IMPROVING EFFICIENCY AND QUALITY USING A PERMANENT ORIFICE STEAM TRAPPING SYSTEM

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Introduction

Thank you for being here to find out about permanent fixed orifice systems. I want to thank Angus at Hampton Lumber for his role in having us on the agenda and for all the help he has given us this past year.

My company, Matrix Northwest is the West Coast distributor for Enercon Systems. Today I will be discussing how fixed orifice steam traps improve fuel efficiency, heat transfer and drying consistency. We are going to break this session into two topics followed by a question and answer period, which will be led by Dave Walker and Dean Trytten who is one of Enercon's representatives on the East Coast. Please hold your questions until the Q&A so I can get through all the information. Angus Low from Hampton Lumber is also available to answer questions. Hampton converted 6 plants within the past year.

I'll pass around a couple of fixed orifices for you to look at while I'm talking. There are a dozen kiln plants on the West Coast that have completely converted their plants to orifices, and this has occurred within the last year. Enercon is converting about one kiln plant a week now in your industry.

Topic 1 – Inconsistent Drying

One of the things we see when we visit kiln companies is inconsistent drying. For example: the wood at the top of the kiln is dry while the wood at the bottom is wet.

Topic 2 – Orifices and Varying Loads

But before I talk more about how orifices improve drying consistency, let me ask you: How many of you have heard that orifices don't work with variable loads? How many of you have variable loads?

All plants have varying loads, and all loads vary – if orifices couldn't handle a varying load they wouldn't be around. In your industry you may dry different types of wood, have different schedules, have different cuts of wood, your condensate loads will vary within a load cycle, and so forth. A little later in the presentation, I'll illustrate how modulating control valves allow orifices to work with varying loads in all of your applications.

Plant Overview Screen

Getting back to inconsistent drying. I'm sure you've all experienced problems with inconsistent drying in your kilns. What you're experiencing is inconsistencies in the heat transfer in your coils. In Figure 1, red indicates hotter temperatures and blue indicates colder temperatures. On the top is an illustration of what happens in a typical plant using mechanical traps. Mechanical traps produce inconsistent temperatures, where heat transfer capability at the bottom of the coil is lower than the heat transfer capability at the top of the coil. Orifices dramatically reduce that problem.

The bottom illustration shows the same plant with a properly-sized orifice system. Orifices allow for consistent heat transfer throughout the plant.
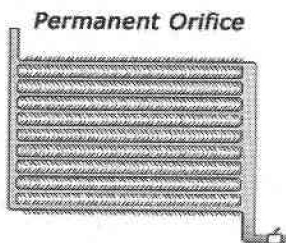
Let's look at what's happening at the coil level.

Typical Center Coils w/ Modulating Control Valve

Mechanical Traps
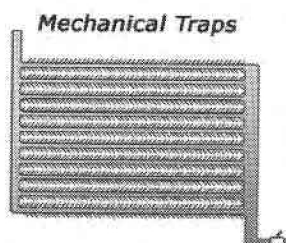
When closed -
holds back water

When open -
drains off water,
but also release steam

Permanent Orifice

Is always open to condensate

The heat transfer rate
is more consistent
from top to bottom
w/ orifice

Figure 1. Typical Center Coils with Modulating Control Valve

Comparison of Two Coils

Coil w/ Mechanical Trap: When mechanical traps are closed, they are holding back flow. The coil is still radiating heat so you have a reduction in energy-to-pound mass. The results of that energy-to-pound mass reduction is water. Water is an insulator that restricts heat transfer. Effectively the mechanical traps have shrunk the usable area of the coil because of the water that's between the coil and the steam, and they've reduced the total amount of energy that the coil can carry by not letting the water out faster.

When the mechanical traps are open, they drain water but release enough steam to cause a pressure gauge to drop. It you have 100 traps in your system, that's about 600 little pressure drops per minute. This adds up to 36,000 little pressure drops per hour, if all traps are working properly, and all of those pressure drops have to be made back up at the boiler. We estimate this costs 8% of total steam production. And this is with properly functioning mechanical steam traps. In a minute I'll show you how you can demonstrate this pressure drop at your own plant with a pressure gauge. You won't ever have these pressure drops with an orifice.

