Automated Ultrasonic Welding Machine for Straw Tube Production for the SPD Straw Tracker

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on behalf of StrawTrackerRD team

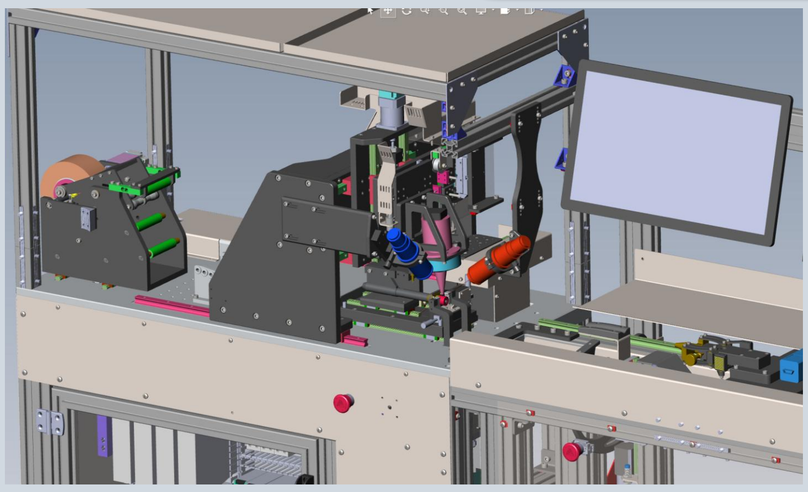
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ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

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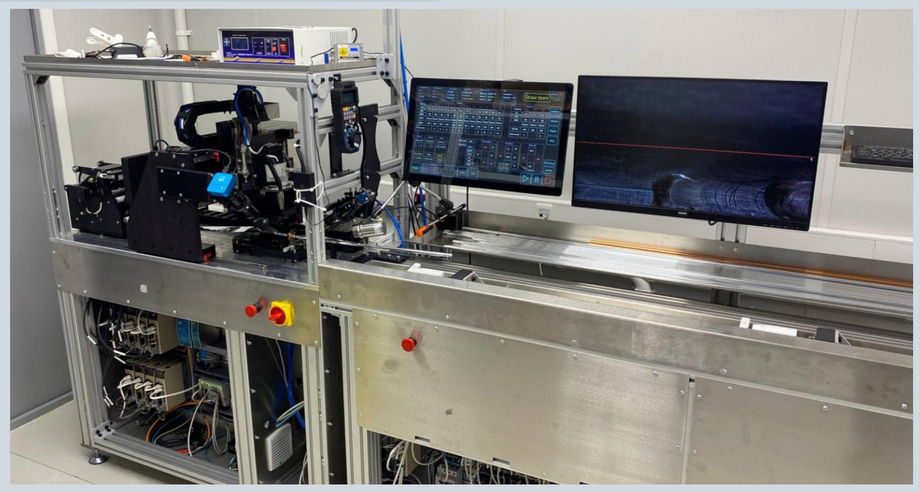
SPD NICA



Introduction

Straw tube detectors are widely used in high-energy physics experiments due to their low material budget, good mechanical stability, and suitability for large-area tracking systems. For the SPD experiment at the NICA collider, reliable large-scale production of thin-walled straw tubes is required.

A new automated ultrasonic welding machine has been developed to improve the precision, reproducibility, and stability of straw tube manufacturing. New functions provide a controlled production cycle and enable direct monitoring of the key parameters affecting straw geometry and weld quality.



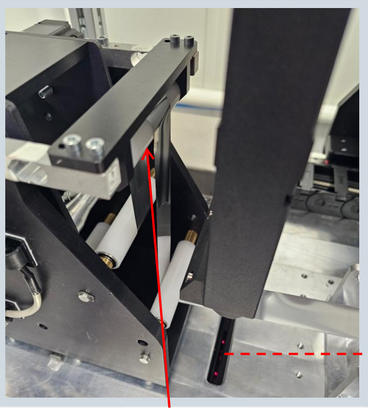
Multi-axis positioning
Precise positioning of the welding head, pin system, film source, extractor, and tube supports.

Internal pressure control
Precise regulation of the pressure inside the straw during welding and pressure testing.

