

Advances in Water Jet Cutting Technology: High Capacity Cutting with 180 kW as the Next Step after 6 kbar Cutting

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1 ABSTRACT

Job shops using water-jet cutting technology are always looking to reduce the specific cutting cost in order to maintain competitive prices. One way is to increase the cutting power for fast and multiple operations. This requires large capacity high pressure pumps and flexible handling systems. On the other hand, the reliability requirements on the equipment has dramatically increased, since in case of a system downtime, cutting is stopped at all cutting heads simultaneously.

This paper describes the practical considerations when building and installing a high power cutting system using a 180 kW pumping system together with 12 abrasive cutting heads.

2 INTRODUCTION

The L&D Jet Techniek Company in Belgium stands for a professionell enlarged Job Shop in water-jet cutting.

The attempt of the L&D company is, to get the water-jet cutting out of the spheres of the „exotical“ cutting processes and to give it the entitled room in the range of the established cutting-technologies.

The tribute of this cold cutting process has been reached by now, thanks to its specific advantage.

Since water jet cutting is competing with a lot of other cutting processes such as laser-cutting or plasma-cutting it has to prove superior to extend its market share. Therefore a further development in the direction of increased power has to be enforced.

By Know-How and publication of the specific advantage, possibilities and variety this kind of cutting technology is used increasingly. The success is the dramatically increase of new business in the Job Shop sphere.

The L&D Jet Technik Company has been one of the first companies in Europe, who dealt with the development in 3D area with very big components (portal frame system, dimensions 4,000 x 6,000 x 1,450 mm) in the day-to-day business.

Furthermore, L&D is the first company, who uses the 6.000 bar water-jet-technology.

In the reference to productivity increase by the acquisition of a CNC portal frame system with 12 abrasiv cutting heads now a new highlight was set.

Target was to cut in an efficient economic way smaller series in aluminium, INOX or other special materials, either finished parts or in addition/co-operation with other mechanical manufacturing processes.

It is already proven that many technical parts can be mostly produced by using water jet-technology, where tolerances are demanded by 0.10 mm. If higher tolerances are demanded, another manufacturing process, e.g. milling or grinding can be connected at the outlet side.

A further highlight of the water jet technology is the „piercing“ which enable the beginning of working in the workpiece. The employment of the nesting technology leads to saving in material.

By pre-working (raw) the outlines accompanying with the nesting technology the following mechanical treatment and costs are thus reduced. The machine cutting expenditure reduces.

Another operational area, where the employment of a multi-head plant for the economic manufacturing is indispensable, is the production of perforated plates of large material thickness. Perforated plates can be manufactured in this way more favorably than by drilling.

Further advantages:

- no temperature-dependent deformations
- no burr formation
- no restriction with the plate thickness

For years users of the water jet technology observe a trend unpleasant for it. When cutting thin sheet production items a substantial order shift takes place to favour of the laser cutting systems.

The reason is that the laser system offerers could increase their plants performance by constant developement and could therefore achieve a large economic advantage for their customers.

These considerable innovative progress of the laser systems led to the fact that the enterprises, primarily JobShops, had to accept substantial order losses in the abrasive cutting of production items. Also the developed 6000 bar technology could not stop this trend. Logically another way had to be hit in the range of the thin sheet series production.

Two solutions were thought of:

Solution 1 - an abrasive cutting system with a small number of cutting heads and large hydraulic power as well as high pressure for each cutting head

Solution 2 - an abrasive cutting system with a large number of cutting heads and smaller hydraulic power as well as high pressure for each cutting head

From the cost/benefit analysis the solution 2 was selected, which also contains still approx. 50% power reserve with additional hydraulic power.

3 DESIGN OF A HIGH POWER CUTTING SYSTEM

Task for the WARICUT system manufacturer (H.G. Ridder automation GmbH) was to develop a precision cutting system with 12 abrasive cutting heads attending the following conditions:

- four fully automatic cutting system axis (Y/Z axis) each equipped with a cross bar
- each cross bar carries three abrasive cutting heads with flexible linear cutting head adjustment
- each abrasive cutting head must be adjustable over a turning adjustment in X/Y direction to the table bearing surface
- for each abrasive cutting head the cutting angle must be adjusted by means of turning of +/- 45°
- dynamic heights control (cutter head to the workpiece)
- dynamic collision control (cutting axis to each other)
- dynamic collision control (for each cutting head)
- Workpiece full penetration recognition for each cutting head
- abrasive monitoring for each cutting head
- Expert system with flexible abrasive cutting head administration
- Process control over Internet/Teleservice
- Workpiece clamping system (electropneumatical)

