PROJECT DATA

Powerscope, Inc. - 02GO12063

Fiber Sizing Sensor/Controller for Optimizing Glass and Polymer Fiber Manufacturing Process

Recipient:	Powerscope, Inc.	Instrument Number:	DE-FG36-02GO12063
Recipient Project Director:	Amir Naqwi 612.331.4247 5656 Deer Trail South Shoreview, MN 55126	CPS Number:	1835
		HQ Program Manager:	Lisa Barnett 202.586.2212
		GO Project Officer:	Gibson Asuquo 303.275.4910
Recipient Type:	For-Profit Organization	GO Contract Specialist:	Melissa Wise 303.275.4907
Subcontractor(s):		B&R Number(s):	ED1811000
		PES Number(s):	02-2268
EERE Program:	Industrial Technologies	State Congressional District:	MN - 4

PROJECT SCOPE: The objective of this project is to develop a controller for optimizing glass and polymer fiber manufacturing that utilizes real-time, on-line measurements of fiber diameter distribution by laser, used for process monitoring and control. The proposed method uses a collimated laser light beam and an array of ring detectors to collect light diffracted by fibers. Project work involves adaptation of existing technology to fiber sizing and extensive field testing. Energy savings are estimated to reach 15 trillion Btu by 2020, or 7% of current usage; and a corresponding reduction of 7% in CO_2. Annual cost savings per fiberglass plant are estimated at $2.9 million. A return-on-investment (ROI) period of less than 2 months is estimated.

FINANCIAL ASSISTANCE

Approved DOE Budget:	$199,260	Approved DOE Share:	$199,260
Obligated DOE Funds:	$199,260	Cost Share:	$89,000
Remaining Obligation:	$0		
Unpaid Balance:	$22,904	**TOTAL PROJECT:**	**$288,260**

Project Period: 07/25/02 to 07/31/04

TECHNICAL PERFORMANCE
DE-FG36-02GO12063
Powerscope, Inc.
Controller for Optimizing Glass and Polymer Fiber Manufacturing Processes

PROJECT SYNOPSIS

The goal of this project is to develop a controller for optimizing glass and polymer fiber manufacturing that utilizes real-time, on-line measurements of fiber diameter distribution by laser that will be taken and used for process monitoring and control. The proposed method uses a collimated laser light beam (typically 1 cm in diameter) to illuminate the fibers. An array of ring detectors is used to collect the light diffracted by the fibers in the forward direction. The diffraction pattern of a fiber becomes narrower with increasing fiber diameters. The proposed sensor will invert the measured diffraction pattern into a fiber size distribution in real-time. The project work involves adaptation of an existing technology for fiber sizing as well as extensive field testing. The project team consists of instrumentation developers with the necessary expertise in the relevant areas of applied science, opto-mechanical engineering, electronics, software, project management, and market development. This team will work in partnership with three major fiber manufacturers to ensure that the practical problems of the fiber industry are addressed.

The methodology will reduce the frequency of shutdowns, and in the event of a shutdown, will minimize the associated energy and material loss; hence, reducing associated emissions. It will also reduce the amount of fibrous material used in products such as building insulation, filter media and fiber reinforcements without compromising desired product specifications; i.e. insulation R-value, filter pore size, tensile strength of reinforcement, etc. Energy savings are estimated to reach 15 trillion Btu by 2020, or 7%; and a corresponding reduction of 7% in $CO_{2\ is}$ anticipated. Annual cost savings per fiberglass plant are estimated to be $2.9 million. A return-on-investment period of less than two months is estimated.

SUMMARY OF TECHNICAL PROGRESS

The light source has been changed to a violet diode laser instead of a red diode laser. Due to its shorter wavelength, it allows for measuring fibers as small as 1.5 µm. The earlier hardware version with the red diode laser was limited to measurements of 2.5 µm. Powerscope also improved the scanning range to 18” from 12”.

A new round of field tests at Procter and Gamble has underscored the importance of bringing the receiver closer to the fibers in order to accurately measure fibers spread over a large distance. Earlier attempts to keep fibers close to the receiving lens had failed as fibers contaminated the lens. A novel purge-air design has enabled close access to the fibers without contaminating the lens. This modification has been incorporated in the design.

