Design & Manufacturing of Metal Multi-tool Linishing Machine

Session 2019-2023

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Aug, 2023

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A thesis submitted for partial fulfillment of the requirements for the Degree of

Bachelor of Science in
Mechanical Engineering

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Abstract

The "Metal Multi-tool Linishing Machine" project aims to design a multipurpose and efficient tool by using abrasive belts, abrasive disc, grinding and buffing wheel for linishing and finishing metal workpieces. Linishing is a critical process in metalworking industries, involving the smoothing and polishing of metal surfaces to achieve detailed finish, remove deficiencies, and enhance the overall appearance and functionality of the finished products.

Main objectives of project are to design and manufacturing, improve the flatness of metal surface, to get required surface roughness of the metals and to prepare refined surface of specimen for crack investigation in metallography practice in engineering materials laboratory. Before manufacturing detailed and a complete CAD model was prepared to visualize its structure, components, space and optimum use of material by using SolidWorks application.

Declaration

I declare that the work contained in this thesis is my own, except where explicitly stated otherwise. In addition, this work has not been submitted to obtain another degree or professional qualification.

Khawar Shafique

Syed Ehtisham Ali

Abdur Rahman

Acknowledgment

First of all, we would wish to express our sincere gratitude to the Allah Almighty for giving us the intellect so used in the course of this project. We pay best of our compliments to our Head of department **Dr. Liaquat Ali Najmi,** Project supervisor **Engr. Fawad Yousaf Malik,** Project Coordinator **Engr. Muhammad Naeem** and all faculty members they provided precious technical guidance to us. We are grateful to them because they sacrificed their valued time and provided all possible facilities. Last but not least from the depths of our hearts, we express our gratitude and respect to our loving parents whose blessings, affectionate love, continuous efforts, magnificent devotions, and sacrifices led us to success throughout our academic career.

Dedication

We dedicate this work to **Almighty Allah**, our creator, constant supporter, and wellspring of understanding, and wisdom. Throughout this program, He has been our source of strength. We also dedicate this effort to our **Parents** and **Teachers** who always provided guidance to us. They are our spiritual support. Encouragement from our parents and teachers was a great motivation in our graduate studies. We also dedicate this effort to our friends who always worked in a team with us.

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Abbreviations

MED	Mechanical Engineering Department
CAD	Computer-Aided Design
CATIA	Computer Aided Three-Dimensional Interactive Application
FYDP	Final Year Design Project
CBN	Cubic Boron Nitride
HP	Horse Power
AC	Alternate Current
3D	Three Dimensional
SDG	Sustainable Development Goals
COVID-19	Coronavirus Disease 2019
$\mathbf{R_a}$	Surface Roughness
MRR	Material Removal Rate
CCD	Central Composite Design
ANOVA	Analysis of variance
ANFIS	Adaptive Neuro-Fuzzy Inference System
MATLAB	Matrix Laboratory
PCD	Polycrystalline Diamond
MS	Mild Steel
SS	Stain-less Steel
AA	Aluminum Alloy
DOC	Depth of Cut
AISI	American Iron and Steel Institute
ASTM	American Society for Testing and Materials
RPM	Revolutions Per Minute
ISO	International Standards Organization
TPD	Technical Product Documentation
OH&S	Occupational Health and Safety
ROI	Return on Investment
LCA	Life Cycle Assessment

CHAPTER 1

INTRODUCTION

1.1 Introduction of Project

Mechanical engineering without production and manufacturing is meaningless and inseparable. Production and manufacturing process deal with conversation of raw materials inputs to finished products as per required dimension specifications and efficiently using recent technology. Finishing of a project plays a major role in the industries.

Our project is to design and manufacturing of Metal Multi-tool Linishing Machine by use of abrasive belt, grinding wheel and polishing wheel. It is used to finish the machining surfaces to super finish. The principle parts of this attachment are main body, motor with pulley, bearings and conveyor abrasive belt etc.

The abrasive belt is rotated by the single-phase induction motor. Hence our project namely Metal Multi-tool Linishing Machine is a Special type of Machine. According to the type of material to be finish, the grinding tool can be changed. Linishing machine will provide the material removal from a work piece by the application of a high-speed stream of abrasive particles. It is the polishing surface technique to produce a high-quality finished surface on the metals will be used for examine the grain structure of metals in material lab. It will also provide the facility to deburr sharp edges of materials and sharpening of tools. This machine may be widely applied in almost all type of industries.

Figure 1.1: Different Types of Abrasives

1.2 History Background

The Linish is an engineering term that refers to the process of using grinding or belt sanding techniques to improve the flatness of a surface. The technique may also be used, with finer grades of grindstone or sanding belt, to polish a surface.

Leonardo da Vinci was a pioneer, creating machines for the production of optical devices. Indeed, between 1513 and 1517, he imagined machines to grind and polish telescope mirrors.

A finishing process proposed at the finest level in 1990s, compliant abrasives have also been investigated for fine finishing with elimination of micro/nano cracks and subsurface damage [31]. A very wide range of methods for compliant processing have been proposed and developed in the past decades, especially since the 1980s. In recent years, some reviews were performed to report on particular aspects, such as advances in ultra-precision grinding [35], high performance grinding, grinding with textured tools, progress on ultra-precision machining, technological advances on ultra-precision finishing, advances in polishing of advanced materials [32], and so on.

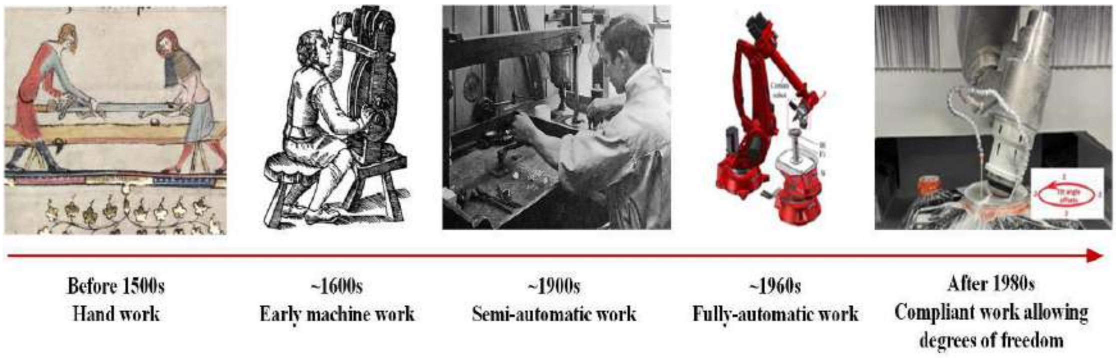

Figure 1.2: Historical Development of Grinding and Polishing Technology

1.3 Problem Statement

In the context of modern metalworking industries, there is a demand for a versatile and efficient solution that integrates various linishing processes such as grinding, sanding, and polishing into a single machine. The challenge lies in designing and manufacturing a Metal Multi-tool Linishing Machine that meets precision, safety, and performance requirements. This machine should offer seamless transitions between different linishing functions, maintain consistent quality across various materials, and ensure operator safety. The problem also involves selecting appropriate materials, optimizing mechanical design, integrating automation and control systems, and establishing efficient manufacturing processes. The successful solution to this problem will result in a state-of-the-art metal multi tool linishing machine that addresses the evolving needs of the metalworking industry, enhances productivity, and maintains standards in terms of performance and cost-effectiveness.

1.4 Aims and Objectives

The aim of this work can be summarized in the following points:

Designing and manufacturing of Metal Multi-tool Linishing Machine, improve the flatness of metal surface, to get required Surface Roughness (R_a) of the metals and to prepare refined surface of specimen for metallography practice in engineering materials laboratory. The technique may get with finer grades of grindstone or sanding belt, to polish a surface.

1.5 Gap Research

In the context of the design and manufacturing of a Metal Multi-tool linishing machine, "gap research" could involve exploring the shortcomings, limitations, or unmet needs in the current state of linishing machines or related technologies.

It is typically referring to identifying areas in existing knowledge or technology where a "gap" exists, and areas where current knowledge, methods, or technology are insufficient or lack solutions to a specific problem.

For example, gap research could involve:

1.5.1 Identifying Technological Limitations

Are there specific limitations in current linishing machines, such as difficulties in transitioning between different linishing functions, achieving consistent finishes across different materials, or ensuring operator safety?

1.5.2 Analyzing Market Trends

What emerging trends in the metalworking industry could the design of a multi-tool linishing machine address? Are there gaps in the market for a machine that offers enhanced versatility and efficiency?

1.5.3 Materials and Processes

Are there gaps in material compatibility or limitations in the range of materials that current linishing machines can effectively process?

1.5.4 Automation and Integration

Are there gaps in integrating automation, control systems, or user interfaces that could enhance the usability and efficiency of the machine?

1.5.5 Precision and Quality

Are there areas where existing linishing machines struggle to maintain the required level of precision and finish quality?

1.5.6 Safety and Ergonomics

Are there unaddressed safety concerns or ergonomic challenges that a new machine design could tackle?

By identifying these gaps, the gap research would provide insights into what aspects of the design and manufacturing process of a Metal Multi-tool linishing machine need special attention and innovation. It helps guide the project toward addressing real-world needs and challenges that current technologies have not fully resolved.

1.6 Applications

The Metal Multi-tool Linishing Machine has a wide range of applications across various industries due to its versatility and ability to perform different linishing tasks. Some of the key applications of the machine include:

1.6.1 Metal Fabrication

The machine is extensively used in metal fabrication processes, including deburring sharp edges, removing surface imperfections, and achieving smooth finishes on fabricated metal components.

1.6.2 Automotive Industry

In the automotive sector, the machine is employed for linishing tasks such as surface blending, polishing, and preparing metal parts for further processing or assembly.

1.6.3 Aerospace Industry

The machine is utilized for precision linishing of critical aerospace components, ensuring high-quality finishes and dimensional accuracy required for safety and performance.

1.6.4 Manufacturing Industry

In general manufacturing, the machine helps in improving the surface finish of metal parts, making them aesthetically pleasing and enhancing their functionality.

1.6.5 Metalworking Workshops

In metalworking workshops, the machine is employed for a wide range of tasks, such as deburring, edge rounding, and surface preparation before welding or painting.

1.6.6 Woodworking

The machine can be adapted for woodworking applications to smooth and refine wooden surfaces, preparing them for painting, varnishing, or other finishing processes.

1.6.7 Sheet Metal Processing

The machine is used in sheet metal processing to remove burrs and sharp edges, ensuring a safe and smooth product.

1.6.8 Die and Mold Making

In die and mold making industries, the machine is used for precision linishing and polishing of metal dies and molds to achieve the desired surface finish and shape.

1.6.9 Metal Restoration and Repair

The machine is valuable for restoring and repairing metal objects, including antique metal items, sculptures, and artifacts, bringing them back to their original condition.

1.6.10 Architectural Metalwork

In architectural metalwork, the machine is used to achieve a uniform and smooth surface finish on metal structures, enhancing their visual appeal.

1.6.11 Metal Art and Sculpture

Artists and sculptors use the machine to refine and polish metal artworks, achieving the desired texture and finish.

The Metal Multi-tool Linishing Machine's adaptability and effectiveness in various linishing applications make it a versatile tool, catering to the diverse needs of metalworking industries, manufacturing processes, and artistic endeavors. Its impact extends across different sectors, offering manufacturers and artisans a powerful and efficient solution to enhance the quality and aesthetics of metal products.

1.7 Project Working Methodology

The methodology adopted is as follows:

The machine has four different work stations, one is buffing, second is grinding wheel, third one is abrasive belt grinding and the fourth is abrasive disc. All are used to polish, grind and material removal. This whole arrangement is fixed on the motor’s shaft and body and the whole assembly fixed on the frame structure pedestal where the assembly rests. There are two type of rollers are used in our project to rotate the abrasive belt. Main driver roller is aluminum which is coupled on rotating shaft of motor by the suitable arrangement. Driven roller is set of bearings of 40mm in diameter. The single-phase induction motor is used to rotate the abrasive belt between the rollers as like as belt drive mechanism. The selected grit of belt, coated in abrasive material, is run over the surface to be processed in order to remove material or produce the desired finish.

1.8 Theoretical Studies

1.8.1 Abrasive

An abrasive is a material, often a mineral that is used to shape or finish a work piece through rubbing. While finishing a material often means polishing it to gain a smooth, reflective surface which can also involve roughening as matte or beaded finishes. Abrasives are extremely usual and are used very extensively in a wide variety of industrial, domestic, and technological applications. This gives rise to a large variation in the physical and chemical composition of abrasives as well as the shape of the abrasive. Most grinding wheels are made of silicon carbide or aluminum oxide, both of which are artificial (manufactured) abrasives. Silicon carbide is extremely hard but brittle. Aluminum oxide is slightly softer but is tougher than silicon carbide. It dulls more quickly, but it does not fracture easily therefore it is better suited for grinding materials of relatively high tensile strength [23].

1.8.2 Abrasive Grain Size

Abrasive grains are selected according to the mesh of a sieve through which they are sorted. For example, grain number 40 indicates that the abrasive grain passes through a sieve having approximately 40 meshes to the linear inch. A grinding wheel is designated coarse, medium, or fine according to the size of the individual abrasive grains making up the wheel.

1.8.3 Abrasive Minerals

Abrasives may be classified as either natural or synthetic. When discussing sharpening stones, natural stones have long been considered superior but advances in material technology are seeing this distinction become less distinct. Many synthetic abrasives are effectively identical to a natural mineral, differing only in that the synthetic mineral has been manufactured rather than been mined. Impurities in the natural mineral may make it less effective.

Some naturally occurring abrasives are:

a) Calcite (calcium carbonate)
b) Emery (impure corundum)
c) Diamond dust (synthetic diamonds are used extensively)

d) Novaculite
e) Pumice
f) Rouge
g) Sand
h) Corundum
i) Garnet
j) Sandstone
k) Tripoli

Some abrasive minerals (such as zirconia alumina) occur naturally but are sufficiently rare or sufficiently more difficult/costly to obtain such that a synthetic stone is used industrially. These and other artificial abrasives include:

1. Borazon (cubic boron nitride or CBN)
2. Ceramic
3. Corundum (alumina or aluminum oxide)
4. Glass powder
5. Steel abrasive
6. Silicon carbide (carborundum)
7. Boron carbide

1.9 Working Principle:

The main function of machine to grind the material. This abrasive belt is rotated by the single-phase induction motor. This machine is fixed on the pedestal. Belt grinding is an abrasive machining process used on metals and other materials. The pre-finished material's surface is fed towards the running belt with gentle force. The abrasives remove material from metal surface. It is typically used as a finishing process in industry.

