MICRONETIXX
Microwave Systems & Components

Engineering Information Bulletin

for:

Visuex[tm] PLC-Based Engineered Lumber Visual Microwave Power Monitoring, Automatic Tuning & Control System

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INTRODUCTION, BACKGROUND and OVERVIEW:

This Engineering Information Bulletin describes the Micronetixx Technologies Instrumentation and Auto-Tuning Up-Grade that is designed, manufactured and available for manufacturers of high quality Laminated Veneer Lumber, (LVL or MDF), using a continuous hydraulic press, (CPS) Line, coupled with a continuous, precision Single-Mode High Power Industrial Microwave Volumetric Pre-Heating System. This continuous microwave LVL or MDF lay-up pre-heating technique and system, when properly operated produces the highest quality LVL or MDF building materials in the world, reliably, efficiently and with excellent productivity and yield profiles.

In the manufacture of this product, the veneer bonding process uses highly reliable PF or PRF thermo-set adhesives, requiring heat, in order to bond the lay-up of the manufactured LVL or MDF billet in the press. The entire process relies on precision heating of particularly the thermo-set adhesive lines within LVL or MDF lay-up, in order to produce high quality LVL or MDF building materials, continuously and reliably. This process uses laminated wood veneers, with adhesive carefully and precisely applied to one side of each veneer in a specifically organized continuous lay-up. During the manufacturing process, the adhesive in between the veneers, (glue lines), in the lay-up requires high amounts of heat very specifically applied in the manufacturing process, in order to cure properly. Since the veneers are highly thermally-insular, applying the required heating energy, when relying on traditional conducted contact-heat transfer into the billet from heated press platens would be very slow and extremely limiting regarding billet thickness and center-billet glue lines bond quality. In order to supply the required heating energy rapidly and properly to a wide variety of LVL or MDF product thicknesses and recipes, a specifically-designed High Power Industrial Microwave Pre-Heating System is used.

The precise and continuous heating requirements for this continuous LVL or MDF manufacturing process are addressed using a precision Arrayed, Single-Mode Industrial Microwave Application System, whose specifically-applied microwave energy is delivered to the internal volume of the LVL or MDF lay-up, exactly where it is needed, within the lay-up volume. Since microwaves travel into and throughout the lay-up ***at the speed of light***, the required heating is deposited internally within the volume of the billet, **instantly.** This approach completely solves the problem of the slow migration of conducted heat transfer from the heated press platens, discussed above.

PROPER APPLICATION OF MICROWAVE HEATING POWER:

