



Laser beam & water jet cutting of Quadrant Engineering Plastic Products' stock shapes

A) Introduction.

Parallel to the development of new plastics and new applications in plastics, new methods for machining them have been discovered and developed.

In the past years laser beam cutting and water jet cutting have been solving more and more tasks, where other conventional methods could not do the job or were too expensive.

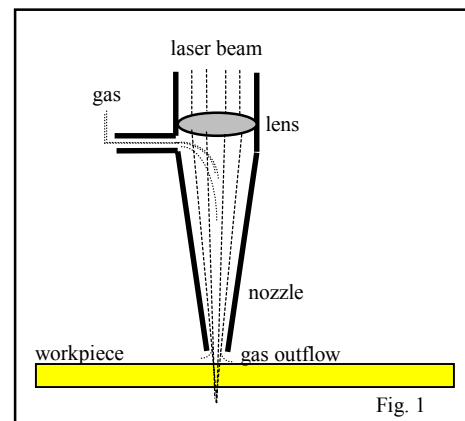
Now these new methods have become durable and economic, and they have some very interesting advantages.

Laser beam and water jet cutting will not replace the conventional cutting techniques, but can rather be used as convenient complements for machining complex geometries in single-part and small series production.

B) Technology.

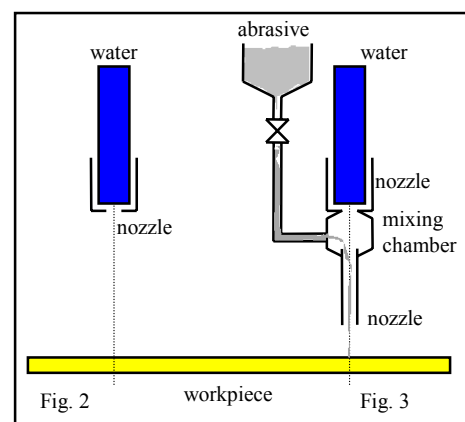
a) laser beam cutting :

For cutting plastics, laser-melt cutting is used. An unfocused laser beam, with a wavelength of $10,6 \mu\text{m}$, is focused by a lens to a diameter of about $150 \mu\text{m}$ (Fig. 1). The plastic is molten by the very high energetic beam and the melt is blown away by a gas and/or evaporated. For cutting inflammable plastics an inert gas is used to prevent the plastic to burn .



b) water jet cutting :

Water is compressed up to 4000 bar by a very high pressure pump. A nozzle with a diameter of 0,1 to 0,3 mm forms it to a very small beam with a velocity up to 900 m/s (Fig. 2). This high energetic beam is capable of cutting through all kinds of plastics, but to cut reinforced plastics an abrasive (e.g. sand) is added to the water (Fig. 3).





C) Comparison.

Both laser beam and water jet cutting can be used in similar applications, although laser beam cutting has its limitations depending on the type of plastic to be cut and the thickness of the workpiece.

The two methods have several similar advantages over conventional machining :

- very complex forms, with sharp edges, are possible
- no tool costs : no tools, no tool changes, no tool wear
- no difficult clamping of the workpiece
- very low clamping forces, resulting in almost no deformation of the workpiece. Therefore, thin walled pieces can be cut without any problem.
- three-dimensional cutting is possible
- it is possible to optimise the whole sheet by nesting the workpieces in the best possible way in the plate
- there are no chips
- cuts can be started or ended at any point in the workpiece
- the cutting width is small
- the machines are easy to operate and very flexible



water jet cutting

As always there are also some disadvantages over conventional machining :



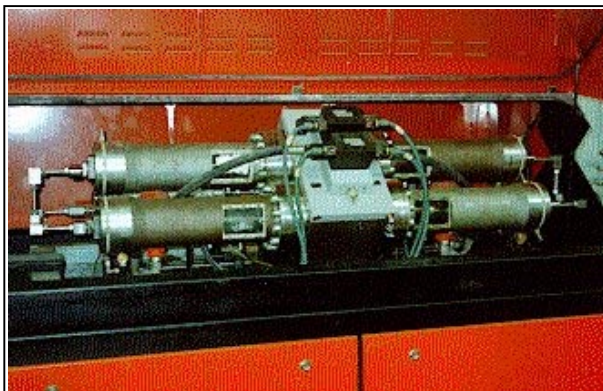
laser beam cutting

- the cut must go right through the whole thickness of the workpiece
- the cutting speeds are limited, depending on the geometry, tolerances, required finish and type of plastic
- not all plastics can be cut with a laser, depending on the rate of absorption of the laser beam by the plastic
- With laser beam cutting there is a conflict between the cut quality (surface finish) on the one hand and the width of the heat affected zone and the hazardous by-products on the other hand. The cut quality can be improved by reducing the cutting speed, but by doing this the heat affected zone becomes larger and thus more, possibly hazardous, fumes can be set free.