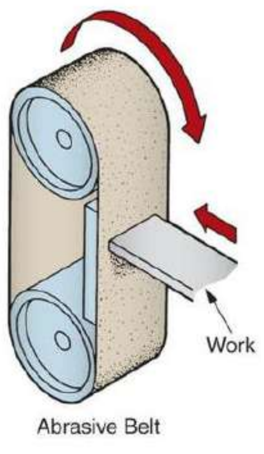

Figure 1.3: Working Principle

1.10 Major Components of Project

1. Belt Size: 2 x 27"
2. Abrasive Disc: 7" (60 grit)
3. Grinding Wheel: 7" (60 grit)
4. Buffing Wheel: 8"
5. Motor: 1HP (220V), 2800 RPM
6. Quick change belt system
7. Spring belt tensioning
8. Belt tracking adjustment mechanism
9. 60, 80, 100, 120, 140 and 160 grit belts
10. Tilting abrasive belt work table head

1.11 Relevant Schematic Diagram

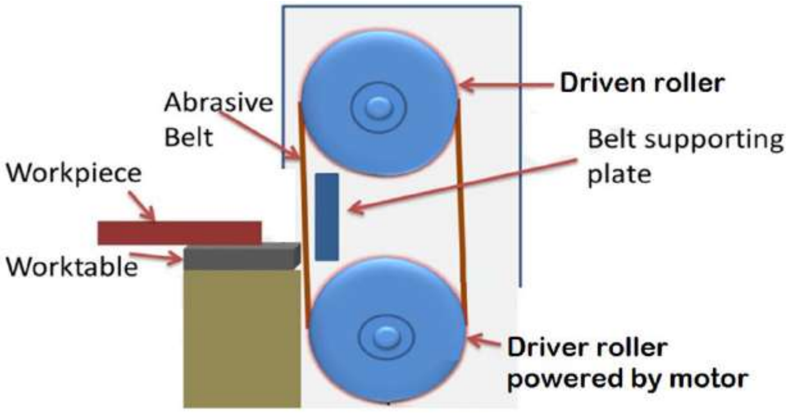

Figure 1.4: Schematic Diagram

1.12 Experimental Setup

The first most step of the setup is to manufacture the various parts of the machine and the then the abrasives are to be selected which is used in belt. The grit size of the belt varies with respect to material and its property that is to be machined. The rollers are fitted in proper location with belt tracking mechanism and spring for proper tension of the grinding belt, and the whole assembly rest on the base pedestal frame which is made up of steel channels. The power is transmitted from motor to rollers and the belt assembled over the rollers carryout the desired surface finishing of the component.

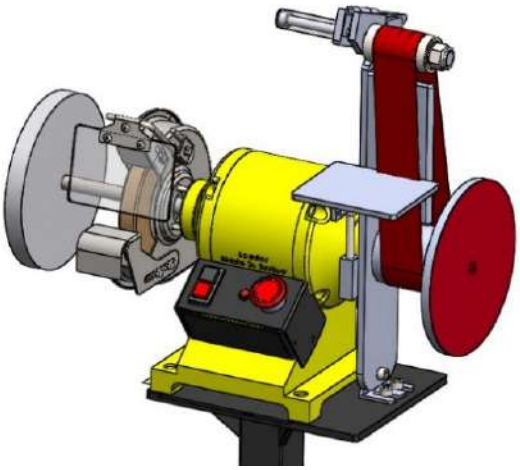

Figure 1.5: Proposed Experimental Setup

1.13 Result Expected

The purpose of designing and manufacturing of Metal Multi-tool Linishing Machine Designing and manufacturing, to improve the flatness, to get required surface roughness of the metals and to prepare refined surface of specimen for metallography practice in engineering materials laboratory. By implementing the above-mentioned experimental setup and methodology we may produce the desired results.

1.14 Things Learnt While Working on Project

Here we can provide insights into what we have learnt while working on our project "Design and Manufacturing of Metal Multitool Linishing Machine". Here are some potential takeaways:

1.14.1 Engineering Principles

Working on our project like Design and Manufacturing a Metal Multitool Linishing Machine, would provide a deep understanding of various engineering principles, including mechanics, material science, control systems, and more.

1.14.2 CAD and Modeling Skills

The project likely involved creating detailed CAD models and simulations on SolidWorks. This would enhance skills in using CAD software and understanding of 3D modeling.

1.14.3 Mechanical Design

We have gained expertise in mechanical design, including creating parts, assemblies, and ensuring proper fits and tolerances.

1.14.4 Materials Selection

Choosing the right materials for different machine components is crucial. This involves understanding properties like strength, corrosion resistance, and thermal characteristics.

1.14.5 Manufacturing Processes

We have learned about various manufacturing techniques of machining and how to select the best techniques for each component.

1.14.6 Safety Considerations

Safety would be a top concern. We have learned about incorporating safety features and conducting risk assessments.

1.14.7 Problem Solving

Projects rarely go perfectly. Overcoming design challenges, unexpected issues, and finding innovative solutions is a key skill.

1.14.8 Project Management

Managing a project from conception to manufacturing involves planning, budgeting, timeline management, and effective communication.

1.14.9 Collaboration

Every project require collaboration with designers and manufacturers. Learning to communicate effectively with different stakeholders is valuable. We have learned how to deal with them in real world.

1.14.10 Testing and Quality Assurance

Learning about testing methodologies and quality control is important to ensure the machine's performance and safety.

1.14.11 Continuous Improvement

Post-production, we should likely gather feedback from users and iterate on the design to make improvements based on real-world use.

1.14.12 Business Understanding

If involved in the manufacturing business, we should learn about pricing, distribution, marketing, and customer service aspects.

1.15 Positive Effects of Project

1.15.1 SDGs:

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing in a global partnership. They recognize that ending poverty and other deprivations must go hand-in hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

Our project will attain some SDGs are following:

1.15.1.1 Goal 8 (Decent Work and Economic Growth)

Decent Work and Economic Growth", which is to promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. Engineers are a key part of the economic growth of the country. In relation to SDG 8, Engineers need to explore what kind of contributions are expected from them and what the engineering community has to offer to enable a faster economic growth, particularly in the global and regional context of post-COVID19 pandemic trends.

1.15.1.2 Goal 9 (Industrial Innovation and Infrastructure)

Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

Figure 1.6: SDGs

1.16 Utilization of Results

The results and outputs from the Metal Multi-tool Linishing Machine's implementation have a significant impact on various aspects of metalworking industries and related fields. The utilization of the machine's results can be observed in the following ways:

1.16.1 Enhanced Product Quality

The machine's precise and consistent linishing capabilities lead to improved product quality. Manufacturers can achieve smoother surfaces, precise dimensions, and better finishes on metal workpieces, enhancing the overall appearance and functionality of the final products.

1.16.2 Increased Efficiency and Productivity

With the automation features and multifunctional design, the machine accelerates the linishing process and reduces manual effort. This increased efficiency leads to higher production rates, shorter lead times, and improved overall productivity in metalworking operations.

1.16.3 Competitive Advantage

Businesses that adopt the Metal Multi-tool Linishing Machine gain a competitive advantage in the market. They can produce high-quality metal products more efficiently, meeting customer demands promptly and gaining a reputation for delivering superior results.

1.16.4 Innovation and Customization

The machine's versatility allows for innovation and experimentation with different linishing techniques. Manufacturers can customize the linishing process to meet specific requirements and achieve unique finishes, contributing to product differentiation and market differentiation.

1.16.5 Sustainable Manufacturing

The machine's efficiency and automation features lead to reduced material wastage and energy consumption, contributing to more sustainable manufacturing practices.

1.16.6 Artistic Expression and Metalworking Creativity

Artists and artisans can leverage the machine's precision and control to create intricate metal artworks and sculptures, pushing the boundaries of metalworking creativity.

1.16.7 Consistent and Repeatable Results

The machine's automation ensures consistent and repeatable results in the linishing process. This reliability is crucial for meeting industry standards and adhering to strict quality control measures.

The utilization of results from the Metal Multi-tool Linishing Machine extends beyond individual projects. Its impact is felt across industries and sectors, shaping the landscape of metalworking, manufacturing, and artistic endeavors, and contributing to a more efficient, innovative, and sustainable future.

1.17 Work Schedule Plan

1.17.1 Project Management Design

The total duration of the project is 12 months which is further divided into following five phases.

1.17.1.1 Phase 1 (Collection of relevant literature and data)

From the beginning of FYDP Started from September 2022 to December 2022 we collect and Study different data like research articles and thesis for designing and manufacturing of our project.

1.17.1.2 Phase 2 (Design Work & Fabrication of Model)

The estimated time for this phase is 5 months. In this time frame we design our project mathematically and on CAD software. After that we have started manufacturing our project.

1.17.1.3 Phase 3 (Experimental work and Compilation of Results)

The Estimated time for this will be 3 Months.

1.17.1.4 Phase 4 (Analysis of Data)

The estimated time for this will be 1 months. In this time period we have completed Experimental and Result analysis.

1.17.1.5 Phase 5 (Thesis Write Up)

The estimated time for this will be 2 months.

Since, the work is to be documented and submitted to concerned quarters in the form of a report for evaluation, also include time slots in our project schedule for preparation and auditing of the Project Report.

1.17.2 Organization and Management

1.17.2.1 Project Work Schedule

Phase	2022				2023						
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Collection of Relevant Literature and Data	■	■	■	■							
Design & Fabrication of Model				■	■	■	■	■			
Experimental Work & Compilation of Results							■	■	■		
Analysis of Data										■	
Final Write-Up										■	■

CHAPTER 2

LITERATURE REVIEW

2.1 Selected Literatures for Project

2.1.1 Plan and Manufacturing of Belt Grinding Machine

(Dipesh Dhaku Warak, Pranav Pundalik Gavali) (2022)

This paper introduces the designing a crushing machine with a little and convenient shape that can give the foremost precise apparatus and crush up to 0.01-0.005 mm profundity with tall accuracy. Objectives of this research work is to consider different perspectives of grinding and rough grinding. And to plan scaled down belt grinding machine and take its trial and testing. Many types of machinery are used for grinding. Although a small grinding belt has a cutting edge that is stronger than that of a grinding wheel. But as the grinding of the wheels has some disadvantages in the way of the time required to eliminate the extra surface, the level of removal of goods and the elimination of the acquired area [1].

2.1.2 Design of a Compact Grinding Machine

(S. Ashvinderjit, W. J. Kelvin Chew) (2021)

This paper highlights the challenge with polishing & grinding tools is that most tools are it is either too large or complex to use or it is light but simply not sufficient. Commercial grinding and polishing machines are heavy weight tools which causes immobility which makes it difficult to store and operate. The upside of commercial grinders is its efficiency in providing a refined high-quality finished product. The availability and cost of tools are among concerns to the public and industries as key operation device used either for commercial or maintenance purposes such precision grinders or polishing machines are usually expensive. Assorted grinding tools in the market differ in terms of cost, required user proficiency levels and have different tool designs that can lead to limitations of flatness of ground surface and significant vibrations with prolonged use. The aim of this study is to develop a design compact grinder that is able to perform precise grinding and polishing while being cost efficient. Both functionality and ergonomic aspects were taken into consideration with market standards derived from datasheets. An initial design of the grinding machine was made using SolidWorks CAD software. A prototype was subsequently constructed and tested by using typical metallurgical sample preparation process with test parameters of grade of grinding paper and usage of lubricant. Microscopic image of ground specimens showed improvement in the quality of grinding with emery paper grades from coarse to fine grits with lubricant during the grinding process. Moreover, the designed compact grinding machine showed better surface finish when compared to using a typical angle grinder on aluminum sample [2].

2.1.3 Prediction of Surface Roughness of Abrasive Belt Grinding of Super Alloy Materials

(Ying Liu, Shayu Song, Youdong Zhang, Wei Li) (2021)

This paper discusses the surface roughness of belt grinding with superalloy materials due to the uneven material distribution and complex material processing. In this paper, a radial basis neural network is proposed to predict surface roughness. The grinding system of the superalloy belt is introduced. The effects of the material removal process and grinding parameters on the surface roughness in belt grinding were analyzed. After the exploratory experiment, an abrasive belt grinding experiment was conducted on super alloy material by setting different linear belt speeds, feed speeds, and grinding pressures. However, the accuracy of the model proposed in the article can be further improved. In addition, the generalization ability of the model is weak, the portability is poor, and the structure needs to be further improved [3].

2.1.4 Design and Manufacturing of Multi-Purpose Belt Grinding

(Mr. Patil Sainath Anada, Mr. Shewale Hrushikesh Ravindra) (2021)

This paper describes operations on belt grinding machine also it will explain the material used in a belt grinder. In next step it will explain abrasive process: An abrasive is material that is used to shape and finish a workpiece through rubbing which lead to part of workpiece being worn away. In final stage it will discuss on Grit, Grade and structure. It used to grind machine surface to super finish and accuracy, it grinding any shape of object like square pipe, flat plate, rectangle shape, fillet operation etc. in this project all component is arranged in one frame. This machine used Horizontal as well as Vertical and also 45-degree inclination Positions. For changing position form horizontal to vertical it designed gears with chain drive with Arduino system [4].

2.1.5 Development of Polishing Machine for Preparation Metallographic Specimen with Re-Manufacturing

(Apollo, R. Nur, M. A.Suyuti, M. Madjid) (2020)

This article presents metallographic specimen should be performed to determine the microstructure of a material. One of the processes of preparation of metallographic specimen is polishing process. The designing and manufacturing a polishing machine will be very helpful in the process of polishing the metallographic specimen. This paper was proposed to design and manufacture a polishing machine for laboratory scale. In this research, several stages of the process are performed, such as designing the model, preparing tools and materials used, making components, assembling and testing the polishing machine. The results obtained are polishing machine that works well and can be used for the metallographic test for students and researchers. It can be concluded that this polishing machine can produce the level of specimen preparation for a metallographic test [5].

2.1.6 Optimization of Grinding Parameters for the Workpiece Surface and Material Removal Rate in the Belt Grinding Process for Polishing and Deburring of 45 Steel

(Fengping Li, Yao Xue, Zhengya Zhang, Wenlei Song) (2020)

In this paper, the two indicators are taken into consideration simultaneously and differently by converting them into a comprehensive goal with using weighting objective method. Surface roughness (R_a) and the Material Removal Rate (MRR) are two important indicators during the grinding process. The former determines the surface quality while the latter reflects the grinding efficiency directly. A prediction model was established for each comprehensive goal with each different combination of surface roughness and MRR weighting coefficient. The optimal value of abrasive size, contact force, belt linear speed, and feed speed were obtained under different grinding situations by using a central composite design (CCD) combined with response surface analysis. The experimental results showed that the comprehensive goal can be used effectively as an indicator to control the grinding performance and improve the optimization process [6].

2.1.7 Modelling of Material Removal in Abrasive Belt Grinding Process

(Vigneashwara Pandiyan, Wahyu Caesarendra) (2020)

This article explores the effects of parameters such as cutting speed, force, polymer wheel hardness, feed, and grit size in the abrasive belt grinding process to model material removal. The process has high uncertainty during the interaction between the abrasives and the underneath surface, therefore the theoretical material removal models developed in belt grinding involve assumptions. A conclusive material removal model can be developed in such a dynamic process involving multiple parameters using statistical regression techniques. The results obtained by the six models have been assessed and compared. All five models, except multiple linear regression, demonstrated a relatively low prediction error. Regarding the influence of the examined belt grinding parameters on the material removal, inference from some statistical models shows that the grit size has the most substantial effect. The proposed regression models can likely be applied for achieving desired material removal by defining process parameter levels without the need to conduct physical belt grinding experiments [7].

2.1.8 Designing and Manufacturing of Portable Polishing Unit for Pipe Mill

(Sadgir Vinod, Shirsat Suvarna, Sharma Shakshi) (2020)

This study examines that now days there is only machine available which can polish single diameter pipe. Variable diameter cannot be polished by this machine. In this polishing unit we are modifying that single polishing machine can polish different diameters pipe at single unit machine with good surface finish overall circular pipe with optimum speed and also better finish of welded joints. Polishing is a more aggressive process while buffing is less harsh, which leads to a smoother, brighter finish. A common misconception is that polished surface has a mirror bright finish, however most mirror bright finishes are actually buffed Polishing is often used to enhance the appearance of an item, prevent contamination of instruments, remove oxidation, create a reflective surface, or prevent corrosion in pipes [8].

2.1.9 Design of Mini Abrasive Vertical Belt Grinding Machine

(Rahul Khadtare, Chavan Pravin, Govind Wagh) (2020)

The main aim of this paper is to design vertical abrasive belts grinding machine to achieve good tolerance as well as better surface finish for various materials such as metal, glass, ceramic, rock and specified material. The abrasive belt grinding can reduce the surface roughness of work pieces and accuracy meanwhile Aluminum oxide belt with high stock removal cleaning and polishing is effectual. The abrasive belt grinding as compared to wheel grinding have more efficient with efficiency and parameter range. It is concluded that Aluminum oxide belt hardness makes it suitable for use as an abrasive and as a component in cutting tools with significant proportion. We have designed such Abrasive Belt vertical Grinding Machine having better advantages over wheel grinding machine [9].

