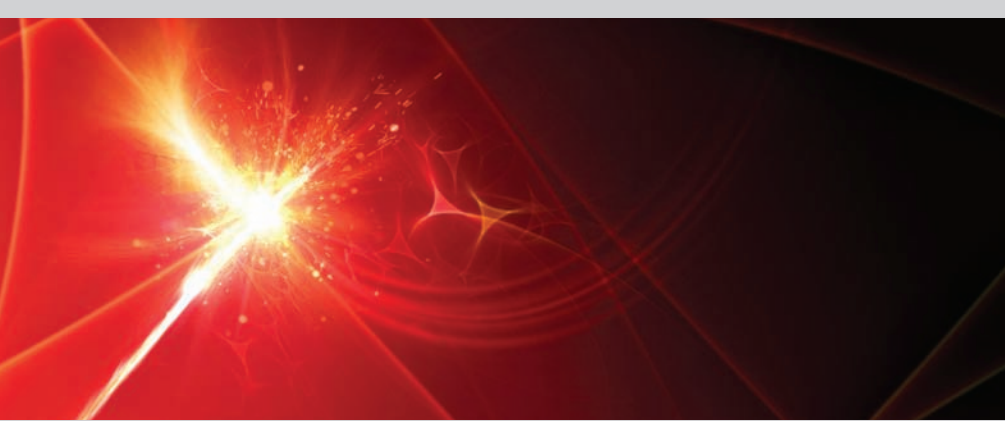


# Thermo. Dynamic.

Innovative Furnaces and Ovens for Advanced Materials Processing



## Making bright ideas brilliant.

Harper offers a variety of thermal processing solutions for customers in advanced materials markets, with thousands of installations worldwide from lab scale to complete production lines. Harper's range of experience across different techniques, process methodologies and applications allows us to deliver unique solutions for every customer and help them propel the next generation of material innovations into the world.



## *From Spark to Finish*

Harper offers furnaces and ovens, from lab to full scale production, unique to each customer's specifications. Our experience in developing distinctive systems for every application covers calcination, graphitization, carburization, controlled oxidation, oxide reduction, purification, pyrolysis, drying, reduction, solid-solid reaction, gas-solid reaction, metalizing, debinding, waste remediation and more.

Our technologies are focused on continuous processing at high temperatures and in controlled atmospheres for a range of advanced materials. The design of a custom Harper system begins with understanding the customer's goals and utilizing our exceptional skilled engineering team to analyze their distinct process requirements. Harper works to devise a complete solution with our range of offerings including gas treatment and handling and fully integrated control systems.

## *Material Markets*

Our involvement in advanced material markets begins in early stages of research and development, whether at universities, government institutions or early stage start-ups. We strive to partner throughout the development process, assisting in the scale-up and eventual commercialization of life-changing materials.

Harper is proud to collaborate with leaders in material development on their most demanding product innovations.

- Fibers and Filaments
- Metal Oxides
- Nanomaterials
- Powders
- Graphene
- Inorganic Chemicals
- Rare Earths
- Energy Storage Materials
- Technical Ceramics
- Carbon Materials
- Energy Generation Materials
- Catalysts

## *Research Facilities*

Let Harper help bring your next material innovation from spark to reality. Hundreds of companies have used our on site Technology Research Center for process development and process optimization as they work toward commercial scale-up or with systems requiring unique process specifications. Customers can utilize numerous on site thermal systems to gather data and fine tune their processes, with a focus on varying production rates, temperature regimes, processing times, atmosphere compositions, and flow rates, resulting in savings on the investment ultimately required for new thermal processing systems.

Harper also offers its complete carbon fiber pilot process line as an open reference and capabilities demonstration to select clients. This facility includes Harper's proprietary multi-flow oxidation ovens, advanced LT and HT slot furnaces rated for 800°C and 1800°C respectively, surface treatment and waste gas abatement systems, and winders. You can utilize the facility for validation of your carbon fiber process, confirmation of material quantities to enable downstream research, assessment of feasibility of continuous operations, and validation of design parameters for further scale-up.





