Lasertechnology

FACTS ABOUT

Laser in material processing
Evaluation of cost efficiency

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Introduction

The success of using laser equipment in material processing is not only determined by technological aspects but also by cost efficiency. In order to evaluate this, it is necessary to compare costs produced by laser processes with the influence of these costs on the production economy and the earnings that laser processes provide. Lasers in material processing are used mainly for one of the following technological or economic reasons:

– The production of a cut contour, a weld seam or a surface property is only possible with lasers. Laser techniques are almost inevitably the most economic production method as alternative solutions are only possible with a disproportionately high amount of engineering work and equipment. Although the issue of cost efficiency is not of primary importance here, it still should not be disregarded.

– Lasers offer technological advantages for the final product compared with conventional manufacturing processes. In such cases cost efficiency is at least one criterion among several others for or against the use of a laser technique. For example, if the service life of a component is increased through the use of a laser welded seam, then laser welding will be able to establish itself as a possible manufacturing process even if the costs are similar.

– A laser technique offers a higher machining speed than conventional manufacturing processes. With technologically comparable machining results, the evaluation of cost efficiency is the only way to prove which method is the more cost effective alternative.

The laser competes with an extremely low cost, conventional manufacturing process. However, to produce good results this process requires preliminary treatments and/or finishing processes, which may necessitate the use of ecologically harmful substances. Lasers, on the other hand, may produce the required quality without additional treatments or decisively reduce it. The cost efficiency of the laser process is then calculated from the reduction in the overall costs.

A suitable method of calculating costs has to be found in order to be able to properly justify the use of lasers based on the possible costs. A calculation using the machine-hour rate or the manufacturing cost rate is the first approach. Together with the calculation of the costs per metre or the costs per component for laser processing meaningful data can thus be

Numbers and prices in all tables in this brochure are not binding and cannot be adapted to your applications. Your own relevant numbers must be determined.

Contents

Pos.								
(1)	Investment (Replacement Value RV)						325.000	
							1-shift production	3-shift production
	Machine runtime	100	%			h/year	1300	3900
(2)	Utilisation time at	90	% availability			h/year	1170	3510
(3)	Calculated depreciation	5	years	(1) : (2) : (3)		€/h	55,56	18,52
(4)	Calculated interest	10	% of 1/2 RV	[(1) :2] X [(4):100] : 2		€/h	13,89	4,63
(5)	Insurance	0,25	% of RV	[(1) X (5) : (2)] : 100		€/h	0,69	0,23
(6)	Building requirements	120	m²					
(7)	Building costs per month	8	€/m²	(6) X (7) X 12Mo : (2)		€/h	9,85	3,28
(8)	Maintenance	2	% of RV	(1) X 0,02 : (2)		€/h	5,56	5,56
(9)	Operating and other costs					€/h	0,50	0,50
(10)	Energy costs							
	Guiding machine					€/h	0,50	0,50
	Extraction					€/h	0,30	0,30
	Cooling system					€/h	0,60	0,60
(11)	Tool costs					€/h	0,50	0,50
(12)	Crane or fork-lift truck					€/h	0,50	0,50
(13)	NC programming					€/h	2,00	2,00
(14)	**Machine Hour Rate, Net**				**Total of (3) to (13)**	**€/h**	**90,45**	**37,12**
(15)	Labour costs					€/h	10,00	10,00
(16)	Non wage labour costs	80	%	(16)x(17)/100		€/h	8,00	8,00
(17)	Shift premium					€/h		5,00
(18)	**Machine Hour Rate, Gross**				**Total of (14) to (17)**	**€/h**	**108,45**	**60,12**
(19)	Overhead costs					€/h	8,00	8,00
(20)	**Manufacturing Cost Rate**				**Total of (18) + (19)**	**€/h**	**116,45**	**68,12**

Table1: Calculation of the machine hour rate and the manufacturing cost rate based on a laser cutting machine in one-shift and three-shift production