2.1.10 Modeling and In-Process Monitoring of Abrasive Belt Grinding Process

(Vigneashwara Pandiyan, Solairaja Pandiyan) (2019)

The aim of this paper is to explore automation and self-monitoring implementation of manufacturing processes will support the development of interoperable ecosystem relevant to the Industry 4.0 concept. Among many industrial cases, abrasive belt grinding is a tertiary machining process used to achieve desired surface quality and to machine off features such as burrs and weld seams. Manufacturers are in the need of an ability to closely monitor and optimize the performance of abrasive belt grinding processes to meet tight tolerances. The abrasive belt grinding process is highly nonlinear due to the complexity of the underlying physical mechanisms, some of which remain unknown. This thesis mainly deals with modeling and monitoring of abrasive belt grinding process in dry condition. The thesis initially explores the effect of cutting speed, force, polymer wheel hardness and feed on pressure distribution using a dynamic pressure sensor to understand material removal characteristics. The observations indicate that altering any of the parameters will have a resultant shift in the magnitude of material removed [10].

2.1.11 Development of a Laboratory Metallographic Grinding/Polishing Machine

(Oyetunji Akinlabi, Barnabas Abel) (2019)

This study centered on the development of a laboratory metallographic grinding/polishing machine using locally sourced materials and indigenous technology to help in polishing metals for production of a flat, smooth and mirror-like surface of any metallic materials to determine their physical structure using microscopy for metallographic examinations. The designed was made, and 3-dimensional architectural design was done to obtain a clear vision of the design. The laboratory grinding/polishing machine was fabricated using the following components: angle-bars, mild steel plate, electric motor, shaft, belt, pulley, coupling, side pulley disc; following the specified dimensions from the 3-dimensional drawing; assembling of the various components follows; and finally, tested and performance evaluation was equally done. In testing the developed machine, the specimen was mounted, ground and then polished using emery paper with frequent application of water to act as a coolant while the side pulley disc is rotating. The result obtained from the developed laboratory grinding/polishing machine showed a metallic specimen that was well ground and well-polished to mirror-like form for further metallographic examination. Based on the efficiency of this developed machine, we, therefore, recommend this research work for the end users and the metallography industry for the metallographic purpose [11].

2.1.12 Study of Surface Roughness of Electronic Substrate on Abrasive Belt Grinding

(Q. B. Tao, M. T. Tran, H. T. Bui) (2019)

This paper describes the machining processing industries have continuously developed and improved technologies and processes to transform finished product to obtain better super finished product quality and thus increase products. Abrasive machining is one of the most important of these processes and therefore merits special attention and study. Indeed, grinding is the process of removing metal by the application of abrasives which are bonded to form a rotating wheel or belt. When the moving abrasive particles contact the workpiece, they act as tiny cutting tools, each particle cutting a tiny chip from the workpiece. The abrasive belt grinding is efficient, economic, widely used and being said "universal grinding". It can get high machining accuracy and surface quality. Surface quality is a very important aspect of machining quality and it is the most important parameter to measure the surface quality. Many factors affect the surface roughness such as performance of abrasive belt, the amount of abrasive belt grinding, hardness of contact wheel. And the most important one is the amount of grinding. Therefore, this article is aimed at that status so that to design and manufacture a new abrasive belt grinding machine. And then the surfaces for soldering of Cu substrates are ground and polished using the machine. Finally, the surface roughness of copper substrates polished by the abrasive belt grinding machine is evaluated and compared with other grinding machines [12].

2.1.13 Abrasive Belt Grinding Machine

(Haadi Mastim, Saad Halde, Sultan Ulde) (2019)

In this work, the Machine designed is used for grinding any shape of object like Circular, Rectangular, and Polygon. In this project the work abrasive belt is used to grinding the material. The abrasive belt is rotated by the single-phase induction motor. This project gives details of grinding various shape and size of components. This machine can be widely applied in almost all type of industries. By varying the pulley size, we can get a high-end speed of over 10,000 rpm if needed. The modification and advancement which we would make is to have a totally enclosed motor to keep out the grit which will improve its efficiency and performance. Abrasive belt grinding has gained increasing importance as chip removal production process in recent years. It is also used for material removal deburring and polishing applications. However, the rate of material removal is higher in the case of grinding compared to that of deburring and polishing which necessitates the analysis of characteristics of coated abrasives to withstand high forces. Thus, selection of the abrasive belt and optimization of the grinding parameters become critical [13].

2.1.14 Design and Testing of Belt Grinding Development

(Sepdirama Setiawan, Arwizet, Budi Syahri, Ambiyar) (2018)

The author observes that the use of belt grinding is still rare in the writer's own environment, both in the fields of education and small industries, because there are still many people who are fixated on ordinary grinders, and think that ordinary grinders are better in all work. The development of belt grinders has changed people's perspectives through the development that the authors have done, with increasing belt grinding functions through development which will certainly make belt grinders even more useful. This belt burrs are made and developed through pre-existing belt grinding shapes. The result of this development is a belt grinder which has a function more than the belt grinder which is already before. This belt burrs have three types of work functions, namely vertical, horizontal, and cutter, and also features speed control. With the development that the author does, of course, it will change people's perspectives because belt grinding has a function that is better than before and can better help the work of a grinding process [14].

2.1.15 Design and Fabrication of Multipurpose Grinding Machine

(Rohit, Naresh, Ravindra, Arun, Akshay) (2018)

It is investigated that every industry desire to make high productivity rate maintaining the quality and standard of the product at low average cost in an industry a considerable portion of investment is being made for machinery installation. This paper presents the concept of Multi-Purpose grinding Machine mainly carried out for production-based industries. Industries are basically meant for Production of useful goods and services at low production cost, machinery cost and low inventory cost. Today in this world every task has been made quicker and fast due to technology advancement but this advancement also demands huge investments and expenditure, every industry desire to make high productivity rate maintaining the quality and standard of the product at low average cost. Also developed a conceptual model of a machine which would be capable of performing different operation simultaneously, and it should be economically efficient. In this machine giving drive to the main shaft to by v-belt drive another shaft driving the multi grinding machine operation done by used only on electric motor. The mode facilitates us to get the operation performed at different working center. Simultaneously as it is getting drive from single power source. Objective of this model are conservation of electricity (power supply), reduction in cost associated with power usage, increase in productivity [15].

2.1.16 Predictive Modelling and Analysis of Process Parameters on Material Removal Characteristics in Abrasive Belt Grinding process

(Vigneashwara Pandiyan, Wahyu Caesarendra, Gunasekaran Praveen) (2017)

This study examines the surface finishing and stock removal of complicated geometries is the principal objective for grinding with compliant abrasive tools. To understand and achieve optimum material removal in a tertiary finishing process such as Abrasive Belt Grinding, it is essential to look in more detail at the process parameters/variables that affect the stock removal rate. The process variables involved in a belt grinding process include the grit and abrasive type of grinding belt, belt speed, contact wheel hardness, serration, and grinding force. Changing these process variables will affect the performance of the process. The literature survey on belt grinding shows certain limited understanding of material removal on the process variables. Experimental trials were conducted based on the Taguchi Method to evaluate the influence of individual and interactive process variables. Analysis of variance (ANOVA) was employed to investigate the belt grinding characteristics on material removal. This research work describes a systematic approach to optimize process parameters to achieve the desired stock removal in a compliant Abrasive Belt Grinding process. Experimental study showed that the removed material from a surface due to the belt grinding process has a non-linear relationship with the process variables. In this paper, the Adaptive Neuro-Fuzzy Inference System (ANFIS) model is used to determine material removal. Compared with the experimental results, the model accurately predicts the stock removal. With further verification of the empirical model, a better understanding of the grinding parameters involved in material removal, particularly the influence of the individual process variables and their interaction, can be obtained [16].

2.1.17 Design and Fabrication of Linishing Machine

(Dr.Venkatesh Babu, Mr. S. Thirumavalavan) (2017)

This study examines tilting the Linishing machine. It is the process of material removal from a work piece by the application of a high-speed stream of abrasive particles. The material removal process is mainly caused by brittle fracture by impingement and then by erosion. The AJM will chiefly be used to cut shapes, drill holes and de-burr in hard and brittle materials like glass, ceramics etc. In this project, a model of the Abrasive Jet Machine was designed using CAD packages like AutoCAD and CATIA. Care was taken to efficiently use the available material and space. The machine was fabricated in the institute workshop with convectional machine tools like arc welding machine, hand drill, grinding machine using commonly available materials like mild steel sheet and rod, aluminum sheet, glue, polythene sheet, glass fiber which are commonly available in the local market. Care has been taken to use less fabricated components, because, the lack of accuracy in fabricated components would lead to a reduced performance of the machine. The machine was be automated to have 3 axes travel using microcontroller and driver arrangement along with stepper motor. The different functional components of unit are the machining chamber, work holding device, abrasive drainage system, compressor, air filter and regulator, abrasive nozzle, and mixing chamber with cam motor arrangement [17].

2.1.18 Design and Fabrication of Abrasive Belt Oblique Grinding Machine

(A Robert Henry, R Anbazhgan, A Kevinraj) (2016)

In this research, the machining processing industries have continuously developed and improved technologies and processes to transform finished product to obtain better super finished product quality and thus increase products. Abrasive machining is one of the most important of these Processes and therefore merits special attention and study. Belt grinding is an abrasive machining process used on metals and other materials. The main objective of this project is to design and fabricate an abrasive belt grinding which can be used as versatile grinding machine, the work area can be rotated from 0 degree to 180 degree. The 0-degree work area can be used for bottom grinding of component, the 90-degree work area can be used for vertical grinding of component and the 180-degree work area can be used for top grinding of component. we can use the surface belt oblique grinder and we can obtain the different super finishing quality with the help of using different grade abrasive belt. This Grinding machine has the versatile operations and achieves the operations of all other Belt grinding methods [18].

2.1.19 In-Process Surface Roughness Estimation Model for Compliant Abrasive Belt Machining Process

(Vigneashwara Pandiyan, Meena Periya Samy) (2016)

This paper presents that the surface roughness inspection in robotic abrasive belt machining process is an off-line operation which is time-consuming. An in-process multi-sensor integration technique comprising of force, accelerometer and acoustic emission sensor was developed to predict state of the surface roughness during machining. Time and frequency-domain features extracted from sensor signals were correlated with the corresponding surface roughness to train the Support vector machines in MATLAB toolbox and a classification model was developed. Prediction accuracy of the classification model shows proposed in-process surface roughness recognition system can be integrated with abrasive belt machining process for capping lead-time and is reliable [19].

2.1.20 Design and Fabrication of a Twin Disc Metallographic Polishing Machine

(Furqan, Abdulfattah) (2016)

The aim of the project is to design and fabricate a laboratory metallographic polishing machine that can be used for grinding and polishing of metallic materials in the metallographic laboratory. For research and training in the laboratory, thereby need for the design and fabrication of a metallographic polishing machine suitable for grinding and polishing for improved training, teaching and research in materials metallography. The machine is easy to operate and requires minimum maintenance. Any of the polishing discs is needed to be disengaged for the other polishing disc to work, although further improvement should be made to the machine. The performance and efficiency of the machine was tested by polishing metal coupons on the fabricated machine using different emery papers and determining the time taken for a fine, smooth and shiny surface to be achieved using a stopwatch. Comparing the machine performance and efficiency with the imported polishing machine available in the laboratory [20].

2.1.21 Development of Metallographic Specimen Polishing Machine

(T.J. Erinle, O.O. Awopetu) (2011)

The objectives of the project are to design and construct a machine that will polish metal for physical metallographic determination and also to design and construct a machine using locally available materials to produce a flat, smooth and mirror-like surface of any metallic materials in order to determine their physical structure using microscopy. The machine consists of motor, pulleys, belt, rotating shaft, wooden disk plate, bush bearing, pillow bearings, metal clip, and metal casing. All of these components are assembled to form the polishing machine. The testing and evaluation of the machine involves test running of the machine at each speed rate without placing any metallic specimen on and also running after that metallic specimen was introduced for grinding and polishing. The machine has the ability to grind and polish any kind of metals, is simple to operate, and requires minimum maintenance. The metallographic specimen polishing machine can be used in the material laboratory for the grinding and polishing of any metallic materials. The machine has the ability to grind and polish any kind of metals, simple to operate and requires minimum maintenance [21].

2.1.22 Coolants and Their Role in Grinding

(Sirsendu Mahata, Jayanta Mistri, Bijoy Mandal) (2011)

This paper illustrates the importance of using cutting fluids in a high-speed machining process like grinding. Coolant type and composition can amply influence work surface quality and wheel wear. The paper gives an insight into the mechanism of action of coolants in grinding. In the present paper, a brief review of different types of cutting fluids and their composition have been made. The application of grinding fluids on different workpiece materials and their functions are also discussed. Coolants play a decisive role in grinding because of the intense heat generation and the consequent thermal damage associated with the process. Different types of coolants with varying and diverse compositions are used for grinding different types of work material in order to reduce the heat generated due to friction and to carry away the heat produced as well as for efficient swarf disposal. The present paper aims at discussing about the different types and composition of coolants used in grinding. The mechanism of action of coolants, their application on different workpiece materials and their functions are also discussed in the paper [22].

2.1.23 Abrasives for Precision Belt Grinding

(S. Mezghani , M. El Mansori) (2008)

This paper addresses a study to achieve a method of assessment of coated abrasives for precision belt grinding based on the identification of the prevailing relationships between the changing features of fixed grains on flexible coated belts and grinding performance. A set of parameters was defined which describe the aluminum oxide resin-bonded belt characteristics including active grits density, cutting edge dullness, chip storage space and mean effective indentation. A parametric study was made of the effects of coated belt characteristics on surface finish performance with different grain sizes for grinding different workpiece materials. Experimental results are discussed in relation to the prevailing mechanisms of the process at the belt-work interface which can be separated into cutting and ploughing components. This is enables also to describe the grit wear mechanisms operating with coated abrasives when grinding two engineering materials. In this work, an approach for abrasive belt morphology assessment based on watershed transform was developed. This morphological characterization of the aluminum oxide resin-bonded belt was applied to study the wear evolution of the abrasive. Hence, the parameters introduced to characterize the abrasive belt properties lead to the identification and the quantification of the most important grain wear modes. Furthermore, the influence of coated abrasive grit size on grit wear mechanisms can be better understood and need to be studied deeply [23].

2.1.24 Polishing of Polycrystalline Diamond Composites

(Chen, Yiqing) (2007)

This chapter discussed the design and manufacture of a special machine for polishing PCD composites. This will include the machine requirements, design considerations of the machine structure and some component assemblies, their manufacture and calibration. For polishing PCD using the dynamic friction method, the polishing machine is required to provide appropriate ranges of speed and pressure to generate high temperatures, and to facilitate the PCD surface contacting a suitable catalytic metal disk. The load/pressure and relative speed between specimen and polishing disk need to be distributed evenly over the whole polishing surface during polishing to obtain a uniform polishing surface. A special PCD polishing machine was designed according to these requirements. In addition, the machine was built in-house. The polishing speed and pressure have been calibrated and can be varied for different polishing conditions [24].

2.1.25 Preparation and Analysis of Ceramic Microstructures

(Richard E. Chinn) (2002)

This chapter addresses a study that grinding removes saw marks and levels and cleans the specimen Surface. Polishing removes the artifacts of grinding but very little stock. The samples typically come as 2 cm circles. In ceramography, especially the perforated pads. Grinding and polishing lubricants are widely used in ceramography; Dry grinding is extremely rare. The lubricant facilitates the interaction Between the abrasive and the specimen, whether the abrasive is fixed or free. The grinding lubricant acts as a coolant to prevent heat Buildup from friction, transports the swarf away from the platen and specimen. And uniformly distributes the contact stresses between the platen and the specimen during grinding. After the finest grinding step and subsequent cleaning, manually polish the specimen on nap fewer polishing cloths loaded with lubricant and diamond paste, respectively. The evolution of the microstructure as a result of each polishing Step is demonstrated. In automatic grinding the pressure, time, and starting abrasive size depend on the number of mounts being ground, the abrasion resistance of the ceramic, the amount of wear on the abrasive particles, and the smoothness of the as-sawed surface [25].

