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Automatic Surface Measurement of Metal Bush During Turning Operation Using Dual Sensor Set Up

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ABSTRACT

This research describes a system built directly into a lathe (in-machine) to continuously check for errors during production (real-time error detection). It uses a laser sensor to constantly measure the surface of the work piece as its being turned. This continuous measurement is a key benefit, allowing for error detection throughout the entire production run. The sensor data is sent to a computer (PC) for processing. A special converter board (flat connector-PCB based A-D converter) translates the data into a format the computer can understand and displays it on screen.

Once processed, key information from the measurements is sent to a cloud storage and analysis platform. This platform can then be used to set up alerts based on average readings. These alerts can warn of potential maintenance issues with machine itself, helping to prevent breakdowns and production delays. Multi-position sensor captured information is sent to a display system using a flat connector-PCB based A-D convertor for further basic formatting. The system takes a two-pronged approach to data handling. First, it saves all the raw measurements locally. This is like having a detailed logbook for the machining process, allowing for in-depth analysis later on if needed. Secondly, the system calculates an average of consecutive measurements. This summarized data is then uploaded to a cloud platform. This platform acts like a smart assistant, analyzing the averages and setting up alerts to operator for manufacturing. This proactive approach helps prevent unexpected breakdowns and keeps the production line running smoothly.

Keywords : Stepped Metal Turning, Timely Measurement, Rejection At End, Ease Of Manufacturing

I. INTRODUCTION

Maintaining consistent surface quality during live turning operations is critical for the functionality and performance of final parts, particularly for components like metal bushings. Traditional methods often involve stopping the machine for manual measurements, impacting production efficiency. This research introduces a novel approach using a sensor set-up for automatic surface measurement of metal bushes during live turning. This in-process monitoring system offers several advantages:

Real-time data acquisition: The sensor set-up continuously collects data throughout the turning process, allowing for immediate detection of any deviations from desired surface quality. Improved quality control: By continuously monitoring surface characteristics, manufacturers can ensure consistent quality and reduce the risk of producing non-conforming parts.

The recent research on in-process monitoring and diagnostics for turning operations. A critical aspect of modern manufacturing is ensuring product quality and production efficiency. In-process monitoring allows for real-time detection of errors and potential issues during machining, leading to improved product quality and reduced downtime. Several key areas of research are highlighted by the provided references

Optical Measurement Techniques: [1, 2, 6] explore the use of optical methods like interference fringes and confocal sensors for high-precision 3D shape and surface roughness measurement of work pieces during turning. Cloud-Based Manufacturing and Data Analytics: Reference [3] discusses the integration of cloud platforms for data storage and analysis from manufacturing equipment. This enables real-time monitoring, predictive maintenance strategies, and on-demand manufacturing services. Machine Diagnostics and Reliability: [4, 5] address the importance of reliable machine operation. They explore using sensors and data analysis to diagnose potential issues with the turning machine itself, preventing breakdowns. These references provide a solid foundation for understanding current trends in in-process monitoring for turning. However, the survey can be further enriched by including additional aspects. Roundness and Spindle Errors: References [11, 12, 13] delve into specific techniques for measuring roundness errors and spindle rotation accuracy. It does not concerns to complete work piece dimensions and other aspects of quality.

Laser system utilizing the principle of triangulation. This design is particularly beneficial for conventional lathes that lack digital control systems. By incorporating this approach, older machines can be brought into the Industry 4.0 era, facilitating their integration with digitalization efforts.

