

Prototype Design and Research Collection

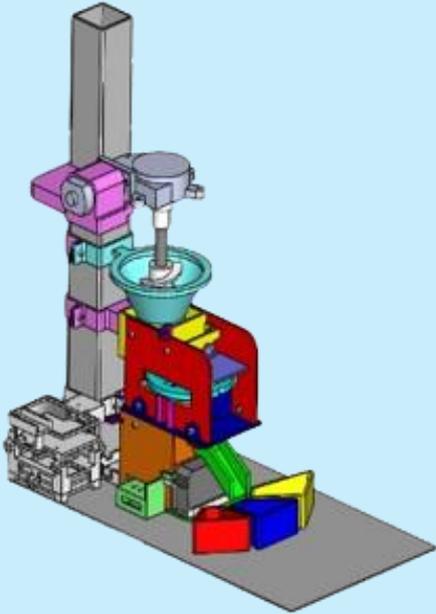
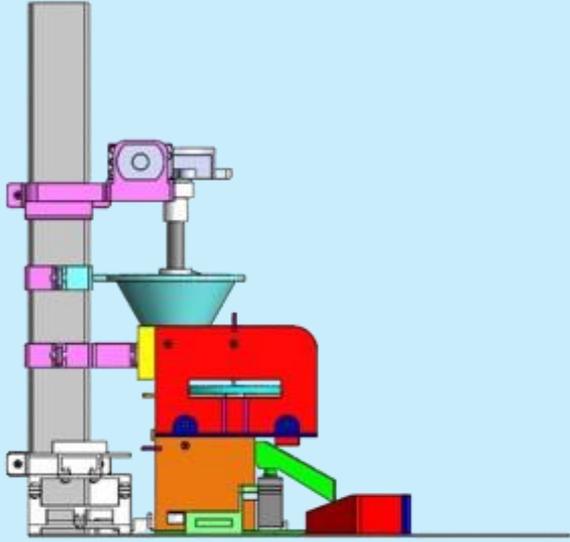
Series 1



Universiti Teknologi MARA
Pasar Gudang Campus

Prototype Design and Research Collection

Series 1



AHMAD NAJMIE RUSLI

**Copyright © 2025 Universiti Teknologi MARA Cawangan Johor, Kampus Pasir Gudang,
Jalan Purnama, Bandar Seri Alam, 81750 Masai Johor.**

All rights reserved. No part of this digital book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the written permission of the Head of the Centre for Studies, Faculty of Mechanical Engineering, Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus.

CHIEF EDITOR:

Ahmad Najmie Rusli

EDITOR:

Nurul Nadiyah Rasdi

PUBLISHER:

Universiti Teknologi MARA
Cawangan Johor Kampus Pasir Gudang,
Jalan Purnama, Bandar Seri Alam, 81750 Masai, Johor
September 2025

eISBN: 978-967-0033-63-1

FOREWORD

This digital book on Prototype Design and Research Collection Series 1 (PDRC Series 1), is designed as a comprehensive reference for mechanical engineering students. The designs featured in this collection undergo an extensive analysis process, incorporating both prototype development and research to ensure a thorough understanding of design principles. Each project is carefully analysed before the prototype fabrication with detailed summaries of the project description and design parameters. The design and research products presented in this series cover a wide range of tools and equipment for various applications including household, workshop and entrepreneurial purposes.

This collection aims to foster innovation by offering students valuable insights into both the technical and research aspects of product design. It is hoped that this book will inspire future engineers and designers to approach product development with a deeper understanding of the design and research processes.