Coil w/ Permanent Orifice: Orifices bleed off hot condensate; there is no pooling of water and no insulating effect. The orifice is constantly open to the condensate. The flow of condensate through the orifice is turbulent, not laminar, and there should be no measurable loss of steam through your entire cycle. You'll have consistent pressure and uniform heat transfer throughout the coil.

Pressure Drop Experiment

Figure 2 shows an experiment you can do at your own plant. Place a pressure gauge before a mechanical trap and you can measure a pressure drop each time the trap opens. This is an example of what we typically find when we measure temperatures with a heat gun at a plant: In the example on the left the pressure is at 100 psi when the trap is closed, and the temperature in the pipe after the trap is 203 degrees. When the trap opens, the pressure drops to 90 psi before the trap, and the temperature measures 240 degrees F through the pipe. In a plant converted to orifices there will be no pressure drop. The pressure remains at 100 psi before the trap, and the temperature measures 203 degrees F through the pipe and remains at 203 degrees.

Now lets look at how these coils impact performance at a kiln.

Animation from Coil to Kiln

With mechanical traps, each coil and trap behaves differently from other coils and traps within a kiln (Figure 3), depending on the cyclical operation of the steam trap. Where the coils are hot, the wood will dry faster while the cold coils will result in wet wood.

In 1992, an orifice company outperformed a prominent mechanical steam trap company in their own labs with brand new Armstrong steam traps. A mechanical trap running a 24-hour schedule has a life expectancy of 4 years. If you have a 100-trap system you need to buy or rebuild 25 traps a year, every year, just to maintain the 8% inefficiency level. If you don't, you'll have a greater level of inefficiency. With 300 total plant conversions and 800 plant projects during Enercon's 14 years, there has never been an increase in fuel consumption. The highest fuel savings have been 40-50%.

Pressure Drop Experiment

Mechanical Trap

100 psi

203°F

Closed

90 psi

240°F

Open

Permanent Orifice

100 psi

203°F

Always
Open
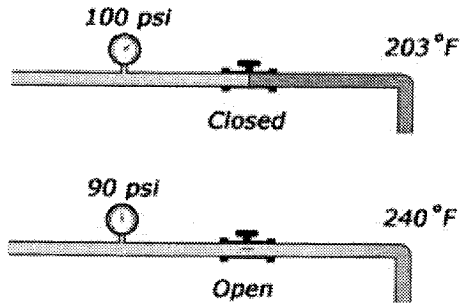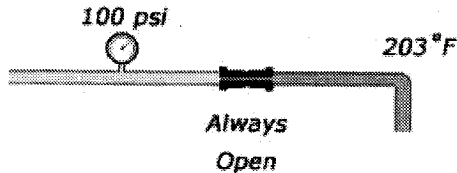
With orifices, each coil consistently has the same heat transfer rate. This results in more consistent drying from top to bottom and from end to end, providing a better quality product and a reduction in drying time per load. Now we can return to the plant level.

Plant Comparison

Plant Using Mechanical Traps: The further away a kiln is from the boiler, the more the kiln is impacted by the mechanical traps. Where coils are ganged together (two or three coils are going to one trap) rather than coils being trapped separately, short-circuiting makes this condition worse.

Plant Using Permanent Orifices: Orifices allow consistent heat transfer rates throughout the plant. Plants are telling us that their energy efficiency is increasing by 10-20%. Plants are reporting more constant steam delivery to the kilns. Some plants have been able to add additional kiln capacity. Hampton has plants that have been able to run one or more additional kilns. Merritt Brothers in Idaho increased their kiln capacity from 3-1/2 kilns to 4 kilns.
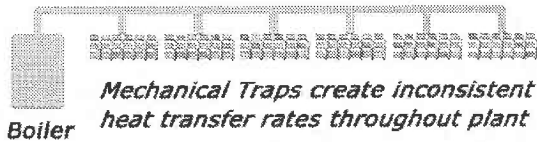
Typical Center Coils w/ Mechanical Traps
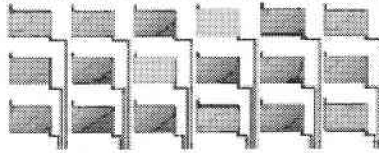
*Inconsistent wood drying
because of variations in heat transfer*