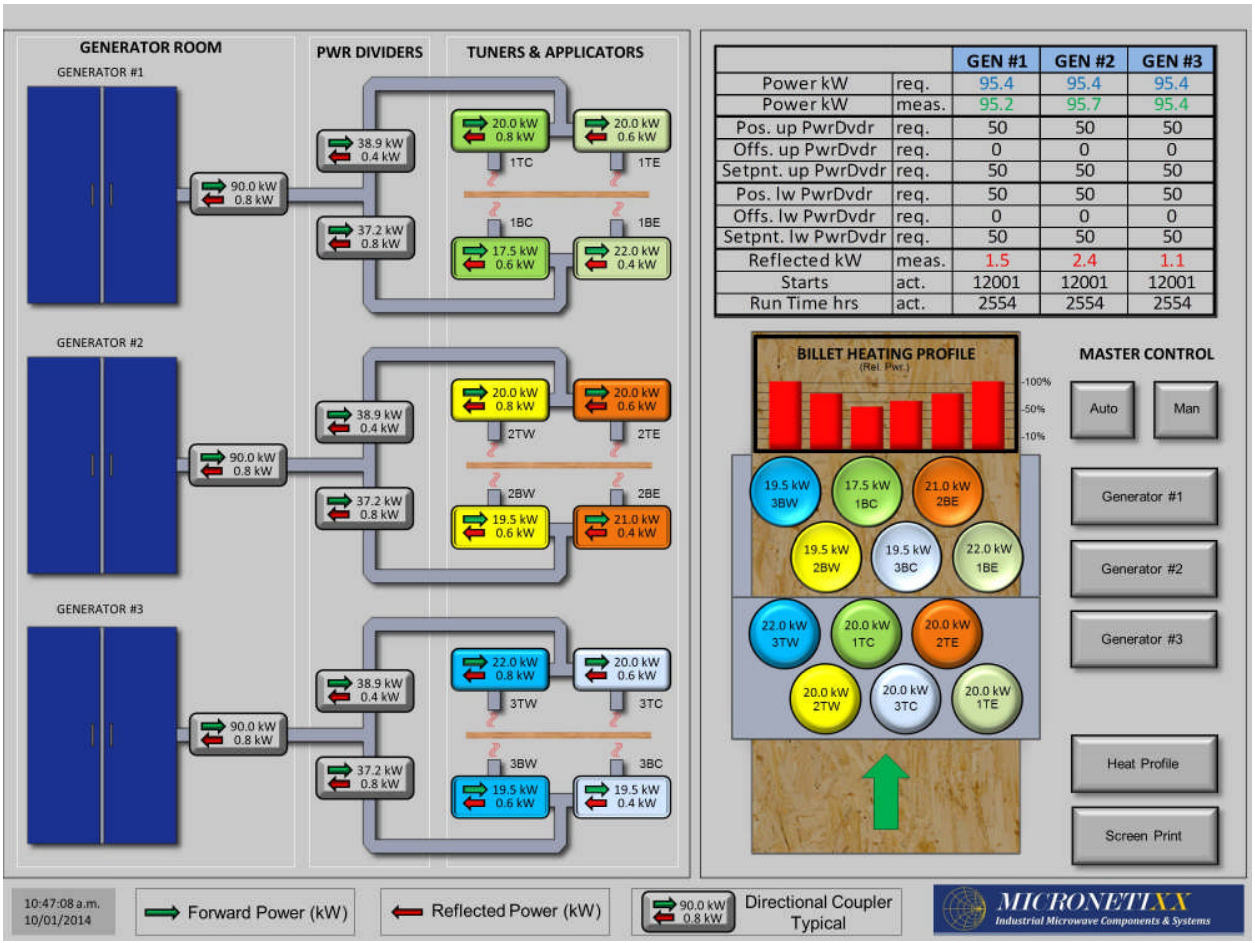
In the LVL or MDF manufacturing process, a wide variety of physical factors and parameters associated with the individual elements in the lay-up will greatly affect the microwave heating characteristics in the process. Some of these parameters include veneer moisture content, glue spread, specific adhesive chemistry and temperature. In

order to ensure a continuously reliable manufacturing process using this industrial microwave energy application method, careful monitoring and control of the delivered microwave heating power ***in real-time during the process*** is **essential**. These elements become more and more critical as the productivity and yield goals increase. As these productivity, quality and yield targets advance, real-time and precise instrumentation and control of the delivered microwave power heating flux over the LVL or MDF lay-up is no longer an option.

In this Bulletin, the Micronetixx Technologies Precision High Power LVL or MDF Microwave TM-Mode Applicator Instrumentation and Automatic Tuning System is discussed. This System will allow production engineers and specialists working on the line to continually maintain and optimize the manufacturing process in real-time during the manufacturing process, reducing loss and inefficiency, while at the same time, continuously increasing the line's capacity and yield.

FUNCTIONAL SYSTEM DESCRIPTION AND ITS BENEFITS:

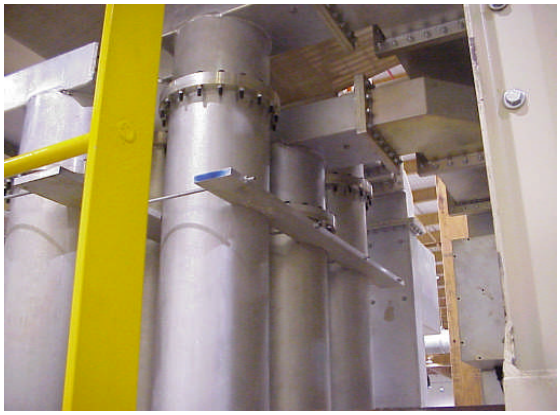
Pictured below is an Example of a suggested HMI Screen set in the Control Room for the Micronetixx LVL or MDF Microwave Instrumentation and Control System Up-Grade.



An Example of an HMI Screen for the Visuex™ Micronetixx LVL or MDF System Up-Grade

The microwave power for the Pre-Heating System is supplied from specially-designed Industrial Microwave Generators. These generators are usually either 75 kilowatt or 100 kilowatt units. The high power microwaves are carried from each of the generators, and distributed to the heating system by hollow rectangular cross-section microwave conduits called **waveguide**. There is a fairly extensive array of waveguide and application components in the "heating cell" elements of this system, that specifically distribute the microwave heating energy to the billet. Critical elements of this System are 12 Transverse Magnetic, (TM), Mode Microwave Applicators, positioned over and under the Billet on the Microwave Heating Cell.

