

Complete Carbon Fiber Process Lines

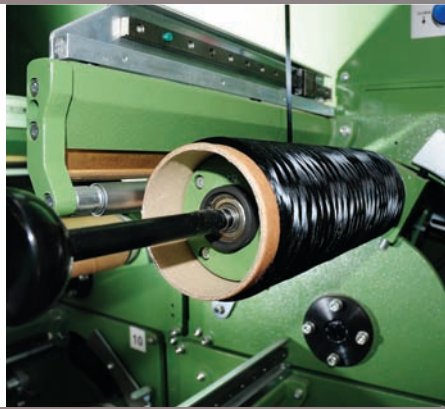
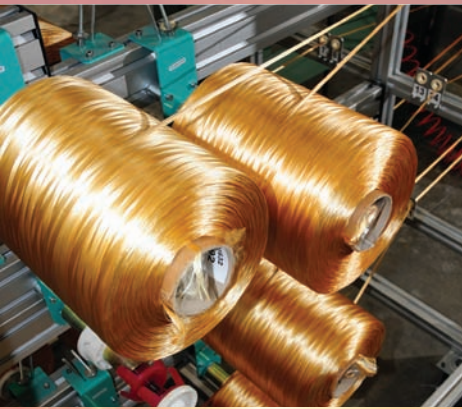
Innovation. It's the fiber of our being.



 **Harper**
International
Spark the future.™

Harper's thermal processing innovations help carbon fiber manufacturers reach newer, greater heights.

Harper's capabilities extend beyond thermal units to integrated lines for the production of advanced materials, such as carbon fiber and metal oxides. Our expertise in both pilot scale and full production plants helps you link the process steps to ensure your line is performing as efficiently as possible. From initial material handling to final product collection, working with one partner helps enable a more seamless and fluid operation.



Material Handling, Treatment and Conditioning

We take a comprehensive view of issues pertaining to material transport that extend beyond individual unit operations. Our expertise is designing end-to-end material handling throughout the system to ensure best functionality, preventing reduced throughput, loss of productivity, and the loss of quality that can result from a poorly devised material handling system.

Harper brings experience in pre- and post-treatment and material conditioning through a variety of techniques for the application of chemical solutions, whether chemical, electrochemical, plasma, or gaseous methods. We focus on thoughtful management of chemical preparation, as well as the minimization and treatment of the effluent solutions from the conditioning.



Oxidation Oven Technologies

Harper offers distinctive Oxidation Ovens to complement its world-leading furnaces for carbon fiber processing. To meet the growing need for an improved carbonization oven, Harper has state-of-the-art designs for PAN precursor ovens available at 300mm to greater than 4000mm tow band width.

Harper's designs incorporate a multitude of improvements beyond what's available on the market today, including:

- Superior atmospheric seals
- Enhanced instrumentation to maintain a mass balance
- Improvements in nozzle design
- Quadrant construction for improved installation
- Advanced flow meters for continuous monitoring of recirculation and exhaust

For the customer, these technological advancements equal faster oxidation, improved velocity uniformity and velocity range capability, assurance of temperature uniformity throughout a variety of flow rates, and optimal control of the reaction, to ensure fiber quality.

Gas Treatment and Handling

Harper approaches gas treatment and handling with several objectives. Not only do our designs focus on managing emissions and treatment of off-gas in an environmentally conscious manner, we also carefully consider opportunities for energy recovery within the process.

We help customers explore expansive opportunities for efficiencies and heat and energy integration – all aimed at reduced operating expenses and garnering a competitive advantage.



Harper's approach goes beyond the simple task of treating and abating from the plant and focuses on points of chemical process interface between the heat treatment and gas abatement equipment.

Our expertise includes:

- Staged oxidizers
- Regenerative oxidizers
- Flares
- Wet scrubbers
- Dry scrubbers
- Filters
- Heat exchangers
- Condensers
- Hydrogen recycling

Furnace Technologies

Harper is the industry standard for continuous furnace technologies for the carbon fiber industry, offering LT, HT and UHT furnaces. Our involvement in carbon fiber began at the market's inception in the 1970s, and since then we have been helping fiber manufacturers evolve with our continuous design innovations. Our experience spans a variety of precursors including PAN, pitch, lignin, polyethylene, and rayon in tow, nonwoven mat, or discontinuous, loose fiber form.