LASER	WATER JET
<ul style="list-style-type: none"> tolerances up to +/- 0.05 mm , standard tolerances : +/- 0.1 mm thickness up to 30 mm cutting width 0,1 to 0,5 mm the smallest possible holes are about : diameter = 1/3 of thickness difficult for reinforced materials possible toxic fumes (*) in some cases burrs can be avoided, by optimising the cutting-conditions it is not possible to cut through more than one plate at a time 	<ul style="list-style-type: none"> tolerances up to +/- 0,1 mm , standard tolerances : +/- 0,2 mm thickness up to 150 mm cutting width +/- 1 mm the smallest possible holes are about : diameter = 2 times the diameter of the water beam suitable for reinforced materials no toxic fumes or dust no burrs it is possible to cut trough several thin plates, one on top of the other
<ul style="list-style-type: none"> structural changes in heated zone 	<ul style="list-style-type: none"> no heat affected zone

(*) Information on the types of fumes, which can come free, can be found in the Material Safety Data Sheets of the Quadrant materials.



high pressure pump for the water jet

In general, the purchase of a laser is about 30 % higher than a water jet but the operating costs of the water jet can be twice as high, depending on the type of abrasive that is used.

D) Possibilities for both methods.

a) Possibilities for CO₂ lasers :

Most plastics can be cut with a laser beam but some are more difficult than the others. When we sort them according to the degree of difficulty :



So PVC is difficult to cut with a laser, whereas ERTACETAL® is rather easy to cut.

For the reinforced materials the degree of difficulty depends on the type of reinforcement :



- Aramide fibres can be cut with a CO₂ laser without any major problems.
- Glass or carbon fibres should be cut with a high performance pulsating laser.

b) Possibilities for water jet :

It is possible to cut all Quadrant-plastics with an acceptable surface finish at an economical speed and with tolerances of +/- 0,25 mm.

A polymer may be admixed to the water to optimise cut quality, or an abrasive may be added to facilitate the cutting of high-strength materials.

c) How to chose between the two methods ?

As we have seen in the comparison, the two methods can be used in very similar applications, so it can be difficult to chose between them. In that case the following questions should be asked :

- which material should be cut ?
- which thickness ?
- are structural changes allowed near the cut ?
- does the cut need to be oxidation free ?
- which tolerances ?
- is it possible to cut more than one layer ?

By answering these questions a choice can be made between the two methods, or it can be decided that neither of them can be used. If the answers to these questions did not eliminate one or both methods, a price calculation should help with the final decision.



