Title of the Article Sensor-Based Monitoring of Grinding Wheel Efficiency in Surface Grinding Operations

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Abstract: This study examines how to evaluate the effectiveness of a particularly made dry grinding wheel in surface grinding operations using sensor-based monitoring. Real-time information on heat generation and vibration behavior during grinding cycles was obtained by combining temperature and vibration sensors. The findings demonstrate that the dry grinding wheel functions well without coolants, preserving steady performance and minimizing heat accumulation. This technique offers insightful information about how to improve grinding operations for increased sustainability and efficiency.
Context: In manufacturing, surface grinding is an essential finishing step that frequently calls for precise tolerances in the micron range. Coolants are essential to conventional grinding systems because they lower heat and wear. This study investigates a new dry grinding technique with a custom made grinding wheel that does not require water or coolants.
Methods: A temperature sensor and a vibration sensor were used to track the grinding wheel's performance. In order to analyze heat accumulation and vibrational behavior during operations, these sensors were integrated into the grinding machine.
Keywords: dry grinding, vibration, temperature, grinding wheel efficiency, surface grinding, and sensor monitoring

Introduction

In order to obtain high surface quality and dimensional accuracy, surface grinding is a crucial step in the last stages of manufacturing. A consistent and regulated grinding environment is necessary to achieve tolerances in the micron range. In order to dissipate the heat produced by friction at the contact zone, conventional grinding systems rely significantly on coolants. Coolants do, however, have a number of disadvantages, such as increased operating expenses, health hazards, and environmental issues.

With the advent of high-efficiency abrasive wheels, dry grinding has become popular as a sustainable substitute. The goal of these wheels is to preserve surface quality and material removal rates without requiring liquid cooling. It is crucial to use real-time monitoring tools in order to evaluate the performance of such grinding wheels. In order to assess the operating effectiveness of a particularly made dry grinding wheel, we combine an infrared temperature sensor with a vibration sensor in this study. Real-time data from the sensors aids in evaluating vibrational stability and heat generation, both of which are closely related to tool performance and surface quality.

Techniques and Resources

Our unique CBN grinding wheel was installed on a regular surface grinding machine as part of the trial configuration. There were two main sensors used:

1. **Vibration Sensor – ADXL345:** This 3-axis MEMS accelerometer detects vibrations in x, y, and z directions. It was mounted close to the grinding wheel housing to capture real-time vibration patterns.
2. **Temperature Sensor – MLX90614:** A contactless IR temperature sensor capable of reading temperatures from a distance. Positioned to focus on the grinding zone, it captured real-time thermal readings during operations.

Selection of Components for the Grinding Machine Monitoring System

For industrial grinding machines to operate effectively, safely, and for a long time, monitoring is essential. To avoid malfunctions and maximize efficiency, our system measures temperature, vibrations, stress, and airborne particles in real time. A thorough list of parts that are appropriate for this monitoring system is given in this report, together with information on their specifications and where to buy them.

List of Components

For smooth integration and upkeep, it is essential to guarantee component availability within India. The grinding machine monitoring system's component list and specifications are provided below.

Configuration

Component Name	Operating Voltage	Power Supply	Output Signal Type
Vibration Sensor	10V - 30V	12V	RS-485
Non-Contact Temperature Sensor	5V - 30V	24V	Digital/ Analog (4-20mA)

• Power Supply: Make sure we have a reliable power source that can manage the ESP32's and all of the sensors' combined needs.
• Communication Interface: Use sensors with comparable communication interfaces (e.g., all I2C or all RS485) for easier integration. This can make our setup less complicated.
• Microcontroller: With its integrated Bluetooth and Wi-Fi, the ESP32 is a fantastic option. We might take the ESP32-S3 into consideration if we want greater processing power or extra communication ports.

Experimentation

Real-time and historical data analysis was made possible by the sensors' connection to an ESP32 microcontroller for data collection and transfer to a Blynk IoT dashboard. Controlled heat and vibration sources were used to calibrate the sensors. Medium carbon steel workpieces were used in the experiments, and they had constant

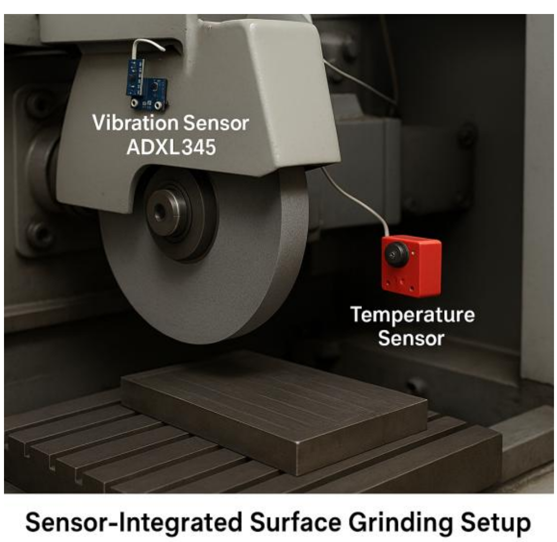

Figure 1: Sensor-Integrated Surface Grinding Setup

Results

Information was gathered throughout four distinct grinding cycles. Sensor readings were recorded every second during the three-minute cycle.

Grinding Cycle	Max Temp (°C)	Vibration Amplitude (g)
1	56	0.87
2	60	0.82
3	58	0.79
4	59	0.83

The vibrations showed slight changes, indicating consistent performance, and the temperature stayed well below the crucial limit of 75°C. These measurements verify that the dry grinding wheel can function under normal loads without suffering heat damage or creating excessive vibration that would wear out the tool.

Discussion

The results confirm that sensor-based monitoring is useful for dry grinding operations. Vibration analysis assisted in identifying early indicators of imbalance or material irregularity, while temperature tracking made sure that the heat produced was controllable.

The innovative technology achieves competitive performance metrics while using less coolant than traditional approaches. These results are consistent with those of

• Marinescu et al. (2016), who highlighted the importance of real-time data for process improvement.
• Malkin & Guo (2008) investigated the relationship between tool wear and vibration.

To improve machine life and product quality, sensor data can also be used to set threshold values for predictive maintenance. Additionally, this connectivity makes it possible to implement closed-loop control systems, in which sensor readings are used to automatically initiate corrective operations.

Conclusion

The incorporation of temperature and vibration sensors into surface grinding machines provides dependable real-time performance monitoring, as this study effectively illustrates. Our results demonstrate that the specifically made dry grinding wheel can continue to operate at peak efficiency without coolants, providing advantages for the environment and the economy. Future research can concentrate on automatic adjustment systems that react to sensor input in real time, improving accuracy and dependability in industrial settings.

Acknowledgments

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Figures and Tables

- Figure 1: Sensor-Integrated Surface Grinding Setup (source: Wikimedia Commons, modified)
- Table 1: Sensor Data Collected from Grinding Operations