3.1 Conversion

This condition converted in the WARICUT cutting system HWM-P3045/4x2D/4T/3SK with the following technical basic data:

	Traverse length	Material bearing area
X-axis	3.050 mm	3250mm
Y-axis	4.550 mm	4750mm
Z-axis	200 mm	
Manual adjustment of each cutting head	0-500 mm	
Adjustment of cutting head (Y/X)	+/-45° +/-10°	



figure 1: WARICUT Cutting system HWM-P3045/4x2D/4T/3SK

The basic machine was taken over from the WARICUT standard systems. Particularly for this cutting machine however the cutting head carrier axis was developed. The challenge for the H.G. Ridder automation GmbH consisted of arranging the carrier system in such a way that despite the high span a variable weight shift high precision is to be obtained (compensation of deflection, twist).

Only in this way precise cutting results of all 12 cutting heads can be obtained. An extension of the plant with a 3D-cutting head system is at any time possible.



figure 3: Siemens-Control 840D

distance, guaranteed to 100%.

A further important point was that all abrasive cutting heads get the abrasives with very high precision in order to obtain identical cutting results. Further developed programmable abrasive dosing systems ensure a deviation less than 2 %.The customer's desire for automatic operational sequence has been responded by the employment of the Siemens-Control 840D. The WARICUT expert system programmed by Ridder permits an absolutely flexible control to the entire cutting machine.



figure 2: cutting heads on a cross bar

A significant condition was the supply of all abrasive cutting heads with a sufficient sand quantity. By the Vacuum technology developed by Ridder themselves was this, even with large

Functionality is developed with the WARICAM system so far that all abrasive cutting heads as well as abrasive cutting axis can be programmed in the job planning or directly at the WARICUT cutting machine. It can be specified, which abrasive cutting heads must work and which abrasive cutting axis can be driven into park position etc.

The WARICUT expert system possesses many further functions, which make a large flexibility possible in the everyday cutting enterprise.

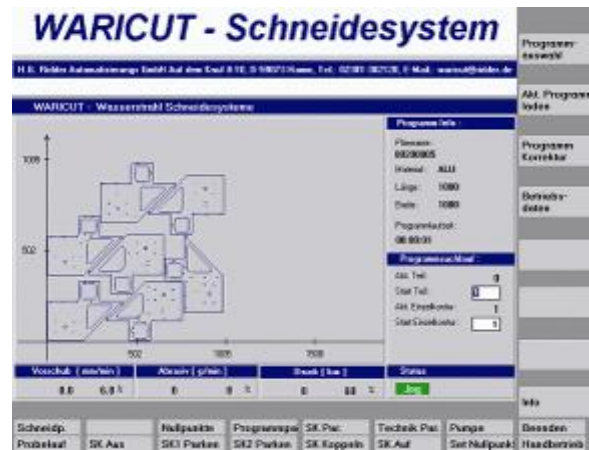


figure 4: WARICUT expert system

4 THE 180 KW HP PUMPING SYSTEM

For industrial waterjet applications typical intensifiers are designed for 3,800 bar design pressure and flow rates up to 8 l/min. Such state-of-the-art intensifiers are offered nowadays by several suppliers, both from Europe and the United States.

Their reliability is acceptable and allows two shifts or even three shift operation. Differences in lifetime for the high pressure components and packings are marginal and depend often on the grade of maintenance.

The development of a 180 kW HP Pumping system for a flow rate of 16.8 l/min at 4,150 bar is a potential factor to increase the productivity of the process and especially for the presented multiple-head system.

Certainly this is one step in the correct direction to increase productivity but the reliability and the flexibility of such a pump has to be taking into account.

Type	Unit	HP19/15-S	HP19/37-S	HP19/45-S	HP19/75-D	HP19/90-D
Discharge capacity	l/min	1.6	3.8	4.2	7.6	8.4
Working pressure	bar	3,800	3,800	4,150	3,800	4,150
No. of HP units	pc.	1	1	1	2	2
Power	kW	15	37	45	75	90
Sound pressure level	dB(A)	75	75	75	78	78
Net weight	kg	1,000	1,450	1,450	1,900	2,100

table 1: Basic characteristics of a Commercial pump series

A commercial pump series [table 1] is based on nearly identical high pressure parts, while the hydraulic drives differ with respect to the flow rate. For instance, the 8.4 litres/min, 90 kW pump combines two parallel high pressure units in order to achieve the larger flow rate.