These are illustrated in the Images below:



The LVL or MDF Microwave Heating System with its TM-Mode Applicators

Illustrated in the two images on the previous page are the Microwave Applicators that are directly responsible for precisely delivering the High Power Microwave Heating Power Flux to the billet. The properly distributed and appropriately apportioned high power microwave energy is precisely configured to the symmetrical TM-Mode, and propagated through the circular cross-section microwave waveguide elements of the Application Cell, and applied through openings in both the top and bottom broad-walls of the Cell, to the LVL or MDF billet. In addition to the relative physical positions of the Applicators on the Cell and with respect to one another, the billet heating profile within the Cell's interior is precisely determined by the exact relative microwave power division ratios. This is completely determined by the rectangular waveguide Power Divider and Instrumentation/Auto-Tuning networks, in the power waveguide power distribution system, around the Cell.

There are two major factors that determine how that microwave heating energy is distributed and applied to the production billet. One factor is the actual microwave power, (measured in kilowatts), that is supplied to each of the 12 Applicators by the waveguide distribution network, described above. (In order to achieve the desired microwave pre-heating result, the ratios of delivered microwave power are determined and set by the Production Engineers, one relative to others in the Applicator Array, and

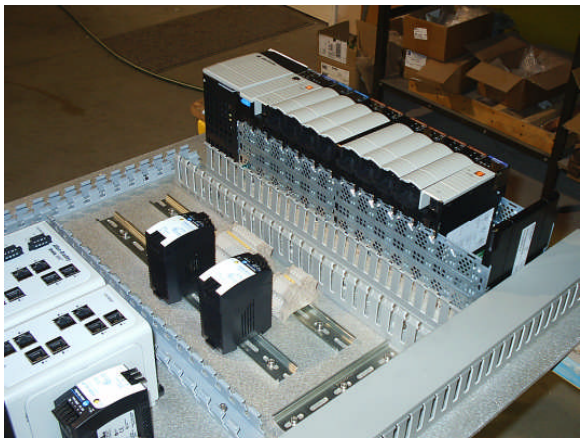
will vary depending on many environmental and mechanical factors in the process.) The other major factor is how efficiently the microwave power that is supplied to each Applicator is actually absorbed by the billet and converted to heat. This second factor is greatly impacted by many characteristics that vary a great deal, including veneer moisture content, physical lay-up profile, (how flat the lay-up is at a specific point in the process), glue spread profiles and resin chemistry, among others. These variable process parameters will cause varying percentages of the applied microwave power to be reflected back out of the billet, and not contribute to the required heating. This undesired effect will also greatly alter the Production Engineer-set microwave power division ratios in the feed and distribution system, possibly leading to un-even heating. In order to eliminate this destructive effect, each of the 12 microwave Applicators will be fitted with a Vector Tuning Network, (as part of this System, described), that will compensate for these varying properties. These variations in LVL or MDF Lay-up characteristics are normal in any manufacturing process such as this. Manual, or sub-optimal automatic adjustment of the existing older tuners may help somewhat, however, this must be done continuously in real-time in order to avoid production of defective or sub-standard billet. As mentioned earlier in this section, un-tuned applicator networks will cause altered microwave power division ratios, resulting in heating un-evenness, possibly causing runs of bad billet due to pre-cure or under cure, and/or simply slowing the process down.

The absolute best approach to ensure a reliable and optimum microwave delivery profile is to continually sample the actual microwave power delivered and then absorbed by the billet, at each separate Applicator in the array individually, and then adjust its corresponding Vector Tuner, automatically, in real-time. In addition, precision monitoring of the microwave power division ratios at all twelve of these applicator locations, as well as at the other critical points throughout the waveguide distribution network, should be monitored in order to provide Process Engineers and Production Control Staff the necessary real-time data to continually enhance the overall manufacturing process.

The Micronetixx LVL or MDF Instrumentation and Auto-Tuning System described here will contain the necessary System Elements to directly sample and then optimize the net Microwave Heating Power, (both incident and reflected microwave power), actually delivered to the billet at all 12 Microwave Energy Application Points. At each of the 12 Cell Microwave Application Points, a Precision Instrumentation Directional Coupler and Micronetixx Anti-Log Detector Module will continuously monitor incident and reflected microwave heating power. These real-time data, (at 42 critical points within the LVL or MDF microwave pre-heating system), are then transported to a dedicated central Rockwell Automation Control Logix PLC, (supplied with the System).

