



## Your Experts in Fiber Processing

Our customers are working in the development of cutting-edge fiber products for a more sustainable future, and we support them from the first laboratory tests to the modular construction of their production lines.

Innovative products like precursor yarns for carbon fibers made from renewable raw materials are produced and improved with DIENES spinning systems. We are aware that growing demands on the varying quality of recycled feedstock and the achievement of a consistent fiber performance require a continuous development and optimization of both technology and production parameters.

A reliable development of textile and technical filament yarns demands an efficient, systematic and, in part, self-optimizing experimental working system, which must be intelligent and flexible. Our approach to meet such demands is called MultiMode®. In a MultiMode® plant, each process step is represented by a module which can be individually adapted to customer-specific requirements and has its own decentralized control. Thus, DIENES production lines consist of several intelligent modular units which can be easily exchanged and rearranged at any time with a reduced programming effort. Moreover, all production parameters can be permanently visualized and recorded, enabling a complete traceability of the process.

Designing special equipment and fully engineered solutions is our passion. With their broad experience in all spinning technologies, DIENES engineers will help you turn your ideas into functioning plants.

Our engineering and quality criteria meet the highest standards, such as enabling a complete traceability of all process data.

With the delivery of a wet spinning plant - validated according to GMP guidelines and GAMP standards - to a manufacturer of medical products, DIENES is now a qualified partner for customers from the pharmaceutical and bio-medical sector.

**For more than 90 years: DIENES “your experts in fiber processing”**

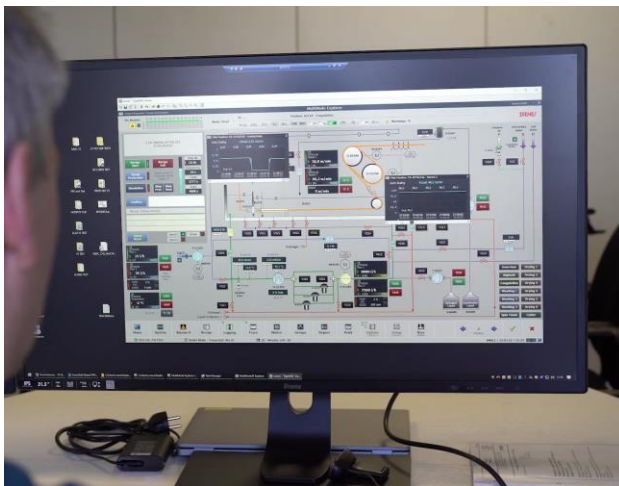
Founded by Fritz Dienes in Mühlheim am Main (very close to Frankfurt am Main in Germany), DIENES is a tradition company which has a long history. In the 70s the company operated as DIENES-Honeywell as it came into the ownership of the Honeywell Group. In the two following decades and under the direction of Wolfgang Gehrman and Max Broßmer DIENES equipped a significant number of machines with its inductive heated rolls, heaters and its own controls. From 2000 to 2006 DIENES belonged to the Temco group. In 2006 Steffen Müller-Probandt took over DIENES as the result of an MBO.

Our team is the perfect combination of the invaluable know-how from long-time employees together with new ideas and inspiration from young colleagues ensuring excellence in the quality of our products and services.

We put our engineering experience at your disposal. It is our commitment to listen and to respond to the requirements of each individual customer.



Bringing your ideas and our technology together will lead to a long-lasting partnership yielding amazing high-tech machines to create and produce innovative fibers and yarns for a better future.



We are specialized in modular laboratory, pilot and production lines for high performance filament yarns based on our competence in yarn guiding and the capability to develop special electrically heated components, suitable control systems and customer driven innovations. Over the years we have developed contactless temperature transmitters, inductive heaters, multi zone technology, AIO godets with on-board electronic, compact steam chambers for efficient yarn treatment, nanofiber spinning installations with centrifugal technology and the flexible DIENES MultiMode® concept for our lines.

Today our scope of supply goes from individual plant modules up to complete production plants for melt, wet, nanofiber spinning and further post-treatment (e.g., stabilization, carbonization, sizing etc.).