System precision
- Axis positioning accuracy: **1 µm**
- Internal pressure setting accuracy: **50 mbar**
- Straw manufacturing accuracy: **5 µm**

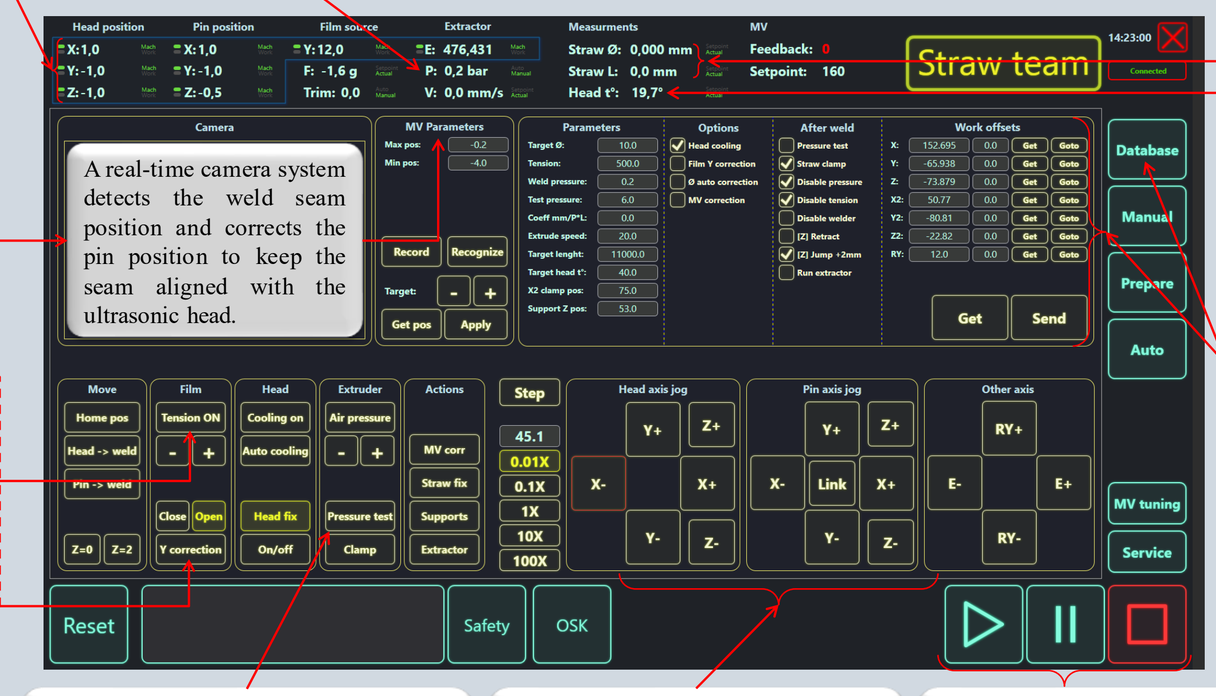
Straw geometry monitoring
Online monitoring of the straw diameter and length during production.

Machine Vision seam tracking



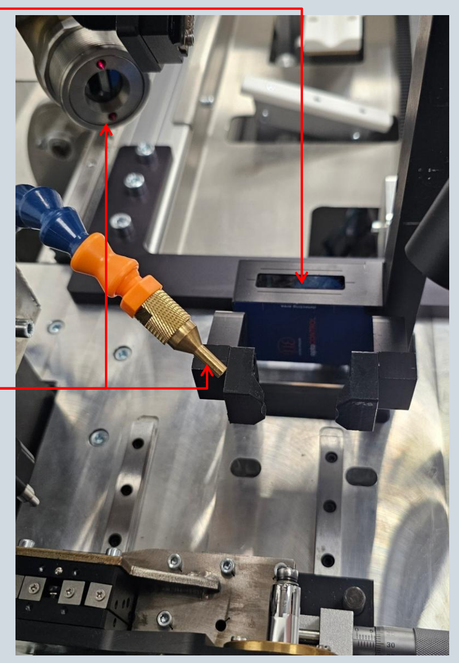
Film feeding and tension control
Controlled film motion and tension provide stable straw formation.

Film source alignment correction
Laser-based correction ensures accurate alignment and coaxial feeding of the film into the welding zone.



Thermal stabilization
Pyrometer-based feedback stabilizes the temperature of the ultrasonic welding head

Operator interface and database
Process parameters can be set, monitored, and stored for reproducible production.