2.1.26 Design and Testing of Belt Grinding Development

Sepdirama Setiawan, Arwizet, Budi Syahri, Ambiyar, Darmawiand Yufrizal (2018)

The study observes that the use of belt grinding is still rare in this project, both in the field of education, and in small industries, because there are still many people who are fixated on ordinary grinders, and think that ordinary grinders are better in all work. The development of belt grinders has changed people's perspectives through the development that the authors have done, with the increase in belt grinding functions through development which will certainly make belt grinders even more useful. This belt burrs are made and developed through pre-existing belt grinding shapes. The result of this development is a belt grinder which has a function more than the belt grinder which is already before. This belt burrs have three types of work functions, namely vertical, horizontal, and cutter, and also features speed control. With the development that the author does, of course, it will change the perspective of people because the belt grinding has a function that is better than before and can better help the work of a grinding process. The results of the research and discussion can be taken the first few conclusions, the advantages of belt grinding machines are in finishing work not in rough workmanship. Second, the rotating speed of the belt grinding machine is directly proportional to the speed of incision by the belt grinding machine. Lastly, the disadvantage of this belt grinding machine is that it is less effective in rough working and deep cutting, and also the weakness of the belt sandpaper which can be damaged if the rotation is less stable [26].

2.1.27 An Experimental Analysis of Grinding Parameters and Conditions on Surface Roughness of Finished Product

P Biswas, P K Bardhan, A Sarkar, M R Islam, D Mondal (2022)

This paper illustrates the study of Higher grade or smooth surface finish mechanical components and mating parts with close limits and tolerances is one of the most important requirement of modern manufacturing industry. Grinding is the most dominating process among various manufacturing finish processes over final products that require in-depth investigation on how material removal processes influence the surface roughness of the finished products. In this work, an experimental analysis was carried out to evaluate the influence of various machining parameters and conditions on surface roughness of the final substrates. The main objective of this experimental work is to study the comparison of the effects of tools and conditions which are abrasive nature between Mild Steel (MS) and stainless-steel surface by using Depth of Cut (DOC). It is found that during dry grinding process, R_a value is more for both Alloy steel and MS than wet grinding condition. It may have been due to improper cooling of grinding zone during dry grinding. So, from this experimental investigation we can conclude that the surface finish of MS is always better than stainless steel in any machining conditions [27].

2.1.28 Design and Experiment of Robotic Belt Grinding System with Constant Grinding Force

Kaiwei Ma, Xingsong Wang, Donghua Shen (2018)

This article aiming at the problems of the lack of engineering practice in robotic grinding, a robotic belt grinding automation production system for complex surface workpiece is designed and built, which is based on the application of hand-grinding production line and industrial robot. In order to design the belt grinder, some key parameters such as driving wheel diameter, belt tension and tension cylinder bore are calculated. On this basis, the construction of the belt grinder is completed. The results fully meet the requirements of parts surface grinding. It provides a theoretical basis and experimental reference for the development of industrial robotic belt grinding system. This article completes the overall construction of the robotic belt grinding system based on actual production requirements. In this process, the belt grinder and system control cabinet are independently developed and produced. The key parameters of the belt grinder are calculated and the control system drawings are completed. This lays a solid foundation for the control of constant grinding force. In the constant grinding force module, the relationship between grinding force and motor current is determined by grinding experiment. The variable-frequency drive is used as the current signal acquisition equipment. The robot is used as the execution device. Then, the module is built. It improves the stability and accuracy of the processing system. Robot Studio is used to realize the simulation of the grinding system and off-line programming of grinding paths, which could ensure the smooth completion of the processing. Finally, the faucet grinding experiment is carried out, which proved the feasibility, scientific and high efficiency of the method. This provides technical support and beneficial exploration for the design of robotic grinding system [28].

2.1.29 Experimental Study on the Belt Grinding Mechanism for Aluminum Alloys

Suo Xian Yuan, Bo Bi (2009)

This paper mainly carried out theoretical analysis and experimental study on abrasive parameters and mechanical parameters that have influence on grinding force and surface processing quality in grinding aluminum alloy. As a new technique integrating grinding and polishing, the technology of abrasive belt grinding is considered as a processing method with high quality, high efficiency, low consumption and wide range of application owing to its features of high processing efficiency, “cold” grinding, stable grinding speed, high precision and low costs. Taking aluminum alloy material as object of study and on the basis of the grinding technology of surface abrasive belt grinding machine, this paper carried out in-depth experimental study on the grinding mechanism of abrasive belt with aluminum alloy materials. Firstly, under the same condition, the abrasive force was significantly reduced with the increase of abrasive belt speed; increased with the increase of work piece travel speed; and significantly increased with the increase of grinding depth. Secondly under the same condition, the roughness of surface of work piece was reduced with the increase of the abrasive belt speed; increased with the increase of work piece travel speed; and increased with the increase of grinding depth [29].

2.1.30 Experimental Study of Surface Roughness on Abrasive Belt Grinding

Hong Li (2011)

This article applies the abrasive belt grinding technology on the conventional lathe. According to the principle and characteristic of abrasive belt grinding, a device is designed using abrasive belt grinding technique. The effects on work piece surface roughness brought by performance of abrasive belt, work piece rotate speeds, grinding depth and feed, hardness of contact wheel and so on are studied in experiments. The results indicate that using the abrasive belt grinding installment on the lathe to carry on the cylindrical precision grinding, can reduce the surface roughness of work pieces effectively and increase the machining precision. An effective way to reform the ordinary lathe as a grinding machine is provided. As elastic properties of abrasive belt grinding, changes in the amount of grinding have certain extent on the surface roughness and impact of longitudinal feed is significant. As the increase of workpiece speed leads to the increased of surface roughness, it should not be chosen too large. It can significantly improve the surface roughness of abrasive belt grinding used soft contact roller by Increasing belt speed and reducing the vertical feed [30].

2.1.31 An Investigation into the Influences of Grain Size and Grinding Parameters on Surface Roughness and Grinding Forces when Grinding

İbrahim Çiftçi, Ulvi Şeker (2010)

This study was carried out to investigate the effects of grain size on workpiece surface roughness and grinding forces when surface grinding AISI 1050 steel. Grinding tests were carried out using different grinding wheels of different grains. Ground surface roughness measurements were also carried out. The results showed that grain size significantly affected the grinding forces and surface roughness values. Increasing grain size and depth of cut increased the grinding forces and surface roughness values. For different grain sizes, depth of cuts of 0.01 and 0.02 mm did not result in any significant variations in the grinding forces but further increase in depth of cut led to variations of up to 50% in grinding forces. Some conclusions can be drawn from the present study investigating the effects of grain size on workpiece surface roughness and grinding forces when surface grinding AISI 1050 steel, grinding wheel grain size was found to have great influence on surface roughness and grinding force values. Increasing grinding wheel grain size increased the surface roughness values and the grinding forces. At 0.04-0.05 mm depth of cuts, the surface quality (in terms of Ra) obtained by 80 grain wheels was better by 30%, 80% and 400% than those for 60, 46 and 36 grain wheels, respectively. Grinding wheel grains were found to penetrate the ground surface at higher depth of cuts of 0.04, 0.05 and 0.06 mm when the grinding wheel of 80 grain was used. At higher depth of cuts, some burns and cracks were observed on the ground surface by the naked eye for the grinding wheel of 80 grain. Grooves, burns and waviness can be decreased if depth of cut is reduced when using grinding wheels with small grains [31].

2.1.32 Effect of Machining Parameters on the Surface Roughness for Different Type of Materials

M H M Ghazali, A Z A Mazlan, L M Wei, T S Sze and N I M Jamil (2019)

This paper designates the Surface roughness (R_a) is an important parameter in determining the quality of surface finishing of any products obtained from the machining process. Surface roughness can be affected by several factors such as machining parameters, workpiece material properties, cutting tool parameters and machine tool conditions. In this study, the effects of machining parameters such as feed rate and cutting speed on the surface roughness was investigated for aluminum, mild steel and brass materials. The experimental R_a values obtained were compared with the theoretical values with discrepancy ranging from 1.14 % to 113.71 %. From the study, it can be concluded that the surface roughness of materials will increases as the feed rate increases and decrease when higher cutting speed is applied. The roughness values that obtained from this experiment is still not acceptable because there are too much of deviations with the theoretical roughness value. This is due to some factors that may affect the accuracy of the roughness value which includes collision between workpieces in storage, rusting and cleanliness of workpiece surface [32].

2.1.33 Design and Fabrication of Abrasive Belt Grinding

M.Chandrasekar, B.Logesh, D.Ramachandran, G.Gnanasekar, P.Karuppaiah (2018)

In this project, Abrasive belt grinding machine has been mainly developed for grinding the specimen to get a good surface finish. In this machine we have using the motor source of ac current operated device. This equipment is good efficient compared to other, so good finishing is obtained by using this machine so we can obtain the quality on specimens in industries. Here we have fabricated the abrasive grinding machine; it’s a new innovative concept. This machine has been mainly developed for grinding the specimen to get a good surface finish. In this machine we have using the motor source of ac current operated device. This equipment is good efficient compared to other, so good finishing is obtained by using this machine so we can obtain the quality on specimens in industries. The project carried out by us made an impressing task in the field of small-scale industries and automobile maintenance shops. It is very useful for the workers work in the lath and small-scale industries. This project will reduce the cost involved in the concern. Project has been designed to perform the entire requirement task at the shortest time available. This machine has been mainly developed for grinding the specimen to get a good surface finish. In this machine we have using the motor source of ac current operated device. This equipment is good efficient compared to other, so good finishing is obtained by using this machine so we can obtain the quality on specimens in industries [33].

2.1.34 Design and Testing of Abrasive Belt Grinder

Marija Matejic, Milos Matejic, Jovana Zivic, Lozica Ivanovic (2022)

The belt grinding machine, presented in this paper, was designed and tested for grinding any shape of object like circular, rectangular, or polygon. In this project, the work abrasive belt is used to grind the various types material of material such as metal, plastic, wood etc. The abrasive belt is rotated by a three-phase induction motor. The particular abrasive belt grinding machine has been developed for the purposes of experimental research. Hence this project namely adjustable belt grinder. The machining accuracy and surface quality of workpieces are the key factors that ultimately determine the performance of the equipment. The paper concludes with comments on achieved results and directions for further research on this topic. The presented paper shows a multiple approach to the efficient grinding processes in the small workshops. Firstly, the design of novel belt grinder has been made, and later the actual grinding machine was fabricated. Before the work samples is processed the functionality of the machine was tested. After that, the samples were prepared on band-saw, and processed on the belt grinder. Visual inspection has been made and it is determined that surface roughness after the hand grinding process is improved very much. In the further work, the authors will vary the grinding speeds and make a surface profile measurement in order to determinate acceptable grinding speeds for various types of the materials [34].

2.1.35 Fabrication of Versatile Grinding Machines Using Round Abrasive Belts

Trần Minh Thông, Tào Quang Bảng, Lê Quốc Tín (2018)

In the cause of industrialization and modernization of the country, mechanics play an important role but traditional mechanics no longer exist suitable for our current situation.

In mechanical engineering, Grinding is one of the most important operations using abrasive particles to cut away a thin layer of metal on the machined surface to create a smooth detailed surface. Traditional grinders Currently operating with low safety, high machine purchase cost, functional limited capabilities, such as manual grinders and grinding wheels. So, to improve the above limitations and disadvantages, ring sanding machines a good solution, more versatile and widely used today. Therefore, this study focuses on the fabrication of abrasive belt grinders versatile ring with low cost, high efficiency and flexible use operated by using a ring sanding belt and adjusting the grinding direction. The article presented the research and manufacture of the grinding machine uses a ring sanding belt to finely grind surfaces detail surface after machining, chamfering of sharp iron edges. The cost of using the machine is cheap due to the cost of buying a cheap ring belt, Using the machine is simpler and safer than grinding with stone. The machine is used for grinding worn cutting tools and batch during use at the unit such as: drill bits, milling buttresses and alloy turning tools. It can be applied to the production of goods series and commercialization of this grinding machine product [35].

2.2 Reference Model

Our project is to design and manufacturing of Metal Multi-tool Linishing Machine by use of abrasive belt, abrasive disc, grinding wheel and polishing/ buffing wheel. The principle parts of this attachment are pedestal, motor, main column, sanding disc and belt tracking adjustment. Hence our project namely Metal Multi-tool Linishing Machine is a Special type of Machine. According to the type of material to be finish, the grinding belt can be change quickly. Linishing machine will provide the material removal from a work piece by the application of a high-speed stream of abrasive particles. It will also provide the facility to deburr sharp edges of materials and sharpening of tools, also obtaining required finish of metals by using variable grit of abrasive belts which are used to investigate cracks in metal surface in engineering materials laboratory and to improve the flatness.

The reference model may be referred to “Design and Manufacturing of Multi-Purpose Belt Grinding” [4]. But we have designed our project much wider concept by combining all these features of grinding, polishing and deburring the metals in a single compact unit.

Figure 2.1: Reference Models

2.3 Literature Gap

Table 2.1: Literature Gap Analysis

Sr. No.	Title	Authors	Year	Compact Size	Rpm
1.	Design of a Compact Grinding Machine [2]	S. Ashvinderjit, W. J. Kelvin Chew	2021	Yes	1500
2.	Design and Manufacturing of Multi-Purpose Belt Grinding [4]	Mr. Patil Sainath Anada, Mr. Shewale Hrushikesh Ravindra	2021	No	2800
3.	Development of Polishing Machine for Preparation Metallographic Specimen with Re-Manufacturing [5]	Apollo, R. Nur, M. A.Suyuti, M. Madjid	2020	Yes	2000
4.	Abrasive Belt Grinding Machine [13]	Haadi Mastim, Saad Halde, Sultan Ulde	2019	Yes	1440
5.	Design and Fabrication of Multipurpose Grinding Machine [15]	Rohit, Naresh, Ravindra, Arun, Akshay	2018	Yes	2800
6.	Design and Fabrication of Linishing Machine [17]	Dr.Venkatesh Babu, Mr.S.Thirumavalavan	2017	No	1450

7.	Design and Fabrication of a Twin Disc Metallographic Polishing Machine [20]	Furqan, Abdulfattah	2016	Yes	1480
8.	Development of Metallographic Specimen Polishing Machine [21]	T.J. Erinle, O.O. Awopetu	2011	Yes	1000
9.	Effect of Machining Parameters on the Surface Roughness for Different Type of Materials [32]	M H M Ghazali, A Z A Mazlan, L M Wei, T S Sze and N I M Jamil	2019	No	2800
10.	Design and Fabrication of Abrasive Belt Grinding [34]	M.Chandrasekar, B.Logesh, D.Ramachandran	2018	Yes	1450

2.4 Conclusions

The successful completion of the project: "Design and Manufacturing of Metal Multi-tool Linishing Machine" marks a significant milestone in advancing metalworking technologies and enhancing productivity in various industries. The comprehensive development process has resulted in a versatile, efficient, and user-friendly machine that offers numerous benefits to manufacturers and metalworkers alike.

Key conclusions of the project are as follows:

2.4.1 Versatility and Functionality

The Metal Multi-tool Linishing Machine's multifunctional design allows it to cater to diverse metalworking needs, including deburring, edge rounding, surface blending, and fine polishing. Its ability to handle various metal materials and shapes makes it a valuable asset across industries like automotive, aerospace, manufacturing, and jewelry.

