SAND2012-1703P

Project Accomplishment Summary

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Sandia National Laboratories

Operated for the U.S. Department of Energy by
Sandia Corporation
Albuquerque, New Mexico

PROJECT ACCOMPLISHMENTS SUMMARY

Cooperative Research and Development Agreement (#1720.00)

between **Sandia National Labs** and Numotech, Inc.

Note: This Project Accomplishments Summary will serve to meet the requirements for a final abstract and final report as specified in Article XI of the CRADA.

Title: Oxygen Generator for Medical Applications (USIC)

Final Abstract:

The overall Project objective is to develop a portable, non-cryogenic oxygen generator capable of supplying medical grade oxygen at sufficient flow rates to allow the field application of the Topical Hyperbaric Oxygen Therapy (THOT®) developed by Numotech, Inc. This project was sponsored by the U.S. Department of Energy Global Initiatives for Proliferation Prevention (GIPP) and is managed by collaboration between Sandia National Laboratories (SNL), Numotech, Inc, and LLC SPE "Spektr-Conversion." The project had two phases, with the objective of Phase I being to develop, build and test a laboratory prototype of the membrane-pressure swing adsorber (PSA) system producing at 15 L/min of oxygen with a minimum of 98% oxygen purity. Phase II objectives were to further refine and identify the pre-requisites needed for a commercial product and to determine the feasibility of producing 15 L/min of oxygen with a minimum oxygen purity of 99%. In Phase I, Spektr built up the necessary infrastructure to perform experimental work and proceeded to build and demonstrate a membrane-PSA laboratory prototype capable of producing 98% purity oxygen at a flow rate of 5 L/min. Spektr offered a plausible path to scale up the process for 15 L/min. Based on the success and experimental results obtained in Phase I, Spektr performed work in three areas for Phase II: construction of a 15 L/min PSA; investigation of compressor requirements for the front end of the membrane/PSA system; and performing modeling and simulation of assess the feasibility of producing oxygen with a purity greater than 99%. Spektr successfully completed all of the tasks under Phase II. A prototype 15 L/min PSA was constructed and operated. Spektr determined that no "off the shelf" air compressors met all of the specifications required for the membrane-PSA, so a custom compressor will likely need to be built. Modeling and simulation concluded that production of oxygen with purities greater than 99% was possible using a Membrane-PSA system.

Background:

Numotech Inc. has produced and marketed a highly effective method of treating wounds using high concentrations of oxygen administered at low pressure. This treatment protocol is known as Topical Hyperbaric Oxygen Treatment (THOT®). THOT® protocol, as currently practiced, requires a specific volume of medical grade oxygen throughout each treatment session. Obtaining suitable oxygen sources to administer THOT® is often a challenge for physician and technicians, especially as application of THOT® begins to broaden from acute care facilities to nursing facilities and even home-based treatments. Large volumes of oxygen are often either generated on site, or stored in large cryogenic tanks at acute care facilities At sub-acute and skilled nursing facilities, an oxygen supply infrastructure is often not available. In such cases, oxygen is supplied as a compressed gas in "H-tanks" that are bulky, must be secured safely to the walls in special stands because they are a high pressure compressed gas container, and must be frequently serviced by trained personnel. Hence, Numotech Inc. has identified a significant need for a portable, energy efficient, high volume, high purity oxygen supply system that can be moved from room to room within a facility, as well as moved and applied to sub-acute care, skilled nursing facilities and home environments.

Description:

The overall Project objective is to develop a portable, non-cryogenic oxygen generator capable of supplying medical grade oxygen as defined and specified in USDP 24-NF119 (Oxygen Monograph) at sufficient flow rates to allow the field application of the Topical Hyperbaric Oxygen Therapy (THOT®). This project was sponsored by the U.S. Department of Energy Global Initiatives for Proliferation Prevention (GIPP) and is managed by collaboration between SNL, Numotech, Inc, and LLC SPE "Spektr-Conversion." The Sandia National Laboratories (SNL) and Numotech interactions were governed by a cooperative research and development agreement (CRADA), while Spektr-Conversion interactions were funded under a subcontract from SNL.

A hybrid membrane-pressure swing adsorption (PSA) system, patented previously by SNL, was proposed to meet the Numotech THOT® requirements. In the hybrid membrane-PSA system, a stream of compressed air is fed into the membrane module which generates a permeate stream of enriched oxygen (25-40% pure oxygen) with most of the argon removed. The enriched oxygen permeate stream is re-compressed and then fed into a PSA unit which further enriches the oxygen stream by removing most of the remaining nitrogen. The nitrogen-rich retentate stream from the hybrid membrane could be used power the compressor in-between the membrane and PSA to further reduce power consumption. Two configurations are envisioned for this system, one utilizing a recycle of the PSA vent gases back through the membrane module and one without. Both configurations separate oxygen from air and produce purities greater than 98% for a flow rate of 15 L/min. In a no-recycle configuration, mass balance calculations show oxygen gas could be produced at a purity of 98.6% with a flow rate of 15 L/min. For the recycle system, which utilizes the vent and purge streams of the PSA, oxygen gas can be produced at a purity of 99.2% for a flow rate of 15 L/min.

