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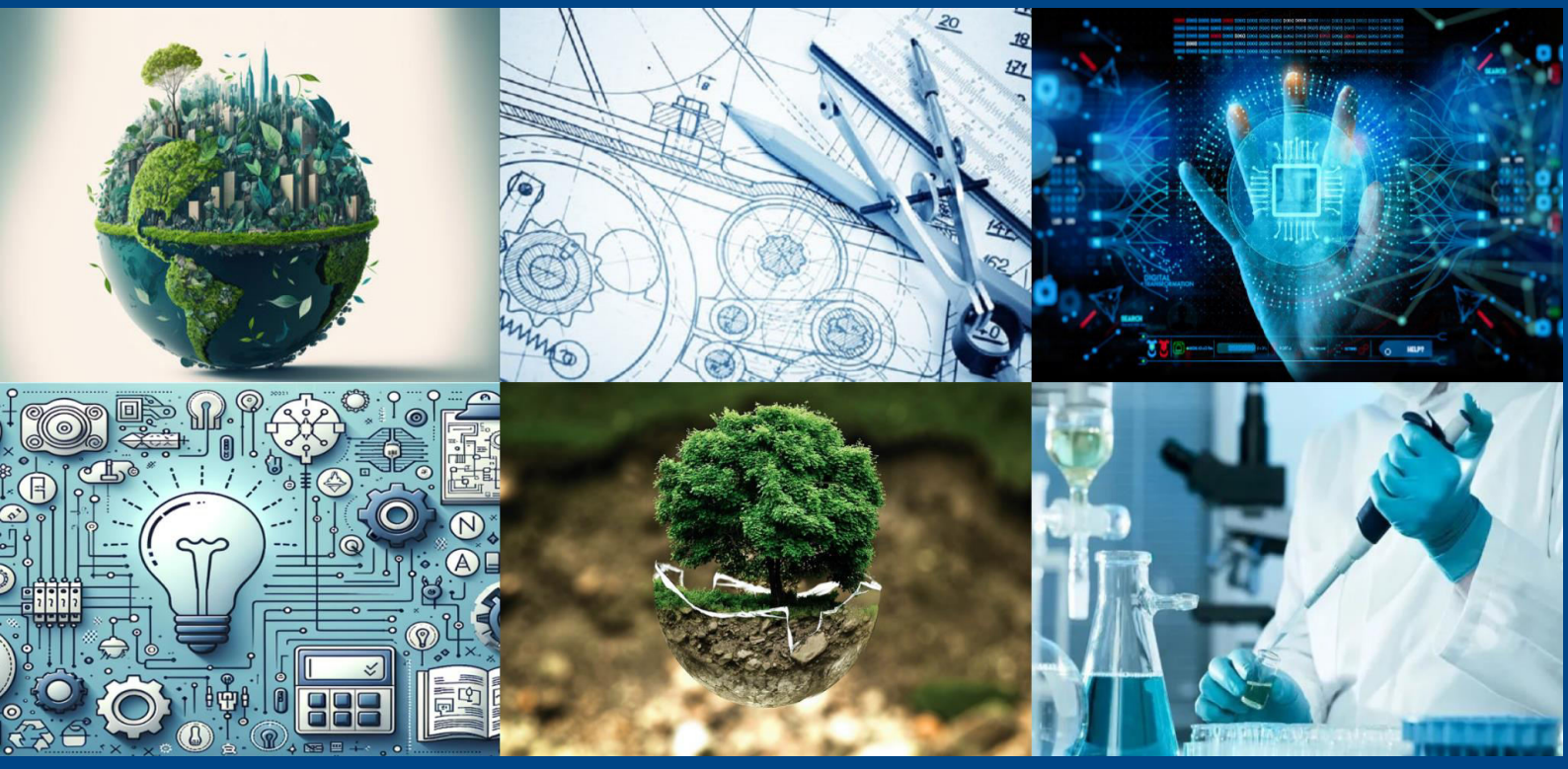

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Design and Development of Chip Removal and Coolant Cleaning System for CNC and VMC

Mr.Prashant Swami, Mr.Yash Pise, Mr.Vaibhav Thakur, Ms.Shital Hublikar, Prof. M.M.Charate