Table 1 lists the basic characteristics of pressure intensifiers with different flow rates that are established in the market for pure water and abrasive cutting.

For this WARICUT cutting machine the company UHDE developed a high-pressure pump system with a rated output of $P=180$ KW and $Q = 16.8$ l/min. with a pressure of 4150 bar.

The system was installed in the work H.G. Ridder for the preliminary acceptance test and tested with the complete WARICUT cutting machine.

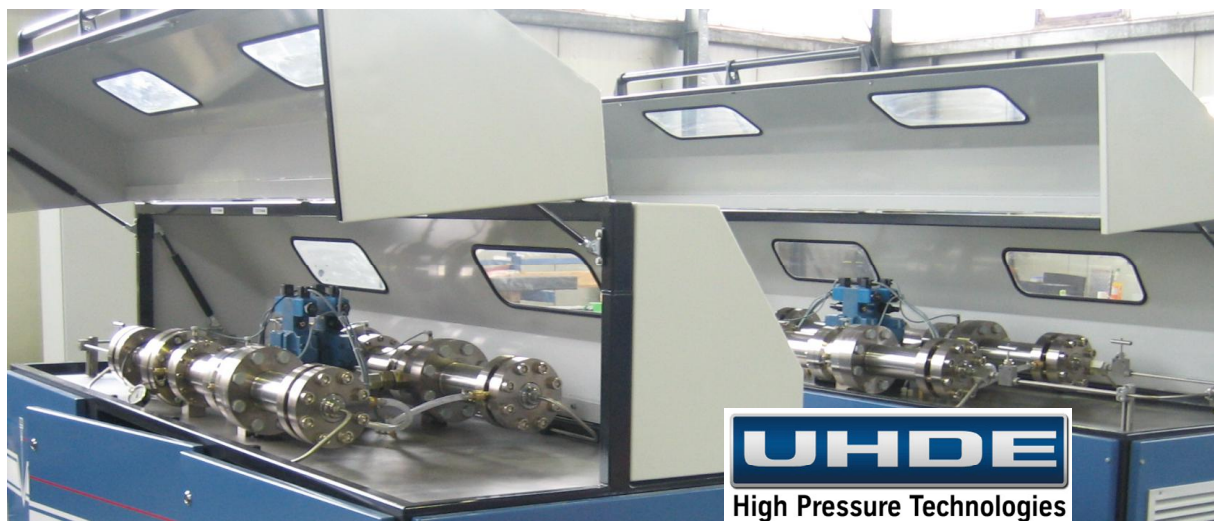


figure 5: System installation at site

4.1 Structure of the pumping system

90 kW HP intensifier are already running satisfactory in the waterjet industry.

Therefore the 180 kW system should comprise out of two standard already proven UHDE pumps type HP19/90-D in combination with its common-rail system.

Thus same reliability and maintenance costs as for the standard UHDE HP intensifiers can be expected.

Each UHDE HP pump type HP19/90-D consists of two HP intensifiers, thus the 180 kW

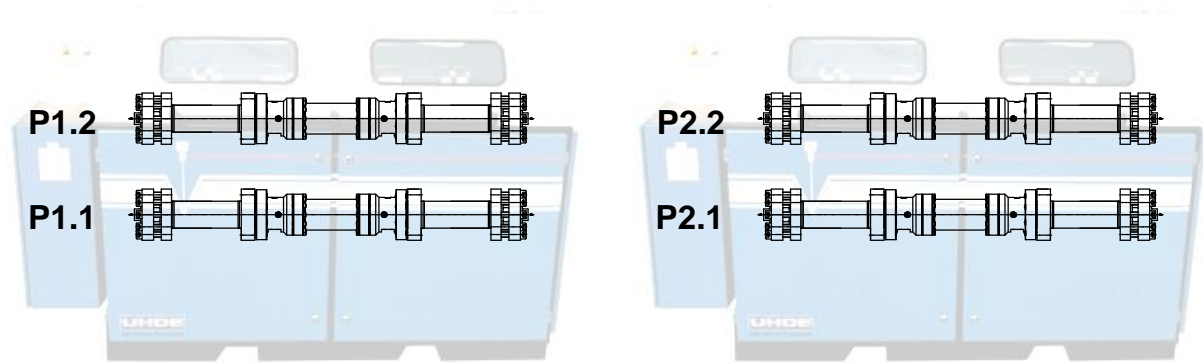


figure 6: Structure of the 180 kW Pumping system / Arrangement of Hp intensifiers

pumping system consist of four.