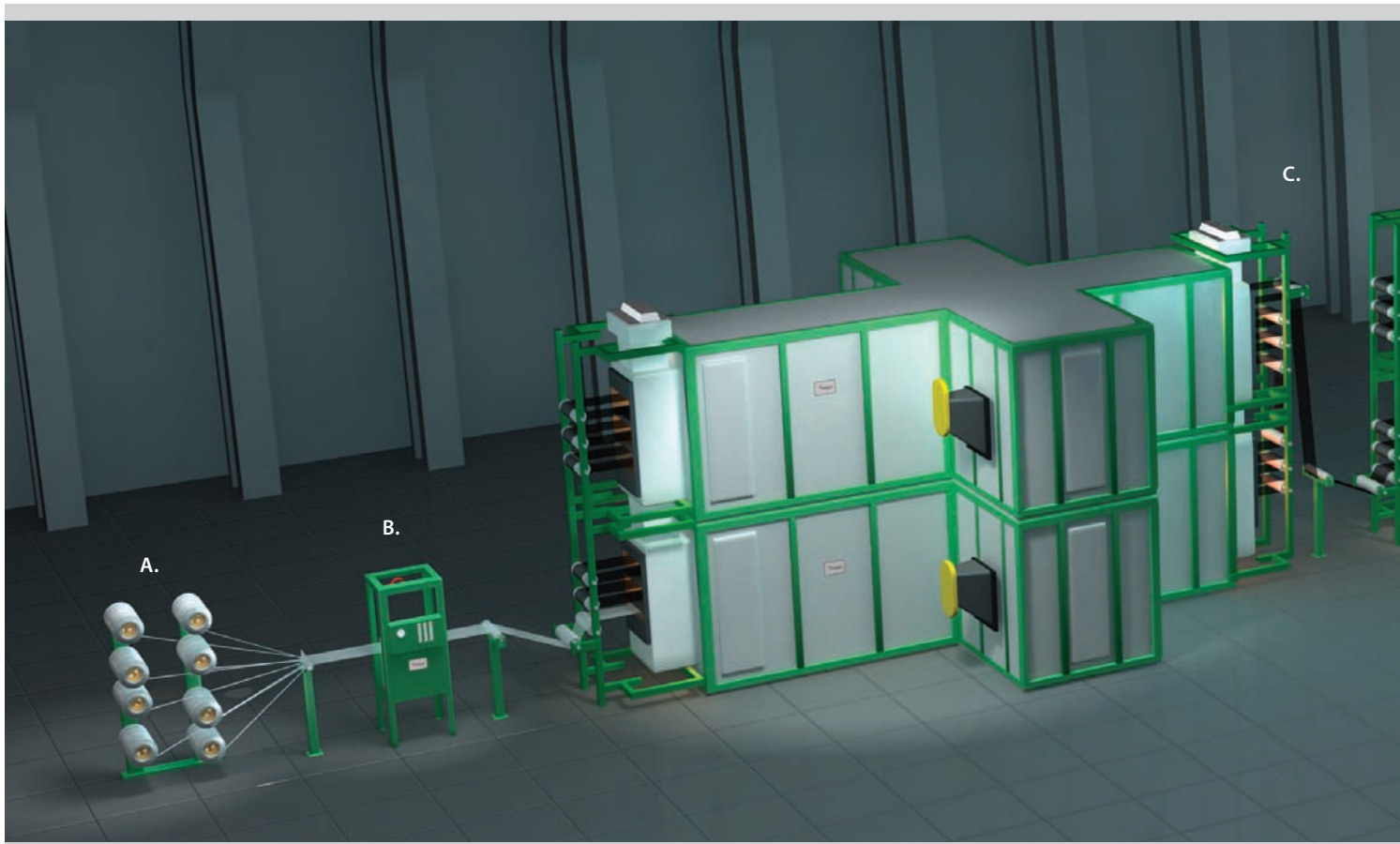
Harper Slot Furnace Design Enhancements

- Unique end-seal design delivers excellent process gas flow uniformity
- Strategic heating element design achieves optimal temperature uniformity
- Advances in insulation packages to reduce energy consumption
- Carburization resistant muffle for extended muffle life
- Truly adjustable inboard and outboard louvers for precise control of fugitive air ingress and egress
- Well-proven atmosphere purge chambers improve product quality and extend the useful life of the insulation



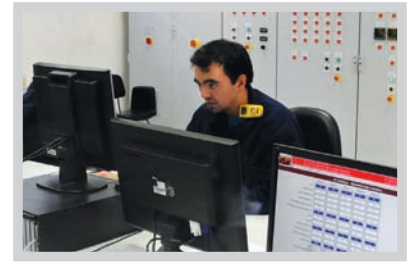
Harper Slot Furnace Capabilities

- Temperatures to 3000°C
- Electric or gas fired
- Carburization resistant muffle
- Easy internal access to facilitate maintenance
- Unique atmospheres (argon, nitrogen, CO₂, steam)
- Vertical HT furnaces, high modulus and other custom designs
- Multiple independently controlled temperature zones
- Fully pre-assembled and carefully broken down to minimize field installation effort



