Ruby nozzles for improved edge trimming and for oscillating HP Showers.

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Ruby tipped needle jet nozzles for edge trimming and high pressure (HP) showering were introduced to the paper making process over 15 years ago. The main feature of these nozzles is the use of a high precision Ruby orifice. This proved to be the best answer to a twofold question:

- How can we create a nozzle which provides an extremely laminar water jet?
- What has to be done to achieve a great lifetime?

Ruby (corundum, Al_2O_3) is a natural or man made crystal which has the second greatest hardness after diamond. Since Ruby is a single crystal with a completely uniform structure, it is possible to machine it to a very high degree of dimensional precision in any respect. This involves grinding and polishing processes, where metal would be machined shaping it by chip removal. Thus, surface finish, tolerances, roundness, cylindricity and uniformity of the edges of the channel producing the water jet are absolutely precise.

This kind of nozzle is used in paper machines primarily for edge trimming and tail cutting, and in High Pressure Showers used for cleaning or conditioning forming fabrics, press felts, dryer felts and various types of rolls.

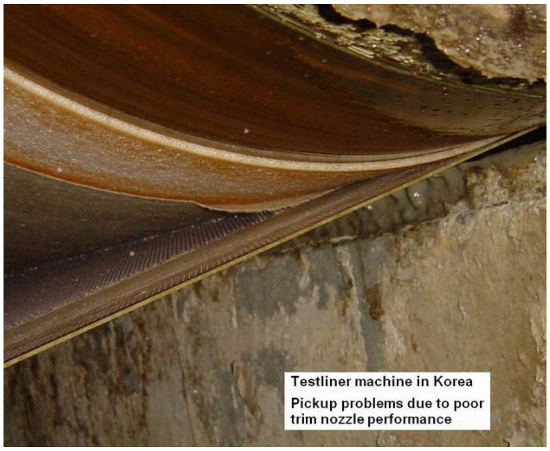
<u>Wet End Edge Trimming</u>

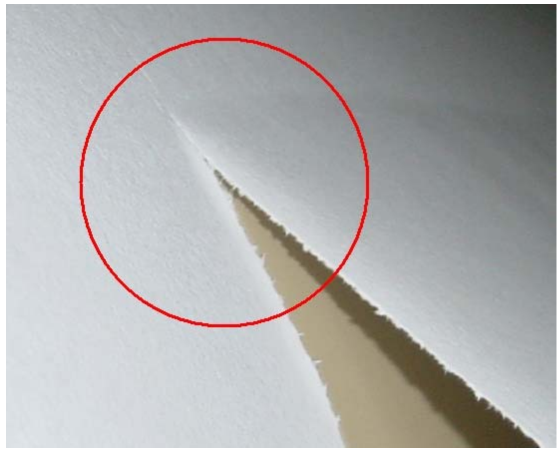
Edge trimming and sheet break frequency are directly related.

The web edge must be uniform and straight, without being thicker than the body of the paper web.