Pos.			1-shift production	3-shift production
(1)	Plate thickness		**3,00 mm**	**3,00 mm**
	Measured values			
(2)	Laser gas		75 l/h	75 l/h
(3)	Cutting gas		3000 l/h	3000 l/h
(4)	Electricity		30 kW	30 kW
(5)	Cutting speed		3,00 m/min	3,00 m/min
(6)	Cutting speed	(5) X 60	180,00 m/h	180,00 m/h
(7)	Lifetime of the lens		1000 h/lens	1000 h/lens
(8)	Lifetime of the nozzle		1000 h/nozzle	1000 h/nozzle
(9)	Cutting meters per lens	(6) X (7)	180000 m/lens	180000 m/lens
(10)	Cutting meters per nozzle	(6) X (8)	180000 m/nozzle	180000 m/nozzle
	Gas and Electricity Consumption			
(11)	Laser gas	(2) : (6)	0,42 l/m	0,42 l/m
(12)	Cutting gas	(3) : (6)	16,67 l/m	16,67 l/m
(13)	Electricity	(4) X 1000 : (6)	166,67 Wh/m	166,67 Wh/m
	Cost Basis			
(14)	Laser gas		20,00 €/m³	20,00 €/m³
(15)	Cutting gas		1,00 €/m³	1,00 €/m³
(16)	Electricity		0,13 €/kW h	0,13 €/kW h
(17)	Lens		750,00 €/piece	750,00 €/piece
(18)	Nozzle		15,00 €/piece	15,00 €/piece
(19)	Machine hour rate		90,45 €/h	37,12 €/h
(20)	Labour costs		18,00 €/h	23,00 €/h
(21)	Overhead costs		8,00 €/h	8,00 €/h
	Costs per Metre Cut			
(22)	Laser gas	(14) X 0,1 X (11)	0,84 cent/m	0,84 cent/m
(23)	Cutting gas	(15) X 0,1 X (12)	1,67 cent/m	1,67 cent/m
(24)	Electricity	(16) X 0,1 X (13)	2,17 cent/m	2,17 cent/m
(25)	Lens	(17) X 100 : (9)	0,42 cent/m	0,42 cent/m
(26)	Nozzle	(18) X 100 : (10)	0,01 cent/m	0,01 cent/m
(27)	Sum	(20) bis (24)	5,11 cent/m	5,11 cent/m
(28)	Machine hour rate	(19 X 100 : (6)	50,25 cent/m	20,62 cent/m
(29)	Labour costs	(20 X 100 : (6)	10,00 cent/m	12,78 cent/m
(30)	Overhead costs	(21 X 100 : (6)	4,44 cent/m	4,44 cent/m
(31)	Total costs	(27) + (31)	69,80 cent/m	42,95 cent/m
(32)	**Cutting Costs per Metre Cut**	(31) : 100	**0,70 €/m**	**0,43 €/m**

Table 2: Cutting costs per metre cut.
Cutting gas: Oxygen. Material: Structural steel. CO_2 laser at 1500 W.
Machine hour rate, labour cots and overhead costs were taken from Table 1.

determined. The consideration of costs per metre does not take secondary processing times into account in the calculation. However, these must be considered for the costs per component, as secondary processing times are very dependent on the type of machine and even on the peripheral equipment (e.g. parts supply or removal equipment). It is very difficult to use realistic values in process comparisons. Since Linde prefers cost considerations that are not machine specific, we will look at the costs per metre more closely in this article.

Machine-hour rate - the basis for evaluation of cost efficiency

We have kept very close to proven methods in the method selected below to calculate machine-hour rate and, subsequently, manufacturing cost rates. Table 1 (page 3) shows a general example of cutting cost calculation using a laser cutting machine and lists all the relevant points.

Costs per metre for cutting, welding and surface treatment

Table 2 (page 3) shows an example of how the cutting costs are calculated per metre for the cutting of structural steel in one-shift and three-shift production. In such evaluations the various cost factors can be classified very easily. This example demonstrates that the machine-hour rate represents the largest part of the overall costs. The costs can therefore be reduced most easily and significantly if the machine is used to fullest capacity.

The method used in Table 2 can naturally also be used to calculate the costs for laser fusion cutting with nitrogen. A slightly modified and extended method is used to calculate the costs per metre for laser welding or surface treatment with lasers. The cutting gas is then replaced by a shielding gas. The method has to be extended to include items such as filler materials, wire or powder or powder carrier gas.

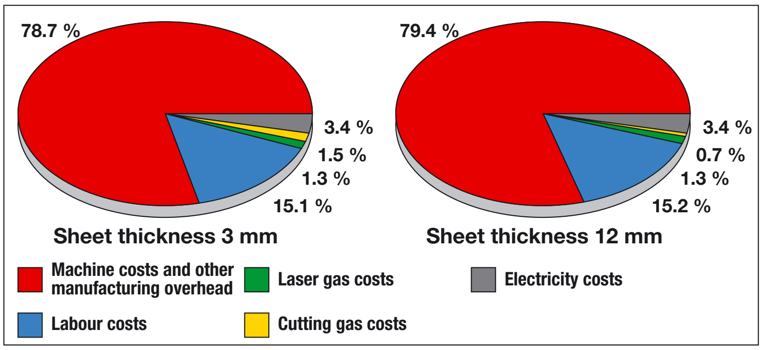

Fig. 1: **Costs incurred in laser cutting of structural steel using oxygen 3.5, one-shift production, 80 % utilisation of the machine**