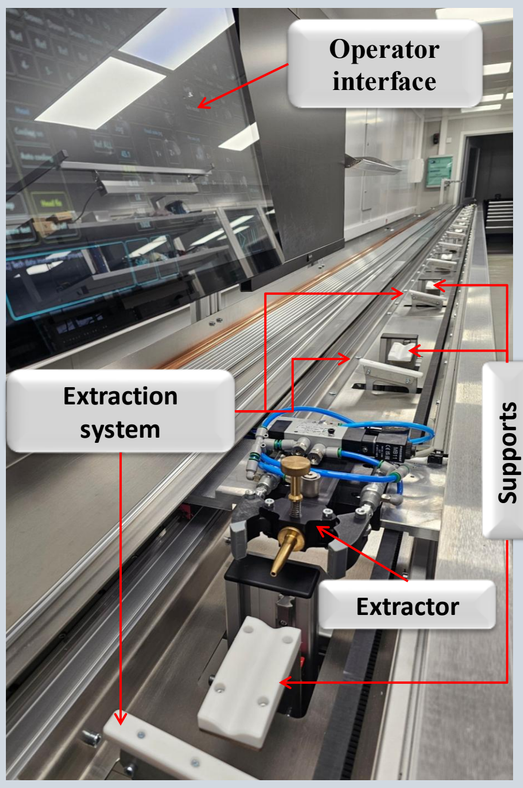


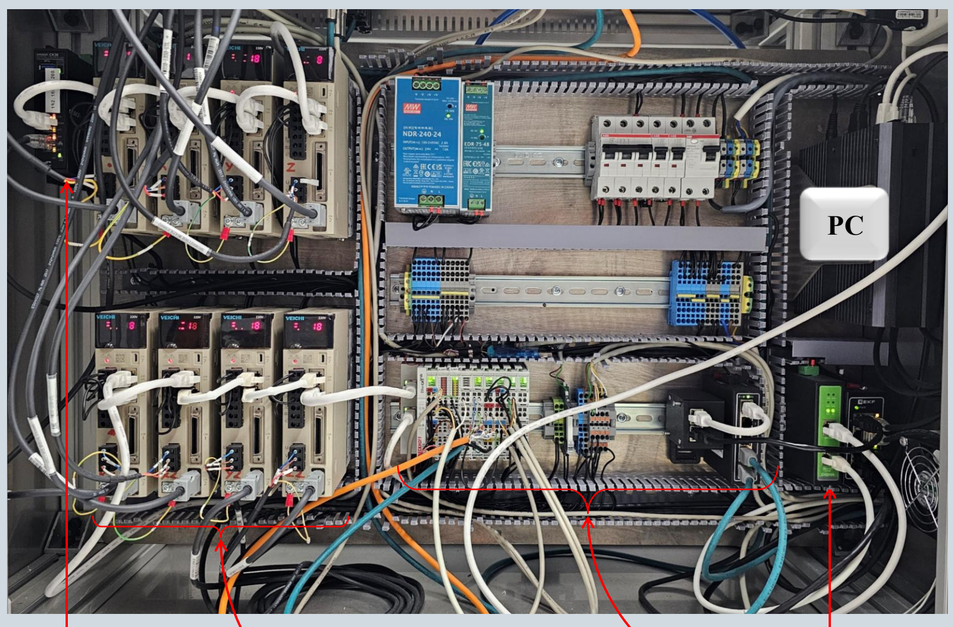
Why ultrasonically welded straws?
- Ultrasonically welded straws provide a low-material tracking technology suitable for large-area detector systems and vacuum applications, where multiple scattering must be minimized.
- They offer sufficient mechanical stability for thin-walled straw tubes and make it possible to produce ultra-light straws with small diameters.
- At the same time, welding of metallized PET film is a technically demanding process, requiring precise control of film tension, pressure, temperature, alignment, and weld quality.

