Fluid Flow Optimization of Aerogel Blanket Manufacturing Process

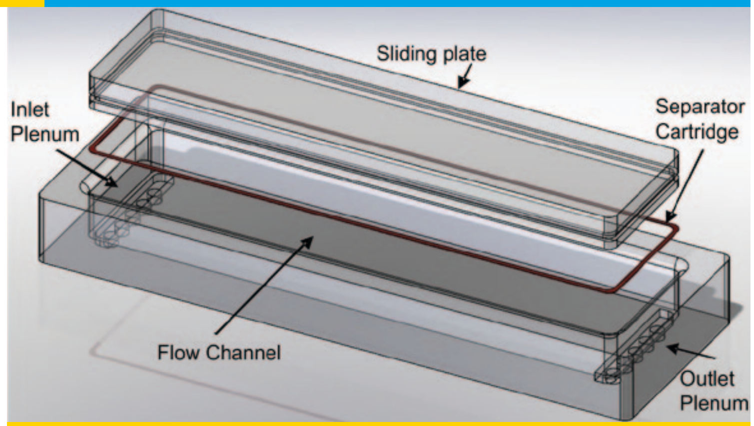
Lowering the Manufacturing Cost of High-Performance Aerogel Blanket Insulation

Introduction

Aerogel is a nanoporous solid material that has an extremely high R-value. R-value is a measure of thermal resistance used in the building and construction industry. Aspen Aerogels, Inc., the primary industrial partner on this project, has developed aerogel products suitable for many building and construction applications with low raw material costs. However, while the aerogel blanket is cost effective for many high-end applications, it is still cost prohibitive for broader use due to high fixed costs.

The aerogel blanket manufacturing process consists of four major steps: casting, aging, extraction, and drying. Of these, aging and extraction involve fluid flow through the blanket. To address the high fixed cost and other issues associated with its production, researchers on this project focused on reducing the cost and energy consumption of high-performance aerogel blanket insulation manufacturing by optimizing the fluid flow portion—the aging and extraction steps—of the manufacturing process. By reducing manufacturing cycle times for individual unit operations, the conversion costs at full capacity will be proportionately decreased.

The end result of this effort is a better understanding of aerogel blanket manufacturing conditions that have been verified experimentally at the production scale and can be used to optimize equipment design and process conditions required to reduce the overall manufacturing costs and provide the industry with cost-competitive insulation for wide-spread energy savings.



Experimental flow set-up for spacer investigation.

Photo courtesy of Tufts University.

Benefits for Our Industry and Our Nation

Significant energy savings and reduced carbon emissions can result from wider deployment of nanoporous aerogel insulation. The potential benefits include:

- Greater adoption of a high-performing, energy-saving insulation in the marketplace.
- Reduced energy consumption in industrial processes (steam lines, power plants, petrochemical plants, refineries, liquified gas production/transport) and district heating systems.
- Favorable performance characteristics including superior thermal properties per unit thickness, attractive water vapor transport properties, excellent fire resistance, and resistance to corrosion under insulation (CUI).

Applications in Our Nation's Industry

Applications for aerogel blankets range from cryogenic systems to fire protection, including numerous industrial uses in refineries, petrochemical facilities, gas processing plants, and widespread potential in the building and construction industry. There is also potential for wider application of aerogel blankets in the refrigeration, shipping, aerospace, and defense industries.

Project Description

During this project, researchers investigated and modeled process fluid flow during aerogel blanket manufacturing operation and made recommendations to optimize the production process by: (1) increasing product throughput; and/or (2) consuming less energy during manufacturing; and/or (3) reducing the raw materials needed per unit manufactured.

Barriers

- Ability to increase productivity without negative impact on material properties

Pathways

The aerogel blanket manufacturing process consists of two major unit operations which are governed entirely by flow of process fluids within the product and equipment:

- Aging – in this process, the nanoporous gel structure is rinsed with a catalyst solution to strengthen the gel and induce hydrophobicity. This solution is heated to a prescribed process temperature, and a solvent is circulated through the coiled blanket to remove impurities. This liquid component must be removed during the next operation.
- Extraction – in this operation the liquid solvent entrained in the gel nanopores is removed with supercritical carbon dioxide (CO_2). During this process, the material is transformed from an alcogel to an aerogel as the liquid is removed from the blanket structure.

During this project, researchers are focused on investigating properties deemed significant to the aging and extraction operations. The successful implementation of actions identified in the project has so far resulted in a 40% decrease in the aging cycle time. The efforts concentrating on extraction have successfully identified diffusion mechanisms which are key to operation cycle time as well as identifying a metric for determining extraction end point. Implementation of improvements to the manufacturing process have helped increase plant capacity by more than 30% and reduced energy consumption per unit product in the facility by 25%.

Milestones

This project started in 2009.

- Identify and investigate the alcogel properties which affect successful aging and extraction (Completed)
- Examine how fluids diffuse through the aerogel blanket. Validate computation model through laboratory-scale experiments (Completed)
- Examine how the fluid enters, exits, and flows through the aging and extraction steps of the aerogel manufacturing process. Validate computation model through laboratory-scale and pilot-scale trials (Completed)

Commercialization

Since incorporating in 2001, Aspen Aerogels has commercialized aerogel technology by developing a flexible blanket form of the material and reducing processing time from months to hours. Aspen's production plant produces flexible aerogel blanket products to supply diverse industries such as oil and gas, aerospace, cryogenics, defense, and apparel industries. In the near future, Aspen anticipates wider application for its products in the fire protection, refrigeration, shipping, and building and construction building markets.

Successful completion of this program resulted in a better understanding of the aging and extraction operations in the manufacturing process. Such understanding will allow Aspen to further optimize these processes and afford shorter cycle times, which in turn will facilitate reduced energy consumption and conversion costs. It is expected that these benefits will be realized across a range of aerogel products, leading to lower production costs and eventually greater usage in the insulation market.

Project Partners

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