Images of the Micronetixx LVL or MDF Microwave Pre-Heating Instrumentation and Control Up-Grade PLC Equipment Enclosure are presented on the following page:

Images of the Allen-Bradley Control Logix PLC and its enclosure are shown below:

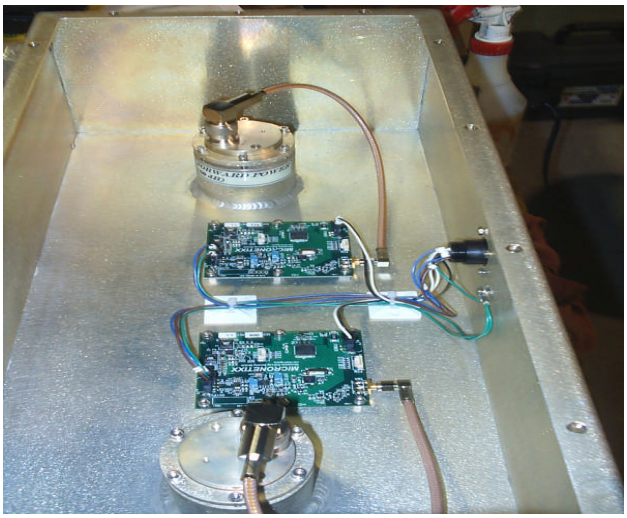


Instrumentation/Auto-Tuning System PLC

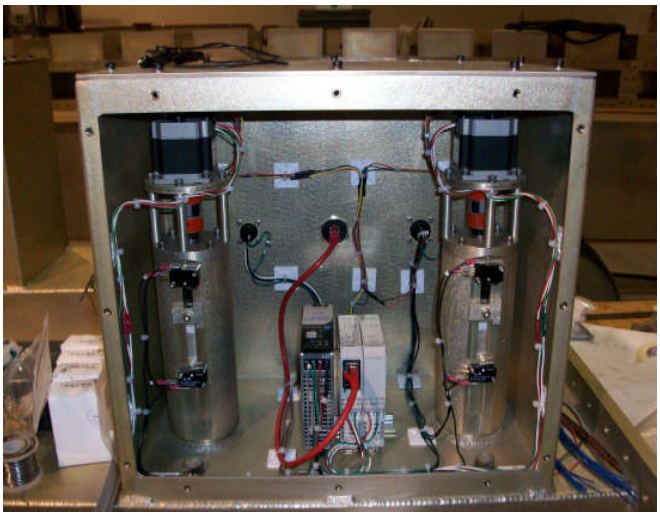
System PLC/Control Enclosure

In addition to its other functions, the PLC will interface with the existing HMI Computer/Console in the Control Room, and a complete, real-time display of the full microwave power delivery profiles are displayed and monitored by Production Staff. If and when real-time Auto-Tuning is required, the PLC will then interface with each of the twelve individual Auto-Tuning Modules via Ethernet, actuating and automatically tuning and optimizing the set-points of these tuners, in order to maintain system heating stability.

Below are images of the Precision Instrumentation Directional Coupler with its Micronetixx Anti-Log Detector and Ethernet-Interfaced Auto-Tuning Network:



Precision Microwave Power Measurement



Ethernet Network-Connected Auto-Tuner

The supplied Allen-Bradley Control Logix PLC will be programmed and configured to automatically and precisely drive stepper motors on the up-graded and included Vector Reflection Tuners, automatically tuning and optimizing the delivered microwave power to the Billet, as each individual Applicator. This entire function will

be continuous in real-time, and will automatically and transparently compensate for the effects on the microwave energy delivery caused by the ever-present variations in veneer moisture content, glue-spread and resin chemistry.

Currently, varying levels of reflected microwave power can disrupt the symmetry and evenness of the microwave application process. The function of the System proposed here will mitigate those effects.

REAL-TIME MONITORING FUNCTION:

In addition to the automatically-tuned microwave TM_{01} Mode Applicator optimization, described above, the System proposed here will monitor the microwave incident and reflected power levels, throughout the waveguide distribution system, as described earlier in this Bulletin. All of the 42 critical microwave monitoring points presented in the previous Proposal will be monitored in real-time and presented to the Control Room Screen at the Microwave HMI.

CONCLUSION:

The Micronetixx Technologies' ***Visuex***^{tm} High Power LVL or MDF Industrial Microwave Instrumentation and Control System described in this Information Bulletin incorporates the very latest in up-graded designs and engineering for operators of advanced CPS LVL or MDF manufacturing plants.

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Thank you very much for your time.

Respectfully Submitted By:

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