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SENSORS FOR FILAMENT DIAMETER CONTROL

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The standard filament diameter for FDM printers is 1.75 mm with a tolerance of ±0.05 mm, which determines the quality of 3D printing. [1]. Deviations of more than 0.05 mm cause unstable material feed, uneven extrusion, surface defects such as “teeth”, “webs” or “ripples”, as well as a decrease in the mechanical properties of parts by 20–30%. Mechanical sensors such as calipers or micrometers are unsuitable for inline inspection due to contact wear from abrasive ABS/CF/Kevlar composites and low measurement frequency (1–5 Hz).

For real-time monitoring, non-contact laser micrometers are used, which measure the shadowing of the beam by the filament between the emitter and the receiver. The best industrial solutions are the Keyence LS-9000 Series with a frequency of 16,000 measurements/s, a repeatability of ±0.03 μm and a range of 0.04–30 mm [2]. The two-axis TM-3000 series monitors ovality <1% with auto-calibration of the edge.

Figure 1 – Filament diameter control using Keyence sensors

Budget alternatives are Chinese laser devices (±0.001 mm, range 0.2–5 mm, USB/Bluetooth). They are less stable with abrasive materials due to contamination of the optics, but are sufficient for laboratory extruders with a capacity of up to 2 kg/h. DIY solutions on Arduino/STM32 (±0.002 mm) support Marlin/Klipper, but require regular calibration and are sensitive to vibrations. Optical sensors Bigtreetech Smart Filament Sensor V2.0 (Hall-effect) monitor the presence/breakage, not the diameter, so they are not suitable for precise measurements.

For laboratory production of composite filament (1 kg/h), Keyence IG Series or Alibaba Gauge with Modbus RTU integration are optimal. Batch lines require LS-9000 with four-axis control. It is recommended to place the sensor after water cooling to minimize thermal drift.

Hybrid laser+AI camera systems for controlling the diameter of 1.75 mm filament are a promising direction that combines non-contact laser micrometers with machine vision for comprehensive detection of microdefects in real time.

Laser profilometers (Micro-Epsilon scanCONTROL) record diameter with an accuracy of ±5 μm and a frequency of 1000 Hz (Fig. 2), while AI cameras (OpenCV/YOLO) analyze ripples, bubbles, ovality and surface contamination. This approach provides 95% automation of extrusion correction through integration with Klipper/Marlin.

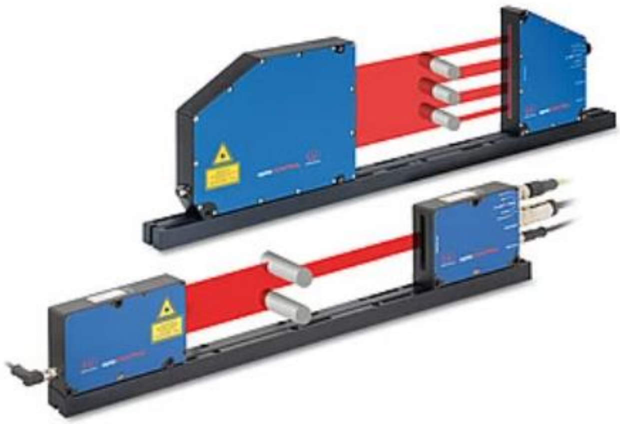

Figure 2 - Laser micrometer for high-precision inline inspection OptoCONTROL 2520 [3]

Application in 3D printing allows you to reduce scrap by 95%, automate Industry 4.0 via the MQTT protocol, and support a full control cycle - from diameter to surface defects.

This hybrid approach is optimal for serial extrusion lines, where not only geometric parameters are important, but also surface quality for impact-resistant parts in robotics and mechanical engineering.

References

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