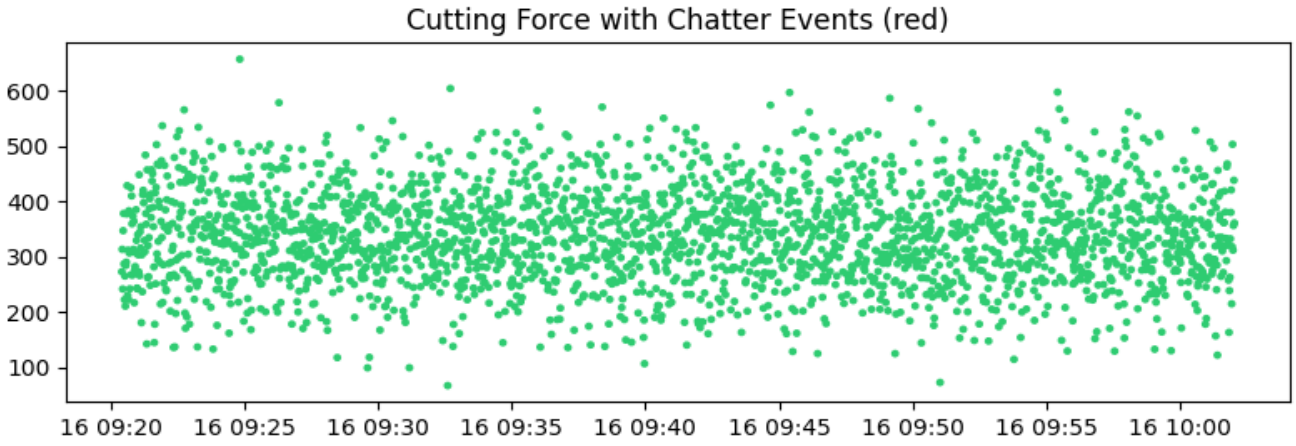
CNC machine digital twin analysis report

1. Executive summary

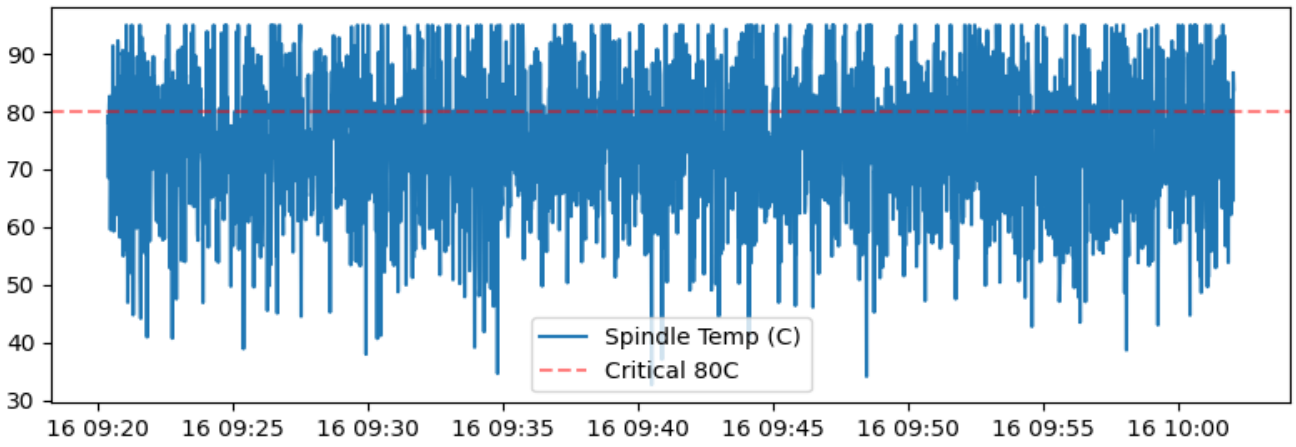
Key finding: Strong correlation observed between vibration amplitude and increased tool wear. Roughness regression R^2=0.91; wear classification accuracy=0.85.
Key recommendations: Implement an adaptive control loop to adjust feed rate based on real-time vibration to extend tool life.

2. Machine health and predictive maintenance

Vibration analysis: Vibration magnitude increases towards end-of-life; 80th percentile at 1.42 g and 95th percentile at 1.62 g.
Recommendation: Use ML models trained on vibration and temperature to predict tool wear and schedule replacement just-in-time.



Thermal performance: Average spindle temperature 74.3 °C with critical threshold at 80 °C.

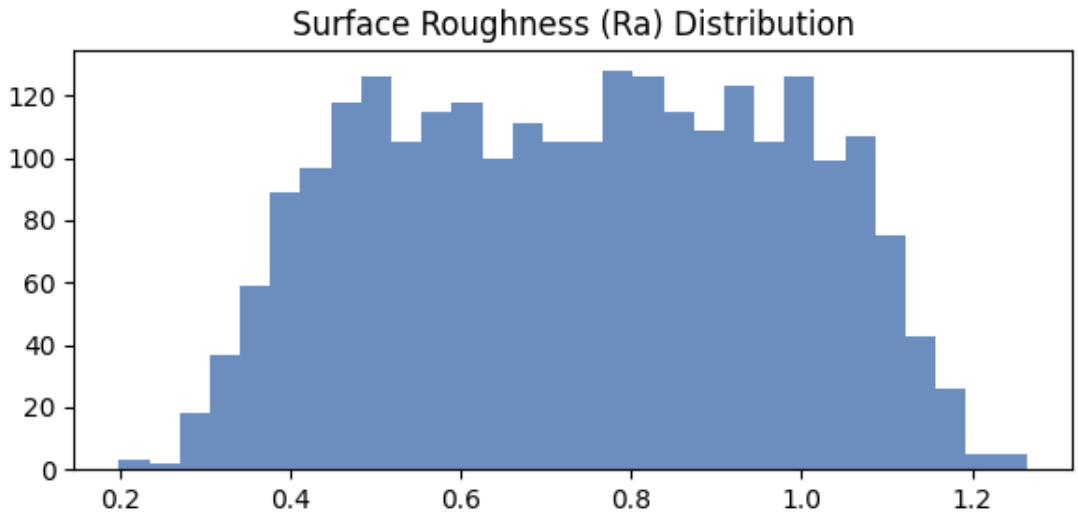


Remaining useful life (RUL): Current tool estimated average RUL of 27.4 minutes based on wear progression.

3. Operational efficiency and quality optimization

Parameter optimization: Models indicate roughness increases with vibration and wear; consider reducing feed and speed when vibration exceeds threshold.
Productivity vs. quality: Maintain Ra below tolerance (e.g., 0.8 µm) by enforcing vibration-aware constraints.

4. Data visualization (sample dashboard)



5. Conclusion

The digital twin pipeline enables proactive decisions, improving reliability and quality. Next, implement closed-loop adjustments based on ML predictions.