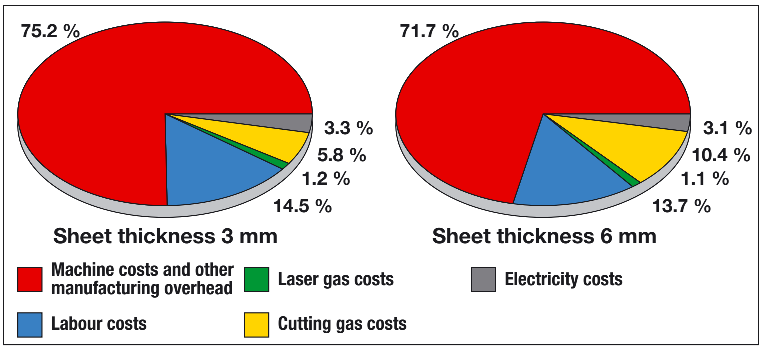

Fig. 2: **Costs incurred in laser cutting of CrNi steel using nitrogen 5.0, one-shift production, 80 % utilisation of the machine**

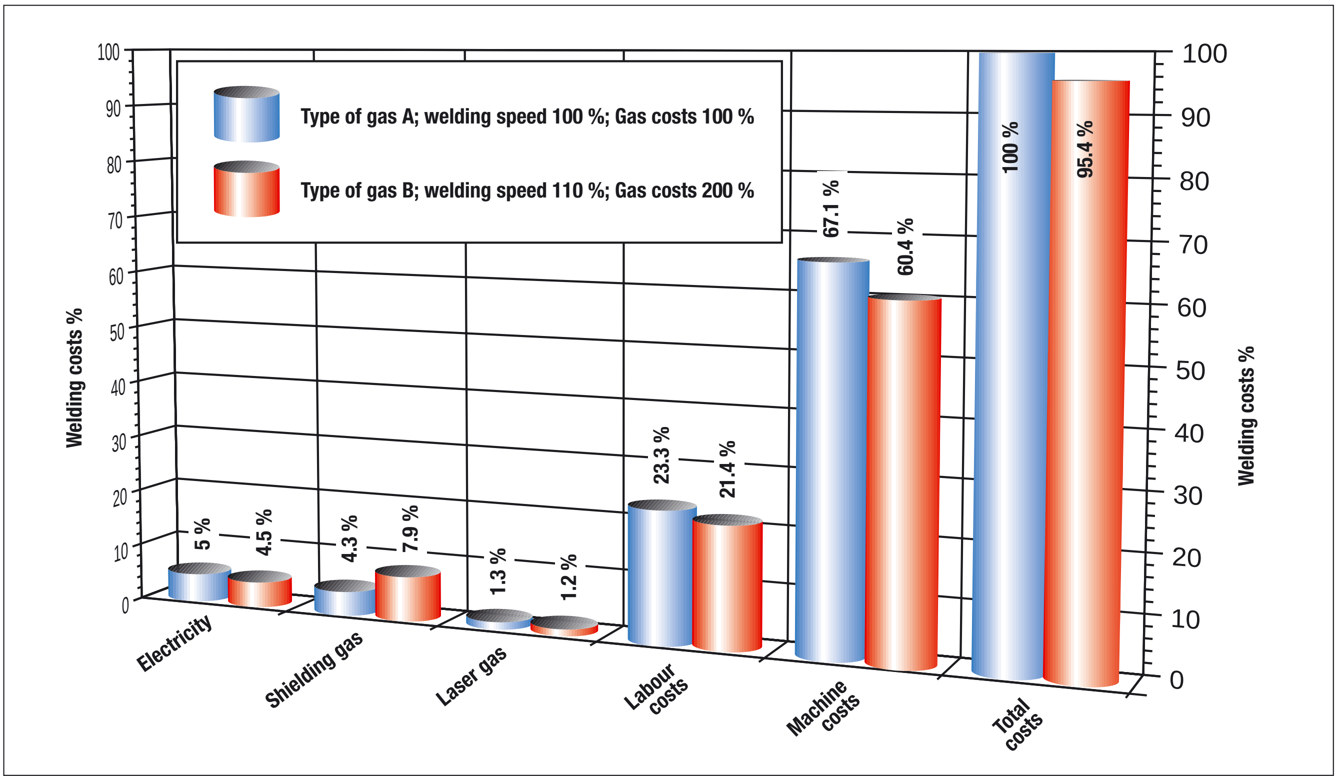

Fig. 4: **Comparison of costs of different types of gas used in laser welding**

Effect of gases on process costs

The diagrams above are very helpful for analysis of the process costs. The separate costs for machines, wages, energy, consumables and other items are shown in detail. Machine costs (overhead costs) together with labour costs account for the major part in all the laser techniques discussed in this article. The costs for laser gases, lenses and nozzles for CO_2 lasers represent just the smallest part. The costs for laser gases are low because modern CO_2 lasers have very low consumption rates. Thanks to their long service life the costs for lenses and nozzles are usually considerably less than 1% of the processing costs.

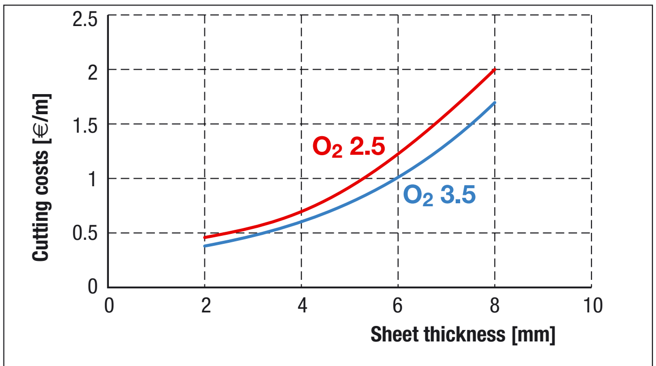

Fig. 3: **Cutting costs incurred in cutting with 99.2 % oxygen with purity 99.7 %**

The assist gases used in each laser technique account for costs to different extents depending on the type of gas and the consumption quantities required. This is illustrated for laser cutting in the two charts (page 4). Whereas the amount of cutting gas used in laser oxy cutting is very small (Fig. 1), the amount of cutting gas used in laser fusion cutting with nitrogen is larger (Fig. 2). In this case the much lower feed speed, the higher gas pressures and thus the higher consumption of the gas affect the calculation. On the other hand, gases offer potential to save costs for lasers to a much higher extent than the actual gas costs represent. The quality of the cuts produced by laser fusion cutting with nitrogen is often considerably higher for further machining of the parts than the specifications require. Therefore, costly finishing processes can be omitted. There is therefore also potential to save costs in the subsequent machining processes.

Savings can also be made with laser oxy gas cutting. The use of oxygen with higher purity (O_2 3.5) results in a higher cutting speed compared to industrial grade oxygen (O_2 2.5). This clearly counterbalances the higher price as shown in Fig. 3. But the higher purity gas also results in higher process reliability. If industrial grade oxygen is ordered there may well be some higher quality oxygen in the cylinder that is not required for the minimum quality of 99.5% purity. Should this be the case the cutting parameters must be adjusted in order to achieve good results. However, if oxygen 3.5 is used, any higher purity in the gas cylinder would affect the cutting parameters only to a negligible degree.