SUMMARY OF PLANNED WORK

Field tests are planned for May or June 2004. All tasks, including the field tests, will be completed during the next semi-annual period.

PROJECT ANALYSIS

The project is on schedule and on budget with no apparent major obstacles. A patent application titled, “Laser Diffraction Process and Apparatus for Width Measurement of Elongated Objects” was submitted to the US Patent Office on April 15, 2003. A presentation titled, "A Laser Instrument of On- and Off-line Sizing of Nonwoven Fibers" was given at the 13th TANDEC International Nonwovens Conference, November 18-20, 2003.

ACTION REQUIRED BY DOE HEADQUARTERS

No action is required from DOE Headquarters at this time.

STATEMENT OF WORK
DE-FG36-02GO12063
Powerscope Inc.
Fiber Sizing Sensor/Controller For Optimizing Glass And Polymer Fiber Manufacturing Processes

PROJECT GOAL

Using a laser technique, real-time, on-line measurements of fiber diameter distribution will be taken and used for process monitoring and control. This will help with energy and material savings and with the industry's goal to meet six-sigma quality standards. The proposed methodology will reduce the frequency of shutdowns and, in the event of a shutdown, will help minimize the associated energy and material loss. This will reduce the associated emissions. This technology will help reduce the amount of fibrous material used in the end products — such as building insulation, filter media and fiber reinforcements, without compromising the desired product specifications; i.e. insulation R-value, filter pore size, tensile strength of reinforcement, etc.

DETAILED TASK DESCRIPTION

Task 1. Basic Inversion Algorithm

The purpose of this task is to develop software that will correctly calculate the fiber size distribution based on the measured optical signals representing diffraction of laser light by the fibers. Similar software already exists for converting laser diffraction data from *particles* into *particle size distribution*. However, laser diffraction characteristics of fibers are different from the particles, hence, new developments are needed. This task is divided into the following subtasks:

Subtask 1.1 Software Design Document
All the computational steps involved in converting optical signals into fiber size distribution will be documented in a text format. The design document will be written by the instrument expert and not the programmer, as the former has the essential knowledge about the workings of the instrument. This will be done by Powerscope with help from PMC.

Subtask 1.2 Programming in Visual C++
Using the design document from Subtask 1.1, the programmer will write the software that will allow Powerscope to implement the calculation of the fiber size distribution in real-time. This will be done by Kauma.

Subtask 1.3 Testing and Debugging
The software developed in Subtask 1.2 will need to be extensively tested and debugged before releasing it to the non-expert users. This will be done by Powerscope and Kauma.

Task 2. Near-Forward Scattering for Various Fiber Materials

Different fiber materials and processes need to be tested in order to find the most effective fitting schemes.

Subtask 2.1 Bench-top Tests Using ELD Prototype
Fiber samples representing different particle materials (glass, polypropylene, polyethylene, nylon, etc.) and different manufacturing processes (meltblown, spunbond, spinnerete, etc.) will be tested with ELD prototype. This will be done by Powerscope.

Subtask 2.2 Single-fiber Experiments
Scattering patterns of single fibers drawn from fiber webs will be measured by traversing a single detector across the scattering pattern. This will be done by Powerscope.

Subtask 2.3 Data Reduction and Mathematical Modeling
A generalized model of light scattering by fibers covering different materials and processes will be developed. This will be done by Powerscope.

Task 3. Modification of the Basic Inversion Algorithm

The scattering matrix for non-standard diffraction patterns needs to be formulated. It may involve parameters whose optimal values must be determined alongside the fiber size distribution. This will lead to a modification of the basic inversion algorithm. The modified algorithm will need to be optimized using the experimental data.

Subtask 3.1 Extended Software Design Document (Powerscope)

Subtask 3.2 Programming (Kauma)

Subtask 3.3 Testing and Debugging (Powerscope and Kauma)

Task 4. Hardware Modifications

Modifications and extensions of the hardware are needed for certain applications. Larger lenses or detector arrays are needed to enhance the sensitivity to smaller fibers. This will require a redesign of the receiving head to accommodate the larger components.