1. Experimental system

Automatic Surface Measurement of Metal Bush during Live Turning: An Experimental Sensor-Based System Ensuring consistent surface quality for metal bushings during live turning operations is crucial for their functionality and performance. However, traditional methods rely on stopping the machine for manual measurements, hindering production efficiency. This research proposes a novel solution: an experimental measuring system for automatic surface measurement of metal bushes during live turning using a sensor set-up. This in-process monitoring system offers significant advantages:

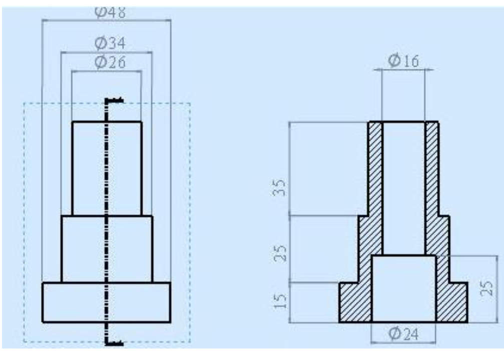

Figure 01 shows drawing of Work piece considered for machining

Real-time data: The sensor set-up continuously gathers data throughout the turning process, enabling immediate detection of surface quality deviations. Improved quality control: Continuous monitoring allows for consistent quality and reduces the risk of producing non-conforming parts. Enhanced efficiency: Eliminating frequent machine stops for manual measurements increases production throughput. This research explores the design, implementation, and evaluation of this sensor-based system. The goal is to assess its potential for revolutionizing in-process surface measurement in turning operations. The findings can pave the way for improved quality control and production efficiency in the manufacturing of metal bushings

