the highest cutting speed.

The cost of cutting equipment has a direct impact on the depreciation costs, but it is also important number and thickness of the cut pieces. A large impact on the cutting costs has required cut edge quality. The cut edge quality determines the cutting parameters and consumables. The high quality of the cut edge caused increasing the cost of cutting process.

Cost estimation of cutting methods and assessment of the most cost effective process for a given type of parts manufacture is quite an involve process.

References

[1] M. Avila, Which metal-cutting process is best for your application?, Welding Journal October (2012) 32-36.

[2] S.M. Ilii, M. Coteata, Plasma arc cutting cost, International Journal of Material Forming 2 (2009) 689-692.

[3] The great debate: plasma cutter or oxyfuel torch, www.millerwelds.com/resorces/articles/plasma-cutter-oxyfuel.

[4] TWI World Centre for Materials Joining Technology, Cutting process - plasma arc cutting - process and equipment considerations, www.twi.co.uk.

[5] J.P. Kinos, D. Ott, A holistic study of automated plasma system costs, Welding Journal November (2012) 28-32.

[6] D. Cook, Cost of operation in mechanized plasma cutting, Welding Design and Fabrication, 2000.

[7] B. Kurpisz, W. Zeman, The economics of welded construction, Guidance Engineer, Welding, WNT, 2003, 957-984 (in Polish).

[8] H.Y. Zheng, Z.Z. Han, Z.D. Chen, W.L. Chen, S. Yeo, Quality and cost comparisons between laser and waterjet cutting, Journal of Materials Processing Technology 62 (1996) 294-298.

[9] H.-S. Lu, J.-Y. Chen, Ch.-T. Chung, The optimal cutting parameter design of rough cutting process in side milling, Journal of Achievements in Materials and Manufacturing Engineering 29/2 (2008) 183-186.

[10] M. Zaied, E. Bayraktar, D. Katundi, M. Boujelbene, I. Miraoui, Effect of laser cutting parameters on surface quality of low carbon steel (S235), Journal of Achievements in Materials and Manufacturing Engineering 54/1 (2012) 128-134.

[11] A. Grabowski, M. Nowak, J. Śleziona, Laser cutting of an AlSi alloy/SiCp composites: theory and experiments, Journal of Achievements in Materials and Manufacturing Engineering 17/1-2 (2006) 61-64.

[12] J. Sorvaag, Comparing thermal cutting processes for beveling, Welding Journal 9 (2011) 36-38.