2.4.2 Precision and Control

The machine's advanced controls and adjustable settings enable operators to achieve precise linishing results with consistent quality. This level of precision contributes to the production of high-quality finished products.

2.4.3 Safety and Operator-Friendly

The integration of safety mechanisms ensures operator protection during machine operation. Additionally, the user-friendly interfaces make the machine accessible to both experienced technicians and newcomers, reducing the learning curve and enhancing productivity.

2.4.4 Automated Processes

The incorporation of automated features streamlines the linishing process, reducing manual effort and optimizing productivity. This automation enhances efficiency and allows operators to focus on other critical tasks.

2.4.5 Durability and Maintenance

The machine's construction with high-quality materials and components ensures its durability and reliability over prolonged usage. Furthermore, its low maintenance requirements contribute to minimizing downtime and maximizing operational efficiency.

2.4.6 Market Impact

The Metal Multi-tool Linishing Machine addresses the growing demands of the metalworking industry, offering a competitive edge to manufacturers. Its versatility, precision, and automation are expected to enhance productivity and product quality, attracting a broader customer base and potential business growth.

2.4.7 Future Enhancements

The project's iterative design process has laid the foundation for potential future enhancements and upgrades. Feedback from users and stakeholders provides valuable insights into areas for improvement and innovation, allowing for continuous development and optimization of the machine.

In conclusion, the "Design and Manufacturing of Metal Multi-tool Linishing Machine" project has successfully produced a cutting-edge solution that fills the gap in the metalworking industry. Its multifunctional capabilities, precision, user-friendliness, and safety features position it as a valuable asset to manufacturers seeking improved efficiency and quality in their production processes. As the machine enters the market, it holds the potential to revolutionize metalworking practices and contribute to the growth and success of businesses across various industries.

CHAPTER 3

DESIGN AND CALCULATIONS

3.1 List of Major Components

1. AC Motor
2. Pedestal
3. Grinding wheel
4. Buffing wheel
5. Abrasive disc
6. Main column
7. Belt tracking mechanism
8. Abrasive belts
9. Work table
10. Driver and Driven roller

3.1.1 AC Motor

The 1 HP, single phase, 2800 rpm motor in the Metal Multi-tool Linishing Machine is used that operates on alternating current (AC) power. It converts electrical energy into mechanical rotational motion, which is used to drive various components of the machine, such as the main roller or the abrasive belts. The AC motor provides the power necessary for the linishing process to be carried out effectively.

Figure 3.1: 1 Horse Power Single Phase 2800 Rpm Motor

3.1.2 Pedestal

The pedestal is a sturdy and stable support structure on which the Metal Multi-tool Linishing Machine is mounted. It ensures that the machine remains securely in place during operation, preventing any unwanted movement or vibration. The pedestal is essential for providing a safe and solid foundation for the machine's components.

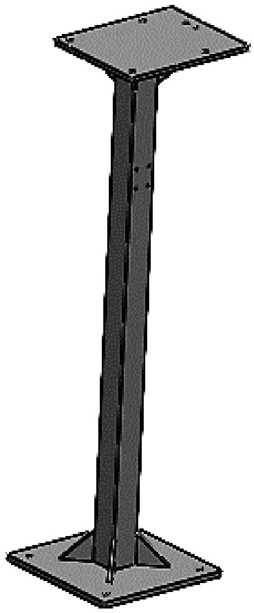

Figure 3.2: Pedestal

3.1.3 Grinding Wheel

In the context of the Metal Multi-tool Linishing Machine, the grinding wheel is an abrasive cutting tool with a circular shape. It is mounted on the machine and used for specific linishing tasks, such as grinding metal workpieces to achieve specific shapes, remove excess material, or create a smooth surface finish.

Figure 3.3: Grinding Wheels

3.1.4 Buffing Wheel

The buffing wheel is another type of abrasive wheel used in the Metal Multi-tool Linishing Machine. It is typically made of cloth or felt and is used for polishing metal surfaces. The buffing wheel, combined with polishing compounds, helps achieve a high-gloss finish and remove minor imperfections from metal workpieces.

Figure 3.4: Buffing Wheels

3.1.5 Abrasive Disc

An abrasive disc is a flat, circular disc of aluminum with abrasive papers pasted on its flat surface. It is used in the Metal Multi-tool Linishing Machine for various linishing operations, including cutting, grinding, and surface smoothness. Abrasive discs are available in different grits and sizes to suit specific applications.

Figure 3.5: Abrasive Disc

3.1.6 Main Column

The main column is a vertical structural component of the Metal Multi-tool Linishing Machine that provides support and stability to abrasive belts mechanism, belt tracker, work table and other support brackets. It connects with pedestal and houses various mechanisms and components.

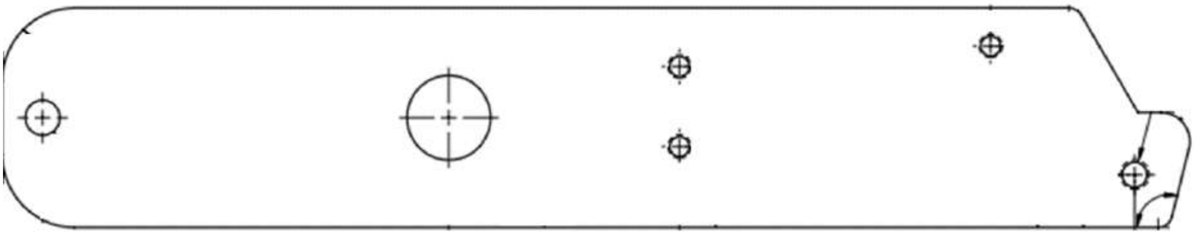

Figure 3.6: Main Column

3.1.7 Belt Tracking Mechanism

The belt tracking mechanism in the Metal Multi-tool Linishing Machine is a system designed to maintain the proper alignment and tension of the abrasive belts. It ensures that the belts run straight and centered on the rollers or pulleys, preventing belt slippage during operation and ensuring consistent and accurate linishing results.

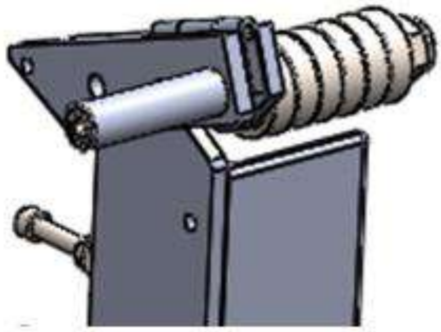

Figure 3.7: Belt Tracking Mechanism

3.1.8 Abrasive Belts

Abrasive belts in the Metal Multi-tool Linishing Machine are flexible belts made of coated abrasive material, such as sandpaper. They are looped around the main roller and other rollers or pulleys, driven by the AC motor's rotation. Abrasive belts are essential for performing various linishing tasks, including grinding, sanding, and polishing metal workpieces.

Figure 3.8: Abrasive Belts

3.1.9 Work Table

The work table in the Metal Multi-tool Linishing Machine is a flat surface on which metal workpieces are placed during the linishing process. The work table provides support and stability for the workpieces, ensuring they remain in the correct position and orientation for effective linishing.

3.1.10 Main Roller

The main roller in the Metal Multi-tool Linishing Machine is a cylindrical component around which abrasive belts are looped. The rotation of the main roller is powered by the AC motor, driving the movement of the abrasive belts and enabling the linishing process to be carried out efficiently and precisely.

Figure 3.9: Main Roller

3.2 Design Methodology

The design methodology for the design and manufacturing of a Metal Multi-tool linishing machine involves a systematic approach to create an efficient, functional, and safe machine that meets the intended goals and user requirements. Here's a general outline of the design methodology for such a project:

3.2.1 Requirements Analysis

Define and gather comprehensive requirements for the machine. Consider factors like the types of linishing processes, materials to be worked on, precision requirements, safety standards, and user interface needs.

3.2.2 Concept Generation

Brainstorm and generate multiple conceptual designs that address the identified requirements. Explore different configurations, mechanisms, and layouts for the machine.

3.2.3 Concept Evaluation

Evaluate the generated concepts against the requirements. Consider factors such as feasibility, performance, ease of manufacturing, and cost. Select the most promising concepts for further development.

3.2.4 Detailed Design

Develop detailed designs for the selected concepts. This involves creating 3D models, specifying materials, components, and mechanisms, and considering factors like ergonomics and aesthetics.

3.2.5 Mechanical Analysis

Perform mechanical analysis using simulations or calculations to ensure the structural integrity, stability, and safety of the machine under different operating conditions.

3.2.6 Automation and Control

If applicable, integrate automation components and control systems into the design. This may include motors, sensors, actuators, and user interfaces.

3.2.7 Prototyping

Build prototypes of the machine based on the detailed design. Prototyping allows for testing and validation of the design before full-scale manufacturing.

3.2.8 Testing and Validation

Test the prototype for various parameters such as performance, accuracy, reliability, and safety. Make adjustments based on the testing results.

3.2.9 Manufacturing Process Design

Develop the manufacturing processes required to produce the machine at scale. This includes selecting appropriate manufacturing methods for different components, considering assembly processes, and estimating production costs.

3.2.10 Final Design Refinement

Incorporate feedback from testing and prototype evaluation to refine the final design. Make any necessary modifications to improve performance, safety, and user experience.

3.2.11 Documentation

Create comprehensive documentation, including engineering drawings, assembly instructions, and user manuals, to guide manufacturing and usage.

3.2.12 Manufacturing and Quality Control

Begin full-scale manufacturing, ensuring that the quality of each component meets the design specifications. Implement quality control processes to maintain consistency.

3.2.13 Assembly and Testing

Assemble the machine using the manufactured components. Test each unit to ensure it meets the design's functional and safety requirements.

3.2.14 Launch and Feedback Collection

Launch the machine to the market or the intended users. Gather feedback and insights from users to identify any areas for improvement and future iterations.

This design methodology ensures a structured and iterative approach, guiding the project from concept to manufacturing while considering technical, practical, and user-oriented aspects.

3.3 Design Calculation and Consideration of Metal Multi-tool Linishing Machine

Designing a Metal Multi-tool Linishing Machine involves several critical calculations and considerations to ensure the machine's efficiency, safety, and functionality. Below are some key design calculations and considerations for the Metal Multi-tool Linishing Machine:

3.3.1 Motor Power Calculation

Calculate the required power of the AC motor based on the load and torque required to drive the main roller and other abrasive components. Consider factors like the maximum workpiece size, material properties, and desired linishing speed to determine the appropriate motor power.

3.3.2 Belt Speed Calculation

Calculate the belt speed required for different linishing tasks. It should be suitable for the material being processed and ensure optimal material removal rates without causing excessive wear on the abrasive belts.

3.3.3 Safety Mechanism Design

Implement safety features such as emergency stop buttons, protective guards, and interlocks to ensure operator safety during machine operation. Consider the safety requirements and standards applicable to the machine.

3.3.4 Abrasive Belt Tensioning

Design a mechanism for maintaining proper tension in the abrasive belts. Tensioning should be adjustable to accommodate different belt sizes and prevent slippage during operation.

3.3.5 Belt Tracking System

Develop a belt tracking mechanism to ensure the abrasive belts run straight and centered on the rollers or pulleys. This prevents uneven wear on the belts and improves linishing accuracy.

3.3.6 Material Selection

Choose high-quality materials for the machine's construction to ensure durability and minimize wear and tear during operation. Select suitable materials for the abrasive belts and abrasive components based on the intended applications.

3.3.7 Structural Integrity

Ensure the machine's structural design can withstand the forces generated during operation. Factor in static and dynamic loads, vibrations, and potential impacts to prevent structural failure and maintain stability.

3.3.8 Noise and Vibration Control

Incorporate features to reduce noise and vibration levels during machine operation, providing a quieter and more comfortable working environment.

3.3.9 Manufacturability and Cost Considerations

Design the machine with manufacturability in mind, considering ease of assembly, availability of components, and cost-effectiveness.

The Metal Multi-tool Linishing Machine's design calculations and considerations are crucial for developing a robust, safe, and efficient machine that meets the needs of metalworking industries while adhering to relevant standards and regulations.

3.4 Calculations

3.4.1 Length of Abrasive Belt

To calculate the length of the abrasive belt using the given measurements in inches, we'll use the formula:

$$\text{Belt Length} = \frac{\pi \times (\text{Dia 1} + \text{Dia 2}) + 2 \times \text{Center Distance}}{2} \quad \text{Eq. 3.1}$$

Belt Length is the length of the abrasive belt in inches.

π (pi) is a constant approximately equal to 3.14159.

Dia 1 is the diameter of Driver Roller in inches.

Dia 2 is the diameter of Driven Roller in inches.

Center Distance is the distance between the centers of the two rollers in inches.

$$\text{Belt Length} = \frac{3.1415 \times (2.36 + 1.57) + 2 \times 10.5}{2}$$

Belt Length = 27 Inches

3.4.2 Surface Speed of Abrasive Belt

SFPM stands for "Surface Feet Per Minute." It is a unit of measurement commonly used in machining and metalworking to express the speed or velocity of a rotating cutting tool or abrasive surface, such as a grinding wheel or sanding belt. SFPM represents the distance in feet that a point on the circumference of the rotating object travels in one minute.

The formula to calculate SFPM is:

$$SFPM = \pi \times Diameter \times RPM \qquad \text{Eq. 3.2}$$

Where:

SFPM is the Surface Feet Per Minute.

π (pi) is a constant approximately equal to 3.14159.

Diameter is the diameter of the rotating object in inches (in).

RPM is the rotational speed of the object in revolutions per minute.

Dia of abrasive belt: 27 inch

Rpm: 2800

$$SFPM = \frac{\pi \times Diameter \times RPM}{12} \qquad \text{Eq. 3.2.1}$$

$$\text{SFPM} = \frac{3.1415 \times 27 \times 2800}{12}$$

SFPM = 1979.5

So, the Surface Feet Per Minute (SFPM) for the given grinding wheel is approximately 1979.5 feet per minute. SFPM is a crucial parameter in machining and metalworking as it helps in selecting appropriate cutting speeds, feeds, and abrasive speeds to achieve the desired results and prevent tool wear or damage.

3.4.3 Calculation of driven Roller

To calculate the rpm of the driven roller in the Metal Multi-tool Linishing Machine, we can use the formula for peripheral speed:

$$Speed\ ratio = \frac{Rpm \times Dia\ of\ driver\ roller}{Dia\ of\ driven\ roller} \qquad \text{Eq. 3. 3}$$

$$\text{Speed of driven Roller} = \frac{2800 \times 60}{40}$$

Speed of driven Roller = 4200 Rpm

So, the speed of the driven roller in the Metal Multi-tool Linishing Machine is approximately 4200 rpm. This value represents the peripheral speed of the driven roller, which is important for understanding the movement and performance of the abrasive belts and achieving the desired linishing results.

3.4.4 Tension in the Tight Side and Slack Side

To calculate the tension in the tight side and slack side of a belt drive system, we need to consider the specific operating conditions, belt type, and design parameters. The tension in each side of the belt is essential for maintaining proper power transmission and preventing belt slippage.

For a simple open belt drive, where there is no idler pulley and both pulleys are of equal diameter, the tension in the tight side (T_1) and slack side (T_2) can be calculated using the following formulas:

i. Tension in the tight side (T_1)

$$T_1 = \frac{(P \times (D + d)}{(2C)} \qquad \text{Eq. 3.4}$$

$$T_1 = \frac{(746 \times (0.06 + 0.04)}{(2 \times 0.266)}$$

$$\mathbf{T_1 = 140\ N}$$

ii. Tension in the slack side (T_2)

$$T_2 = \frac{(P \times (D - d)}{(2C)} \qquad \text{Eq. 3.5}$$

$$T_2 = \frac{(746 \times (0.06 - 0.04)}{(2 \times 0.266)}$$

$$\mathbf{T_2 = 28\ N}$$

Where:

T_1 is the tension in the tight side of the belt in Newtons (N)

T_2 is the tension in the slack side of the belt in Newtons (N)

P is the transmitted power in watts (W) or horsepower (hp).

