# ASSESSMENT OF ENVIRONMENTAL PERFORMANCE OF MILLING MACHINING

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Thesis submitted in partial fulfillment of the requirements for the Degree Master of Science in Mechanical Engineering

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## DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgment any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

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The above candidate has carried out research for the master's thesis under my supervision.

Name of the supervisor: Dr. J. R. Gamage

Signature of the supervisor: Date:

## ABSTRACT

The manufacturing industry largely contributes to the economy of a country. Thus, manufacturing by material removal processes leaves a significant environmental footprint. This is caused by the influence of process energy, resources, and releases. Due to that, increased attention on sustainable means of machining operations can be seen today. Thus, environmental sustainability assessments and preventive measures are being researched for promoting green manufacturing. In conventional machining, milling is a widely used machining method in the production and manufacturing industries. Thus, the purpose of this study is to assess the environmental performance of milling machining in an industrial setup.

A literature review is conducted to understand the requirement of empirical assessment on sustainable milling and to identify the factors contributing to environmental damage while identifying sustainable machining practices. To conduct the empirical assessments, an industrial milling operation is monitored. At the experiment stage, different consumables and releases are identified and monitored such as power consumption, workpiece material usage, tool material, and coolant while controlling the machining parameters and the tool path. Design of Experiments were used to efficiently manage the controllable machining parameters relevant to environmental performance. The contribution to the environmental damage is analysed and quantified according to the ReCiPe endpoint impact assessment method using SimaPro® (Version 8) life cycle assessment (LCA) software following the guidelines of ISO 14044.

The review revealed several factors that are significantly contributing to the environmental impact. Further, a number of operational level improvements were identified to improve the environmental performance. The results identified the electrical energy consumption and workpiece material usage as the most influencing contributing factors to the adverse environmental impact. Further, an operator's guide was also developed to harness the operational level savings to ensure the better environmental performance of milling.

Keywords: Sustainable machining; Environmental performance; Milling machining

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## LIST OF PUBLICATIONS

- Sustainable machining: Assessment of environmental performance of milling - 17th Global Conference on Sustainable Manufacturing (GCSM2019), Shanghai, China Published at ***Elsevier***

  *(M. Kurukulasuriya, J. Gamage, and J. Mangala, "Sustainable machining: Assessment of environmental performance of milling," Procedia Manuf., vol. 43, pp. 455–462, 2020, [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2351978920307745)*

- A review on the impact of process energy on the environmental performance of milling –International conference of production and operational management society (POMS-2018), Kandy, Sri Lanka. Published at ***IEEE Xplore***

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# LIST OF ABBREVIATIONS

| Abbreviation | Description |
|---|---|
| LCA | Life Cycle Analysis |
| Rc | Rough Cut by End Milling |
| Fi | Finishing by End Milling |
| Dg | Drilling |
| Ho | End Milling of a Hole |
| Re | Reaming |
| MQL | Minimum Quantity Lubrication |
| MQCL | Minimum Quantity Cooled Lubrication |
| $Al_2O_3$ | Aluminium Oxide |
| Expt. | Experiment |
| wt% | Percentage by Weight |

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