Monitoring the Function of an Electric Screwdriver in Industry 4.0

Group's Members: Benedetta Pacilli, Valentina Pieri & Parisa Sokuti

Introduction

One critical aspect of Industry 4.0 is the monitoring of tools and machinery to ensure optimal performance. This report focuses on the monitoring of a Makita electric screwdriver with a tip made in cobalt, during its operation, with a primary focus on movement and temperature monitoring to prevent overheating and enhance the tool's longevity.

Objectives of Monitoring

The decision to monitor the electric screwdriver arises from several critical needs:

1. **Optimal Performance**: Ensuring the screwdriver operates at its best capacity by monitoring its movement and performance metrics.
2. **Overheating Prevention**: Tracking temperature levels to prevent overheating, which can lead to tool damage and operational delays.
3. **Voltage Stability**: Monitoring voltage to ensure it does not fluctuate from normal values, which can affect performance and longevity.
4. **Enhanced Longevity**: Extending the lifespan of the screwdriver through proactive maintenance and timely interventions based on monitoring data.

Monitoring Parameters

To achieve the above objectives, the following parameters are monitored:

1. **Movement**: Monitoring the motion, vibration, and consistency of the screwdriver's operation.
2. **Temperature**: Keeping track of the temperature at critical points of the screwdriver, especially near the motor and handle, to prevent overheating.
3. **Voltage**: Ensuring that the voltage supplied to the screwdriver remains stable and within the specified range to prevent performance issues and damage.

Movement Monitoring

Movement monitoring involves the use of sensors to track the rotational speed and torque of the screwdriver. This data helps in:

- **Performance Analysis**: Ensuring the screwdriver operates within the optimal speed and torque ranges.
- **Anomaly Detection**: Identifying any deviations from normal operation that might indicate issues such as wear and tear or impending failure.
- **Quality Control**: Ensuring screws are driven consistently to the desired specifications, which is critical for maintaining product quality.

Temperature Monitoring

Temperature sensors placed at strategic points on the screwdriver provide real-time data on the tool's thermal conditions. This monitoring helps in:

- **Overheating Prevention**: Identifying and mitigating instances where the screwdriver might overheat, which could lead to damage or safety hazards.
- **Maintenance Scheduling**: Using temperature trends to predict when the tool might require maintenance, thus avoiding unexpected downtime.

Voltage Monitoring

Voltage monitoring involves measuring the electrical supply to the screwdriver to ensure it remains stable. This is important for:

- **Performance Stability**: Preventing fluctuations that can affect the operation and efficiency of the screwdriver.
- **Component Protection**: Avoiding voltage spikes that could damage internal components.

Data Collection and Visualization

Data Collection

Data is collected through the use of Puck.js an easy to use, programmable Bluetooth sensor and button. During our visit to the SCA Mechanical Engineering we saved data of the electric screwdriver's functioning.
We have executed a simulation of the device, by using a similar tool but from a different brand and even in this case we have stored the tool's data.

Dashboard Creation and Real-Time Data Visualization

A dashboard has been developed to visualize the real-time data collected from the electric screwdriver. This dashboard serves as a central hub for monitoring key performance indicators, providing an intuitive and comprehensive overview of the screwdriver's operational status. The dashboard shows:

- **Temperature Data**: Displayed in real-time, showing the current temperature readings from multiple sensors placed on the screwdriver. Historical temperature data can also be viewed to analyze trends and identify patterns.
- **Motion/Vibration Data**: Real-time visualization of the screwdriver's movement and vibration, helping to detect anomalies that might indicate operational issues.
- **Voltage Data**: Continuous monitoring of the voltage supplied to the screwdriver, ensuring it remains stable and within the optimal range.
- **Battery Status of Puck.js Sensor**: Live updates on the battery level of the Puck.js sensor, ensuring that the data collection device is always operational without unexpected power failures.
- **Environmental Luminosity**: Measurement of the ambient light conditions in the working environment, which can affect the operator's efficiency and precision.