**Our main products are:**

### **MultiMode® Lines**

- Research and production lines at lab, pilot and industrial scale focused on high performance fiber spinning and carbon fiber production.
- Maximum flexibility for the optimization of the overall production process
- Smart software for data processing and production control

### **MultiMode® Modules**

- Innovative modules in the field of yarn spinning & treatment equipment, especially for the heating of synthetic high performance filaments during production.

### **High Performance Components**

- Cold and heated DIENES godets for speeds up to 7.000 m/min and temperature up to 550°C
- Various special heaters for the production & treatment of all types of synthetic yarns

### **Services and Specialties**

- Conversion and modernization of existing spinning installations
- Customized solutions for your process



## High Flexibility - Easy Scalability - Plug and Play

Laboratory and pilot spinning lines need to be varied for every new experiment. Thus, DIENES followed this need and established intelligent modules which can be flexibly combined to a prototype line and re-combined without re-programming the controls.

The **DIENES MultiMode® System** is known for high flexibility and easy scalability. Customers worldwide rely on customized solutions for demanding tasks. Starting from lines for yarn measurements, complex coating units to complete pilot and production lines for melt, wet, nanofiber spinning and further post-treatment – all your ideas can be realized with DIENES MultiMode®. A thorough portfolio of modules is ready to be combined and implemented as a customized solution meeting your needs.



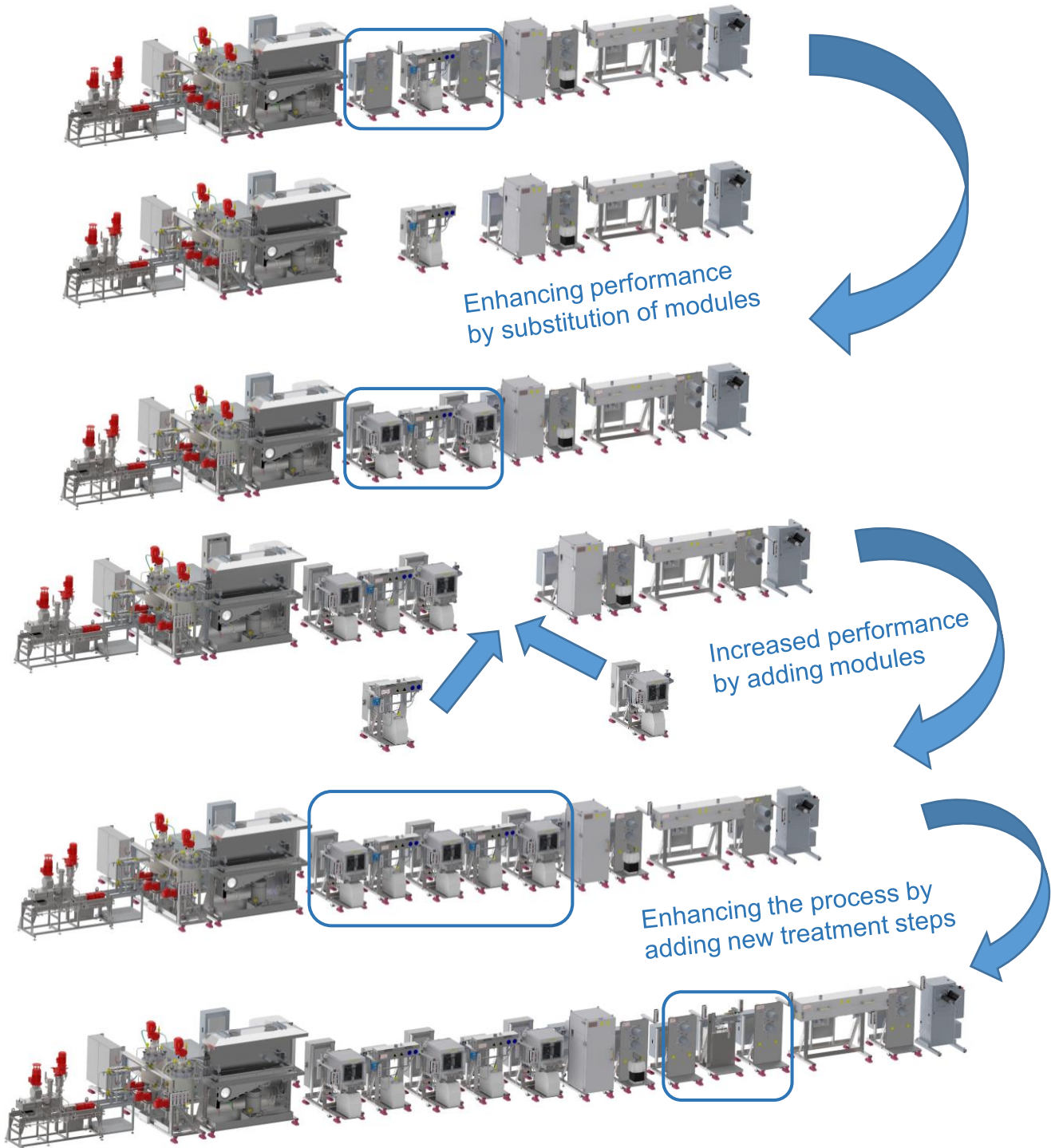
An accelerated growing demand for textile fibers demands a more proactive approach which includes implementing frameworks and technologies for recycling and a broad use of biobased materials as an alternative to polymers like polyester and nylon. Biobased and recycled fiber products pose a big technological challenge as growing demands on the varying quality of feedstock and the achievement of a consistent fiber performance require a continuous development and optimization of both technology and production parameters.

