

Classifying Foam Fusion Using Infrared Thermography

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INTRODUCTION

Lost Foam Casting utilizes an injection molded pattern as a sacrificial investment to be replaced by the advancing molten metal. Lost Foam Casting (LFC) produces castings with:

- High Dimensional Accuracy
- Complex Shapes
- Minimum Cleaning and Machining
- Superior Surface Finish
- Lower Cost

Expanded polystyrene patterns are produced by injecting polystyrene beads into a mold where they are expanded by steam entering and exiting the mold through vent holes. The steam expands the beads, which fuse together to form a pattern. Recent research has revealed bead fusion as a key factor in reducing casting defects.

MOTIVATION

A robust technique for classifying foam fusion is yet to be developed. Such a method would:

- Reduce scrap parts
- Increase understanding of the LFC process
- Reduce environmental impact of casting

Conventional infrared techniques were examined to determine feasibility in reliably classifying fusion. Infrared cameras are able to detect many features and defects that are subsurface or indistinguishable by any other means.

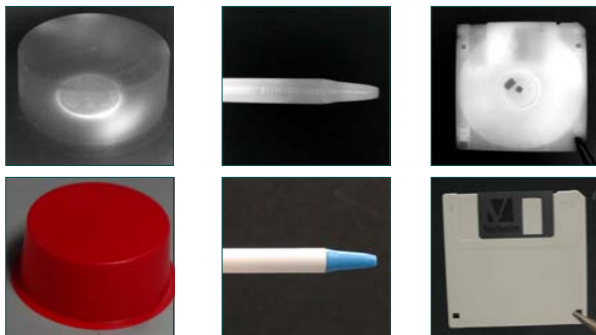


Fig. 1
Some materials that are opaque in visible light can be transparent in the infrared spectrum, and vice versa.

OBJECTIVE

To develop a non-destructive technique to reliably classify bead fusion in expanded polystyrene foam patterns. An ideal technique would be:

- Non-Destructive
- High Resolution
- Capable of classifying complex patterns
- One-Sided

METHODS

Due to the desirability of a one-sided technique, several methods were examined. A one-sided technique relies on measuring the reflection and refraction of radiation as it is absorbed into the foam. Several sources of radiation were experimented with including an IR LED, a fiber optic coupled to a blackbody Source, a Xenon flash lamp, and two quartz lamps. However, Due to the extremely high reflectivity and low conductivity of the patterns, each of these methods failed to produce useful characterization of fusion.



Fig. 2
Left to right, IR LED, Fiber Optic, and Xenon Flash methods.

After the one-sided techniques failed, a two sided transmission method was examined. A blackbody source was used to supply radiation which propagated through the pattern. Images were captured of the radiation transmission using a mid-IR camera. Patterns of varying bead types, fusion level and venting method were tested.

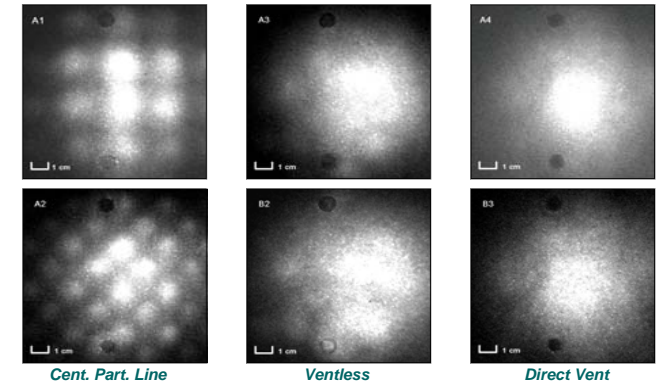
RESULTS

Qualitative Analysis

- The A1 and A2 images reveal variations at locations of only steam holes, while the A2 image reveals both steam and vent holes. This illustrates the visible differences between normal and low fusion patterns
- Nonuniformity in fusion can be observed in the ventless patterns due to insufficient removal of steam.
- Directly vented patterns are observed as having the most uniform bead fusion due to the effective removal of steam.

Foam Pattern Properties

Pattern	Tool	Bead	Fusion	Density (pcf)
A1	Vented, Center Parting Line	Nova F271T	Normal	1.6
A2	Vented, Center Parting Line	Nova F271T	Low	1.6
A3	Ventless	Nova F271T	Normal	1.6
A4	Direct Vent	Nova F271T	Normal	1.6
B2	Ventless	StyroChem T185	Normal	1.6
B3	Direct Vent	StyroChem T186	Normal	1.6



Quantitative Analysis

- Image processing techniques were employed to achieve a relative intensity value for a 35x35 pixel area of interest.
- More radiation being transmitted implies a poorly fused pattern
- Results demonstrated that not only is the method repeatable, but is also consistent with theory

Transmission in Blackbody Transmission Method

Pattern	Trial 1	Trial 2	Trial 3	Average	Std. Dev.
A1 Vent	65.18	65.14	63.01	64.4	1.24
A1 No Vent	40.55	40.91	40.12	40.5	0.40
A2 Vent	42.91	41.37	42.91	42.4	0.89
A2 No Vent	28.81	27.41	28.58	28.3	0.75
A3	41.47	40.97	41.94	41.5	0.49
A4	40.83	40.75	40.86	40.8	0.06
B2	46.25	44.81	43.86	44.9	1.20
B3	32.21	32.96	33.29	32.8	0.55

CONCLUSION

- One-sided techniques are a challenging proposition
- Any method relying on conductivity is difficult to implement due to low conductivity of patterns
- Two-sided technique utilizing radiation transmission can be effective in qualitatively and quantitatively characterizing fusion

