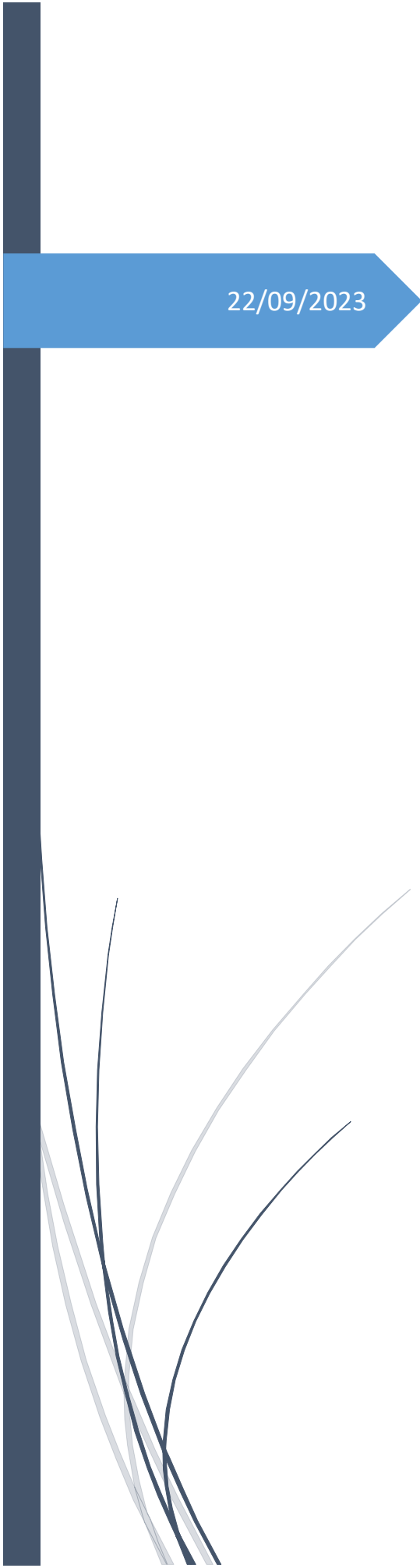




22/09/2023

PROJECT PROPOSAL

Independent Project

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ENGINEERING MANUFACTURING USING CNC MACHINES

Reasons For and Relevance of the Project

CNC machines stand as pivotal instruments in modern manufacturing, orchestrating the meticulous production of intricate components. However, the operational vitality of these machines hinges crucially on the integrity of their coolant systems. Coolants, integral to CNC machining, shoulder diverse responsibilities spanning from temperature modulation to chip evacuation and lubrication. Notably, the presence of tramp oil in coolant emerges as a pronounced challenge, inducing a spectrum of adversities, from shortened tool life to compromised surface finish and dimensional precision (Yang et al., 2023). Furthermore, the subtle dynamics of low oxygen levels in coolants furnish a fertile breeding ground for bacterial proliferation, precipitating coolant corrosion and degradation - a process intrinsically detrimental to machining performance (Eppert et al., 2003). The pertinence of coolant temperature to CNC machine thermal compensation, while recognized, remains a facet warranting deeper inquiry. Oscillations in coolant temperature introduce the potential for thermal expansion or contraction, bearing the risk of machining errors (Maurya et al., 2022).

Given the instrumental role of CNC machines in our manufacturing framework, the rectification of these coolant-related predicaments emerges as an imperative. The project's relevance is underscored by its potential to enhance productivity, quality, and cost-effectiveness. By systematically investigating tramp oil contamination, low oxygen levels, and temperature fluctuations in coolants, we aim to develop tailored strategies that can be seamlessly integrated into our daily work area. These solutions will not only optimize the performance of CNC machines but also contribute to substantial savings in operational costs, tool replacement, and maintenance. Consequently, this research endeavor holds promise in elevating the overall efficiency and competitiveness of our manufacturing processes.

Aims of the project

1. Conduct a comprehensive analysis of current coolant contamination levels, oxygenation, and temperature variation issues in the CNC machining workspace. This will establish baseline measurements and quantify the scope of these problems.
2. Identify root causes of tramp oil ingress, oxygen depletion, and temperature fluctuations in the coolant systems. This will pinpoint where and how these issues originate so targeted solutions can be developed.
3. Research and evaluate potential solutions to mitigate tramp oil, maintain oxygen levels, and regulate coolant temperature. This will provide options to address each problem area through modifications to tools, coolant, maintenance procedures, etc.
4. Develop a strategic implementation plan to phase in the most promising solutions identified. This will outline a practical approach to rolling out changes in a logical order that maximizes benefits while minimizing disruption.
5. Establish methods to monitor the effectiveness of implemented solutions in improving coolant conditions and CNC machine performance. This will ensure the solutions are working as intended and allow for refinement.
6. Recommend optimized coolant practices, specifications, and maintenance procedures based on findings. This will provide actionable guidance for sustaining improvements in the CNC machining workspace.