Research work in this field is characterized by a high degree of adaptation needs. Thus, facilities must be able to be adapted after initial experiments and the knowledge gained thereby. MultiMode® is an approach enabling researchers to work optimally supported by the system. Necessary adjustments are made under the conditions of a highly complex manufacturing process, which is determined by many parameters. This results in the following requirements for the flexibility of modular research facilities:

- INTEGRATION:** Easy integration of new production modules
- SCALABILITY:** Easy replacement of production modules with modified specifications
- FLEXIBILITY:** Easy modification of production steps' positioning within the production line
- HIGH PERFORMANCE:** Intelligent production modules synchronized by a master process control level
- ANALYTICS:** Continuous monitoring and evaluation of process parameters

## MultiMode® modular design:

Simply change and expand existing DIENES MultiMode® configurations shown as an example in a wet spinning line:

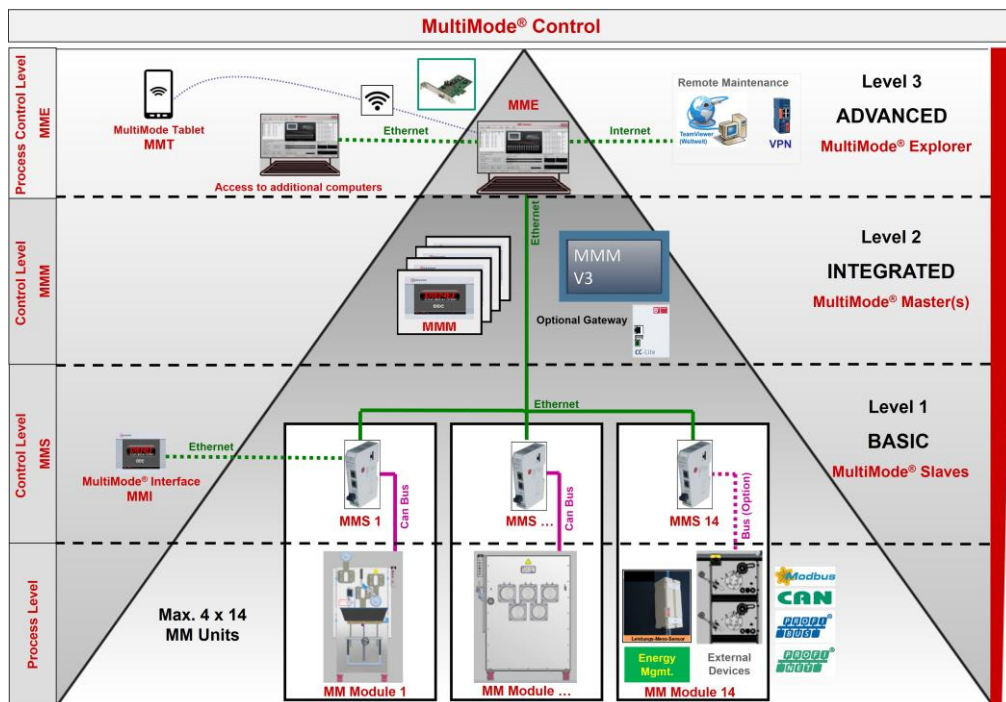