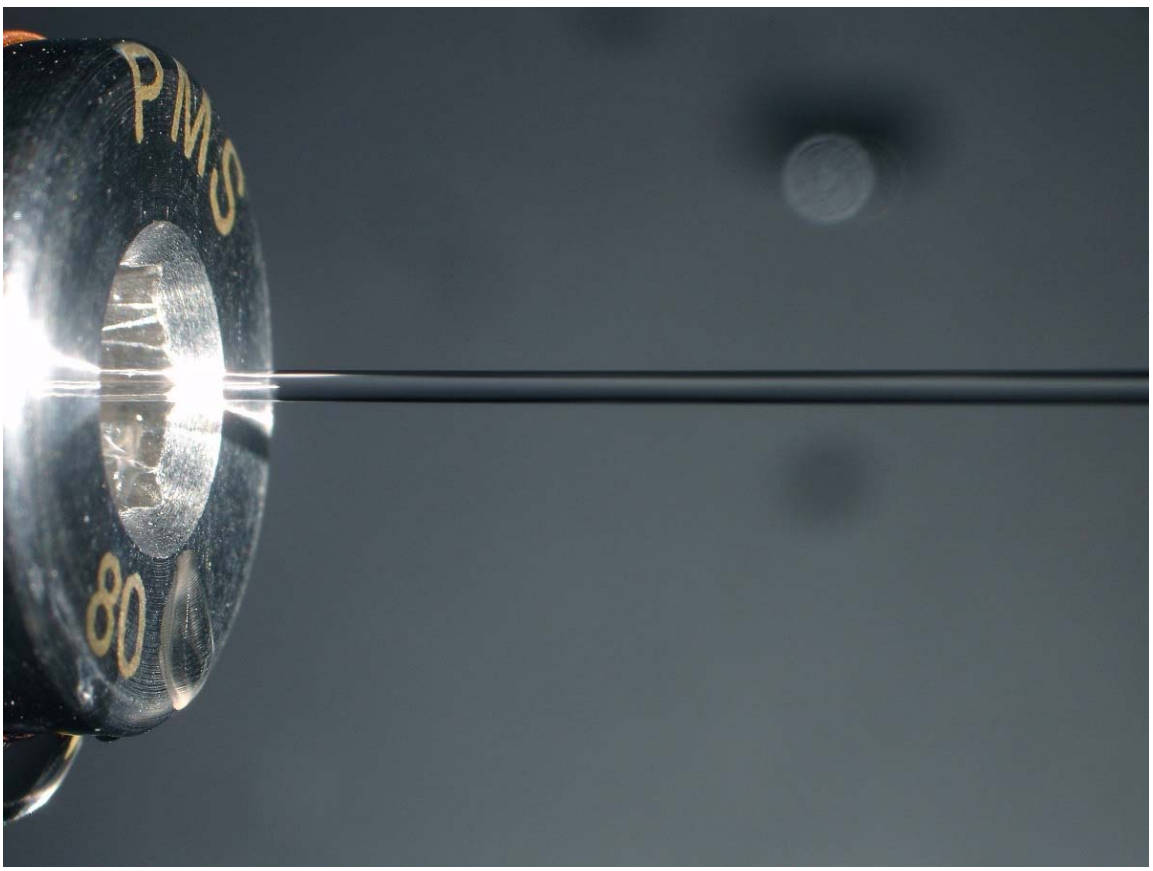
If edge faults appear, these will lead to a sheet break eventually. Breaks may occur in the dryers, Size Press area or around the calender, and not all papermakers can see the relationship with trim nozzle performance right away.

On many paper machines more than 50 per cent of web breaks are related to defects of the paper edge. That means that tons of production ends up in the pulper and not on the reel.





For a perfect edge trim, water jets must be extremely laminar in order to avoid edge defects, and to create as little fiber mist as possible.



Laminar jet

High speed machines mostly use double jet nozzles: the first jet cuts a furrow and the second jet makes it a little wider, moving the edge of the furrow towards the wire edge slightly. These nozzles usually have metric threads and O-rings for sealing – avoiding the use of Teflon tape which often caused nozzle plugging in the past.

A recent further development is the triple jet Ruby trim nozzle which features 3 perfectly parallel laminar jets. This nozzle allows the use of even smaller jet diameters for an improved edge cut, triple jet nozzles are now in use on some of the fastest graphic paper machines in the world, as well as on “normal” paper machines.

One important element is the need to use sufficient water pressure. The kinetic jet energy is what creates the furrow in the pulp, as the water jet hits it. Due to the fact that energy is a function of mass and acceleration, smaller jet diameters require a higher operating pressure. This also means that if the water pressure is low, a greater jet diameter is required. And papermakers know that a smaller jet makes a more even cut.

To determine the water pressure required, there is no real rule to apply, but experience is required, acquired on other comparable machines. If the pump supplies ample pressure, it is easy to reduce it to the most suitable value, but if the pump does not supply enough pressure, there is no way of increasing it.

Jet diameter and water pressure for trim squirts
(double and triple jet nozzles)