Typical Center Coils w/ Permanent Orifices
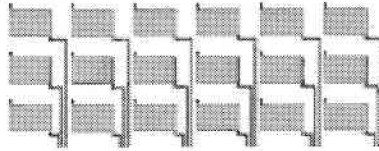
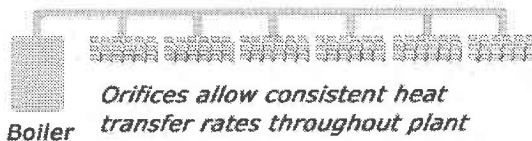*Wood dries more consistently
top to bottom and end to end*

Figure 3. Kiln with modulating control valve.

Boiler

*Mechanical Traps create inconsistent
heat transfer rates throughout plant*

*Kilns furthest away from boiler are
colder with mechanical trap systems*

Typical Kiln Plant w/ Permanent Orifice

Boiler

*Orifices allow consistent heat
transfer rates throughout plant*

*Kilns have consistent heat transfer
rates throughout plant with orifices*

Figure 4. Typical kiln plant with mechanical traps.

Summary of Topic One

What makes an orifice installation successful?

Proper sizing, quality hardware, and a warranty.

Topic Screen

Now I am going to talk about how orifices work with varying loads. People will say something like my boiler runs at 60,000 lbs per hour, but sometimes it only runs at 40,000 lbs per hour. How will orifices work with all of my loads?
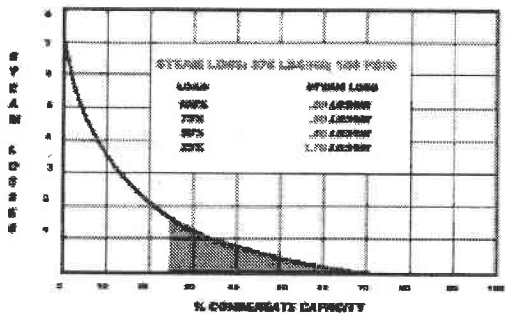

Figure 5. Steam losses under varying loads.

Steam Losses Under Varying Loads Chart

This graph shows steam loss from an orifice at a constant flow – 100 psi, 375 lbs of condensate per hour. With linear flow, you'd need 100% condensate capacity of the orifice to prevent steam from leaking. This isn't the case with turbulent flow. At 25% load, less than 2 lbs of steam per hour are lost. We estimate a new mechanical steam trap will lose about 35 lbs of steam per hour from the 8% inefficiency I've been talking about. There is no measurable loss of steam at 68% and above condensate capacity. Sometimes people think orifices improve efficiency only where the mechanical steam traps are bad. Actually, the worst case with an orifice is better than the best case with mechanical steam traps.

The guidelines for loads that qualify for an orifice are 25% to 100% of load. This is also known as a 4:1 turndown. When you have a modulating control valve, when more heat is needed, the control valve opens to increase steam flow, which translates to greater pressure differential across the nozzle, and higher nozzle capacity. As demand drops, the control valve closes and both pressure and condensate load are reduced. This keeps the load at the orifice itself within the 4:1 turndown ratio.

With a modulating control valve, the load physically can't vary outside of the guidelines, whether you're at 5 lbs or 150 lbs. of pressure. Virtually all properly designed applications will not vary outside the guidelines for an orifice. In 14 years and 800 plants, over 99% of mechanical steam traps have been convertible to orifices. Most of the remaining portion of 1% is not converted because of improper design or it is not cost-effective.

I have an example of how we size a permanent orifice to work with three varying loads in a kiln plant. The plant has a control valve that modulates from 100 psi to 0 psi.

The following conditions prevail in all three cases:

1) Our product in each case starts at a temperature of 100 degrees Fahrenheit.
2) We are working with 10 square feet of stainless steel coil surface in water.
3) The BTU transfer rate is 150

The formula used in each case is as follows:

The transfer rate in BTUs per square ft of surface area per degree F differential multiplied by the surface area of the stainless steel coil multiplied by the difference between the temperature of the steam at the given pressure and the temperature of the product.