Other hardware modifications will cover (i) larger standoff, (ii) generation of analog signals to control process parameters and (iii) water cooling and radiative shielding to protect the hardware in a hostile environment.

Subtask 4.1 Opto-mechanical Design and Development (PMC)

Subtask 4.2 Electronic Design and Development (iO Engineering)

Subtask 4.3 Testing and Debugging (Powerscope)

Task 5. Field Tests: First Run

During the project period, the product will be completed and laboratory tested. Furthermore, several extensive field tests will be conducted. These tests will require the resources of Powerscope as well as the participating fiber manufacturers. The tests will be designed to demonstrate the return on investment.

Subtask 5.1 Measurement of Glass Fibers
Two week-long tests will be conducted at the fiberglass plants of Owens Corning and Johns Manville. Fiber measurements will be closely monitored during this period and used to control the process. Energy expenses will be monitored during this period and compared with the regular energy expenses (without fiber size monitoring and control). These tests will provide the data to verify the ROI estimates. This will be done by Powerscope.

Subtask 5.2 Measurement of Polymer Fibers
A week-long test at the polymer fiber plant of 3M will be performed with the same objectives as Subtask 5.1. This will be done by Powerscope.

Task 6. Product Upgrades and Refinements

Subtask 6.1 Design and Development
Mechanical and optical design enhancements will be done to provide the thermal stability needed for the plant environment. This will be based on the test results from Task 5. Modifications will include:

- Optimization of the bridge joining the transmitter to the receiver and selection of beam power detector and associated optics to collect all the beam power under various operating conditions. This will be done by Powerscope and PMC.
- Software modifications to report the results in the format as needed by the plant personnel. This will be done by Powerscope and Kauma.
- Electronic design to generate the signal needed by the plants for controlling their process. This will be done by Powerscope and iO Engineering.

Subtask 6.2 Testing and Debugging
Testing of the system with known fiber samples in order to validate the modifications done in Subtask 6.1. (Powerscope)

Task 7. Field Tests: Second Run

The second run of the field tests will follow the upgrades and refinements undertaken in Task 6. This will involve week-long testing at each of the Owens Corning and 3M fiber plants. This will involve the resources of Powerscope as well as the fiber manufacturers.

Subtask 7.1 Measurement of Glass Fibers (Powerscope)

Subtask 7.2 Measurement of Polymer Fibers (Powerscope)