Table of Contents

| | |
|--|----|
| CHAPTER 1 | 1 |
| Development of a Motorized Skateboard Prototype | 1 |
| Nurzarifah Athirah Binti Zamanhuri ¹ and Kamariah binti Md Isa ^{2*} | 1 |
| CHAPTER 2 | 7 |
| Designing and Development of a Rechargeable Screwdriver for Assembly Project | 7 |
| Yusuff Badrisyah bin Mohd Din ¹ and Ab Aziz bin Mohd Yusof ^{2*} | 7 |
| CHAPTER 3 | 14 |
| Conceptual Design of a Multifunctional Barbeque Set | 14 |
| Syukri Amin Bin Rashid ¹ , Syahminisa Binti Nazri ² , Ahmad Nabil Ariff Bin Rafik Ahmad ³ , Syasya Umira Binti Shaharin ⁴ , Dmitri Luping Chong Qianlun ⁵ and Nur Aini Sabrin Binti Manssor ^{6*} | 14 |
| CHAPTER 4 | 23 |
| Stress and Strain Analysis of Egg Yolk Separator | 23 |
| Norjasween Abdul Malik ¹ , Mohammed Khadzid Iman bin Mohammed Dzulhardy ² and Nurrul Amilin Zainal Abidin ^{3*} | 23 |
| CHAPTER 5 | 27 |
| Innovative Design and Construction of a Mini Coin Sorter Device | 27 |
| Ikhwan Hafiz bin Hayaroni ¹ and Ab Aziz bin Mohd Yusof ^{2*} | 27 |
| CHAPTER 6 | 32 |
| Mini Electric Sander Belt Machine: Design, Development, and Testing | 32 |
| Muhammad Bariq bin Mohd Bakhit ¹ and Ab Aziz bin Mohd Yusof ^{2*} | 32 |
| CHAPTER 7 | 36 |
| Stress Analysis of Mini Compact Manually Operated Crane Design | 36 |
| Nurrul Amilin Zainal Abidin ¹ , Muhammad Irsyad bin Fauzi ² and Norjasween Abdul Malik ^{3*} | 36 |
| CHAPTER 8 | 39 |
| Development of a Prototype Spray Paint Hut | 39 |
| Muhammad Farhan Mahadi ¹ and Nurul Hanna Mas'aud ^{2*} | 39 |
| CHAPTER 9 | 43 |
| Development of An Automatic Barbeque Grill: A Prototype | 43 |
| Muhammad Nazirul Bin Mohd Sani ¹ and Mohd Ghazali Mohd Hamami ^{2*} | 43 |
| CHAPTER 10 | 51 |
| Development of Adjustable Table Lifter Transport Using Hydraulic Jack | 51 |
| Amy Malissa bt Mohd Sam ¹ and Hazriel Faizal bin Pahroraaji ^{2*} | 51 |
| CHAPTER 11 | 56 |
| Introducing the PrecisionFlex Grinder: A Revolutionary Adjustable Cutting Solution | 56 |

CHAPTER 11

Introducing the PrecisionFlex Grinder: A Revolutionary Adjustable Cutting Solution

Mohamad Fauzan Akmal b Zulkarnain¹, Ab Aziz bin Mohd Yusof² and Haszeme bin Abu Kasim^{3*}
^{1,2,3}*Faculty of Mechanical Engineering, Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus, Bandar Seri Alam, 81750 Masai, Johor Darul Ta'zim.*
**Corresponding author (e-mail): haszeme9720@uitm.edu.my*

ABSTRACT

This study develops the PrecisionFlex Grinder as an innovative solution to meet the modern manufacturing demand for adaptable cutting tools by overcoming traditional grinders' limitations. Traditional cutting tools struggle with varying material thicknesses, hardness levels, and cutting angles, resulting in operational inefficiencies and higher costs because of the need for multiple specialized tools. The research tackled these problems using a systematic process that combined design conceptualisation with SolidWorks simulation and iterative testing to achieve performance optimisation. Stress tests on the grinder holder confirmed material suitability, as the maximum stress remained below the yield strength limit. Performance tests revealed traditional tools were outperformed as cutting times dropped by up to 50% across aluminum and mild steel sheets of different thicknesses. The PrecisionFlex Grinder demonstrates enhanced workflow efficiency while minimising costs and improving precision and adaptability. The next development phase will incorporate intelligent systems while minimizing noise and vibration levels and testing new eco-friendly materials to boost performance attributes. The study demonstrates that merging theoretical design principles with practical manufacturing techniques leads to the development of advanced tools that address industries' changing requirements.

