

# LASER-BASED MOISTURE SENSOR (LAMSOR)

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## INTRODUCTION

A novel optical technique for measurements of the moisture content in wood products is described. This method has been designed in response to the urgent requirement from the industry for a non-contact, accurate and rapid sensor, which could be used in on-line applications. The requirement called for a sensor which could be used with wood products for moisture measurements over the fibre saturation point in a wide range of moisture content classes.

The existing moisture meters such as electrical detectors, drying chambers, balances, temperature gradient detectors, etc. do not provide the required characteristics to be efficiently used in on-line sorting systems. These meters major shortcoming are: (a) moisture content range limitations (i.e. below 30% for electrical devices) and (b) speed limitations (as in the case of temperature gradient measurements).

The new method<sup>1</sup> is based on diagnosis of a laser beam, which is used to probe analyzed samples. This is non-contact, rapid and precise technique for moisture measurements. Implementation of this laser-based sensor ("LAMSOR") for on-line measurements will allow saw mills to sort the lumber into moisture content groups before the kiln. Thus, it will be possible to reduce kiln degrade, accelerate kiln throughput, and reduce subsequent planing machine downtime. Plywood mills will be able to reduce losses from degrade due to overdrying and from press blows due to improperly dried veneer. A hog-fuel line will allow the control computer to precalculate fossil fuel needs and thus yield substantial savings.

## SYSTEM DESCRIPTION

A laser is a source of coherent and collimated light radiation. This radiant energy is very well defined and it can be precisely controlled. For example, duration of laser pulses can be controlled with the accuracy of fractions of millisecond. Therefore characteristics of laser-based systems in time-dependent measurements are superior to any other conventional method.

A response of an analyzed substance to a laser beam can be characterized by a set of parameters such as intensity, wavelength, direction, degree of collimation, mode structure, and pulse duration. These parameters are primary ("immediate") responses to a laser beam as compared to secondary responses such as -for example- the temperature gradient caused by exposure to laser radiation. Therefore, in order to take the full advantages of a laser-based system, a method which is based on analysis of the primary responses provides much faster data analysis than - for example- a method where the temperature gradient is the basic measurement.

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<sup>1</sup>Patent Pending

By defining these characteristics for the incident laser beam and by analyzing changes in these quantities after reflection from a tested substance (Figure 1), one may obtain valuable information about that substance. The moisture content of a substance has been identified as one of these characteristics, which can be measured by a laser beam.

A laboratory prototype of a laser-based moisture sensor ("LAMSOR") has been built and tested. Series of experiments have been carried on with wood, paper, cardboard and other products in order to determine precision and applicability of this novel instrument. Some results related to moisture measurements in selected lumber samples are briefly presented in this paper.

## RESULTS

A schematic illustration of the laser-based moisture sensor is shown on the Figure 2. A laser-head with a set of optics is positioned above analyzed sample. The probing beam is analyzed by a set of detectors attached to the sensor-head.

Figure 3 explains time-scale of the measurements. Two (2) situations are analyzed. In the first case (Figure 3a) a static case is shown, where an analyzed sample is stationary with respect to the probing beam. A laser beam 2 cm in diameter is considered and a laser pulse at 5 kHz is assumed. Therefore, a interaction surface with a laser beam ( $S$ ) is equal to  $S_1$ . If the same laser beam is used with a sample traveling at the speed of 300 ft/min (Figure 3b), then the interaction surface between the laser beam and the sample will be changed 4% only ( $S = S_1$ ) as compared with the static case. This example illustrates how little the sample speed will influence the reading of the moisture content.

Figure 4 shows experimental data for two (2) lumber species: Fir and Pine. In order to illustrate the flexibility of the sensor, the presented measurements were taken at two (2) different intensities of the probing laser beam,  $I_1$  and  $I_2$  ( $I_1 > I_2$ ). One can see, that the sensitivity of the moisture measurements [i.e.  $dS/dM$ , where  $S$  is the sensor response (in Volts) and  $M$  is the moisture content (in %)] can be adjusted by using various intensity levels of the incident laser beam.

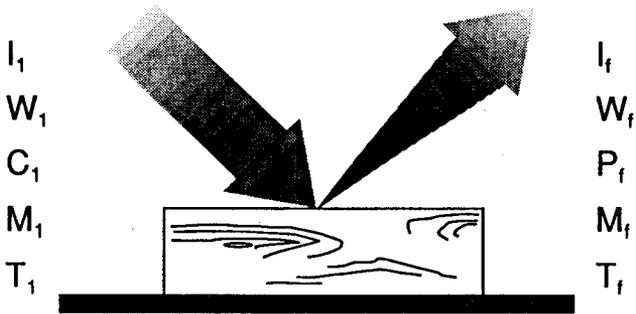
Some preliminary characteristics of the laser-based moisture sensor are summarized in Table 1.

Table 1. Characteristics of the Sensor ("LAMSOR").

Power consumption:	0.5 k Watt
Sample speed:	Unlimited
Overall size:	1 cubic ft
Warm-up time:	0.005 sec
Distance between sensor and sample:	Adjustable (up to 1 meter)
Price	\$70,000 (est.)

