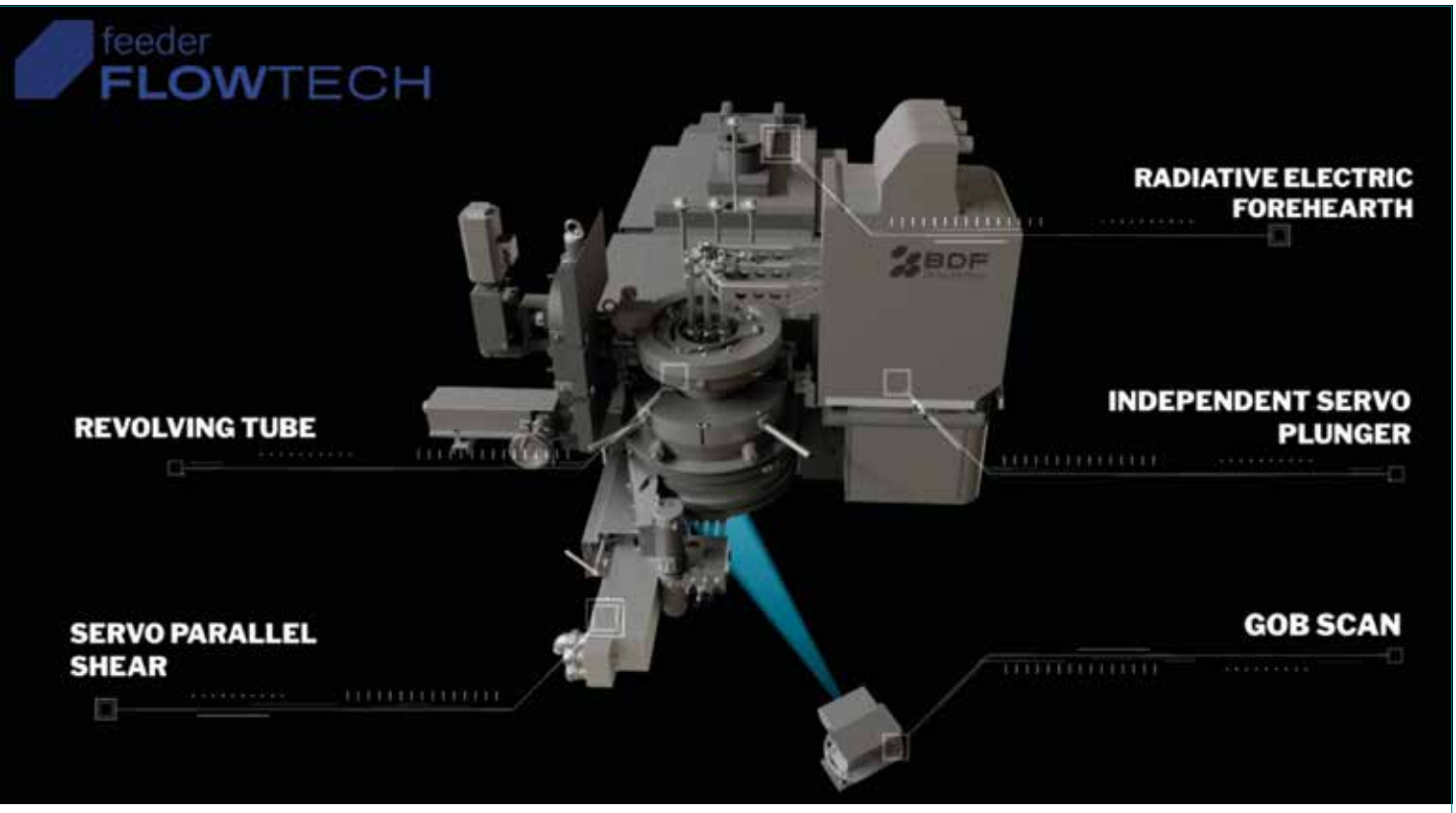
FLOWtech Integration sees BDF INDUSTRIES finetune data-driven processes

Headquartered in Vicenza, Italy, and with over a century of expertise, BDF INDUSTRIES is a global leader in glass machinery solutions. For higher quality products and an ever greater commitment to simplicity, safety and sustainability, the company is shaping the future of glass manufacturing through constant research and development for high-performance solutions that can meet modern industry demands.

Over recent years, BDF has remained focused on creating and making available to its customers products that are consistent with the company's fundamental principles and values. These include the basic safety of operators, the simplicity of interpreting process data and machine operation, attention to the environment and reduction of plant operation costs.