## *Furnace Technologies*

Harper brings innovative solutions to designs for continuous processing of advanced materials in high purity and specialty atmosphere environments at temperatures up to 3000°C. Harper systems accommodate multiple independently controlled temperature zones, can be electric or gas fired, incorporate patented advanced sealing systems, and are designed with easy internal access to facilitate maintenance and other service considerations.

### **Harper Furnace Designs**

- Horizontal and Vertical Slot Furnaces
- Rotary Tube Furnaces
- Belt Conveyor Furnaces
- Pusher Tunnel Furnaces
- Elevator Furnaces
- Ultra High Temperature (UHT) Furnaces

## *Oxidation Oven Technologies*

Harper offers distinctive Oxidation Ovens for carbon fiber processing to complement its world-leading furnaces. Our design incorporates a multitude of improvements beyond what's available on the market today, including:

- Superior atmospheric seals
- Continuous monitoring of supply, recirculation, and exhaust flow rates
- Improved, patent-pending nozzle design
- Quadrant construction for improved installation
- Process based instrumentation array

For the customer, these and more technology advancements equal faster oxidation through elimination of the chimney effect, improved velocity uniformity and range, assurance of temperature uniformity at a variety of flow rates, and optimal control of the reaction ultimately enhancing fiber quality and production rates. These improvements come in the form of clearly stated performance guarantees.





Get to market faster and more efficiently with Harper's Ignite™ process. Harper enables companies in the development of advanced materials, from the lab to full commercialization, helping make their innovations a reality. Utilizing our depth and breadth of experience, we partner with our customer to ensure success as they scale up their process operations.

### *Feasibility and Testing*

Optimization of process parameters is critical prior to investment in thermal processing equipment to ensure capacity and quality requirements are achieved. At our Technology Research Center, customers utilize Harper's systems and expertise in their process development and process optimization for use in commercial scale-up and for those systems with unique specifications. Harper also provides a variety of additional analytical services such as gas analysis (critical to ensuring compliance with environmental regulations) electron microscopy, XRD, BET, and other thermal and elemental analysis.

### *Engineering Studies*

Count on our extraordinarily experienced engineering staff to conduct in-depth studies to determine equipment requirements and help define process parameters for optimal plant design to assist with technical and business strategy and financial planning. Our vast capabilities in thermal processing engineering studies include, but are not limited to:

- Process cost models
- Economics of increased production capacity with current and future state technologies
- Analysis of best-suited thermal process technology system for new material innovations
- Identification of opportunities for improved product quality and cost reduction
- Investigation of solutions for transition from batch to continuous processing
- Engineering of material handling solutions for unique processing systems

### *Lab, Pilot and Production Scale Systems*

As customers ramp up their operations, Harper offers the widest range of solutions in lab scale, pilot scale and full-production scale sizes. We have the building blocks to design for the most challenging thermal processes, using our vast experience to devise a first-of-a-kind system every time. From material handling to final product collection, and everything in between, Harper provides complete solutions for your advanced material process plant. We're focused on helping customers link the process steps to achieve greater efficiencies in reduced operating costs, increased quality and productivity, and strategic risk mitigation.



## *Higher degrees of innovation*

Harper International is a global leader in complete thermal processing solutions and technical services essential for the production of advanced materials. From concept to commercialization, from research scale to full production line operations, Harper is perpetually on the cutting edge. For decades, we have pioneered some of the world's most innovative, customized systems, with a focus on processing materials at high temperatures and in non-ambient atmospheres.

Harper's value proposition is unequalled — decades of industry experience, a highly specialized, multi-talented group of employees, and a passion for partnership. We don't shoehorn a standard line of products to fit our customers' requirements. We specialize in first-of-a-kind solutions using our exceptional depth and breadth of knowledge. Harper's culture is one of genuine ingenuity and creativity, which ensures we are constantly challenging ourselves to craft the best-engineered technology solution for our customers' unique thermal processing needs.

*"There's nothing standard here at Harper, almost everything we do is one-of-a-kind."*

*— William Stry Ph.D.  
Director of Research and Development*



*"In the field we work one-on-one with everyone, from the site supervisor to the contractors, to the engineers and the project manager."*

*— Renee Bagwell Ph.D.  
Process and Technology Engineer*

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