This yields a number of pounds of water to pass through the orifice at the given pressure. This number is used in a proprietary look-up table to yield the desired orifice for the given pressure along with a percentage of water occupancy of the orifice. This calculation is repeated for all three conditions and used to determine the optimal orifice size. This size then provides an associated percentage of occupancy of the orifice under each of the three pressures. From this we can determine the amount of steam loss for that orifice size under the three varying loads.

The first case (Figure 6) we want to size the orifice for is for 100 psi.

The btu heat transfer rate of the metal used here at start up is 150 btus per sq ft of surface area per degree Fahrenheit differential. Under these conditions you need to pass 405.7 lbs of condensate at 100 psi.

The second case we want to size the orifice for is for 50 psi.

The btu heat transfer rate of the metal used here at start up is 150 btus per sq ft of surface area per degree Fahrenheit differential. Under these conditions you need to pass 303.0 lbs of condensate at 50 psi.

The third case we want to size the orifice for is for 10 psi.

The btu heat transfer rate of the metal used here at start up is 150 btus per sq ft of surface area per degree Fahrenheit differential. Under these conditions you need to pass 220.6 lbs of condensate at 10 psi.

Summary of Information on the Three Cases

This screen summarizes the information we just covered. As pressure is lowered, with the modulating control valve, the btu's per hour are reduced and the amount of condensate in lbs per hour is reduced.

Common Conditions:

stainless steel coil surface: 10 square feet
transfer rate: 150 BTUs/sq ft/degree F difference
product temperature at start: 100 degrees Fahrenheit

Formula for calculating water flow per hour:

	Case One	Case Two	Case Three
steam pressure in psig	100	50	10
associated temperature of steam	338	284	240
minus product temperature at start	-100	-100	-100
BTUs per sq ft of surface area per degree F. difference	238	184	140
multiplied by the surface area of the stainless steel coil	10	10	10
and by the difference between the temperature of the steam	150	150	150
BTUs per hour	357000	276000	210000
divided by BTUs transferred per pound	880	911	952
water flow per hour	405.7	303.0	220.6
orifice size	9	9	10
percent occupancy at given pressure	100%	100%	96%
orifice size	10	10	10
percent occupancy at given pressure	72%	76%	96%
associated steam loss	0	0	0

Figure 6. Example of varying load for a kiln with a modulating control valve.

Sizing: Now we are going to use this information to properly size the orifice to best meet these three cases.

100 psig: When we look up a proprietary table associated for 100 psi we size the orifice for optimal capacity. We select an orifice #9 with 100% condensate capacity or a 4:4 turndown.

50 psig: When we look up in the table associated for 50 psi we size the orifice for optimal capacity. We again select an orifice #9 with over 100% condensate capacity or a 4:4 turndown.

Again we can see from the Orifice Steam Loss graph below that you have no measurable steam loss from the orifice.

10 psig: When we look this up in the table for 10 psi we size the orifice for optimal capacity. This time we select an orifice #10 with 96% condensate capacity or nearly a 4:4 turndown.

Once again we can see from the Orifice Steam Loss graph below that you have no measurable steam loss from the orifice.

Now using the information in the proprietary charts for a number 10 orifice where the water passing fits the three cases we see what percentage of occupancy occurs.

Under 50 psig with 303 lbs of water passing per hour the #10 shows an occupancy of 76%. Under 100 psig with 406 lbs of water passing per hour the #10 shows an occupancy of 72% or again 0 lbs of steam loss.

Steam Losses Under Varying Loads Chart – Showing Three Percentages

We go with the size #10. We can see from the Orifice Steam Loss graph that we have no measurable steam loss from the orifice under all three cases.
Summary of Comparisons between Permanent Orifices and Mechanical Traps

A steam trap's job is to let water out and hold back steam.

An orifice is more efficient than a mechanical trap at doing both.

Summary of Operational Benefits

◆   More Consistent Drying for improved quality and grade recovery
◆   Improves fuel efficiency 8% to 20% for more usable steam supply or cost savings
◆   Faster Drying Times – approximately 8% to 12% of time
◆   Eliminates maintenance and repair of traps permanently

Benefits to Our Environment

◆   Reduction of air pollutants and greenhouse gas emissions per load permanently and profitably

◆   Less makeup water used reduces chemicals and water pollution