Dept. of Mechanical Engineering, Zeal Polytechnic, Pune, India

Lecturer, Dept. of Mechanical Engineering Zeal Polytechnic, Pune, India

ABSTRACT: The Design and Development of a Chip Removal and Coolant Cleaning System project aims to create an innovative, automated solution for removing metal chips and cleaning coolant in machining and manufacturing environments. In industries such as metalworking and precision manufacturing, metal chips and contaminated coolant often accumulate during operations, affecting machine performance, product quality, and worker safety. Traditional methods of cleaning and chip removal are often inefficient, labor- intensive, and can lead to increased downtime and maintenance costs. This project focuses on designing an integrated system that can automatically remove chips, filter coolant, and ensure a continuous flow of clean, high-performance coolant to the machine tools. The system utilizes a combination of mechanical, electrical, and filtration technologies to automate the chip removal process and remove contaminants from coolant, thereby reducing human intervention and improving operational efficiency. Sensors will monitor coolant quality and chip accumulation, triggering the cleaning and removal processes when needed. The goal is to develop a cost-effective, reliable system that not only reduces maintenance costs but also enhances machine life, operational safety, and the overall productivity of manufacturing processes. By improving coolant quality and ensuring effective chip management, the project aims to provide a significant advancement in automated machining environments.

KEYWORDS: Chip Removal, Coolant Filtration, Automated Cleaning, Micro-Filtration, Precision Machining, Coolant Recycling, Chip Conveyor, Waste Recovery, Energy-Efficient,

I. INTRODUCTION

In modern manufacturing environments, particularly those involving precision machining, the efficient management of byproducts such as metal chips and coolant contamination is crucial for maintaining the overall performance of machinery and ensuring high-quality products. Machining operations such as milling, turning, and grinding generate significant amounts of metal chips (also known as swarf) and require the use of coolant to maintain optimal cutting temperatures and extend tool life. However, over time, both chips and coolant become sources of major operational challenges, as chips can accumulate within machinery, obstructing critical components, while coolant becomes contaminated with metal particles and other debris, reducing its effectiveness and creating health and environmental concerns.

The traditional methods of managing chips and cleaning coolant often involve manual intervention or semi-automated processes, which are not only inefficient but also lead to machine downtime and increased maintenance costs. Operators must regularly clean chips, replace coolant, and perform other time-consuming tasks to maintain the system. These methods can also expose workers to safety hazards due to sharp metal chips and contaminated fluids, posing a risk to both worker health and overall productivity. As a result, the need for a more efficient, automated solution for chip removal and coolant cleaning is becoming increasingly critical in modern industrial settings.

The **Chip Removal and Coolant Cleaning System** project aims to address these issues by developing an integrated, automated system that performs both chip removal and coolant cleaning simultaneously. The proposed system will automate the processes of chip conveyance and coolant filtration, reducing human intervention, improving machine performance, and increasing productivity in machining operations. By integrating sensor-based monitoring, energy-efficient filtration technologies, and real-time feedback mechanisms, the system will ensure that coolant remains clean

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and effective while preventing chip buildup, thus minimizing downtime and maintaining consistent operation of machinery.

The project is designed to improve manufacturing efficiency by continuously monitoring and managing coolant quality and chip accumulation, which will not only enhance the overall performance of machine tools but also extend their lifespan. Furthermore, the system will reduce operational costs by eliminating the need for manual cleaning, replacing contaminated coolant, and lowering energy consumption. The automatic filtration and chip removal system will also improve workplace safety by reducing the risks associated with manual handling of chips and coolant.

This project also aligns with the growing trend toward sustainable and environmentally-friendly manufacturing practices. By extending the life of coolant through effective filtration and reducing the waste generated by inefficient chip removal processes, the system contributes to the overall reduction of material waste and supports greener, more resource-efficient manufacturing processes.

In summary, the **Chip Removal and Coolant Cleaning System** is a pioneering solution designed to optimize the machining environment by automating two critical tasks—chip removal and coolant filtration. This system promises to enhance operational efficiency, reduce costs, improve safety, and contribute to sustainability in industrial manufacturing processes, marking a significant step forward in the evolution of automated systems in manufacturing.