Keywords: SolidWorks Simulation, Adaptability

1 INTRODUCTION

In modern manufacturing and fabrication, precision tools are key to productivity, accuracy and meeting industry demands. Among these tools, cutting grinders are essential for shaping, refining and processing materials from metals to composites. Traditional cutting grinders lack adaptability and are limited to specific tasks or material types. This necessitates the use of multiple tools for different applications, increasing costs and inefficiencies [1-3]. To fill this gap, we have developed the PrecisionFlex Grinder, a game changing solution that combines precision engineering with unlimited adjustability. Designed to cover a wide range of cutting needs this tool will redefine industry standards with one tool for all complex fabrication challenges. As industries demand tools that can handle multiple materials and geometries the introduction of an adjustable cutting grinder is a major step forward in machining [3].

One of the biggest challenges in modern cutting and grinding is the lack of versatility in existing tools to accommodate varying material thickness, hardness and cutting angles. This inflexibility leads to suboptimal performance, equipment wear and tear and higher operational

costs due to the need for multiple specialized tools [4]. Industries like aerospace, automotive and construction which demand high precision and adaptability, are particularly affected by the shortcomings of conventional grinders.



Fig. 1: Normal hand grinder

For example, in aerospace manufacturing, where tight tolerances and materials like titanium and carbon fiber are common the lack of adaptable cutting solutions results in material waste and production delays [5,6]. This limitation hampers operational efficiency and stifles innovation in material processing. To address these challenges the PrecisionFlex Grinder has been designed with a dynamic system that allows users to change cutting parameters. The objectives of this project are to design, analyse and build a tool that improves workflow, reduces costs and enables industries to achieve better outcomes.

2 LITERATURE REVIEW

Research in manufacturing and material science has focused mostly on the evolution of cutting tools since their crucial influence on the quality and efficiency of fabrication techniques. Although they are useful for use, traditional cutting grinders have been limited by their incapacity to change in geometries and material properties. Kumar et al. [6] found that the lack of adaptability in traditional grinding tools often leads to suboptimal performance when processing materials with varying hardness or thickness. This restriction has made one more dependent on several specialised tools, which raises running expenses and causes workflow inefficiencies. Moreover, Brown and Martinez [7] underline that developments in material science, including the creation of sophisticated composites and alloys, have outpaced the capabilities of traditional cutting tools, creating a growing demand for more versatile solutions. These studies highlight the urgent need for tool design developments that can overcome rigidity constraints and improve adaptability in cutting operations.

By including adjustable mechanisms in cutting tools, recent developments in machining technology have started to solve certain difficulties. Zhang and Chen [8] for example carefully examined adaptive cutting systems, stressing the need of dynamic parameter changes in enhancing tool performance and lifetime. Their results imply that tools with changeable characteristics help lower material waste and improve consistency and accuracy in many different uses. Roberts and Thompson [9] also investigated how cutting tools might incorporate smart technologies such as sensors and real-time feedback systems into their design, so increasing their adaptability and accuracy. These developments closely relate to the idea behind the PrecisionFlex Grinder, which uses changeable cutting settings to satisfy the changing needs of contemporary sectors. But even with these developments, there is still a lack of affordable, approachable tools that blend durability, accuracy, and adaptability. By providing a workable

solution that tackles both technical and financial difficulties in material processing, the PrecisionFlex Grinder aims to close this gap.