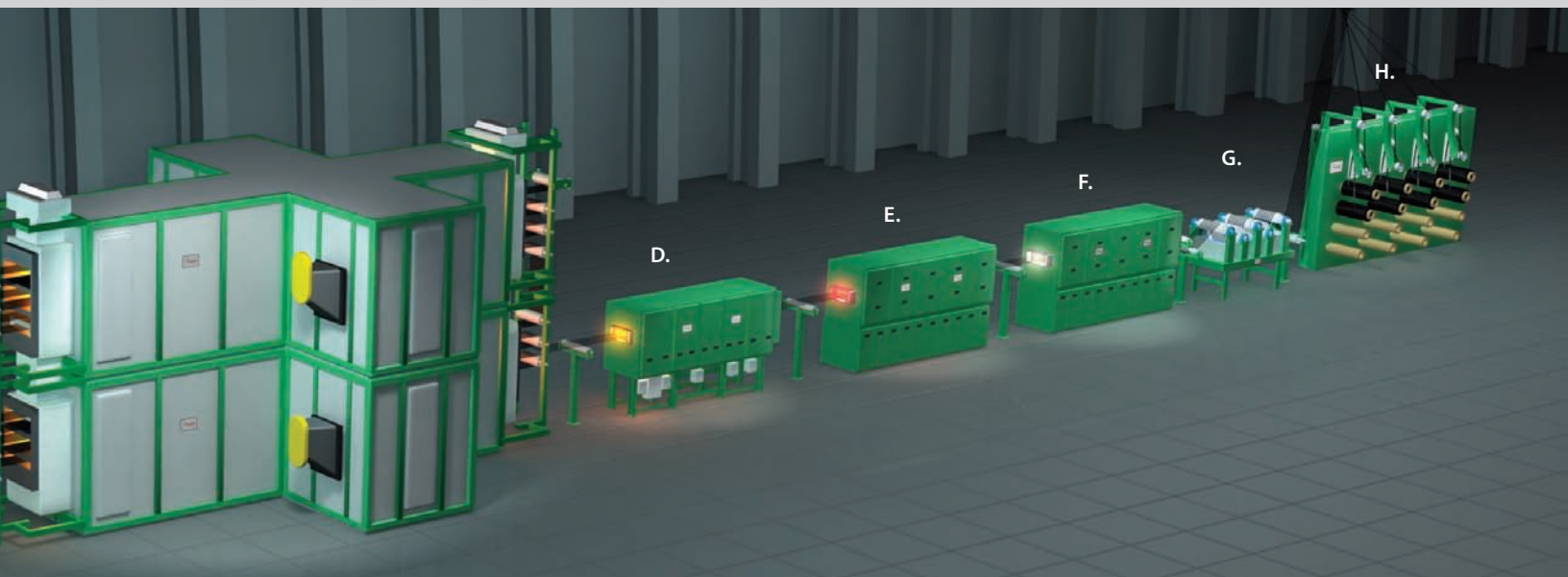
Fully Integrated Control Systems

From the first point of engagement on a project, Harper designs with rigorous and thoughtful operations sequences to drive improvements in operations and quality. Our fully integrated controls connect all equipment to one centralized system, to ensure a cooperative plant, functioning on the same control platform rather than isolated platforms.



Harper's advanced operator interface system features high-resolution color graphics and Windows®-based software, enabling simple control of temperature, alarm management, thermocouple linearization, program recipe storage and retrieval, and archiving of data and interface to central control systems, as well as advanced functions such as remote monitoring and proactive predictive maintenance.

Our designs not only allow for normal operations, but also focus on enhancements of plant safety and protective measures in transitional states, ranging from start-up and shut-down regimes, where the individual unit operations are coordinated in proper sequence to protect both the operator and equipment, to disruptive events such as exotherms and loss of utilities, where multi-level security helps to manage the facility in a safe fashion.



Visit carbon-fiber-lines.com, and take a virtual tour of our full line or watch our video of a real line in action.

- A. Initial Material Handling
- B. Pre-treatment and Material Conditioning
- C. Oxidation Ovens
- D. LT Furnaces
- E. HT Furnaces
- F. UHT Furnaces
- G. Post-treatment and Material Conditioning
- H. Final Material Handling

Thermo. Dynamic.

Harper is the industry standard in continuous thermal processing technologies for the carbon fiber industry. Our involvement in carbon fiber began at the market's inception in the 1970s, and since then we have been helping fiber manufacturers reach new and greater heights with our evolutionary design innovations.

We tailor each design to the customer's requirements, considering the best possible solution for your needs, spanning a variety of precursors including PAN, pitch, lignin, polyethylene, and rayon in tow, nonwoven mat, or discontinuous, loose fiber form. Harper's philosophy is not only to deliver comprehensive systems with the latest technologies, resulting in distinctive solutions, but also to design features that ensure the most efficient and effective operations. Whether it's optimized waste gas treatment, control systems with predictive maintenance, or energy-efficiency techniques, Harper always has the complete solution in mind.

With Harper, you will find a partner uniquely qualified to make your thermal process challenge a success. No one else offers an end-to-end service approach with an all-encompassing range of technology solutions, delivered by a passionate and exceptionally skilled staff. That's why world-leading material technology companies, as well as cutting-edge start-ups, depend on Harper for ingenious, first-of-a-kind systems.

"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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