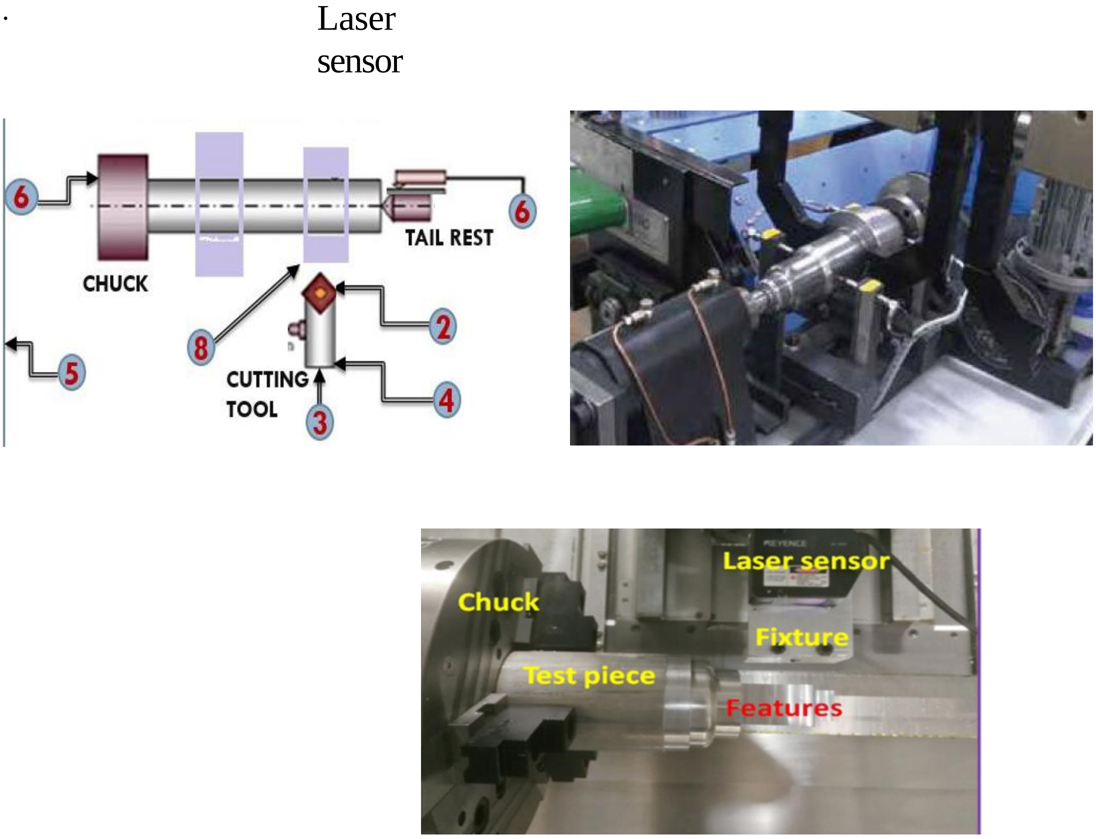

Figure 02 shows simple set up for automatic monitoring measurement

2. Working phase

2.1Controlling, actuation and real time monitoring

The experiment utilized two types of sensors: A high-precision laser sensor for distance measurement with a range of 100 millimeters and a resolution of 0.001 millimeters. An optical sensor for detecting the start of each rotation using a reflective label. Data Acquisition and Communication: The laser sensor data was transmitted digitally through an amplifier. An industrial communication protocol facilitated communication sensor system and displays system for operator and system control. Lathe Integration: The sensors were installed on a classic lathe lacking a built-in digital control system. The lathe's spindle speed was set to a specific value (170 RPM) for the experiment. Visualization depicts the positioning of the two sensors on the lathe.

2.2Optimizing the manufacturing process using algorithm

Optimizing the manufacturing process involved two key steps:

Data acquisition and learning: Researchers analyzed the component's blueprint to understand the manufacturing process. Self-learning tools were then used to gather data that could be used for optimization. a new algorithm which plays a crucial role in processing and decision-making is introduced. *Real-time monitoring and control:* During processing, a laser line triangulation sensor technology was linked with the self-learning module to monitor the dimensions of the held stepped shaft. A Python image analysis algorithm was employed. This algorithm takes the sensor's length and diameter outputs as real-time profile measurements and compares them section-by-section with the standard drawing specifications. Python libraries like Pillow and OpenCV were utilized for optimization and benchmarking purposes, allowing the system to assess the job's status in real-time.

Data Acquisition: The algorithm will gather data section-wise from both sensors, including length and diameter measurements. The sensor itself measures linear distances.

Simplified Operator Interface: The operator's primary role is to operate the machine. However, the system streamlines the process by:

Section Sequence: The operator enters the sequence of sections to be processed into the algorithm. Standard Dimension Input: Standard dimensions for each section are entered via a data window. New Job Setup: For a new job, the operator only needs to scan a representative image of the part. Minimal Manual Intervention: Beyond initial setup and new job scans, the operator's interaction is minimized. Automatic Image Display: The scanned image will be automatically displayed on the screen for reference.

Naming of parts: Each section within the image requires a unique identifier (e.g., A, B, C). The operator assigns these names directly on the image. Corresponding standard dimensions, upper tolerance limits, and lower tolerance limits are then entered for each section in a dedicated window. The section name assigned on the image must be linked to the corresponding standard dimension information.

Real-Time Process evaluation: With all data entered, the algorithm is ready to function. It continuously compares the standard profile of the job (including dimensions and tolerances) with the real-time measurements obtained from the sensors.

Reference Setting for Measurement: To establish a baseline for comparison, the initial distance between the raw work piece and the laser sensor will be set to zero and used as an input value. Similarly, the final distance of the finished product from the sensor will also be recorded.

Conclusions

This research presented a novel in-machine system for automatic surface measurement of metal bushes during live turning operations. The system offers significant advantages over traditional methods:

Real-time error detection: A laser sensor continuously monitors the surface, enabling immediate identification of deviations from desired quality. Enhanced quality control: Continuous monitoring ensures consistent quality and reduces production of non-conforming parts. Improved production efficiency: Eliminating frequent machine stoppages for manual measurements increases throughput.

This approach builds upon existing research in in-process monitoring for turning. It utilizes a laser sensor and data analysis for real-time monitoring, specifically focusing on automatic surface measurement for metal bushes.

Beyond In-Process Monitoring: Retrofitting Older Lathes: The laser triangulation principle allows integration with conventional lathes lacking digital control systems, aligning them with Industry 4.0 goals. This research opens doors for further development in automatic surface measurement for turning operations like advanced algorithms for real-time process control and anomaly detection. Machine learning integration for predictive maintenance. Standardized sensor data communication protocols for broader adoption.

By continuing to develop and refine these in-process monitoring systems, manufacturers can achieve significant improvements in quality control, production efficiency, and overall production line performance.

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