Oil & Natural Gas Projects
Exploration & Production Technologies

Development of High Temperature Capacitor Technology and Manufacturing Capability

DE-FC26-06NT42949

Goal
The goal of this project is to design and carry out controlled experiments to systematically optimize manufacturing and testing processes for fluorene isophthalate terephalate (also known as fluorene polyester or FPE) capacitors, such that the commercial availability of a reliable and affordable supply of these capacitors will be encouraged. The processes to be optimized include film casting, film metallization, and final capacitor assembly.

Performers
Hamilton Sundstrand, Rockford, IL 61125
Brady Corporation, Milwaukee, WI 53201
Dearborn Electronics, Inc., Longwood, FL 32750
SteinerFilm, Williamstown, MA 01267

Results
This project began in October 2006. A Research Management Plan and Technology Status Assessment have been completed. Hamilton Sundstrand has begun working on the first of four production-sized batches of capacitors, optimizing steps in the manufacturing process/supply chain during each batch. Brady Corporation has successfully manufactured 5 rolls of FPE film. SteinerFilm has metallized these rolls and provided them to Dearborn for the first batch of capacitors. Through experimentation, Brady and SteineFilm have improved the FPE formula and machine handling, respectively. Additionally, a definition of the capacitor technical requirements and initial packaging design is under development.

Benefits
If a reliable supply of affordable HT capacitors is available, these components can be used in downhole drill motor drives and downhole MWD communication devices. The increased temperature capability of HT capacitors will minimize the cooling requirements in line replaceable units (LRUs), allowing other components to utilize valuable heatsink areas. Alternatively, size and weight can be taken out of LRUs by decreasing the heatsink mass. In addition, increased thermal capability will greatly increase the reliability of capacitors. By providing a large thermal de-rating, a capacitor rated at 250 °C will have a much higher reliability under 150 °C operating condition. The root-mean-square (RMS) current handling capability of HT capacitors will not be thermally limited when a 250 °C capacitor is used in a 150 °C application in place of the conventional low temperature capacitors that are now used.

It is important to realize that this project is primarily focused on the commercialization aspect of FPE capacitors. By making reliable, affordable electronic components widely available, the reliability of downhole electronics will be improved and the cost of using such equipment reduced. This in turn will reduce the cost of drilling for and developing deep gas resources, improving the likelihood that larger volumes of such resources can fill domestic consumer demand for natural gas at a reasonable price.

Background

Capacitors are an important component of downhole logging-while-drilling(LWD) and measurement-while-drilling(MWD) electronics. There is a need to develop and enhance the electronics industry's capabilities to produce temperature resistant capacitors that will support the use of such tools at greater depths under more hostile conditions.

FPE technology is currently used to provide high temperature (HT) capacitors utilized in the aerospace industry. This industry has been using metalized film capacitors for power conditioning, filtering and energy storage applications for decades. Metalized film capacitors have the ability to “clear” small defects, exhibit high reliability, and tend to fail in a controlled and manageable fashion at the end of a long and useful life. The alternatives have weaknesses: multilayer ceramic (MLC) capacitors have violent failure modes and are highly susceptible to vibration and thermal cycling environments, while electrolytic capacitors have problems with “dry-out,” and exhibit short lives and low reliabilities at elevated temperatures. For these reasons, the aerospace industry has focused on metalized film capacitors as the most viable high temperature capacitor solution.

Unfortunately, FPE capacitors have been manufactured on a “one-of-a-kind-special-order” basis and the industry suffers from poor manufacturing yields at all stages of the manufacturing process for these capacitors. Widespread use of FPE film capacitors (particularly for oil field drilling services applications) will not be practical until they can be efficiently mass-produced in a financially self-sustaining manner. Evidence of this practicality is required for Hamilton Sundstrand and downhole drilling equipment suppliers to design FPE capacitors into saleable, distributable, serviceable, production units.

Summary

Since the feasibility of this technology has already been proven and the focus is now on optimizing the manufacturing process, this project began with Phase II activity. Four production size batches of FPE capacitors will be managed through the entire supply chain, with Batch 1 nearing completion. Each of the following tasks will be performed:

- An evaluation of FPE constructions for web-handling and final capacitor assembly properties will be carried out.
- The FPE film casting process will be optimized, using web-handling properties and HT capacitor properties as the desired optimization metrics.
- The metallization process will be optimized.
- The manufacturing process will be optimized.

The final product of this project will be the successful manufacture of production quality HT FPE capacitors and a complete documentation of the processes involved.

This research project builds on the strong partnerships already in place among Ferrania (FPE resin manufacturing), Brady Corporation (film casting), SteinerFilm (film metallization), Dearborn Electronics (capacitor manufacturing), and Hamilton Sundstrand (applications and systems expertise) to develop an optimized production process for HT FPE capacitors. These partners will collaborate on the systematic design of experiments involving four production-sized batches of FPE capacitors. The successful execution of this effort will result in commercially available, reliable, and affordable 250 °C rated capacitors by the end of 2009.

Current Status (July 2007)

Thus far, 5 rolls of FPE film have been manufactured, metallized and delivered for the fabrication of the first batch of capacitors. The FPE formula and machine handling have been improved via experimentation throughout the manufacturing process for batch 1. Upon fabrication and testing of the batch 1 capacitors, the process will be repeated for batch 2, where the metallization process will be the focus for optimization. Further optimization will begin in early 2008 during batch 2.

Project Start: October 16, 2006
Project End: October 15, 2009

DOE Contribution: $543,117

Performer Contribution: $334,065

Contact Information:
NETL – Jamie L. Brown (jamie.brown@netl.doe.gov or 304-285-5428)
Hamilton Sundstrand – Jeff Nelson (jeff.nelson@hs.utc.com or 815-226-6141)

Additional Information:

Technology Status Assessment [PDF-168KB]