Real Case Scenario and Simulation Data

The dashboard incorporates data from two primary sources:

1. **Real Case Scenario**: Actual data collected while the electric screwdriver was functioning in a production environment. This includes temperature, movement, voltage, battery status of the Puck.js sensor, and luminosity data.
2. **Simulation Data**: Fictitious data stored from a prototype or substitute tool, which is also an electric screwdriver but from a different brand. This simulated data helps in comparing performance metrics and validating the monitoring system's robustness.

By integrating real and simulated data, the dashboard provides a comprehensive tool for analysis and decision-making. A video has been created where the basic working of our dashboard is shown and it has been uploaded on youtube.

Example Use Case

Consider a scenario where the electric screwdriver is used in an assembly line. The dashboard continuously receives data from the screwdriver, showing a steady increase in temperature during prolonged use. The real-time temperature graph on the dashboard indicates that the temperature is approaching a critical threshold. Simultaneously, the motion data reveals slight irregularities in the screwdriver's operation, suggesting increased friction or resistance.

The voltage monitoring display indicates that the voltage supplied to the screwdriver remains stable, ruling out electrical supply issues as a cause of the operational anomalies. The battery status of the Puck.js sensor display alerts that the battery level is depleting, ensuring that data collection can continue uninterrupted. The luminosity readings show adequate lighting conditions, ruling out environmental factors affecting the operator's performance.

Based on these insights, maintenance personnel can proactively address potential overheating by scheduling a brief cooldown period and inspecting the screwdriver for any mechanical issues. The battery of the Puck.js sensor can be recharged or replaced to ensure uninterrupted data collection. This proactive approach prevents tool failure, reduces downtime, and maintains production quality.

Benefits for SCA Mechanical Engineering

Process Improvement and Efficiency

Implementing real-time monitoring of electric screwdrivers can significantly enhance SCA Mechanical Engineering's manufacturing processes. By leveraging detailed data on tool performance and operational conditions, SCA can optimize their production lines in several ways:

- **Increased Uptime**: Proactive maintenance based on real-time data reduces unexpected breakdowns, ensuring that production lines remain operational.
- **Enhanced Productivity**: Monitoring allows for fine-tuning of operational parameters, ensuring that each tool operates at peak efficiency, which in turn boosts overall productivity.
- **Quality Assurance**: Real-time data on torque and movement ensures that screws are driven accurately, maintaining high standards of product quality and consistency.

Cost Reduction

Monitoring tools can lead to substantial cost savings for SCA Mechanical Engineering by:

- **Preventing Damage**: By detecting and addressing overheating and other issues before they cause significant damage, SCA can avoid costly repairs and replacements.
- **Optimizing Maintenance Schedules**: Data-driven maintenance scheduling ensures that tools are serviced only when necessary, reducing downtime and maintenance costs.
- **Extending Tool Lifespan**: Proper monitoring and maintenance can extend the life of electric screwdrivers, reducing the frequency of replacements and associated costs.

Competitive Advantage

By adopting advanced Industry 4.0 technologies, SCA Mechanical Engineering can gain a competitive edge in the market. Real-time monitoring and data-driven decision-making enable:

- **Innovation**: Continuous improvement of manufacturing processes and tools, staying ahead of industry trends and standards.
- **Customer Satisfaction**: Delivering high-quality, reliable products that meet customer expectations, thereby enhancing customer loyalty and market reputation.
- **Sustainability**: Efficient use of resources and reduction of waste, contributing to more sustainable manufacturing practices.

Conclusion

The monitoring of an electric screwdriver in an Industry 4.0 environment offers significant benefits, including performance optimization, overheating prevention, voltage stability, and enhanced tool longevity. By leveraging advanced sensors and a comprehensive real-time dashboard, SCA Mechanical Engineering can ensure their tools operate within optimal parameters, reduce downtime, and improve overall productivity and product quality. This proactive and data-driven approach not only transforms manufacturing processes, making them smarter and more efficient, but also provides a substantial competitive advantage in the ever-evolving market landscape.