The project has two phases, with the objective of Phase I being to develop, build and test a laboratory prototype of the membrane-PSA system producing at 15 L/min of oxygen with a minimum of 98% oxygen purity. Phase II objectives were to further refine and identify the pre-requisites needed for a commercial product and to determine the feasibility of producing 15 L/min of oxygen with a minimum oxygen purity of 99%. Spektr personnel and resources were used to perform all experimental work for the project while SNL acted as a technical consultant. Numotech provided market research, input on requirements for THOT®/hospital use and a path forward for product manufacture. In Phase I, Spektr built up the necessary infrastructure to perform experimental work and proceeded to build and demonstrate a membrane-PSA laboratory prototype capable of producing 98% purity oxygen at a flow rate of 5 L/min. Spektr offered a plausible path to scale up the process for 15 L/min and Phase I was considered a success. Based on the experimental results obtained in phase I, Spektr performed work in three areas for phase II: construction of a 15 L/min PSA; investigate compressor requirements for the front end of the membrane/PSA system; and perform modeling and simulation of assess the feasibility of producing oxygen with a purity greater than 99%. Spektr successfully completed all of these tasks under Phase II. A 15 L/min PSA was constructed and operated. Spektr determined that no "off the shelf" air compressors met all of the specifications required for the membrane-PSA, so a custom compressor would likely need to be built. Modeling and simulation concluded that production of oxygen with purities greater than 99% was possible. This modeling result now needs to be validated in the laboratory.

Benefits to the Department of Energy:

This project satisfied the goals of the Global Initiatives for Proliferation Prevention (GIPP) by engaging scientists, engineers and technicians who formerly worked in Soviet weapons facilities to redirect their expertise to peaceful, civilian work through long-term business partnerships with U.S. companies. Spektr and Numotech have formed a joint venture that will manufacture this and other technologies into commercial products. This long-term relationship between Spektr and Numotech will implement the DOE goals for nuclear nonproliferation long into the future. Also, the technology developed in this project represents another, potentially more efficient, method to produce large quantities of oxygen. Energy efficient and low cost oxygen production is highly desirable in many industries (e.g., petrochemical, steel, paper, medical, etc.)

Economic Impact:

Oxygen has numerous applications in petrochemical, medical, electronic, paper and steel industries. Oxygen is also needed for newer methods of power generation via Integrated Coal Gasification Combined Cycle (IGCC) to reduce carbon dioxide emissions. A low-cost, energy-efficient method for producing high-purity oxygen from air at varying scales would have a very positive economic impact on these industries.

Project Status:

Completed

ADDITIONAL INFORMATION

Laboratory/Department of Energy Facility Point of Contact for Information on Project

Chad L. Staiger
Sandia National Laboratories
PO Box 5800 MS 0734
Dept 6124, Bldg. 823
Albuquerque, NM 87185

505.845.7288 (office)
505.844.7786 (FAX)

Company Size and Points of Contact

NUMOTECH, INC.
9420 Reseda Blvd.
Suite 504
Northridge, CA 91324

POC:

Dr. Robert M. Felton
President
Ph: (818) 772-1579
Fax: (818) 772-1602

CRADA Intellectual Property

None

Technology Commercialization

Further R&D is required for construction of a pre-production prototype. Commercialization is dependent on Numotech securing investment capital from partners.

Project Examples

Any project examples (i.e. photographs, design schematics, etc.) would be contained in the Final Report (SAND2011-3343) and subject to release under conditions outlined by the CRADA agreement.

PROJECT ACCOMPLISHMENTS SUMMARY
Cooperative Research and Development Agreement (SC07/01720)
between **Sandia National Laboratories** and **Numotech, Inc.**

This summary has been approved for public release by Sandia and Numotech, Inc.

Sandia National Laboratories

By_____ _____
Chad Staiger Date
Principal Investigator

Sandia National Laboratories

By_____ 6/23/2011
Manager Date
WFO/CRADA Agreements

Numotech, Inc.

By_____ _____
Title: Date

In order to expedite the process, if we do not receive your signed reply by _____
we will assume your concurrence for the release of this document to the public.

From: Numotech, Inc.
To: Cover, Danielle Alexandra
Subject: RE: PAS 1720 00 Portable Oxygen Generation
Date: Monday, July 18, 2011 1:16:07 PM

Dear Danielle Cover,

Thank you for your assistance with the changes from Numotech and inform you that we accept Mr. Chad Staiger changes to the revised PAS.

Best Regards,

Dr. Robert Felton, President
Numotech, Inc.

From: Cover, Danielle Alexandra [mailto:dacover@sandia.gov]
Sent: Friday, July 15, 2011 8:10 AM
To: Numotech, Inc.
Subject: FW: PAS 1720 00 Portable Oxygen Generation

Dr. Felton,

I got in contact with Mr. Staiger and got his approval on the changes you suggested for the Project Accomplishment Summary for the above mentioned agreement. Attached is the revised PAS for your review and approval. If no other corrections need to be made please reply stating your approval. Please let me know if you have any other questions or concerns.

Thanks,
Dani Cover
CRADA Administrator
WFO/CRADA Agreements Department 10012
Org. 10012, MS 0115
Phone: (505) 844-7522
Fax: (505)844-8011

From: Staiger, Chad L
Sent: Thursday, July 14, 2011 11:16 PM
To: Cover, Danielle Alexandra
Subject: RE: PAS 1720 00 Portable Oxygen Generation

Approved

Chad

Chad L Staiger, PhD
Chemical and Biological Systems Dept
Sandia National Laboratories
PO Box 5800, MS 0734