ROBUST CORE VALUES

BDF's philosophy of 3S, namely Simplicity, Safety and Sustainability, guides all company choices in the development of any technological, up-to-date product in the glass industry. Since 2001, the company has been a truly unique hot end process integrator, able to support design while supplying customers with furnaces and forehearths - all thanks to the strong skills of its melting division as well as IS machines for the production of hollow glass. This includes a range of solutions that today spans the whole of production. Within this framework, FLOWtech is a technological platform which aims to drive continuous improvement in the glass manufacturing process through cutting-edge technology. Indeed the glass production process is monitored through all phases, detecting any deviation from the optimal state. Such an innovative



approach and the great strength of the system ensures that no detected anomaly would simply correct the effect. It would also identify the root causes of the deviation and correct it automatically or notify the operator where to act with a clear feedback signal. It is therefore possible to intervene in the process at the earliest possible stage and correct the source of the defect - all with great benefits in terms of timeliness, quality of the result and overall process efficiency.

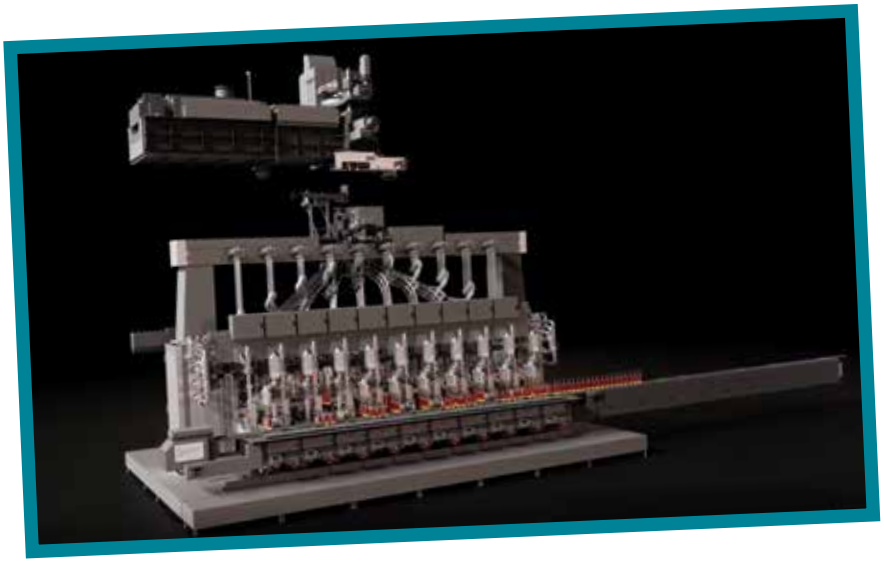
DATA TRACTION

A systematic and statistical approach in data analysis also allows the database of deviations with related causes and countermeasures to augment - ensuring a continuous refinement of the process but also increased precision and a thorough operator feedback.

The Feeder flowtech application is the Flowtech approach to the feeder area. Composed of five devices, these work as a single analysis and feedback system in which reference parameters are continuously acquired and managed by way of three specific control loops - until the perfect process configuration is reached and maintained. These control loops keep the production stable on the optimum state - not only acting upon feeder parameters. They also start from glass conditioning in the forehearth, intercepting those differences in the glass temperatures that are the root cause of many of the defects in the final ware; thereafter they can also fine-adjust shape, weight and falling angles that evaluate and adjust the feeder settings.

FEEDER FLOWTECH EQUIPMENT

- The Gob Scan consists of two vision systems positioned on a horizontal plane below the shear section;
- each includes a visible, thermal camera that reconstructs a 3D image of every gob - thus measuring and detecting a set



of relevant parameters, namely the gob shape and dimensions, weight, falling angle, temperature distribution, inclusions as well as cold and hot spots.

The acquired information is passed to a processing unit in which a proprietary software correlates the data and can act on the operating parameters of the other components of the System.

- The Radiative foreheart guarantees the homogeneity of the glass temperature in the conditioning zone and takes the glass to the plunger mechanism at the correct temperature;
- The revolving tube can regulate gob weight by means of tube height;
- The independent servo plunger creates each gob with real time independent dynamic parameters, determining the ideal shape and weight based on reference data for the process. It has an innovative modular design and is able to manage different electric cams for each section and cavity;
- The Servo Parallel Shear is an high speed shear mechanism that can regulate the length and the falling angle of the gob, by acting on start time, travel and duration of each cut and each gob.