D is the diameter of the larger pulley in meters (m)

d is the diameter of the smaller pulley in meters (m)

C is the center distance between the pulleys in meters (m)

It is crucial to follow manufacturer guidelines or engineering standards specific to the belt type and application to ensure proper tension and safe and efficient power transmission in a belt drive system.

3.4.5 Power Transmitted by a Belt Drive System

The power transmitted by a belt drive system can be calculated using the formula:

$$Power\ (P) = (T_1 - T_2) \times \omega \qquad \text{Eq. 3.6}$$

Where:

Power (P) is the transmitted power in watts (W) or horsepower (hp).

T_1 is the tension in the tight side of the belt in Newtons (N)

T_2 is the tension in the slack side of the belt in Newtons (N)

ω is the angular velocity of the driven roller in radians per second

$$\text{Power (P)} = (140 - 28) \times 194$$

Power (P) = 2172.8 Watts (W)

3.4.6 Tension of belt

The tension in a belt drive system used in a grinding machine can be calculated using the following formula:

$$Tension\ (T) = \frac{(P \times D)}{(2 \times \pi \times V)} \qquad \text{Eq. 3.7}$$

Where:

T is the tension in the belt (measured in Newtons, N).

P is the power transmitted by the belt (measured in Watts, W).

D is the diameter of the driven pulley (measured in meters, m).

V is the belt speed (measured in meters per second, m/s).

$$\text{Tension (T)} = \frac{(2172.8 \times 0.04)}{(2 \times 3.1415 \times 100.5)}$$

Tension (T) = 1.4 Newtons

It's important to ensure that the tension in the belt is appropriate for the specific grinding machine application. Insufficient tension can result in slippage and reduced power transmission efficiency, while excessive tension can cause increased wear on the belt and bearings.

3.4.7 Purely Rotational Load (Torque Load)

If the load on the motor shaft is purely rotational (i.e., a torque load), we can calculate it using the following formula:

$$Torque\ (T) = \frac{(P \times 60)}{(2 \times \pi \times N)} \quad \text{Eq. 3.8}$$

$$\text{Torque (T)} = \frac{(746 \times 60)}{(2 \times 3.1415 \times 2800)}$$

Torque (T) = 2.54 N-m

Where:

T is the torque on the motor shaft (in Newton-meters, Nm).

P is the power transmitted by the motor (in Watts, W).

N is the motor speed in RPM (Revolutions Per Minute).

This formula assumes that the load on the shaft is steady and consists of only rotational forces. If there are additional forces or complex loading conditions, further analysis is required to calculate the total load.

3.4.8 Determine the Spring Constant (k)

The spring constant depends on the design and material properties of the spring. we can typically find this information from the spring manufacturer's specifications or test data. If we don't have this value, we can calculate an approximate value using the modulus of rigidity (G) and the number of active coils (N) in the spring using the following formula:

$$K = \frac{(G \times d^4)}{(8 \times D^3 \times N)} \quad \text{Eq. 3. 9}$$

Where:

G is the modulus of rigidity of the spring material (in Pascals, Pa).

d is the wire diameter of the spring (in meters, m).

D is the mean coil diameter (in meters, m).

$$\text{K} = \frac{(8600 \times 10^6 \times 0.002^4)}{(8 \times 0.015^3 \times 20)}$$

K = 203.8 N/m

3.4.9 Tension in a Spring

To calculate the tension in a spring, we need to know the spring constant (*k*) and the amount of displacement or deformation (*x*) from the spring's equilibrium position. The spring constant represents the stiffness of the spring and is typically measured in Newtons per meter (N/m)

The formula to calculate the tension in a spring is:

$$Tension\ (F) = k \times x \qquad \text{Eq. 3. 10}$$

Where:

Tension (F) is the force applied by the spring in Newtons (N)

k is the spring constant in N/m

x is the displacement or deformation from the spring's equilibrium position in meters (m) or inches (in).

$$\text{Tension (F)} = 203.8 \times 0.02$$

$$\textbf{Tension (F) = 4.07 Newtons}$$

So, the when displaced 1.5 inches (0.03m) from its equilibrium position.

3.5 Finalized Calculations

Table 3.1: Finalized Calculations

Parameter	**Value & unit**
Belt abrasive Length	27 Inches
SFPM	1979.5
Speed of driven Roller	4200 Rpm
Tension in the tight side	140 N
Tension in the slack side	28 N
power transmitted by belt	2.1 KW
Tension in the belt	1.4 N
Torque on the motor shaft	2.54 N-m
Spring constant	203.8 N/m
Tension in the spring	4.07 N

3.6 Selection of material

Mild steel is a type of carbon steel with a low amount of carbon – it is actually also known as “low carbon steel.” Although ranges vary depending on the source, the amount of carbon typically found in mild steel is 0.05% to 0.25% by weight. Less carbon means that mild steel is typically more ductile, machinable, and weldable than high carbon and other steels, however, it also means it is nearly impossible to harden and strengthen through heating and quenching. We use mild steel to design a frame of machine. Following are the properties of mild steel according to base on ASTM A53-Standard Specification for MS [17].

Table 3.2: Mild Steel Properties

Property	Material
Density	7,860 kg/m^3
Hardness (Rockwell)	24 HRB
Elongation	30%
Tensile strength	400 MPa
Yield Strength	250 MPa

3.7 Design analysis

Design analysis for a Metal Multi-tool linishing machine involves a thorough examination and evaluation of the machine's design from various perspectives. The goal is to ensure that the design meets the intended performance, safety, and usability requirements. Here are key aspects of design analysis for a Metal Multi-tool linishing machine:

3.7.1 Mechanical and Kinematic Analysis

This involves assessing the structural integrity and mechanical performance of the machine. Simulation tools can help identify stress points, deformation, and potential failure areas in different load scenarios. Analyze the machine's motion and movement mechanisms. Check for proper functionality, range of motion, and potential collisions or interferences between moving parts.

3.7.2 Dynamic Analysis

Consider the dynamic behavior of the machine during operation. This involves analyzing vibrations, resonance, and dynamic loads that could affect the machine's stability and accuracy.

3.7.3 Thermal Analysis

If the machine generates heat during operation, analyze the thermal distribution to ensure that components remain within safe temperature limits.

3.7.4 Safety Analysis

Evaluate the design for potential safety hazards and risks to operators and maintenance personnel. Ensure that safety features like emergency stops, guards, and interlocks are appropriately incorporated.

3.7.5 Ergonomics Analysis

Assess the machine's design in terms of user comfort, accessibility, and ease of operation. Ensure that controls, displays, and interfaces are well-designed for user interaction.

3.7.6 Materials and Compatibility Analysis

Examine the compatibility of chosen materials with the intended processes and environment. Ensure materials can withstand mechanical stresses, abrasion, and chemical exposure.

3.7.7 Manufacturability Analysis

Evaluate how easily the design can be manufactured using available processes. Assess factors like complexity, tolerances, and assembly feasibility.

3.7.8 Cost Analysis

Estimate the manufacturing and operational costs associated with the design. Balance the performance requirements with cost-effectiveness.

3.7.9 Energy Efficiency Analysis

If applicable, analyze the energy consumption of the machine during operation. Identify opportunities for energy-saving measures.

3.7.10 Maintenance and Serviceability Analysis

Consider how easily the machine can be maintained, serviced, and repaired. Access to components, ease of replacement, and minimal downtime are important considerations.

3.7.11 Environmental Impact Analysis

Assess the environmental impact of the design in terms of materials used, energy consumption, and potential waste generation. Seek opportunities for sustainability improvements.

3.7.12 User Feedback and Usability Analysis

Gather user feedback through testing and evaluations to identify any usability issues, pain points, or suggestions for design improvements.

Design analysis involves a combination of simulations, calculations, prototyping, testing, and validation. The goal is to ensure that the Metal Multi-tool linishing machine not only meets its functional requirements but also delivers reliable performance, safety, and a positive user experience.

3.8 ISO Standards for Project Design

We have made efforts to prosper ISO standards in our project to achieve project goals and desired outcomes to aligns with the international standard of metal parts with interchangeability. Selected ISO standards are directly relevant to the goals and objectives of the project. Clearly articulate how adherence to these standards. ISO standards often represent internationally recognized best practices in various fields. Discuss how complying with these standards ensures that the project follows industry-proven methods and processes. ISO standards contribute to quality assurance and control within the project. Explain how they help maintain consistency and reliability in project deliverables. ISO standards can mitigate risks. For example, ISO standards often include guidelines for safety, security, and risk management, which can be critical in project execution. ISO standards promote efficiency and effectiveness in project processes, reducing waste, errors, and rework. This can lead to cost savings and improved project timelines. ISO standards often encourage a culture of continuous improvement. Explain how the project can leverage these standards to refine processes and outcomes over time.

3.8.1 ISO 14120

Safety of Machinery - Guards - General Requirements for the Design and Construction of Fixed and Movable Guards, this standard outlines requirements for designing protective guards to prevent access to hazardous machine areas.

3.8.2 ISO 14982

Safety of Machinery - System of Audible and Visual Danger and Information Signals, this standard defines a system of audible and visual signals to warn operators about potential hazards or provide information about machine status.

3.8.3 ISO 4871

Acoustics - Declaration and Verification of Noise Emission Values of Machinery and Equipment, if noise emissions are a concern, this standard provides methods for declaring and verifying noise emission values of machinery.

3.8.4 ISO 5845-2

Technical drawings, simplified representation of the assembly of parts with fasteners, Part 2: Metric sized Screws, Bolts, Nuts and Washers for aerospace equipment.

3.8.5 ISO 10721-2

ISO 10721-2 specifies the requirements for the fabrication, erection and inspection of structural steelwork in buildings designed in accordance with ISO 10721-1, including steelwork.

3.8.6 ISO 15614-5

Specifies how a welding procedure specification is qualified by welding procedure tests. It defines the conditions for the execution of welding procedure tests and the range of qualification for welding procedures for all practical welding operations within the range of variables.

3.8.7 ISO 13203

Belts and accessories, List of equivalent terms.

3.8.8 ISO/TS 128-71

Technical Product Documentation (TPD), general principles of presentation and Part 71 simplifies the representation for mechanical engineering drawings. (Appendix-B)

3.8.9 ISO 2503:2009/AMD 1

Gas welding equipment, pressure regulators and pressure regulators with flow-metering devices for gas cylinders used in welding, cutting and allied processes up to 30 MPa.

3.8.10 ISO 45001:2018

ISO 45001:2018 specifies requirements for an occupational health and safety (OH&S) management system, and gives guidance for its use, to enable organizations to provide safe and healthy workplaces by preventing work-related injury and ill health, as well as by proactively improving its OH&S performance.

We consider these few standards although the wide range of ISO standards that could be relevant to the design of a Metal Multi-tool linishing machine. The specific standards to be followed depend on factors such as the machine's function, components, processes, and intended use. It's crucial to consult with experts in the field and thoroughly understand the relevant ISO standards applicable to our project.

3.9 CAD Modeling

The general steps to create a CAD model of the Metal Multi-tool Linishing Machine:

3.9.1 Choose CAD Software

Select a suitable CAD software that fits our requirements and proficiency level. Popular options include SolidWorks, Autodesk Inventor, Fusion 360, CATIA, or any other CAD software we are familiar with. So, we choose SolidWorks as it is user friendly and convenient in customize features.

3.9.2 Gather Design Specifications

Gather all the design specifications, dimensions, and features required for the Metal Multi-tool Linishing Machine. This includes dimensions of rollers, motor, work table, abrasive belts, safety features, and other components.

3.9.3 Model Individual Components

Create 3D models of each individual component using sketches and features provided by the CAD software. Pay attention to details and accurately model each part according to the design specifications.

3.9.4 Assemble Components

Assemble the individual components in the assembly workspace, ensuring they fit together properly. Use constraints, mates, and joints to establish connections between components.

3.9.5 Create Belts and Abrasive Components

Model the abrasive belts, grinding wheel, buffing wheel, and other abrasive components based on their dimensions and properties.

3.9.6 Create Drawings and Documentation

Generate 2D drawings (Annexure) from the 3D models to create detailed engineering drawings for manufacturing. Add annotations, dimensions, and other necessary information.

Created a CAD model of the Metal Multi-tool Linishing Machine involves a series of complex steps, so it's essential to have a good understanding of CAD software and engineering principles. Depending on the complexity of the machine, it may require multiple iterations and adjustments to achieve an optimal design.

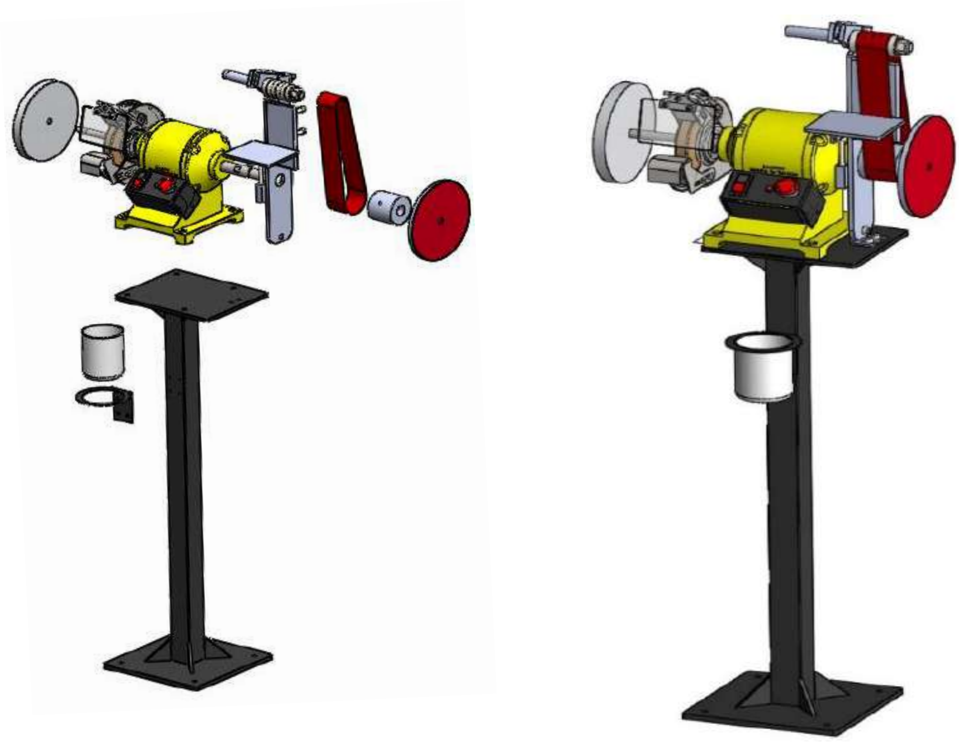

Figure 3.10: 3D CAD Model of Project

3.10 Fabrication Explanation

Fabrication refers to the process of creating physical objects or structures by assembling and shaping various materials, components, or parts according to a predefined design. In the fabrication of Metal Multi-tool linishing machine, fabrication involves the actual construction and assembly of the machine based on the detailed design specifications. The fabrication process requires careful attention to detail, precision, and quality control to ensure that the final product matches the intended design and meets all functional and safety requirements. Here's an explanation of the fabrication process:

3.10.1 Material Preparation

Begin by procuring the required materials based on the design specifications. These materials may include metals, plastics, electronics, bearings, fasteners, and more. Ensure that the materials are of the specified quality and dimensions.

3.10.2 Cutting and Shaping

Use appropriate tools such as laser cutters, plasma cutters, waterjets, or machining tools to cut and shape the materials according to the design. This step involves creating the various components and parts that will make up the machine's structure.