## Customized process control systems

All DIENES MultiMode® modules have an independent local control. In connection with a DIENES visualization unit all process-relevant data is graphically available for the user. Changes in the process can be made effectively by entering data via touchscreen. Through the combination of several DIENES MultiMode® modules and the integration of a MultiMode® Master (MMM), all local controls are displayed in a central control panel.

The graphic representation on a large touch display enables a convenient overview of all connected MultiMode® modules and an easy setting of all relevant parameters.

For the analysis of complex relationships to carry out process analysis the MMM is getting extended by a DIENES MultiMode® Explorer (MME). From system expansions to process development: customized process control systems for your application.



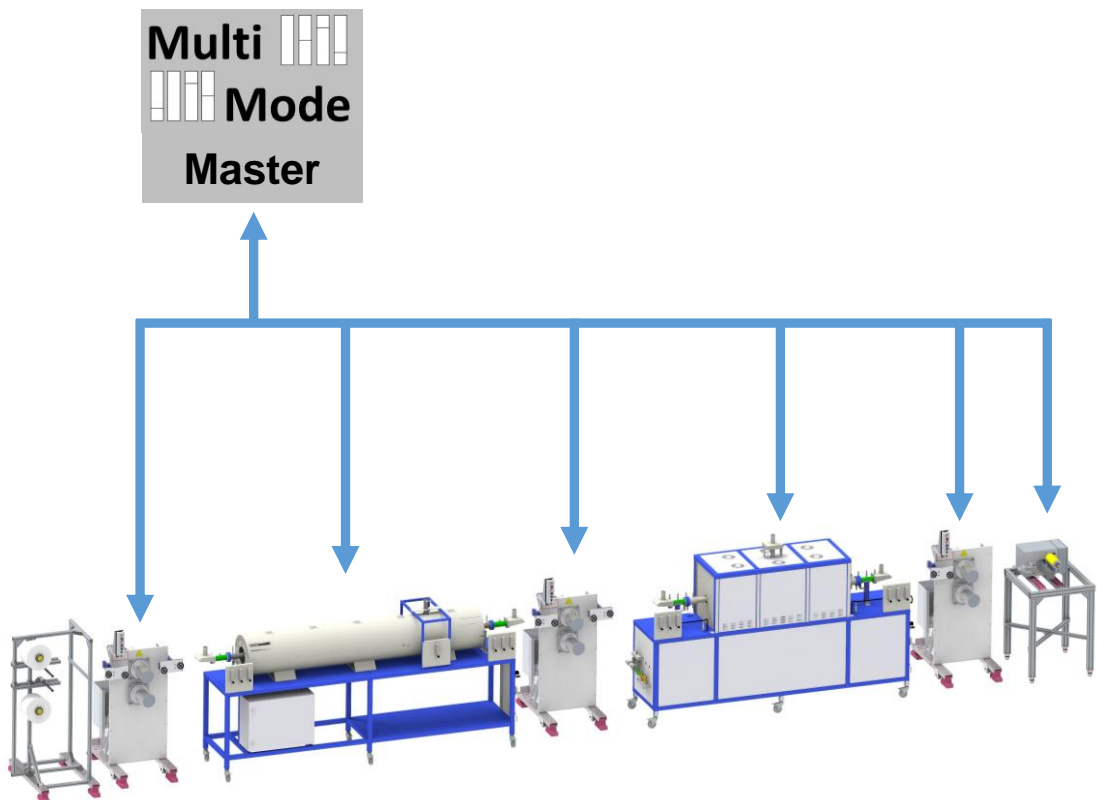


## Synchronous data acquisition

DIENES MultiMode® installations allow a high degree of flexibility in process development. The consistent implementation of the modular design is continued in the control environment.