The HP pumps are connected via a manifold (HP piping) [fig. 7]. At the junction of the HP manifolds two (2) high-pressure transducers PT1 and PT2 are installed for redundancy and safety reason. A manual HP Stop valve is installed in the HP discharge line of each HP Pump for maintenance reason.

To allow independent operation, each HP pumps is equipped with its own LP filter, HP filter, pulsation dampener and HP relief system.

Both HP pumps are controlled by the same PLC and are operated from one local control panel. Furthermore they can be operated externally by the control of the CNC Waterjet system.

4.2 Hydraulic principle

The working principle of state-of-the-art water-jet cutting pumps is that of a reciprocating hydraulic piston, which compresses water on one side of the piston while suctioning on the other side [fig. 7].

Each UHDE HP pump type HP19/90-D consists of two HP intensifiers, independently driven by an axial-multi-plunger pump which generates an oil pressure of approx. 200 bars.

The hydraulic drive is equipped with a dynamic hydraulic controller to adapt it to the pressure and flow requirements.

Due to manual stop valves with electric position switches in the line from the hydraulic pump to the hydraulic cylinders, it is easy and safe to disconnect intensifiers for maintenance work (fig. 7).

The hydraulic oil is fed to one side of the hydraulic reciprocating piston which causes a movement to the other direction. The end of travel is detected by a pressure resistant proximity switch installed inside the hydraulic cylinder. The signal from the switch causes a fast 4/3-proportional-way oscillating valve to re-direct the oil flow in a manner which is fast (to limit pressure peaks on the HP side) but smooth, in order to avoid damage of the hydraulic components. The interruption of the water compression at the reversing point of the piston