3.10.3 Welding and Joining

Assemble the fabricated parts by welding, bolting, or other joining methods. Welding is a common technique for metal structures, and it involves fusing the materials together using heat. Ensure strong and precise joints.

3.10.4 Machining

Use machining processes such as milling, turning, and drilling to create detailed features and ensure accurate dimensions on critical parts like shafts, bearings, and mounts.

3.10.5 Surface Cosmetics

Apply surface cosmetics like sanding, or polishing then spray paint to achieve the desired finish product. This step enhances both the appearance and functionality of the components.

3.10.6 Assembly

Assemble the individual components according to the assembly instructions and engineering drawings. This involves attaching parts, attaching motors, integrating electrical components, and ensuring proper alignment.

3.10.7 Electrical Integration

If the machine involves electrical components like motors, sensors, and control systems, carefully integrate these components into the design. Proper wiring, cable management, and connection to the control interface are essential.

3.10.8 Quality Control and Testing

Before the machine is fully operational, perform thorough quality checks and tests. This may include functional tests, dimensional checks, safety checks, and performance evaluations.

3.10.9 Finishing Touches

Apply any finishing touches such as labeling, branding, and safety decals. Ensure that all parts are securely fastened, and the machine's appearance is professional and polished.

3.10.10 Documentation

Create detailed documentation, including assembly drawings, parts lists, maintenance procedures, and user manuals. These documentations are essential for future reference, repairs, and maintenance.

3.11 Fabrication Visuals

Figure 3.11: Manufacturing Parts on Milling Machine

Figure 3.12: Manufacturing Parts on Turning Lathe

Figure 3.12: Completed Parts

Figure 3.13: Parts Fabricated by Welding

Figure 3.14: Cosmetics Process

Figure 3.15: Integration of Parts

Figure 3.16: Manufactured Masterpiece

3.12 Labelling of Complete Assembly

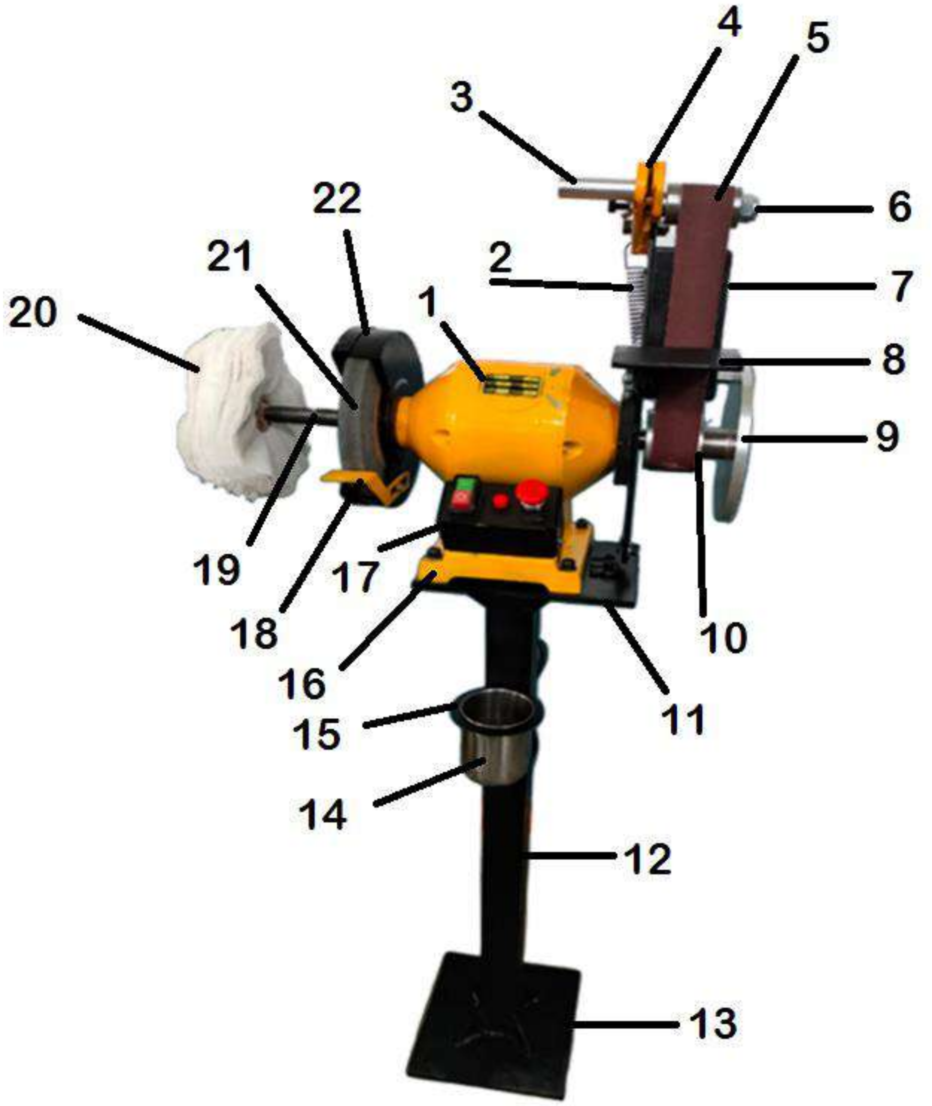

Figure 3.17: Labeling of Parts

Table 3.3: Labeling of Machine Parts

1	AC Motor	12	Pedestal Pipe
2	Spring for Tension	13	Pedestal Base Plate
3	Belt Tracking Assembly Handle	14	Coolant Jar
4	Belt Tracking Mechanism	15	Coolant Jar Bracket
5	Abrasive Belt	16	Motor Base Plate
6	Upper Roller	17	Electric Panel
7	Work Support Bracket	18	Tool Rest
8	Work Table	19	Shaft
9	Abrasive Disc	20	Buffing Wheel
10	Main Roller	21	Grinding Wheel
11	Pedestal Top Plate	22	Grinding Wheel Guard

3.13 Discussion on design

Certainly, let's discuss the design considerations for a Metal Multi-tool linishing machine. This discussion will cover key aspects that need to be addressed during the design process:

3.13.1 Functionality and Versatility

The design should prioritize the ability to perform multiple linishing processes such as grinding, sanding, and polishing on a variety of metal materials. The machine should be versatile enough to accommodate different workpiece sizes and shapes.

3.13.2 Precision and Accuracy

Achieving precise and accurate finishes is crucial. The design should minimize vibrations and deflections, ensuring that the linishing tools maintain consistent contact with the workpiece for uniform results.

3.13.3 Interchangeable Tooling

Consider designing a system for quick and easy tool changeover. Interchangeable tool heads or attachments would enhance the machine's adaptability for different linishing tasks.

3.13.4 Safety Features

Safety should be a top priority. Incorporate guards, emergency stop buttons, and interlock systems to prevent operator injuries and ensure compliance with safety standards.

3.13.5 Ergonomics and User Interface

Design the machine with ergonomic considerations in mind. Controls and user interfaces should be intuitive and user-friendly. Operators should be able to set parameters easily and monitor the process.

3.13.6 Material Compatibility

Choose materials for the machine components that are durable, corrosion-resistant, and compatible with the type of linishing processes involved. Different materials might have varying wear characteristics.

3.13.7 Power and Drive System

Determine the power requirements based on the materials and processes involved. Choose appropriate motors and drive systems to ensure sufficient power for the linishing tools.

3.13.8 Maintenance and Serviceability

Design the machine for easy maintenance. Accessible components, modular design, and clear documentation will help reduce downtime during maintenance and repairs.

3.13.9 Aesthetics and Space Efficiency

Consider the overall design aesthetics, as well as the footprint of the machine. Space-efficient design is crucial, especially if the machine needs to fit into existing workshops.

3.13.10 Quality Control and Testing

Implement quality control measures during the manufacturing process. Thoroughly test each machine to ensure it meets design specifications and provides the expected performance.

3.13.11 Compliance with Standards

Ensure that the machine design complies with relevant industry standards and regulations, including safety and quality standards.

In summary, designing a Metal Multi-tool linishing machine requires a holistic approach that balances functionality, safety, precision, and usability. Collaboration between mechanical engineers, and end-users is essential to create a machine that effectively addresses the complexities of linishing different metal materials while ensuring operator safety and achieving desired finishes.

3.14 Comparison with Design of Reference Model

To effectively compare the design of a Metal Multi-tool linishing machine with a reference model, we need specific details about the reference model we are considering. However, we can provide a general framework for conducting such a comparison:

3.14.1 Functionality and Features

Compare the range of functionalities offered by our designed machine with those of the reference model. Identify any additional capabilities or innovative features in our design that the reference model lacks.

3.14.2 Versatility and Adaptability

Assess how well our machine accommodates different linishing processes and workpiece sizes compared to the reference model. If our design offers enhanced versatility or adaptability, highlight these differences.

3.14.3 Precision and Accuracy

Compare the precision and accuracy of both machines. If our design incorporates mechanisms to minimize vibrations and ensure consistent finishes, demonstrate how this improves upon the reference model's performance.

3.14.4 Safety Measures

Evaluate the safety features of both machines. Highlight any advancements in safety mechanisms, such as improved guards, emergency stop systems, or interlocks, that make our design stand out.

3.14.5 Ergonomics and User Interface

Compare the user interfaces of both machines in terms of ease of use, accessibility of controls, and overall user experience. If our design offers a more intuitive interface, emphasize this advantage.

3.14.6 Material Compatibility

Assess how well the materials chosen for our machine's components compare to those of the reference model in terms of durability, wear resistance, and compatibility with linishing processes.

3.14.7 Compliance with Standards

Ensure that our design meets or exceeds relevant industry standards and regulations, and compare this compliance with the reference model's adherence to standards.

3.14.8 Cost-effectiveness

Compare the overall cost of our design with the reference model, factoring in not only the initial manufacturing costs but also long-term maintenance and operational costs.

By conducting a comprehensive comparison along these lines, we can effectively demonstrate how our designed Metal Multi-tool linishing machine surpasses the capabilities and features of the reference model, ultimately highlighting its value and innovation.

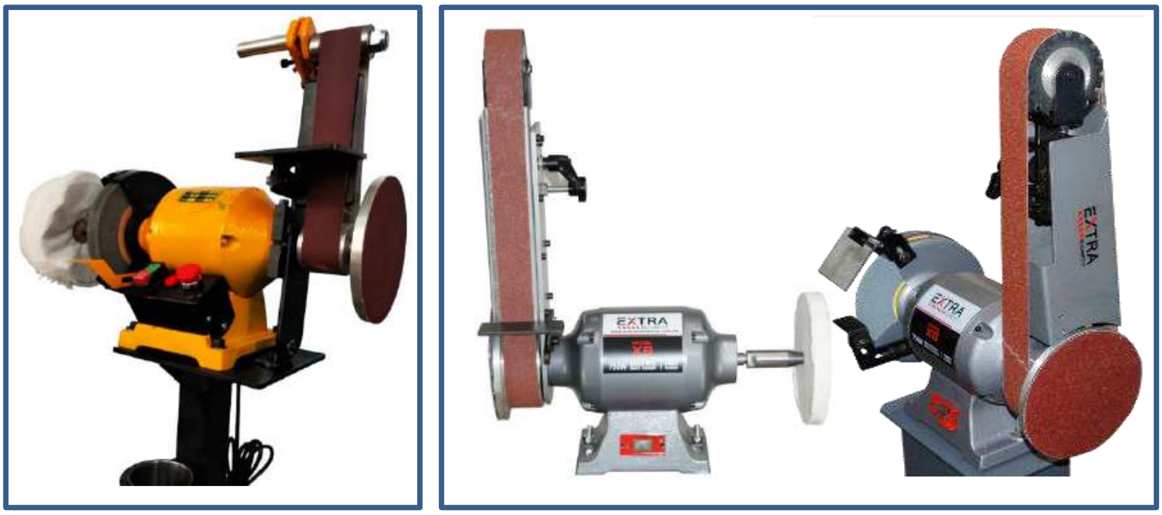

Figure 3.18: Comparison of Manufactured Model with Reference Model

3.15 Project Cost Analysis

A project cost table involves listing all the expenses associated with the project, including materials, labor, equipment, and other miscellaneous costs. The table is organized in a clear and easy-to-read format. Below is a simplified cost table of our project:

Table 3.4: Project Cost Analysis

Item	Description	Quantity	unit	Unit Cost in PKR	Total Cost in PKR
Mild Steel	Material Construction of machine frame	12	Kg	250	3000
Aluminum	Parts	2.5	Kg	600	1500
Abrasive Belts	Various grits and sizes	10	Pcs	200	2000
Grinding wheel+ Buffing wheel	60 Grit grinding wheel	1	Pc	2000	2000
Skilled Labor	Assembly and fabrication	200	Hrs	50	10000
AC Motor	Main motor for machine	1	Pcs	14000	14000
Electrical	Electric panel	1	Set	3200	3200
Miscellaneous	-	-	-	5000	5000
Shipping and Handling	Transportation costs	-	-	600	600
Total Project Cost in PKR		**41300**			

CHAPTER 4

EXPERIMENTATION & RESULTS DISCUSSION

4.1 Experimentation Steps

Metal Multi-tool Linishing Machine involves a series of tests and evaluations to assess its performance, functionality. Conducted the testing on the prototype to evaluate its performance, accuracy. Also make an effort to validate the machine's compliance with industry standards and regulations. We choose a variety of materials commonly used in the industries to test the machine's versatility. Determine the key test parameters, such as flatness, Material Removal Rate (MRR), Average Roughness (R_a). Also Identify variables that may affect the results, such as time, workpiece material and abrasive belts. Measurements taken using metrology tools such as dial indicator, Vernier calipers, digital surface roughness tester.

Figure 4.1: Experimental Verification Procedures on Digital Surface Tester and Dial Indicator on Granite Surface Table

4.2 Experimental Methodology and Procedure

The first most step of the setup is to manufacture the various parts of the machine and then the abrasives are to be selected which is used in belt. Based on the material and its property that is to be polished by buff, grind by wheel and polish by the grit size of the belt varies. The base frame is made up of Mild steel and the rollers are fitted in proper location for proper tension of the Metal Multi tool Linishing Machine. The power is transmitted from motor to rollers and the belt assembled over the rollers carryout the expected results of the component.

4.3 List of Experimental Parameters

1. Investigate the Flatness values on Mild Steel by changing different grits of abrasive belt in 2 minutes on Metal Multi tool Linishing Machine.
2. Determine surface roughness by using different grits of abrasive belts and RPM drop during operation on Stain-less Steel on Metal Multi tool Linishing Machine.
3. To prepare polished surface of specimen for crack investigation in metallography.

4.4 Operation Methodology

This Metal Multi tool Linishing Machine is generally used for polishing the metallic components mostly. In this machine abrasive belt fitted on the rollers. The power is transmitted from electric motor to the roller shaft. As the first shaft from the motor is rotated then all the rollers rotated with same speed because of abrasive belt wound over the surface. When we keep any part on abrasive belt and apply the pressure over the surface of the belt, then the component polished. Because of this machine, good quality of glassing also obtained for good looking component. The abrasive belt is available in various sizes in the market. Belt grinding machine is used for heavy stock removal or for light polishing work depending upon the type of belt grade used. This machine is used for the grinding of any oblique surfaces. The angle grinding will also be done based on the changing position of the work table adjustment. The flexibility of the belt is adjusted using the spring. Thus, the finishing will be smooth and any angled parts are finished [3].

Research experiments are aimed the study on Metal Multi tool Linishing Machine that has been developed through the manufacture and carried out grinding tests on three types of materials, Stainless Steel, MS (Mild Steel), and Aluminum alloy with the different parameters [32]. Test materials used are made of the different size in the touch area of the belt sandpaper sharpening media to obtain accurate test results. The following is a table of trial material data used in testing belt grinding machines which can be seen in Table 4.1.