water jet cutting with a double head



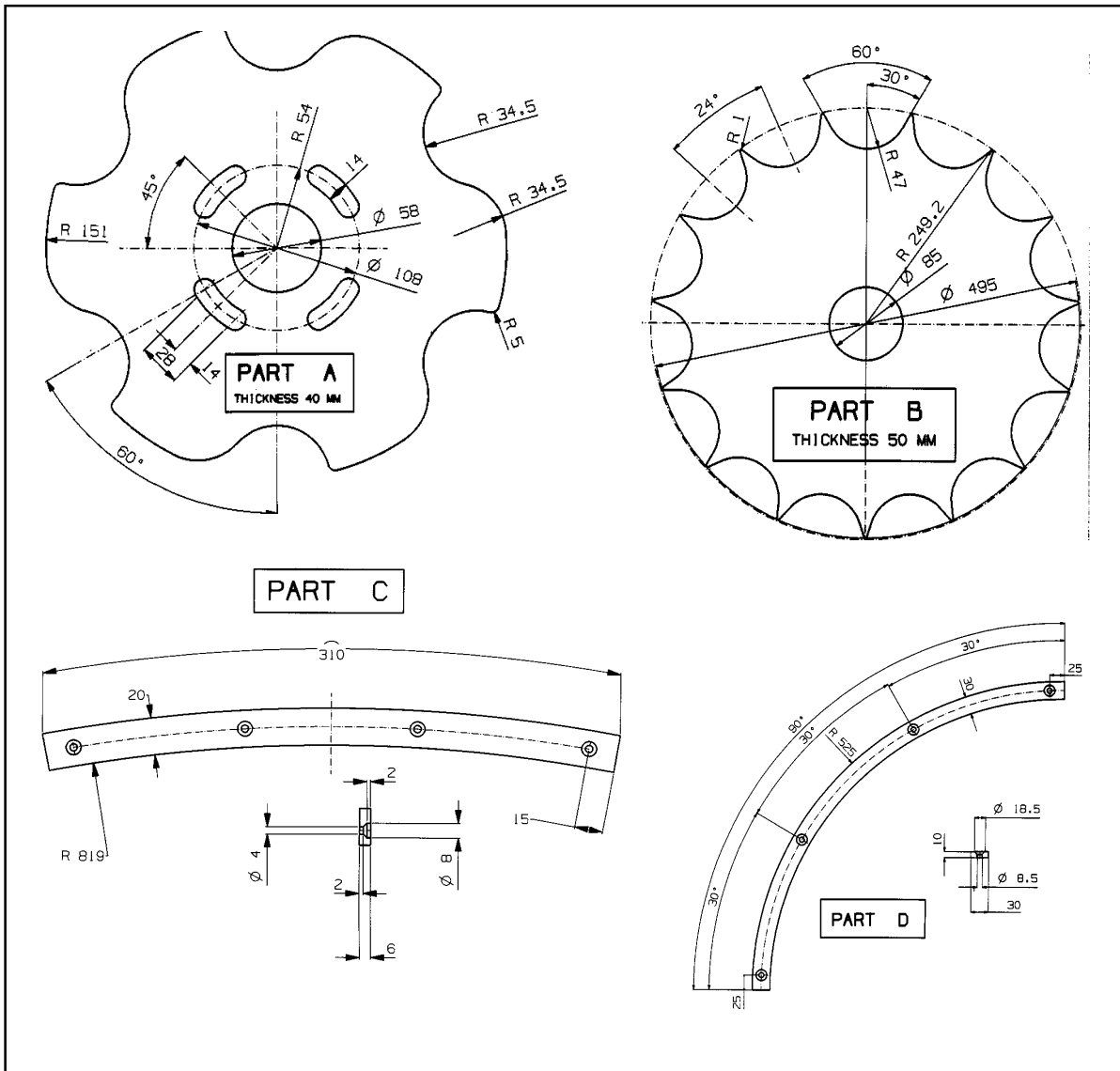
E) Some case histories.

Just to give an idea of the price levels for laser beam and water jet cutting, we compared the prices for four different machined parts. As a reference we used the price for the CNC machined part (ref. value : 100).

		<u>LASER</u>	<u>WATER JET</u>	<u>CNC</u>
PART A	1 pc	not possible	134	100
	2 pcs	not possible	114	100
PART B	1 pc	not possible	169	100
	2 pcs	not possible	142	100
PART C	41 pcs	64	102	100
PART D	100 pcs	59	47	100

Remarks :

- Material : ERTALON® 6PLA
- General tolerances : +/- 0.25 mm.
- General surface roughness : Ra 3.2 µm.
- For the parts C and D the holes can't be chamfered with a laser or water jet, this has to be done afterwards by conventional machining. The cost for this operation is included in the price.
- The parts A and B can't be cut with a laser because they are too thick.
- When parts A and B were cut with a water jet the holes were not perfect because, in thick plates, the water jet diverges at the end of the cut. The holes had to be adjusted manually so that the pieces could fit on the shaft.





F) Future developments.

A new, very interesting and revolutionary technique is being developed : the waterlaser !

This new technique combines a laser beam with a water jet ! Here the laser beam is guided through a water jet in a similar way as in an optical fibreglass cable. In doing so, the water jet also functions as a coolant, making it possible to cut materials without the disadvantage of creating a heat affected zone. The water jet also prevents the laser beam to diverge, because it focuses the beam. According to the inventor, it should be possible to cut plates up to a thickness of 100 mm. We are very interested from hearing about this new development in the near future !

G) Conclusions.

The laser beam as well as the water jet cutting process have their pros and cons for certain applications and neither of them can be claimed to be basically superior to the other. Both methods have the right to exist and complement the existing cutting or machining methods. When two or more methods are possible for the same application the cost factor will decide.

H) Literature.

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With special thanks to Mr Lefèvre (L & D Jet Techniek) and Mr Braeckvelt (Neon Elite).