# Nondestructive Evaluation of Polystyrene Fusion Level

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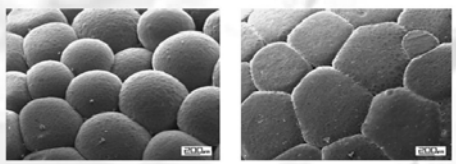
## The Goal of This Poster

This poster will present research work done towards developing a nondestructive and quantitative method for evaluating the fusion level of expanded polystyrene foam used in Lost Foam Casting (LFC). It should be noted that this research is simply in the stage of developing a method and has yet to be proven with results.

Two Different Types of EPS Foam Used Throughout Testing

## What is the "Fusion Level"?

Expanded Polystyrene (EPS) Foam is produced by placing small, individual foam beads in a metal tool and heating the beads so they expand into each other and match the shape of the tool. The fusion level of EPS foam is a measure of how well the polymer chains of these individual beads have intertwined at the resulting bead to bead boundaries.



SEM Pictures Representing Low (left) and High (right) Fusion

## Importance of Measuring the Fusion Level of EPS foam

- The fusion level of a given foam pattern is linked to many quality parameters of the metal part cast in its likeness.
- It is estimated that as much as 90% of the problems associated with the LFC process result directly from problems with the foam itself.
- Problems such as: beady surface defects, porosity and fold defects can all be linked back to fusion strength.
- The ability to locally measure fusion level will give the LFC industry increased control over the quality of castings.

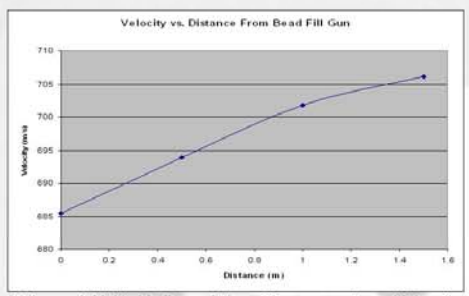
## Using Ultrasound to Measure Fusion Level

A low frequency, air-coupled, thru-transmission ultrasonic device was initially used as the workhorse of this research. The goal with this equipment was to obtain velocity measurements in the EPS foam at various locations of parts with varying manufacturer specified fusion levels. The reasoning behind this was: the speed of sound in solid media is proportional to the square root of Young's Modulus and the fusion strength in EPS foam has been shown to correlate with Young's Modulus.

The Initial Ultrasonic Testing Set-up

## Flaw's Associated With the Initial Ultrasound Test

- The speed of sound is also proportional to the square root of one over density, $(1/\rho)^{1/2}$.
- There are relatively large density gradients across a given foam pattern resulting from the production process. These are especially prominent around the bead fill gun location.
- Thus density variation must be known before stiffness can be independently determined using ultrasound velocity measurements.
- The lateral resolution of standard low frequency transducers is poor (~3 $in^2$).
- Control and thus repeatability of this test is very difficult since the ultrasound transducers have few limits on their degrees of freedom.



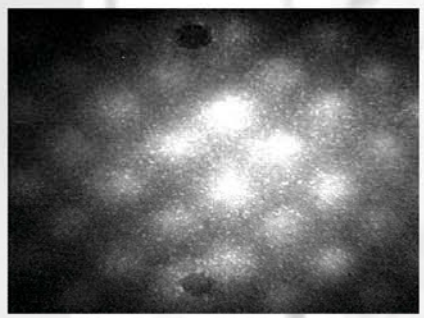

This graph highlights the variation of foam properties with location.

## Future of this Research

In order for the original goals of this research to be achieved, it is important that the density variation become a known quantity for the EPS foam plates. Once density differences between two locations on a plate can be evaluated, differences between the stiffness can also be determined using ultrasound velocity measurements. Once these stiffness differences are known it would become necessary to correlate them with differences in fusion through destructive mechanical testing.

## Proposed Method for Density Determination

A good testing candidate for isolating density is electromagnetic radiation. Infrared testing is of extra interest to this project. The feasibility of using X-rays to accomplish this is also being considered. An important criterion for choosing the type of radiation is: the testing technique that goes along with it must be nondestructive.



Resulting Picture of an Infrared Test Preformed by Viktor Orekhov

## Plan for Improving Sound Velocity Measurements

An ultrasonic C-scanning set-up will be utilized. This will eliminate the control problem associated with the previous test since the C-scan device has a plotter which allows for complete control along the x, y and z axes. This plotter coupled with the C-scan software allows data to be precisely stored verses location. In order to improve lateral resolution a focused ultrasonic transducer would be used with the C-scan.

*This work was supported by the National Science Foundation grant number EEC-0552860, Research Experiences for Undergraduates (REU) Industrial Applications of Sensing, Modeling, and Control.*