II. LITERATURE REVIEW

1. **Importance of Chip Removal and Coolant Systems in CNC/VMC Operations**

CNC and VMC machines are widely used in modern manufacturing for precision machining. However, during the machining process, chips (metal fragments) are generated, and coolant (usually a mixture of water and oil) is used to lubricate and cool the cutting tool and workpiece. Both chips and coolant need to be managed effectively for several reasons:

- **Machine Efficiency**: Accumulation of chips can interfere with machining, leading to tool wear, poor surface finish, and decreased machining efficiency.
- **Workpiece Quality**: Improper coolant application can cause poor surface quality, overheating, and dimensional inaccuracies in the workpiece.
- **Health and Safety**: Inadequate cleaning of the coolant or chip removal can create hazardous working conditions, increasing the risk of contamination and machine malfunctions.
- **Machine Longevity**: Failure to manage chips and coolant effectively can lead to machine wear and breakdowns, affecting the overall lifespan and performance of CNC and VMC machines.

2. **Chip Removal Technologies**

Chip removal is a critical process in maintaining the efficiency of CNC and VMC machines. Several techniques have been studied and developed for this purpose:

1. Purpose and Functionality

The **chip removal system** within the CR&CC system serves as a crucial component to efficiently manage the debris (chips) that accumulate in the coolant sump during machining processes. This system is designed to remove both large and small chips, as well as any floating oil or debris from the coolant, ensuring the coolant remains effective for use in further machining operations. Here's how it works:

- **Chip Suction and Collection**: The coolant and chip pump cleaner uses powerful suction mechanisms to draw chips and other debris from the sump. The suction system is typically connected to the sump via hoses or pipes, drawing the accumulated material into a collection bin or filtration system.
- **Automatic Chip Removal**: The system operates automatically, requiring minimal human intervention. Once installed, cleaner can continuously monitor and remove chips from the sump, especially in high-production environments where chips accumulate rapidly. This automatic chip removal reduces downtime and labor costs typically associated with manual cleaning.

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3. **Coolant Management and Cleaning**

Efficient coolant management is essential for maintaining the performance of CNC and VMC machines. Coolant not only helps to cool the tool and workpiece but also plays a crucial role in removing chips. The cleaning and recycling of coolant systems are an active area of research.

- **Centrifugal Separators**: These devices use centrifugal force to separate fine particles from the coolant. They are more efficient than simple filters for removing small chips and contaminants (Brahme & Phalke, 2012). Centrifugal separators are widely used in the metalworking industry for coolant recycling.
- **Ultrasonic Cleaning**: Ultrasonic waves are used to agitate the coolant and remove contaminants from its surface. This method is less common in industrial applications but has shown promise in laboratory tests for coolant cleaning and contamination removal (Bharadwaj et al., 2014).

4. Challenges in Chip Removal and Coolant Cleaning

Despite the availability of various chip removal and coolant cleaning technologies, several challenges persist in the optimization of these systems:

- **High Cost**: Advanced chip removal and coolant cleaning systems, such as vacuum and centrifugal separators, can be expensive to implement and maintain, making them less accessible to small-scale manufacturers (Pechere et al., 2009).
- **Space Constraints**: In many manufacturing environments, space is limited. Implementing complex systems may not be feasible due to the space needed for machinery and maintenance areas (Vijay & Bansal, 2012).
- **Environmental Concerns**: Disposal of contaminated coolant is an environmental issue. Many coolant systems end up as waste due to the difficulty in cleaning and recycling the fluids effectively. This problem is exacerbated by the toxicity of some coolants, particularly synthetic oils and lubricants (Kowalski et al., 2014).
- **System Integration**: Integrating chip removal and coolant cleaning systems into existing CNC and VMC machines without causing significant disruption to operations can be challenging. Retrofit solutions must be carefully designed to ensure compatibility with existing machines (Goswami & Sharma, 2008)

III. PROBLEMSTATEMENT

In modern CNC (Computer Numerical Control) and VMC (Vertical Machining Center) operations, the accumulation of **chips**, **sludge**, and **contaminants** in coolant sumps poses a significant challenge. These impurities not only reduce the efficiency of machining operations but also affect the quality of the workpieces, increase maintenance costs, and reduce the operational life of the machines. Managing coolant cleanliness and chip removal in such environments is essential to ensure optimal machine performance and productivity.