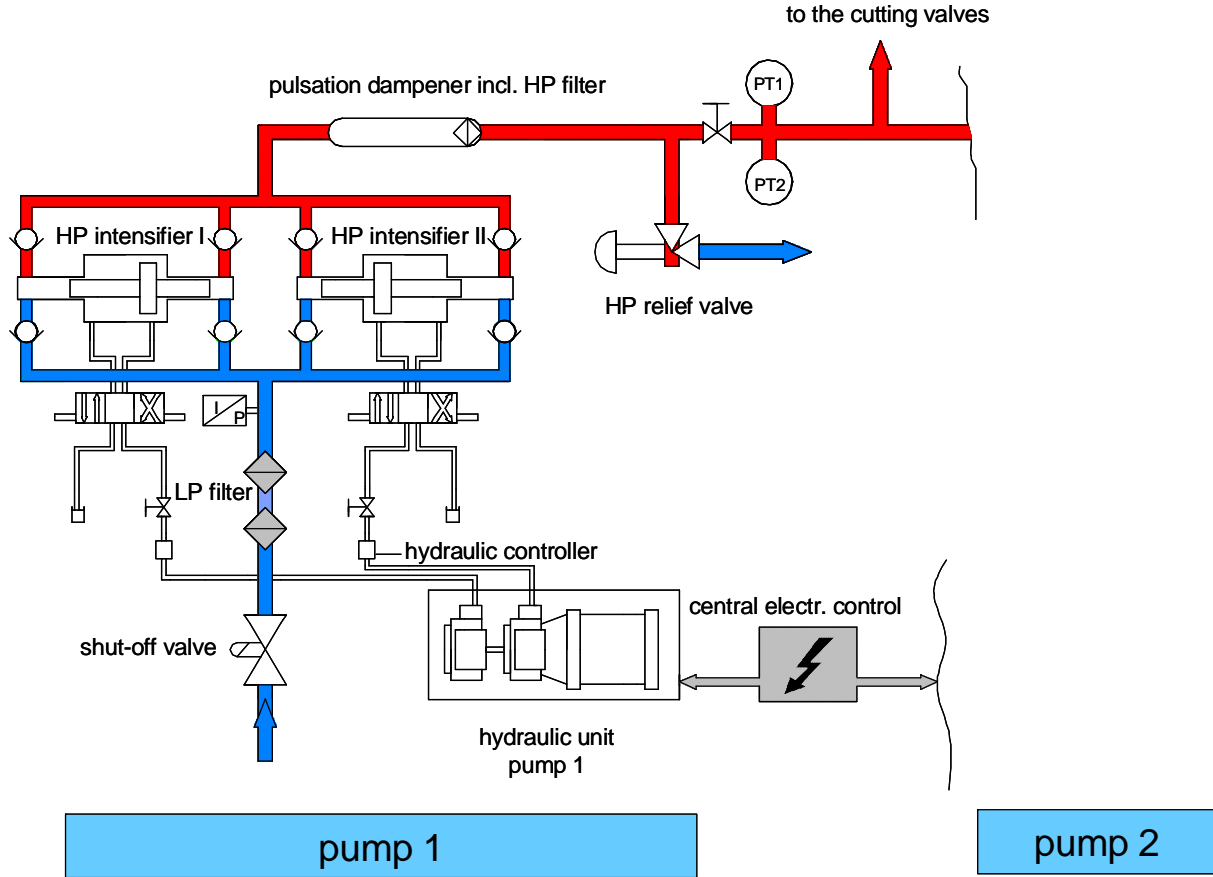


figure 7: Structure of the 180 kW Pumping system

produces a pressure pulsation. A high-pressure pulsation dampener is used to lower the pressure pulsation.

4.3 Common Rail System

Larger flow rates, in this case 16.8 litres/min at 4,150 bar, are realised by operating two UHDE Standard pumps HP19/90-D with a common rail system. This means that four HP intensifiers (two per HP pump) run in parallel and feed into the same line (fig. 6 and 7).

The signals from the limit switches inside the hydraulic cylinder are used for phasing / control mode of all connected plungers of the common-rail system and to equalize all plunger speeds.

The overall control system ensures a synchronous run of all pumps with the same stroke rate and hence the same work load.

The HP intensifiers of the common rail system are running with a maximum difference of approximately +/- 1 number of strokes per minute.

An advantage of the 2 pump / 4-intensifier pumping system is that even when one intensifier fails, cutting can be continued with reduced power of 75%.

In general it is possible to run each HP pump with only one HP intensifier or only to use one HP pump at all of the 180 kW system (Fig. 6 and 7). Thus, instead of using the full flow rate of 16.8 l/min, the system can easily be reduced to 25 % (4.2 l/min) power.

Due to the chosen Common-Rail Hard- and Software system in combination with the plunger speed monitoring, the level of pressure pulsation is reduced to superior +/- 50 bars at full flow and maximum pressure by using only one HP pulsation dampener with 2 l volume per HP pump.

Current pressure intensifiers for water-jet cutting technology have been developed with the aim to guarantee a maximum of availability and reliability under continuous operation while reducing the operational and investment cost for the owner.

Operational cost of this pumping system have reduced by

- design with few wear parts
- usage of already proven and well-established HP intensifier and hydraulic components
- realisation of short maintenance and repair times
- long intervals for standard maintenance through long service life
- infinitely variable pressure over the full operating range which enables the user to set the most efficient working pressure
- pressure variations of less than 1.5 % which guarantees high cutting power

5 SUMMARY

Certainly still new possibilities and market segments for high-pressure water jet cuts can be found. Again the possibility offers the technological advantages of this water jet cutting machine of producing small series with short delivery times. This abrasive waterjet system can be used flexibly between 1 to 12 heads.

Depending on customer inquiry programmes can be adapted over the plant control.

Cutting with the maximum operating pressure of the plant of 4.150 bar has further advantages: With same cutting speed one reaches opposite 3.500 bar plants precise planes of section and surface qualities of 3,2 µm.

If separation cuts without large requirements to the surface quality are requested, speed can be increased with simultaneous reduction of the abrasive mass flow quantity due to the 600 bar higher pressure.

The HP pump system convinces by the high quiet running, the pressure fluctuation at rated operation point is only +/- 50 bar. Also this pressure stability has not only the advantage of high wearing part service lives, but the smaller these pressure deviations are, the higher is the reachable cutting quality. These qualities lead inevitably for the user to higher efficiency and better productivity.

The presented high performance cutting system offers certainly still further possibilities. They have to be tested and selected.

Surely there are some, today still unknown possibilities, which can enrich the niche market of the water jet cutting engineering. These can be made only by close co-operation between users, machine and pump manufacturers and brought ready for the market one.

A permanent exchange of experience between users and developers of water jet systems is absolutely necessary in order to develop customized, highly available systems.

6 RESUME

The WARICUT cutting system works since the beginning of July 2006 for the complete satisfaction of the client company L&D. The common development of this large water jet technique project was an interesting challenge, and a ambitious setting of tasks, which were solved. This is an important step for the further development of the high-pressure water jet technology.

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