Work Plan

Preliminary Research and Proposal Refinement (Sep '23 - Nov '23)

- Review literature on coolant management in CNC machining.
- Refine research proposal.
- Identify potential partners.

Facility Setup and Procurement (Dec '23)

- Arrange CNC access.
- Procure lab equipment.

Software and Tools (Jan '24)

- Install analysis software.
- Set up workstation.

Experimental Phase (Feb '24 - Mar '24)

- Begin coolant testing.
- Collaborate with technicians.

Data Compilation and Analysis (Apr '24)

- Organize data.
- Preliminary analysis.

Solution Development and Testing (Apr '24 - May '24)

- Research and test solutions.

Implementation Plan (Apr '24 - May '24)

- Develop phased plan.

Monitoring and Refinement (May '24)

- Establish monitoring methods.
- Continuously refine solutions.

Report Compilation (May '24)

- Compile findings and recommendations.

Final Review and Submission (May '24)

- Review report.
- Submit by May 20, 2024.

Literature Review on Coolant Management in CNC Machining

Computer numerical control (CNC) machining relies extensively on coolant fluids for regulating temperature, chip removal, and lubrication during metal cutting operations (Kumar et al., 2023). However, contaminants in CNC coolant systems can significantly hinder machining performance. A prevalent issue is tramp oil contamination from lubricants, hydraulic fluids, and other extraneous oils (Eppert et al., 2003). Studies have shown that tramp oil levels above 2-4% markedly increase friction and cutting forces, accelerate tool wear, and reduce surface finish (Maurya et al., 2022; Jayal & Balaji, 2009). For instance, tool life declined by over 40% with 4% tramp oil contamination in an investigation by Pimenov et al. (2022). Oils also foster rancidity and harmful anaerobic bacterial growth in coolants over time (Kespohl et al., 2020).

Another critical factor is dissolved oxygen concentration in water-miscible coolants. Sufficient oxygenation inhibits corrosion and deleterious microbial activity (Eppert et al., 2003). But agitation and temperature fluctuations during machining can deplete oxygen. Low oxygen promotes proliferation of anaerobic sulfate-reducing bacteria which generate corrosive hydrogen sulfide gas (Adler et al., 2006). This leads to pitting and corrosion of machine components. Oxygen levels below 4 ppm have been associated with significantly higher microbial activity and corrosion rates (Eyu et al., 2016).

Furthermore, variations in coolant temperature affect machine thermal expansion and dimensional accuracy of machined parts (Maurya et al., 2022). Studies by Maurya et al. (2022) and Soori & Arezoo. (2023) demonstrated that fluctuating coolant temperatures increased size deviation by up to 30% compared to a controlled temperature. Thermal stability of coolant is thus critical for precision machining, especially with tight tolerances.

Contamination, oxygen depletion, and temperature instability in CNC coolants can substantially reduce machining performance. Mitigating these issues through coolant analysis, treatment, and monitoring is vital for supporting efficient and high-quality manufacturing.

Facilities and Software

- a) Access to CNC machining centers matching daily production operations for coolant sampling and data collection.
- b) A well-equipped fluid testing lab with specialized instruments like an oil content analyzer, dissolved oxygen meter, particle counter, and thermocycling equipment.
- c) A dedicated workstation with statistical analysis software (e.g., Minitab, R, or JMP) for efficient data evaluation.

Laboratory Support

- a) Proficient lab equipment to execute coolant tests, operate instrumentation, follow sampling protocols, and manage data.
- b) Experienced fluid analysts for result interpretation and correlation with machining performance.

Industrial Partners

- a) Collaboration with coolant suppliers for representative samples of in-use formulations.
- b) Cooperation with CNC machine OEMs for insight into baseline coolant system design.
- c) Partnership with filtration companies for rigorous evaluation of tramp oil removal solutions.
- d) Engagement with microbe detection firms to test new quick-check contamination kits.

Together, these resources and partnerships will underpin the research, enabling a thorough examination of coolant management in CNC machining.

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