Each MultiMode® module communicates via a standardized interface to the central controller, the so-called MultiMode® Master (MMM). Changes in the module assembly are automatically detected and entered by the system. For optimal processes the control data is synchronized on request by the MMM, so you can put your focus entirely on your development process. You can comfortably start with a basic configuration which can be expanded anytime by integrating new modules as the process requires. This means 100% flexibility for your process development.

With MultiMode® all data are automatically saved and synchronized. You will always be able to backtrack the journey of your yarn.



## From the first lab trials to your first production line

DIENES designs and implements complete systems consisting of individual modules, which are assembled according to the MultiMode® principle.

DIENES MultiMode® lines cover a variety of the complete processes from the spinning of the fibers to stabilized and carbonized carbon fibers. For each process step a selection of DIENES MultiMode® modules are available, with additional equipment (i.e. thread tension measurement on a duo or oiling etc.).

For your specific process parameters an adaptation of the DIENES MultiMode® modules to your needs is possible at any time.

We will be delighted to inform you about the DIENES MultiMode® modules, which are best suited for your process.

The modular design allows us to take into account specific customer requirements as well as modules from other manufacturers which can be easily integrated.

In addition to complete lines it is also possible to implement only individual treatment steps in an existing system. Also DIENES MultiMode® modules can be integrated in non-DIENES systems by using on-board controls combined with a MultiMode® Interface MMI.

The number of DIENES MultiMode® modules continues to expand, thereby new assembly and expansion possibilities result constantly.

## Mono and multifilament melt spinning lines for nearly all spinnable polymers

DIENES offers mono- and bicomponent compact melt spinning plants according to the MultiMode® principle. The production speed of these lines is up to 6.000 m/min.

The lay out of the extruder with dosing, spinning unit, quench, drawing sections and high-speed winder is adapted to the specific needs of the developers in order to lead to the achieved results.

- Individual yarn path adjustment
- Actively cooled godet
- Speed up to 6.000 m/min



## Nanofiber centrifugal electrospinning lines for creating fiber webs in a solution spinning process

DIENES offers nanofiber spinning installations with centrifuge technology which represent a leap forward in many aspects. By the use of high and constant throughput the installation can produce fibers with diameters as low as 80 nm in a simple and compact machine configuration at highest productivity. Centrifugal spinning line with only three heads provide a throughput which is 1.000 times higher than conventional electro spinning installations with 25 rows of 1.250 spin jets. Various polymers can be processed such as PUR, PI, PAN, PVA, PEO, PLA, PS, cellulose acetate, PC, PA, paramide, polycaprolactone, collagene, peptides and all others for which a solvent is available. The technology is used for low budget laboratory units as well as in high capacity production lines while for all systems the same technological advantages are present.

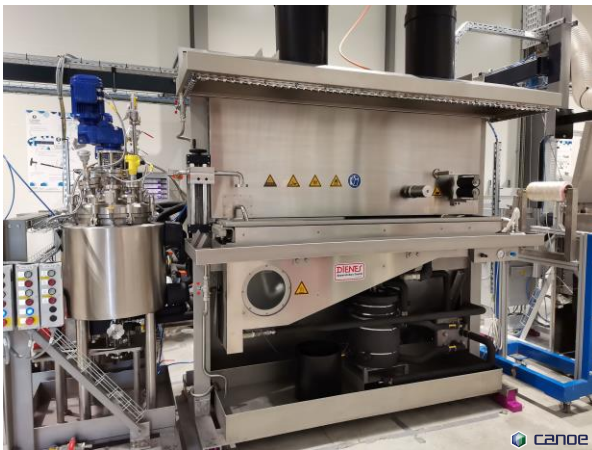




## Synthetic fiber solution spinning lines for wet and dry processes

The DIENES wet spinning lines in standard or air-gap execution enable highest performance in the production process. The wet spinning lines consist of various main steps: coagulation - washing – drawing – drying – fixation – winding. The general set-up and the complexity of the machine depend on the process and the customer's target.