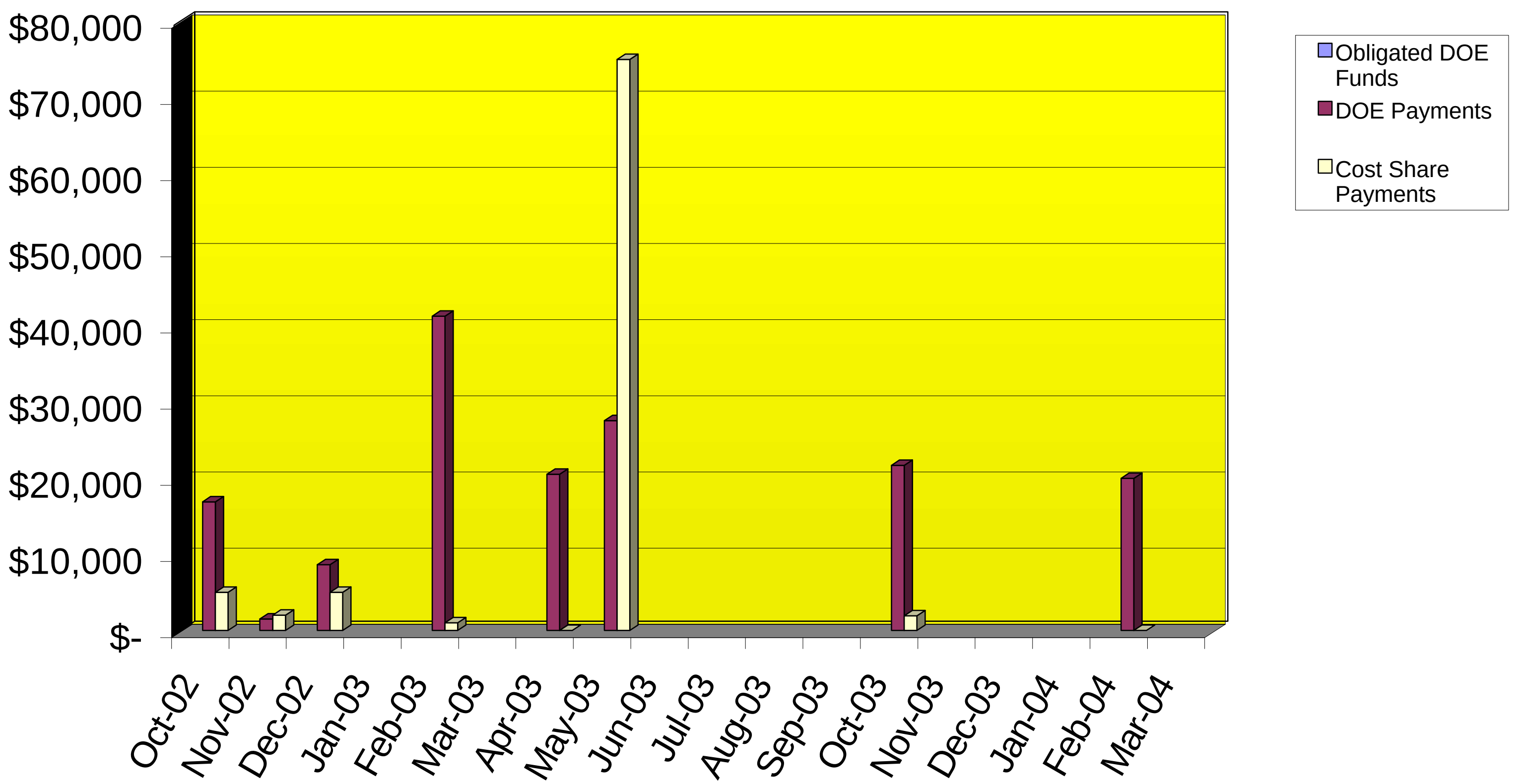
Task 8. Project Management and Reporting

Powerscope is responsible for submitting both Semi-Annual Progress Reports and a Final Report to DOE. The Semi-Annual Reports are due every April 30 and October 31. The Final Report is due 90 days after the project completion date as specified in the agreement. This task also includes other DOE requirements for market assessments, fact sheets, benefits analyses, workshops, etc.

Project Cost Performance in DOE Dollars for Fiscal Year 2003

DE-FG36-02GO12063 **Powerscope, Inc.**

Fiber Sizing Sensor/Controller for Optimizing Glass and Polymer Fiber Manufacturing Processes



	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03
Obligated DOE Funds	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
DOE Payment	$16,896	$1,523	$8,636	$0	$41,255	$0	$20,516	$27,547	$0	$0	$0	$0
Cost Share Payment	$5,000	$2,000	$5,000	$0	$1,000	$0	$0	$75,000	$0	$0	$0	$0

	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	PFY*	Cumulative
Obligated DOE Funds	$0	$0	$0	$0	$0	$0	$199,260	$199,260
DOE Payment	$21,687	$0	$0	$0	$19,961	$0	$18,335	$176,356
Cost Share Payment	$1,920	$0	$0	$0	$0	$0	$0	$89,920

Approved DOE Budget:	$199,260
Approved Cost Share Budget:	$89,000
Total Project Budget:	$288,260

* Prior Fiscal Years

Powerscope, Inc. - 02GO12063

ID	Task Name
1	Task 1: Basic Inversion Algorithm
2	Task 2: Near-Forward Scattering for Various Fibrous Materials
3	Task 3: Modification of the Basic Inversion Algorithm
4	Task 4: Hardware Modifications
5	Task 5: Field Tests: First Run
6	Task 6: Product Upgrades and Refinements
7	Task 7: Field Tests: Second Run
8	Task 8: Project Management and Reporting