The influence of the gas can also be seen with laser welding although in most cases it is more complex. In the simplest case the welding speed can be increased through the use of a shielding gas or shielding gas mixture that is optimally suited for the process. The savings are evident even in the case of an expensive shielding gas, as shown in fig. 4. It is not so easy to evaluate the effects of less spatter formation, an optically pleasing seam or increased process reliability. Such factors cannot be taken into consideration in the calculation method described above. However they must be included in a complete cost evaluation, i.e. any savings in work or costs in following steps must be taken into account. It must also be taken into consideration that a construction designed for laser welding can make a major contribution to low-cost laser welds. Simply replacing a conventional welding seam with a laser seam without making design modifications will seldom be successful in economic terms.

The above-mentioned examples of laser cutting and laser welding are indicative only. For individual cases there is a MS-Excel data sheet available for an exact calculation.

Conclusion

The first impression of laser techniques is that these are not among the most economic manufacturing processes. These often even have the reputation of being extremely expensive processes because of the high investment costs. However, an evaluation of all the circumstances reveals that lasers can achieve not only technological but also economic advantages. This includes both preliminary and finishing treatments and design work. The calculation methods shown can be very helpful in calculating costs and have proven their case practically in many applications. Linde offers anyone interested in lasers the possibility of making individual calculations for machine-hour rate and process costs, such as costs per metre cut or costs per metre weld seam. We would be pleased to assist you with your individual cost/benefit evaluations.

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