While traditional chip removal methods (such as conveyors and manual cleaning) have been used, they often suffer from several limitations:

1. **Inefficient Chip Removal**: Traditional methods are not capable of handling high chip volumes efficiently, especially in high-speed machining scenarios, leading to chip buildup in critical areas, such as the sump and the coolant tank.
2. **Frequent Coolant Contamination**: Over time, chips, oils, and debris accumulate in the coolant, contaminating it and compromising its cooling and lubricating properties. This leads to the need for more frequent coolant replacements, which are costly and environmentally harmful.
3. **Increased Downtime**: Manual or less efficient chip removal systems cause increased downtime for cleaning and maintenance of machines. This downtime reduces overall productivity, particularly in high-production environments where continuous operation is essential.
4. **Machine and Tool Wear**: Accumulation of chips and coolant contaminants can cause blockages in the coolant system, pump failures, and clogging of filtration systems. This results in higher maintenance costs and reduced machine lifespan.
5. **Health and Safety Hazards**: Contaminated coolant can become a breeding ground for bacteria and fungi, posing health risks to workers. Additionally, the presence of large metal chips can cause physical injuries or equipment damage if not properly managed.

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IV. METHODOLOGY

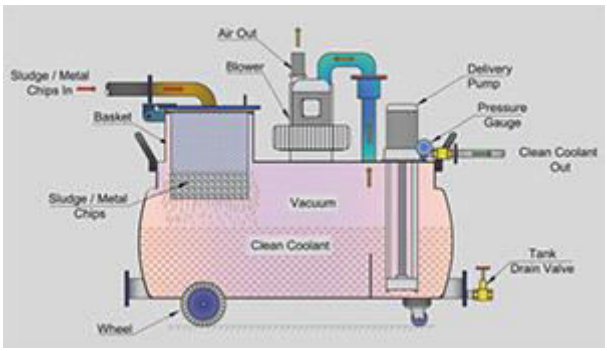
The development of the **Chip Removal and Coolant Cleaning System** is carried out in a structured approach to address the core challenges of chip accumulation, coolant contamination, and system automation. The methodology involves the following key phases:

1.1 Requirement Analysis

- **Chip Characteristics**: Understand the nature of the chips generated (e.g., size, shape, material type). Different chips (e.g., long, stringy, fine, or heavy) require different removal mechanisms.
- **Coolant Contamination**: Assess the type of coolant used and the rate of contamination due to particles, oils, and other debris.
- **Machine Specifications**: The system must be compatible with CNC and VMC machine models and configurations.

1.2 Conceptual Design and System Selection

- **Chip Removal Method**: Determine the best method to remove chips, based on size, material, and the type of machining process (e.g., suction-based, mechanical conveyors, or vibrating sieves).
- **Coolant Filtration**: Decide on filtration types like magnetic filters for ferrous chips, mesh or paper filters for small particles, and centrifugal systems for efficient separation of coolant and debris.



1.3 Testing and Optimization

- Test the prototype under various conditions to assess its efficiency in removing chips, cleaning coolant, and maintaining continuous machine operation.
- Optimize system components for better performance (e.g., refining suction power, filtration mesh size, or sensor accuracy).

1.4 Final Implementation and Integration

- Install the system on CNC and VMC machines, ensuring proper integration with minimal interference in existing operations.
- Conduct operator training and provide maintenance guidelines to ensure smooth system operation

1.3 Prototype Development

- **Component Selection**: Choose appropriate components such as vacuum pumps, filtration units, conveyors, control systems, and sensors for feedback mechanisms.
- **System Integration**: Assemble components into a functioning prototype, ensuring smooth communication between different subsystems.