3 METHODOLOGY

The process of designing and fabricating the PrecisionFlex Grinder begins with identifying the problem statement, which highlights the limitations of existing cutting tools, such as their inability to adapt to varying material thicknesses, hardness levels, and cutting angles. Once the problem is defined, a conceptual design is developed, and a suitable design and materials are selected. Precise measurements are then taken to finalize the design specifications, after which the design is subjected to SolidWorks simulation to evaluate its performance under real-world conditions. If the simulation reveals shortcomings, iterative adjustments are made until the desired functionality is achieved. This iterative process ensures that potential issues are addressed before fabrication.

Once the design passes the simulation phase, the fabrication process begins, where the physical components of the grinder are manufactured using advanced techniques like CNC machining or 3D printing. After fabrication, the grinder undergoes rigorous testing to verify its performance in practical scenarios, including cutting precision, adaptability, and durability assessments. Any issues identified during testing are resolved through further refinements. The process concludes when the final product meets all performance criteria, ensuring that the PrecisionFlex Grinder is a reliable, cost-effective, and adaptable solution for modern manufacturing challenges. This systematic approach ensures the development of a high-quality tool tailored to meet industrial demands.

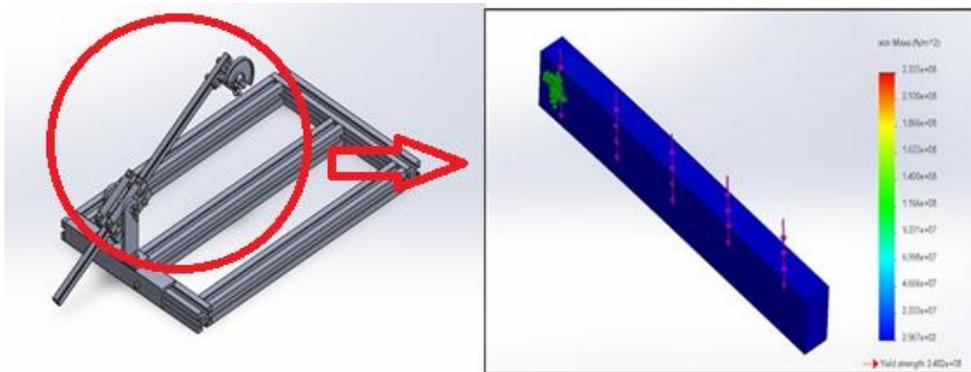


Fig. 2: SolidWorks simulation to evaluate

4 RESULTS AND DISCUSSION

During the design and fabrication of the PrecisionFlex Grinder, a critical focus was placed on analyzing the structural integrity of its key components, particularly on the holder grinding, which plays an essential role in the tool's performance. The holder underwent stress analysis to assess its ability to withstand operational forces without bending or breaking. A force of 10N was applied to assess the load-bearing capacity and the results revealed a maximum stress value of $2.333 \times 10^8 \text{ N/m}^2$, which is below the material's yield strength of $2.482 \times 10^8 \text{ N/m}^2$. This indicates that the material size used is highly suitable for holding the grinder, as it can resist deformation under the expected operational loads. Stress, defined as resistance to deformation per unit area ($P = F/A$), was mathematically validated to ensure durability and reliability. These findings confirm that the selected material meets the necessary performance criteria, ensuring the grinder's robustness and longevity.

Table 1: Data of performance analysis

| Adjustable cutting grinder | | | | Angle grinder (using hand) | |
|----------------------------|--------|------------|--------|-------------------------------|--------|
| Aluminium | | Mild steel | | Mild steel | |
| Thickness | Time | Thickness | Time | Thickness | Time |
| 1mm | 7 sec | 1mm | 15 sec | 1mm | 30sec |
| 2mm | 14 sec | 2mm | 30 sec | 2mm | 64sec |
| 3mm | 21 sec | 3mm | 45 sec | 3mm | 90 sec |