We offer lab lines with independently driven modules, MultiMode® pilot plants and production lines, equipment for the production and treatment of multifilaments low speed spinning (e.g. precursor) & monofilaments (e.g. medical and reinforcement)



## Lines for stabilization of precursor material for carbon fiber yarn

Stabilization is considered to be one of the most important process steps and gives the greatest improvement potential in the creation of high quality carbon fibers. For this process DIENES offers furnace systems with high temperature accuracy of  $\pm 2\text{K}$  at  $300^\circ\text{C}$ . This system is combined with transportation godets to implement a tension controlled stabilization.



## Lines for carbonization & activation for carbon fiber yarn

Subsequently to the stabilization the carbonization of the material follows, which is usually performed in a two-stage process in an inert atmosphere and at temperatures of up to 2.800 °C. DIENES offers thread guiding equipment and together with its partners carbonization ovens.

DIENES also offers modules for the activation process of the carbon fiber which includes treatments such as electrolytic surface treatment and sizing application.

Semi industrial carbonization Line  
for the carbonization of 10 times 12K precursor

- Realized for Plateforme CANOE, France -





## Lab scale lines for different spinning processes

DIENES MultiMode® Lab Lines are especially designed for research & development. This entry level compact lines are suitable for validating the process at lab scale. We have already implemented solutions for wet spinning and nanofiber centrifugal electrospinning. Currently we are developing concepts for carbonization and melt spinning.



Lab scale line for wet spinning



Lab scale line for nanofiber centrifugal electrospinning



## Washing systems & applications of spin finish

We provide technology and equipment in all established washing technologies such as washing bathes, washing duos, bath roller washers, jet washers and perforated drum washers. Last but not least the DIENES T-box offers highest shear forces and penetration. The use of these equipments leads to a cost-efficient production process.



## Drying & thermo setting systems for yarn treatment

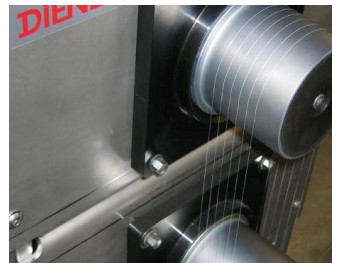
Our product range comprises a variety of drying and thermosetting equipment.

For special fibers we offer hot air channel up to 500°C together with high performance godet duo's, which thermo set at high temperatures or realizes a high evaporation power.



## Coating systems for various substrate-coating combinations

We proposes liquid yarn coating in dip bath with non-contact air drying and heated dwell chamber for crosslinking of the coating. Other coating lines like transfer coating, online coating, melt coating and calendaring can be realized in pilot stages.



## LLC dancer arm winder

Our winder was originally designed for our LLC and simple integraion into existing lab scale lines. By and by it was developed for further applications and now it is also available as tower for several positions.



### High performance godets for FDY production machines and high temperature drawing / heat treatment processes

DIENES became known as one of the first companies in Europe launching inductive heated draw rolls for multi-position machines. An important breakthrough for DIENES was the sophisticated high performance godets - available with integrated drive and control system - used for high speed and up to 550°C for special processes and also for high power distribution in drying processes. Our godets offer exceptional reliability and consistent operating conditions for high product quality. All godets of DIENES are multi zone induction heated with an even temperature profile & without hazardous additives. Customer-specific designs are available for special operating conditions.

DIENES equips among others melt spinning lines for POY & FDY with complete draw sections, separator rolls & cooled godets by using our own standards. We supply services and parts for the modification, modernization or conversion of production lines and proposes customer-specific concepts with the aim of improving productivity, increasing efficiency and enhancing product quality.



### Static heaters, plate and slit heaters for heat setting / relaxation

In addition to the godets DIENES also provides a wide range of electrically heated components for the thermal treatment of textile materials. Besides the possibility for contact or indirect non-contact heating between the heater and the material, DIENES supplies heating and drying ovens for contact or non-contact drying.