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V. WORKING PROCESS

The **Chip Removal and Coolant Cleaning System** for CNC and VMC machines operates through an automated, efficient process that ensures chips are effectively removed, and the coolant is cleaned and recycled continuously. Below is a detailed explanation of the working process of this system:

The **Sump Cleaner** operates in a straightforward process to remove chips and clean the coolant (water):

1. **Suction Process**:
   - The **machine uses a powerful vacuum** system that sucks the coolant and chips from the sump (the coolant tank of CNC or VMC machines).
   - **Vacuum hose** is inserted into the sump, where the system draws in both the contaminated water (coolant) and chips.

2. **Chip Collection**:
   - The **chips** are separated from the water during the suction process and **stored in a collection tank**.
   - The chips are trapped and stored in a separate container or bin for easy disposal or recycling.

3. **Water Separation**:
   - The suctioned water, now contaminated with small particles, passes through a **filtration system**.
   - The filtration system **removes any remaining debris or particles** from the water.
   - The clean water is then **returned to the sump** for reuse in the CNC or VMC machine.

4. **Continuous Cleaning**:
   - The process continues automatically to ensure that the sump stays clean, the coolant remains effective, and the machine operates efficiently without interruption.

5. **Outlet (Return of Clean Coolant to Sump)**
   - **Coolant Return**:
   - The **cleaned coolant** is pumped back into the CNC or VMC machine's **sump** (coolant tank).
   - The coolant is now **ready for reuse** in the machine, maintaining proper lubrication and cooling during the machining process.

VI. RESULT AND TESTING

Testing Process

1.1 Start the System

- **Power on** the Sump Cleaner.
- **Activate the suction mechanism** to begin drawing in the contaminated coolant and chips from the sump.

1.2 Chip Removal

- Observe the **chip collection process**:
  - The **vacuum suction** will pull the mixture of coolant and chips into the system.
  - Larger chips should be **separated** and directed into the chip collection tank.
  - Verify that the **chip collection tank** is being filled properly with the chips, and that the coolant is being separated.

1.3 Filtration Process

- The contaminated coolant should now pass through the **filtration system**:
  - **Visual inspection**: Look for any visible debris in the coolant as it passes through the filtration system.
  - **Coolant clarity**: After filtration, inspect the coolant being returned to the sump. It should be visibly clean, with no visible particles or debris.

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1.4 Return Clean Coolant

- The cleaned coolant should be pumped back into the sump.
- **Check the flow of clean coolant**: Ensure it is being returned smoothly to the sump without any interruption.

Result

1.1 Chip Collection Rate

- **Measure the amount of chips collected** in the collection tank over a given period. The system should remove **almost all visible chips** from the sump.

1.2 Coolant Filtration Quality

- **Inspect the coolant quality** after filtration:
  - The coolant should appear **clear and free of particles**.
  - If there are any visible particles in the returned coolant, it indicates the filtration system may need adjustment or optimization.

1.3 System Efficiency

- Observe how well the **system runs automatically**.
  - The system should operate with minimal human intervention, switching on and off as required.
  - There should be no significant delays in starting or stopping the cleaning process.

1.4 Chip Disposal

- **Check the ease of chip disposal**. The collection tank should be easily accessible for removal and disposal or recycling of chips.

Fig. During Testing of System

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VII .CONCLUSION

In conclusion, the **Sump Cleaner** provides an effective, automated solution for maintaining clean coolant and removing chips from CNC and VMC machine sumps, significantly improving the operational efficiency of the machine. The system's ability to continuously and efficiently separate chips from the coolant ensures that the machine runs smoothly without interruptions, preventing issues caused by coolant contamination or chip buildup. The **high-efficiency filtration** process effectively removes both large and small particles, keeping the coolant clean and reusable, which not only extends the life of the coolant but also reduces the frequency of coolant changes, leading to cost savings. Additionally, the **automatic operation** of the system minimizes the need for manual intervention, allowing operators to focus on other aspects of the machining process. The Sump Cleaner also contributes to a cleaner work environment by collecting chips in a designated tank, making disposal or recycling easier. With its ability to operate continuously without significant downtime, the system helps reduce maintenance costs, enhance machine uptime, and improve overall productivity. Ultimately, the Sump Cleaner is a highly efficient and cost-effective solution that improves the performance of CNC and VMC machines while reducing operational costs, waste, and downtime, making it an invaluable addition to any machining operation.

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