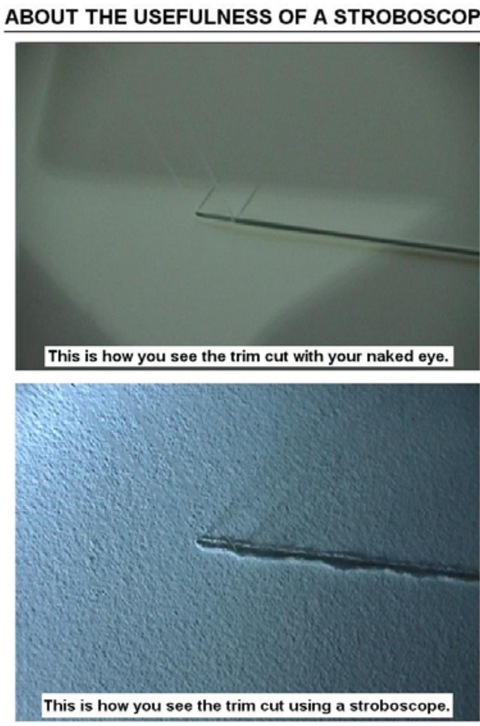
V_{Wire} (m/min)	sheet weight (g/m²)				
	< 50	50 - 80	80 - 120	120 - 170	> 170
< 500	0.5	2 x 0,4	2 x 0,4	2 x 0,5	2 x 0,6
500 - 700	2 x 0,4	2 x 0,4	2 x 0,4	2 x 0,5	2 x 0,6
750 - 1000	2 x 0,4	2 x 0,4	2 x 0,4	2 x 0,5	2 x 0,6
1000 - 1250	2 x 0,4	2 x 0,4	2 x 0,4	2 x 0,5	
	3 x 0,3	3 x 0,3	3 x 0,3	3 x 0,35	
1250 - 1500	2 x 0,4	2 x 0,4	2 x 0,4		
	3 x 0,3	3 x 0,3	3 x 0,3		
1500 - 1750	2 x 0,4	2 x 0,4	2 x 0,45		
	3 x 0,3	3 x 0,3	3 x 0,3		
> 1750	2 x 0,4	2 x 0,4			
	3 x 0,3	3 x 0,3			

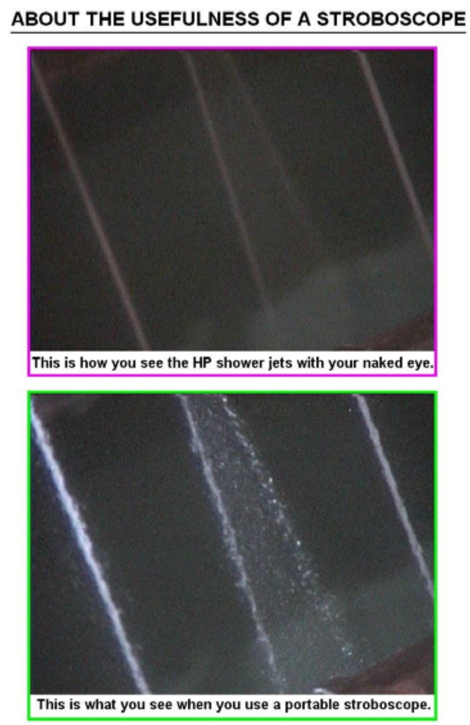
color code pressure (bar)
12
15
20
25
30
35
40

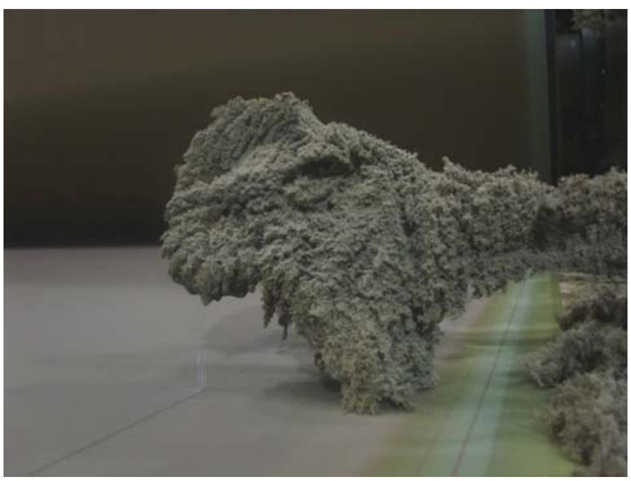
The major factors to consider when making general recommendations are:

- Basis weight
- Paper grade
- Machine speed

Any setting of nozzles during start-up and all observations of nozzle performance must be carried out by using a hand-held stroboscope with the flash frequency set in the range of 50 Hz. This allows seeing if the nozzle operates properly, which otherwise is not possible considering the inertia of the human eye (or the slowness of visual processing).







Build-up of fiber on the trim nozzle, and the pipe it is fitted to may cause a lot of issues. If particles, lumps and drops fall down, this may cause sheet breaks.