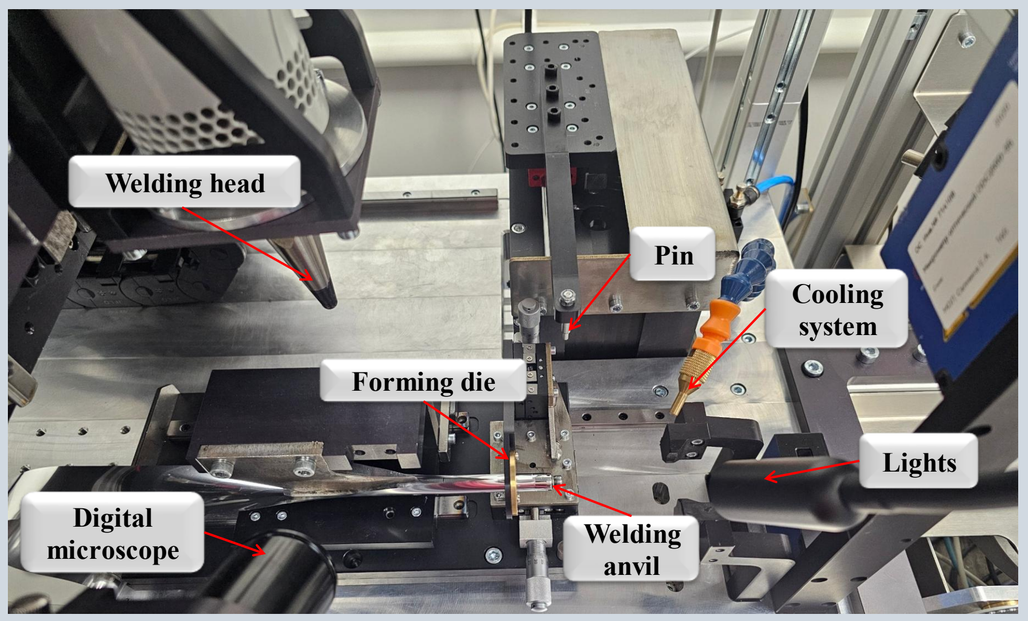
Integrated pressure test
The welded seam quality is checked by applying controlled internal pressure after welding.

Manual axis control
Manual control of all axes is available for setup, calibration, and service operations.

Automated welding cycle
The full production sequence, except cutting, can be launched and controlled automatically.







CK3E (µPowerPMAC) Controller

- High-speed real-time motion control
- Precise multi-axis synchronization
- Compact and space-saving design
- Flexible integration with servo drives and I/O modules
- Built-in PLC and machine control functions
- Support for feedback-based closed-loop control
- High positioning accuracy and repeatability



Servo Drives

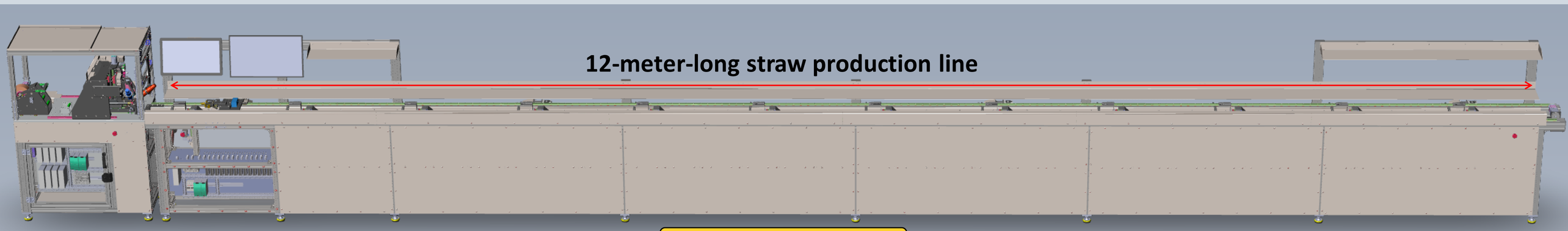
Servo drives control the motion of the machine axes, providing precise positioning and synchronized movement during the welding cycle.

Power Distribution and I/O Modules

The upper section distributes 220 V and 24 V power, while the lower I/O modules connect sensors, actuators, valves, and control signals to the machine control system.

Internal Network Switch and PoE Camera Supply

The internal Ethernet switch provides communication between machine devices and supplies PoE power to the camera used for monitoring and process control.



Summary

• The line was entirely **designed and manufactured at JINR**. The creation of this facility has made JINR an absolute world leader in the field of straw technology.

• The developed ultrasonic welding machine provides an automated and reproducible procedure for the production of thin-walled straw tubes. Precise control of film alignment, tension, internal pressure, welding head temperature, axis positioning, and seam position improves the stability of the welding process. The integration of machine vision feedback and pressure testing allows the weld seam position and quality to be controlled during and after production.

• This system forms an important technological basis for straw tube production for the SPD Straw Tracker at NICA, as well as for other detector projects using straw tube technology, such as SHiP, FCC, etc.

STRAW TEAM