To further validate the effectiveness of the PrecisionFlex Grinder, performance tests were conducted using materials such as aluminium and mild steel with varying thicknesses (1mm, 2mm, and 3mm). As shown in Table 1, the PrecisionFlex Grinder demonstrated superior efficiency compared to traditional tools like angle grinders operated manually. For instance, cutting aluminium sheets of 1mm, 2mm, and 3mm thickness required only 7 seconds, 14 seconds, and 21 seconds, respectively, whereas an angle grinder took 15 seconds, 30 seconds, and 45 seconds for the same task. Similarly, cutting mild steel sheets of identical thicknesses was significantly faster with the PrecisionFlex Grinder (30 seconds, 64 seconds, and 90 seconds) compared to manual grinding methods. These results highlight the grinder's ability to deliver consistent and efficient performance across different materials and thicknesses. The stress analysis and performance testing demonstrate that the PrecisionFlex Grinder successfully fulfills its design objectives, offering a versatile, precise, and time-efficient solution for modern cutting applications.



Fig. 3: Final appearance PrecisionFlex Grinder

5 CONCLUSIONS

The PrecisionFlex Grinder's design and construction effectively illustrate how theoretical ideas and real-world manufacturing procedures can be integrated. The development process used SolidWorks to balance manufacturability, utility, and simplicity while tackling important issues like minimizing vibration, optimizing power consumption, and simplifying blade replacement. The proof-of-concept prototype confirmed the design's feasibility, and its functionality was further improved through iterative testing modifications. This interdisciplinary approach emphasises how crucial it is to match creative design with reliable fabrication methods to produce an effective and user-friendly tool.

The PrecisionFlex Grinder has significant potential for future growth. The grinder can improve usability and simple control by integrating smart technologies like sensors and real-time monitoring. Its appeal will be further enhanced by initiatives to lessen noise, vibration, and environmental impact using eco-friendly materials and energy-efficient motors. Refinements will be guided by testing feedback and scalability evaluations, opening the door for mass production and wider market acceptance. Ultimately, this project establishes a strong foundation for continuous innovation, ensuring the PrecisionFlex Grinder evolves into a cutting-edge solution that meets and exceeds user expectations in precision and adaptability.

REFERENCES

- [1] J. Anderson and M. Roberts, "Advancements in precision machining: Tools for the future," *J. Manuf. Technol.*, vol. 45, no. 3, pp. 112–125, 2022.
- [2] R. Brown, L. Carter, and P. Hughes, "The evolution of cutting tools in industrial applications," *Int. J. Eng. Res.*, vol. 18, no. 7, pp. 89–102, 2019.
- [3] A. Smith and K. Johnson, "Cost implications of tool redundancy in manufacturing processes," *Ind. Econ. Rev.*, vol. 29, no. 4, pp. 45–60, 2020.
- [4] D. Taylor and S. Lee, "Challenges in material adaptability for cutting tools," *Adv. Mater. Process.*, vol. 12, no. 2, pp. 67–82, 2021.
- [5] G. Williams, "Precision machining in aerospace: Challenges and opportunities," *Aerosp. Manuf. J.*, vol. 34, no. 1, pp. 23–35, 2018.
- [6] S. Kumar, A. Patel, and R. Singh, "Limitations of conventional grinding tools in modern manufacturing," *Int. J. Mech. Eng.*, vol. 15, no. 4, pp. 78–92, 2019.
- [7] R. Brown and J. Martinez, "Adaptive machining technologies: Bridging the gap between material science and tool design," *J. Adv. Manuf.*, vol. 36, no. 8, pp. 145–160, 2020.
- [8] L. Zhang and H. Chen, "Dynamic parameter adjustment in cutting tools: A review of recent advancements," *J. Mater. Process. Technol.*, vol. 48, no. 5, pp. 89–104, 2021.
- [9] M. Roberts and P. Thompson, "Smart machining systems: The role of sensors in adaptive cutting tools," *Smart Manuf. Technol.*, vol. 10, no. 2, pp. 210–225, 2022.