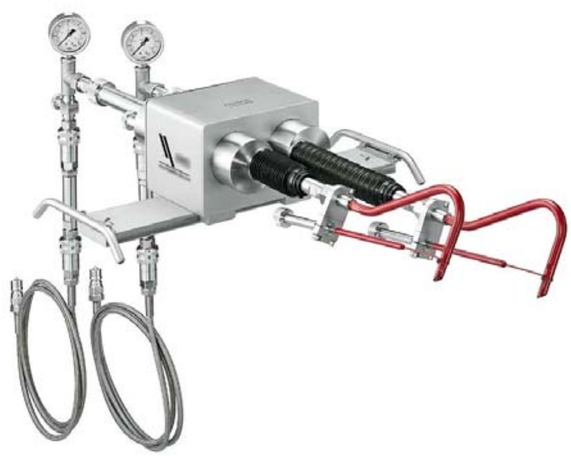
Adjusting the nozzle to its optimum geometrical position (MD and CMD inclination of the nozzle in respect to the wire) as well as suitable water pressure will help to reduce fiber mist, which can be generated by the nozzle. It goes without saying that a nozzle with poor jet laminarity will create more fiber mist than a nozzle with a perfect jet quality.

Heating the water, to approx. 120° F will help to reduce condensation on the nozzle body. Condensation would lead to wet build-up and create issues, while dry and fluffy build-up would be less critical.

In many cases it is recommended to modernize the water pumping system. There are compact systems on the market, featuring

- efficient dual pre-filtration
- double wall storage tank with level control sensors
- temperature control for water heating or cooling
- ceramic 3-plunger pumps with pulsation damping
- low energy drives with frequency converters
- automatic pressure control

The wet end edge trimming system on the machine should be easy to adjust and in a manner that is safe. Systems requiring dangerous gymnastics during adjusting should be replaced. Simple clamp designs which do not allow sensitive and precise adjustment lead to sheet breaks during operation.



The wet end Tail Cutter (travelling squirt) deserves attention: If it does not function properly, tail threading will become difficult and secondary sheet breaks may occur when widening the sheet.

A Tail Cutter installed over the forming fabric basically and logically has to be set like the DS trim nozzle, concerning nozzle type, geometry and operating parameters.

A Tail Cutter under the Pickup Felt should use single jet nozzles, in order to avoid marking of the felt. Some of these systems are equipped with a slow motion oscillation.

High Pressure Showering

The purpose of HP showering is to keep paper machine clothing and certain rolls clean and to maintain their performance and drainage capacity.

For wires and rolls we can speak about cleaning, whereas the term Conditioning is more adequately used for Press Felt showering.

The main requirements are

- efficient cleaning/conditioning using the smallest water quantity possible
- uniformity of operation in CMD, to avoid profile problems

Ruby nozzles have proven to be the leading product for HP Showers, due to their properties:

- perfect jet laminarity
- identical jets across the width
- extremely high lifetime

Considering both economical and ecological aspects, nozzle diameters must be reduced, to minimize water and energy requirements. This requires improved water treatment and filtration and state-of-the-art shower oscillation.

Incorrect stroke adjustment, uneven and/or inadequate oscillation speed and any dwell time at the return points need to be avoided, and showers should be installed in the proper position for the best performance.

By optimizing HP showers regarding the two key elements – nozzles and oscillator – substantially improved profiles are obtained and significant savings in water and energy usage are possible.

$$V_{osc} = \frac{\text{PM speed (m/min)} \cdot \text{Jet diameter (mm)}}{\text{Cloth length (m)} \cdot 60} = \text{mm/sec}$$

Water Consumption of Needle Jet Nozzles (litres/minute)								
	Water Pressure (bar)							
Jet dia. (mm)	5	10	15	20	25	30	35	40
0.30	0.10	0.14	0.17	0.20	0.22	0.25	0.27	0.28
0.40	0.17	0.23	0.28	0.33	0.37	0.41	0.44	0.46
0.50	0.25	0.36	0.44	0.51	0.57	0.62	0.68	0.72
0.60	0.36	0.51	0.63	0.73	0.81	0.90	0.97	1.02
0.70	0.49	0.69	0.86	1.00	1.12	1.24	1.31	1.38
0.80	0.64	0.87	1.08	1.27	1.45	1.62	1.71	1.79
0.90	0.80	1.11	1.37	1.61	1.83	2.04	2.15	2.25
1.00	1.03	1.41	1.76	2.06	2.35	2.60	2.82	2.97
1.20	1.53	2.04	2.48	2.88	3.27	3.71	4.04	4.32
Jet Velocity (m/min)	1,300	1,800	2,220	2,590	2,915	3,240	3,480	3,670