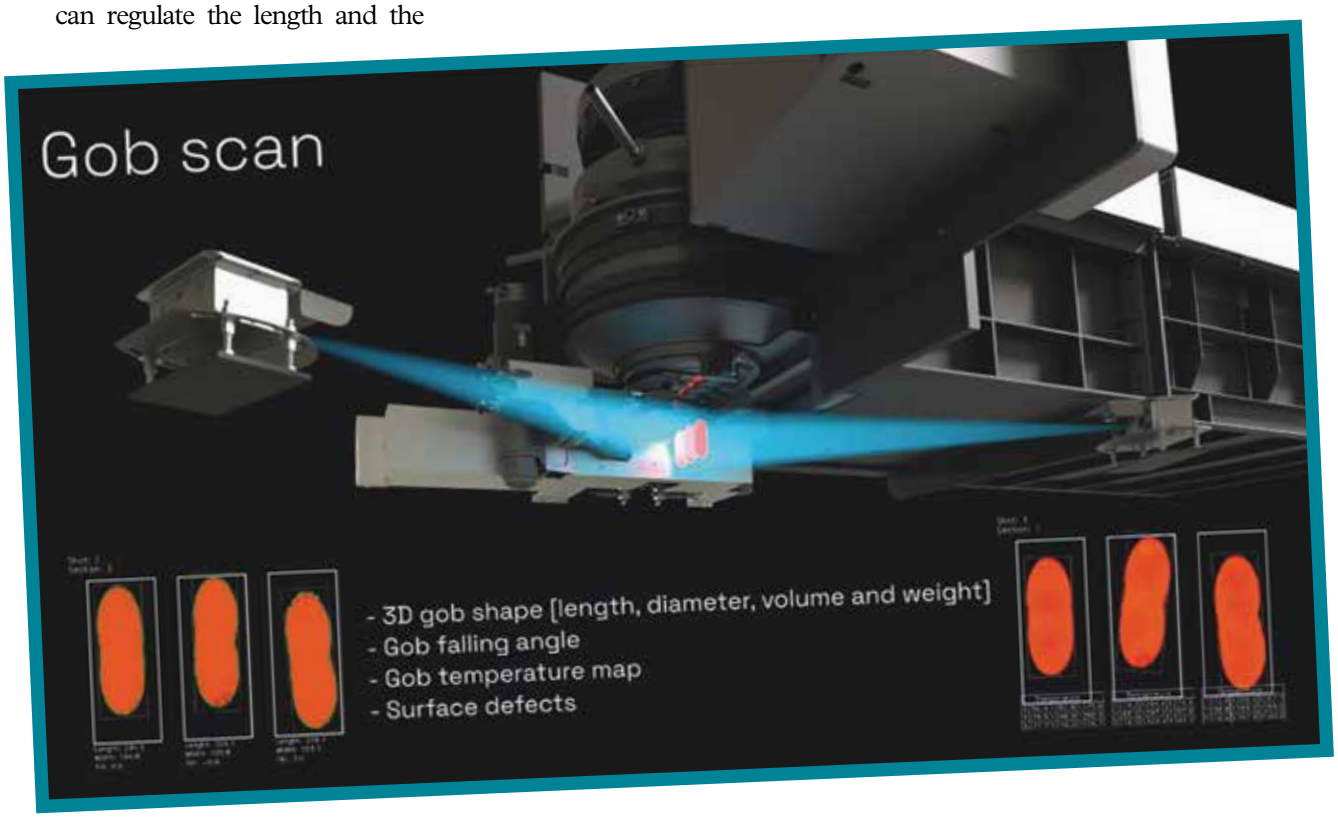
The three main control loops that contribute to process parameter optimization are as follows:

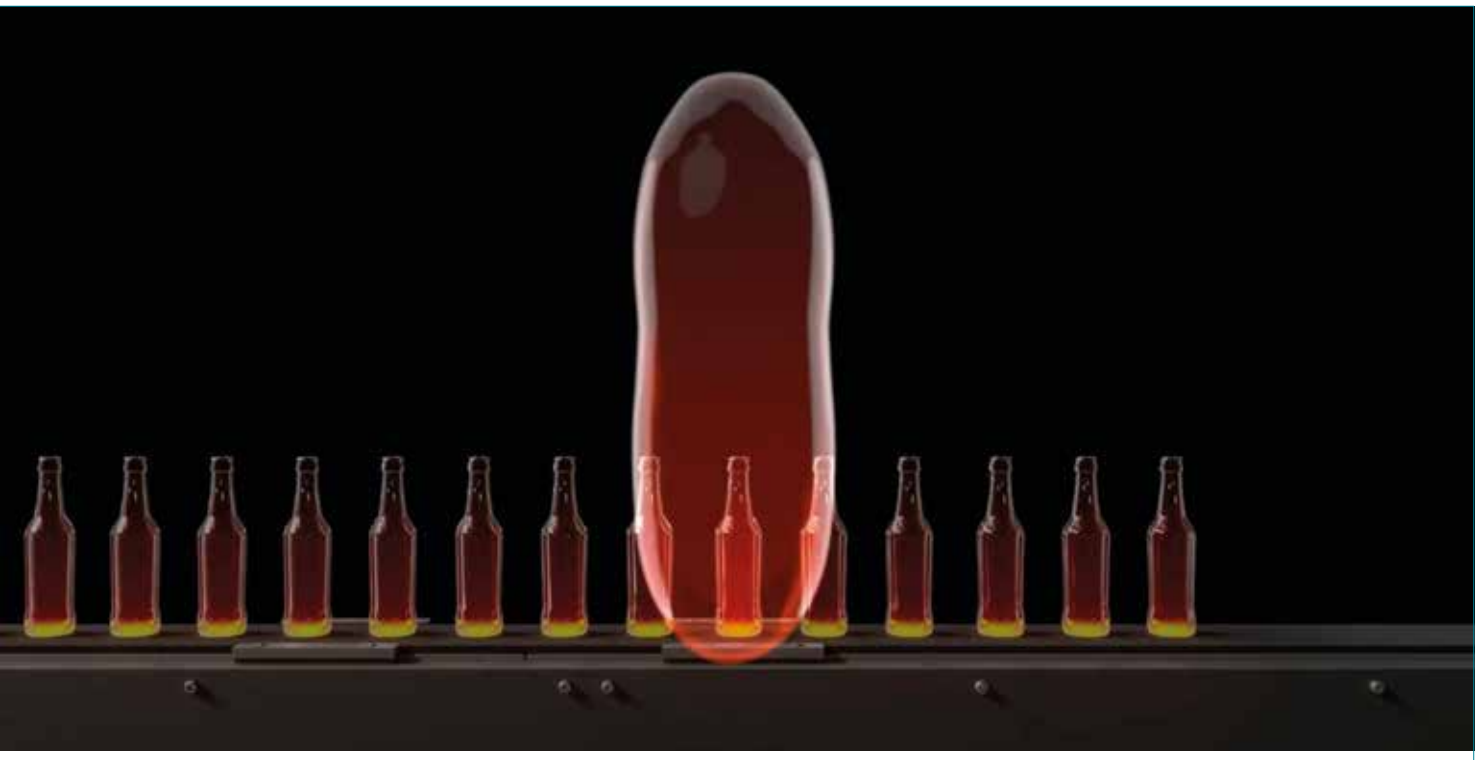
1. TEMPERATURE HOMOGENEITY LOOP WITH FOREHEARTHS

This loop ensures the temperature homogeneity on the gobs remains as close as possible to 100 percent. For each cut, a thermal map of the gob temperature distribution is calculated. The Gob Scan system continuously acquires this thermal map from the forehearths control. These maps are compared and combined to provide the forehearths control system with the actual temperature homogeneity map, which is then used as the input for the conditioning loop. The algorithm used for map combination is patented by BDF. The company's forehearth control system employs the Advanced Control System (ACS) to translate the thermal map into appropriate settings for the glass conditioning loops across each forehearth zone.

2. WEIGHT LOOP WITH SERVO PLUNGER AND TUBE LIFTING

This loop maintains consistent weight for each section and cavity, enabling automatic variable weight setup. The weight of each gob on every cavity and section is calculated. If any deviation from the target weight is detected, adjustments are made to the servo plunger settings. The tube's height is adjusted to control the average gob weight, while the height and stroke of individual cavities are fine-tuned if specific gobs do not meet weight specifications. In variable weight production, the system can automatically configure the feeder setup based solely on target weights. This functionality is made possible by a BDF-patented feeder configuration calculation algorithm, which includes automatic calculation of feeder characteristic parameters and the height and stroke values for each section and cavity. In the event of abnormal behaviour, alarms and notifications are displayed on the HMI.





3. LENGTH AND FALLING ANGLE LOOP WITH SERVO PARALLEL SHEARS

This loop keeps gob length and shape consistent while adjusting the falling angle. Users can define the desired gob shape based on a stable process and gob imagery. The shape and length of each gob on every cavity and section are calculated. If any deviation from the target values is detected, the affected section and cavity are highlighted. When such deviation persists beyond a programmable number of cycles, an alarm is triggered (also on the ADV system). The stroke of the specific cavity is then adjusted to bring the gob shape back to the desired target.

In alignment with 3S philosophy at BDF, the FLOWTECH Feeder already enables significant improvements to the production process.

a) Simplicity:

- Root-cause process optimization
- Optimized gob forming with reduced variation
- Enhanced automatic closed-loop feeder controls
- Simplified maintenance of the plunger mechanism

b) Safety:

- 60 percent reduction in human intervention on the feeder system

c) Sustainability:

- 100 percent decarbonization of forehearth heating
- 70 percent increase in thermodynamic efficiency
- Improved glass quality with reduced waste

LOOKING AHEAD: AI INTEGRATION

The journey doesn't stop here. BDF is already developing the next phase of FlowTech: the integration of Artificial Intelligence into the main steps of the hollow glass melting and forming process, which will further extend automation, optimize decision-making and elevate operational excellence throughout the glass production line. ■