USA

High Temperature Materials Processing – Challenges and Innovation

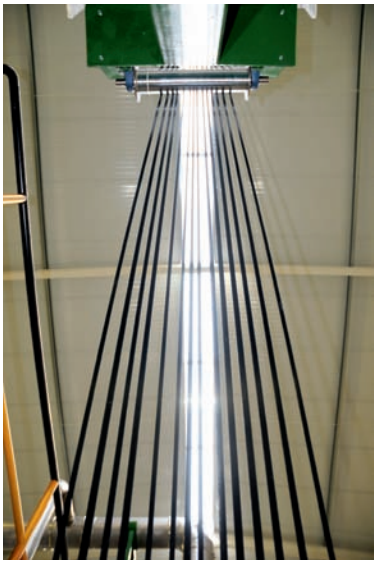

Fig. 1 Carbon fibers (courtesy: Harper International)

Introduction

The advancement of human civilization has been aided and consequently marked by progress in the processing and use of advanced materials. Advances in materials processing have been critical inputs to the economic prowess of societies throughout history. As evidenced by artifacts found through the stone age, bronze age and then iron age, the processing of materials into tools lay at the heart of the socio-economic fabric of societies.

Today, advanced materials ranging from the latest silicon-based solar panel, nanoscale electronic devices to advanced composites in cars and aircrafts play a central role in the advancement of technology.

Technological challenges in materials processing, particularly in the area of high temperatures, should be viewed as opportunities to innovate and create value.

In a recent engagement with one of America's leading research centers at *Georgia Tech*, a demonstration of innovation was brought to bear on advancing state-of-art high temperature processing in carbon fibers. Georgia Tech required an especially distinctive configuration in the line to accommodate fractional tow sizes in the range of less than 100 filaments. This condition was a challenge as it pushed the boundaries for typical carbon fiber processing, as traditional commercial CF lines handle tow sizes of 3K, and rarely down to 1K. *Harper International's* expert design team was able to devise a proprietary solution to this challenge, enabling researchers to achieve their goals of processing material more quickly and utilizing less expensive additives.

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Carbon Fibers – a Focus in Material Research

"Harper's thermal processing systems will be used in our advanced materials research at Georgia Tech," commented *Dr. Satish Kumar,* Professor at the School of Materials Science and Engineering. "Solving tough problems with real world solutions is part of what we do at Georgia Tech. We are always interested in finding creative, technologically-focused partners to assist with our research."

Carbon fibers including carbon nanotubes containing carbon fibers are a prime area of focus in advanced materials research due to their increased strength, flexibility, and unique electrical properties. Carbon nanotubes are of potential use in many applications across almost all fields of science, engineering, and technology, and help expand the realm of nanotechnology through their utilization in controlling other nanoscale structures.

Additionally, it is critical to place importance on viewing innovation through the lens of environmental and economic sustainability. This is one of today's foremost challenges that our society must address. It is ideal to strive toward reaching and becoming the benchmark in energy efficiency, which translates into higher operational efficiencies. In an effort to advance this position, a unique furnace system with dual functionality was recently developed for a major US national laboratory engaged in research, development, and commercialization of new advanced materials that emulates the ideals of energy efficiency.

Fig. 2 Carbon fiber furnace (courtesy: Harper International)

Oak Ridge National Laboratory (ORNL) is researching the development of a wide range of carbon materials from renewable resources.

Thermal Processing Systems for Carbon Fibers

To simulate commercial production of carbon materials, a continuous thermal processing system was selected by the ORNL research team. Precursor materials planned for this development project have a wide variation in both particle sizes and particle shapes. These variations in precursor materials would require two distinctive types of furnace systems, a rotary furnace for one type of material and a mesh belt furnace system for other materials.

ORNL contacted Harper International for assistance in designing a single continuous thermal processing system that could satisfy both requirements efficiently. Harper's engineering team developed the dual functionality furnace due to limited space within the lab, and the need for flexibility in processing a wide variety of materials in both rotary and mesh belt furnace systems. The Harper team designed a multi-functional thermal processing system that can be transformed from a rotary tube furnace to a mesh belt furnace while utilizing a single thermal platform.

"The design of this custom furnace system demonstrates the commitment Harper makes to provide solutions, investments, and new concepts to achieve the needs of our valued customers," said *Rick Rehrig*, Harper Vice President of Sales. "The world of advanced materials continues to change at an accelerated pace. The engineers and scientists here at Harper International provide custom solutions and technical assistance for the economical commercialization for the advanced materials industry."

The single thermal processing system features a clam-shell design that allows the top half of the furnace to open, exposing the internal section of the furnace. The rotary tube may be removed from the system, allowing for the installation of a mesh belt within the same thermal section of the furnace. Both furnace systems have been designed to be gas tight and operate with a variety of atmospheric gases including reactive and corrosive gases. Additionally, the systems have been designed to operate in the 1000°C range with thermal

Fig. 3 Furnace with inset delivered to Oak Rich National Laboratory (courtesy: Harper International)

processing cycle variations from 30 min up to 10 h. ORNL will have the flexibility to test and develop new carbon materials from a variety of sources, including renewables. This project will enhance the use of a variety of renewable technologies while advancing the advanced composites industry as well.

Thermal Processing of Nuclear Fuel Pellets

As another example of overcoming technology complexities in high temperature material processing and energy efficiency priorities, a recently developed system for the advanced thermal processing of nuclear fuel pellets required a confluence of skill sets drawn from mechanical engineering, nuclear engineering, ceramic engineering, and electrical engineering. Concerns over global warming have sparked renewed interest in the nuclear industry to reduce greenhouse gas emissions. The global nuclear industry has 437 power plants in operation today with 55 facilities under construction and an additional 134 facilities in the planning stage.

Sintering is the crucial final step in the refinement of nuclear fuels before they can be used in nuclear power plants. Nuclear fuel sintering systems must meet several critical requirements such as hydrogen gas atmosphere with controlled dew point in the 1700 to 1800 °C temperature range, as well as temperature uniformity, and safety control systems. Harper International's systems meet or exceed these requirements and have proven highly reliable and durable, a very important aspect for this application. Harper's advanced furnace systems for the nuclear industry are currently in operation on four continents.

Summary

Advanced technology due to the research and development of advanced materials is now considered the norm. Cell phones, solar cells, nanomaterials, flat-screen displays, lithium ion batteries, advanced catalysts, and carbon fiber are all fairly standard items in today's world. Harper International has played an important role in assisting companies with the development and commercialization of many of these advanced materials with their highly engineered thermal processing systems.

Enabling the production of such advanced materials, Harper International has been on a path of constant innovation since founding in 1924. Over the past decades Harper's business and technical focus has evolved into collaborating with world-class clients in development, scaling up, designing, and commissioning first of a kind complex processes. Today, Harper serves a wide variety of markets including nanomaterials, advanced ceramics, inorganic chemicals, advanced energy markets, lighting products, catalysts, solar silicon, nuclear fuel, carbon fibers, and others. Harper's strong focus on enabling customers to reach their goals through the path of world-class innovation has been at the heart of Harper's business success. Leading manufacturers in advanced materials industries worldwide appreciate the combination of high-level process assistance, world-class custom equipment, and after sales support that are the foundation of Harper technological experience.