At the present time the final design of a commercial system is being finalized and it is planned, that the first unit will be tested in a mill trial by the end of this year.

## Laser Beam Characteristics



1. Adjustable intensity ( $I$ )
2. Adjustable wavelength ( $W$ )
3. Adjustable collimation ( $C$ )
4. Adjustable mode structure ( $M$ )
5. Adjustable time duration ( $T$ )

Figure 1

## Laser Probe

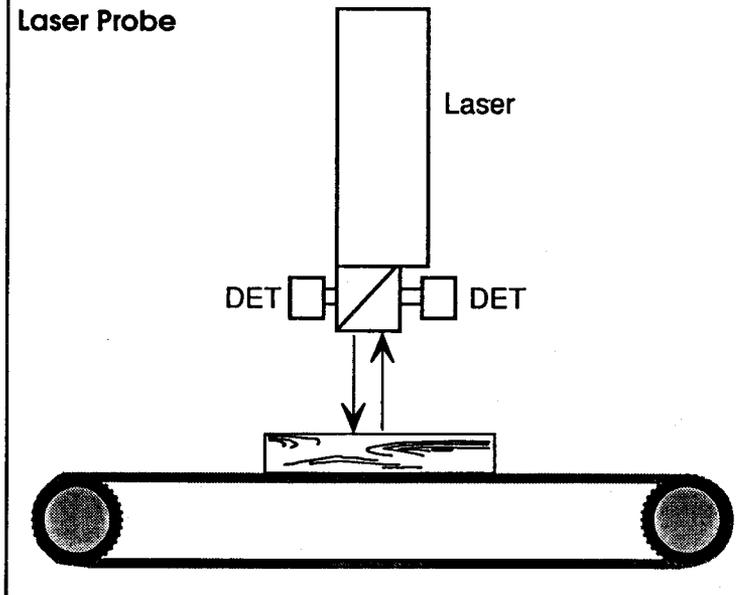


Figure 2

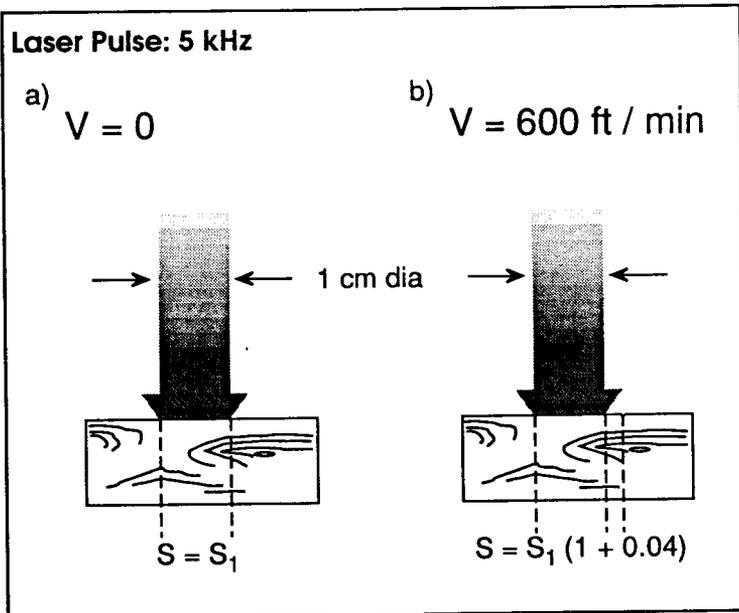


Figure 3

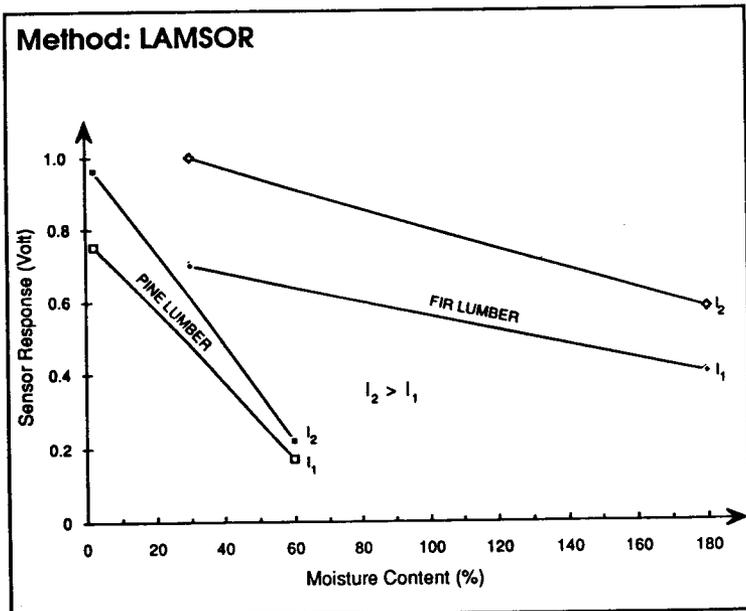


Figure 4