Table 4.1: Specifications of Materials Used in Experiments

Stainless Steel	**Mild steel**	**Al. Alloy**
Stainless Steel rod used with a size of Ø25, L:25mm	Mild steel square rod used with a size of 25×25×50mm	AA rod used with a size of Ø25, L:25mm

4.5 Discussion

4.5.1 Experiment# 1: Investigate the Flatness values and material removed on Mild Steel by changing different grits of abrasive belt in 2 minutes on Metal Multi tool Linishing Machine.

The speed of the belt sandpaper greatly affects how thick the dip is produced from the grinding using a belt grinding machine. This is because the faster the rotation, the less time the sandpaper is needed to scrape. In addition, there are still many other factors that determine the grinding speed such as the sandpaper grid used, the type of material being sharpened, and the size of the honed material. Grinding is a tool that serves to cut with an abrasive process with friction between abrasive with objects, its function is to grind and also for finishing. In the experimentation we use to display the test of the Metal Multi tool Linishing Machine that has been made to the MS material, constant speed of 2800rpm, 2 minute of time, and size of the sharpened material is 25×25×50mm, along with the results.

4.5.1.1 Flatness

The allowable variation of the surface, measured in units of length (usually millimeters or inches). For example, a flatness symbol with a tolerance value of 0.030 mm means that the surface can deviate from a plane by no more than 0.030 mm in any direction.

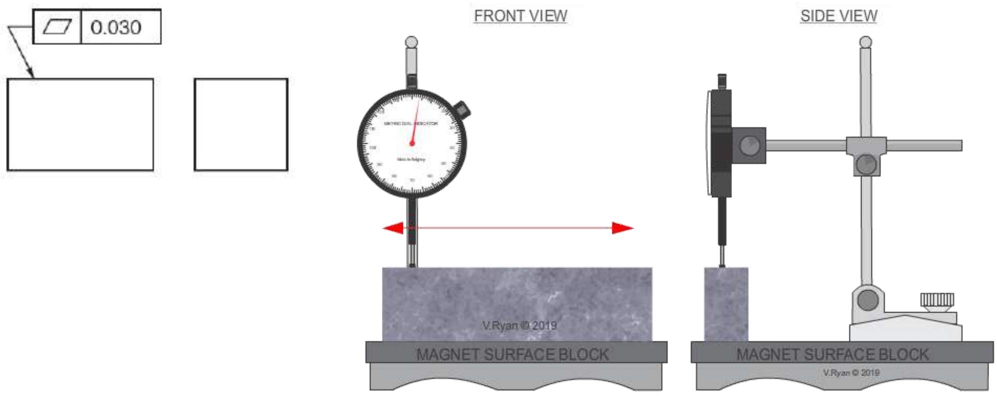

Figure 4.2: Geometric Flatness Measurement

Geometric flatness refers to the property of a geometric object or space that lacks curvature or deviation from being perfectly straight. In a geometrically flat space, lines remain parallel and do not converge or diverge, and the angles of a triangle sum to exactly 180 degrees.

A flat surface is one that can be perfectly represented by a plane, meaning that if we were to draw a straight line on the surface, it would remain straight and not curve in any direction. In a flat space, the geometry obeys the rules of Euclidean geometry, where the shortest distance between two points is a straight line.

4.5.1.2 Experimental Parameters

Following values are taken from an article "Effect of Machining Parameters on the Surface Roughness for Different Type of Materials" [32].

Table 4. 2: Experimental Parameters

Material	Mild Steel 25×25×50mm		
Time	2 minutes		
Rpm	2800		
Grit Size	60	100	140

4.5.1.3 Reference Values

Table 4.3: Reference Values

Material	**Rpm**	**Results**	**Grit size**	**After 2 Minutes of Grinding**	
				Material Removed (mm)	**Flatness (mm)**
Mild Steel	2800	Reference	60	0.4	0.35
			100	0.3	0.3
			140	0.15	0.08

Figure 4.3: Performing Experiment

4.5.1.4 Achieved Values

Table 4.4: Achieved Values

Material	Rpm	Results	Grit size	After 2 Minutes of Grinding	
				Material Removed (mm)	Flatness (mm)
Mild Steel	2800	Achieved	60	0.5	0.35
			100	0.25	0.2
			140	0.15	0.1

4.5.1.5 Comparison Chart between Reference and Achieved Values

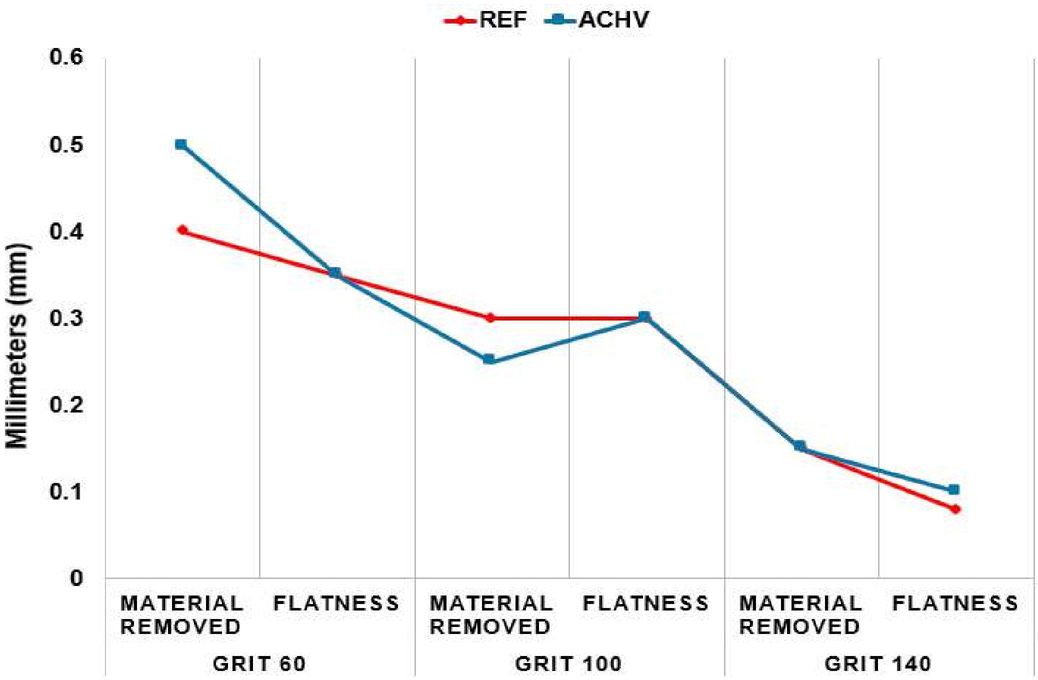

Figure 4.4: Comparison between Reference and Achieved Values

4.5.1.6 Discussion of Experimental Results

In this experiment there are 3 Type of Grits 60,100 & 140 to check surface roughness of Mild steel and material removed. Parameters are given to perform this experiment. Then we are able to check that how much flatness value we get and how much material removed in millimeters during duration of 2 minutes. After getting results we conclude that we get better results and close values by utilizing our machine in all prospects as compared to reference parameters.

4.5.2 Experiment# 2: Determination of surface roughness by using different grits of abrasive belts and RPM drop during operation on Stainless Steel on Metal Multi tool Linishing Machine.

4.5.2.1 Roughness Average

This measurement is most commonly shown as “R_a” for “Roughness Average” and that value is used to determine compliance of equipment with various industry standards.

Surface Roughness (R_a) is an important parameter in determining the quality of surface finishing of any products obtained from the machining process. Surface roughness can be affected by several factors such as machining parameters, workpiece material properties, cutting tool parameters and machine tool conditions. In this experiment, the effects of abrasive grinding parameters such as surface roughness will be investigated for aluminum, mild steel and stainless-steel materials. The experimental R_a values obtained and compared with the reference values. It can be concluded that the surface roughness of materials will increases as the grit size of abrasive belt increases.

Roughness values *R_a µm*	*Roughness grade number*	*Roughness grade symbol*
50	N12	∼
25	N11	▽
12.5	N10	
6.3	N9	▽▽
3.2	N8	
1.6	N7	
0.8	N6	▽▽▽
0.4	N5	
0.2	N4	
0.1	N3	▽▽▽▽
0.05	N2	
0.025	N1	

Figure 4.5: Surface Roughness Chart

4.5.2.2 Experimental Parameters

Following values are taken from an article "An Experimental Analysis of Grinding Parameters and Conditions on Surface Roughness of Finished Product" [27].

Table 4.5: Experimental Parameters

Material	Stain-less Steel Ø25×L:25mm	
Time	1, 2 & 3 minutes	
Grit Size	80	120

4.5.2.3 Reference Values

Table 4.6: Reference Values

Reference			**Time (Minutes)**		
			1	**2**	**3**
Grit size	**80**	R_a **(µm)**	0.9	0.55	0.2
		RPM drop	15	2	5
Grit size	**120**	R_a **(µm)**	0.3	0.15	0.09
		RPM drop	6	2	1

4.5.2.4 Achieved Values

Table 4.7: Achieved Values

Achieved			**Time (Minutes)**		
			1	**2**	**3**
Grit size	**80**	R_a **(µm)**	1	0.6	0.2
		RPM drop	10	4	0
Grit size	**120**	R_a **(µm)**	0.4	0.1	0.08
		RPM drop	2	0	0

4.5.2.5 Comparison Chart between Reference and Achieved Values

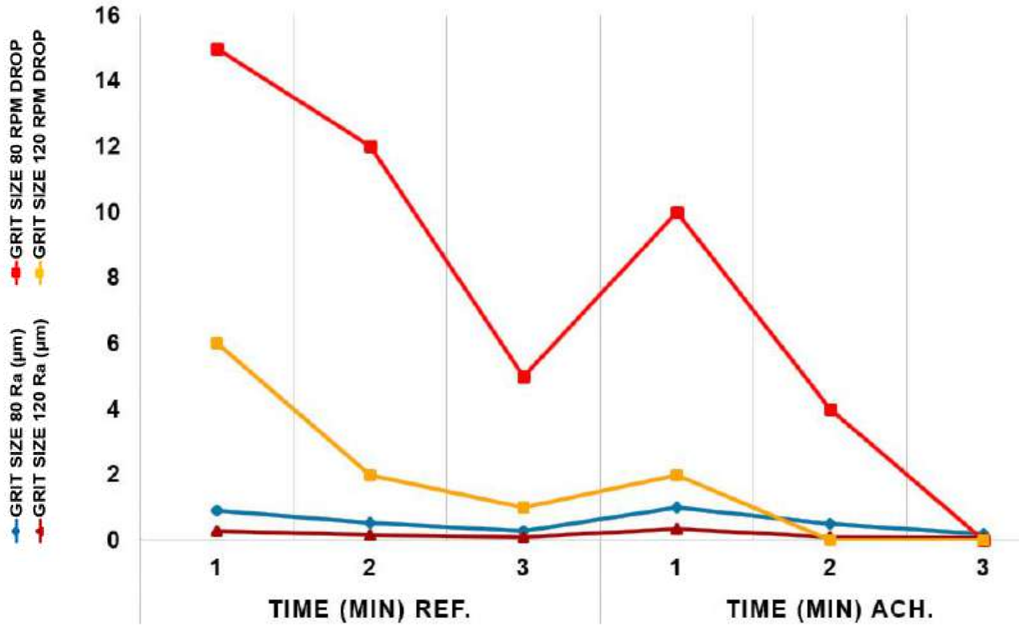

Figure 4.6: Comparison between Reference and Achieved Values

4.5.2.6 Discussion of Experimental Results

In this experiment there are 2 Type of Grits 80 & 120 to check surface roughness of stainless steel and RPM Drop. Parameters are given to perform this experiment. Then we are able to check that how much R_a values we get and how much RPM Drop during duration of 1, 2 and 3 minutes of intervals [27].

From the graphs, there are some deviations of roughness value between the experimental results and theoretical results. The roughness values that obtained from this experiment are somehow closer to the theoretical roughness value. This is due to some factors that may affect the accuracy of the roughness value which includes hand feed the workpieces with abrasive belt and might be glazing factor. Anyhow, after getting results we conclude that we get better results and close values by utilizing our machine in all prospects as compared to reference parameters.

4.5.3 Experiment# 3: To prepare polished surface of specimen for crack investigation in metallography on Metal Multi tool Linishing Machine.

Metallography is the study of the microstructure of all types of metallic alloys. Discipline of observing and determining the chemical and atomic structure and grains in metallic alloys.

A crack investigation in metallography involves the detailed examination of cracks or fractures that occur in metallic materials, typically through the use of metallographic techniques. Metallography is the study of a material's microstructure, which includes the arrangement and properties of its grains, phases, inclusions, and other microconstituents. Investigating cracks is crucial for understanding the causes of failure, improving material performance, and ensuring the structural integrity of metal components. Here's a main outline of the experiment.

4.5.3.1 Sample Preparation

Obtain a representative sample containing the crack or fractured area. The sample should be carefully removed to preserve the crack's features. Prepare the sample by cutting, mounting, grinding, and polishing it to achieve a flat, smooth surface. This is essential for accurate microscopic examination [25]. Use 60 grit and then 160 grit of abrasive belts to remove excess material and flatten the sample's surface. This step removes cutting-induced damage and ensures a flat, even surface for subsequent polishing. Polishing involves using buffing wheel moreover use of polishing compound. This step produces a mirror-like surface finish that is essential for accurate microscopic examination.

Following steps will be adopted for sample preparation.

1. Cutting
2. Semi Grinding
3. Finishing
4. Polishing

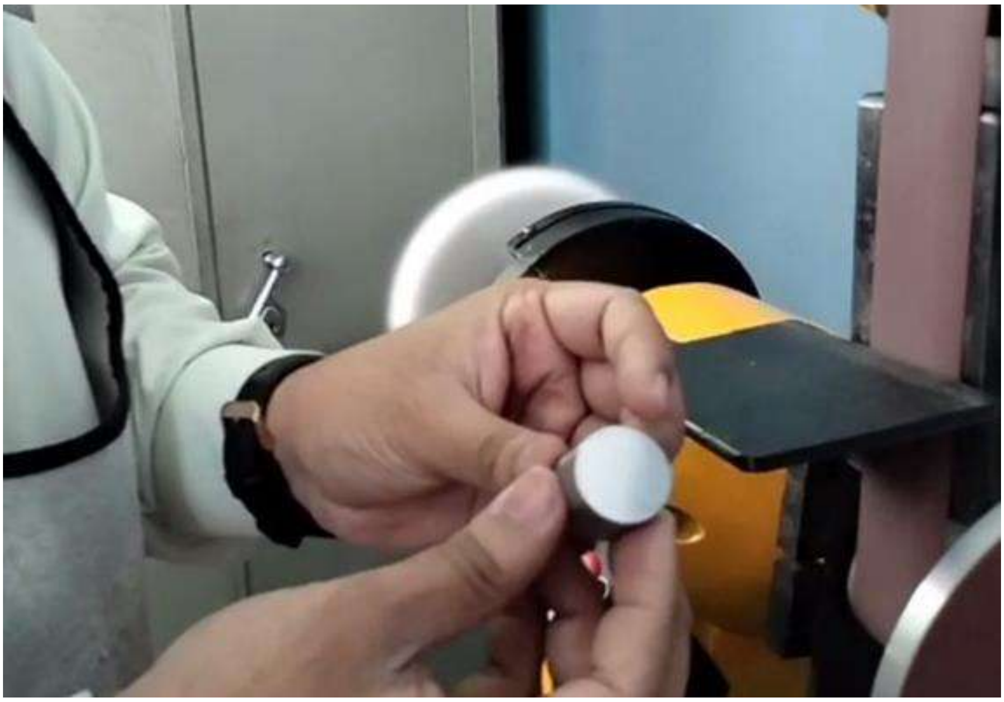

Figure 4.7: Performing Experiment

4.5.3.2 Experimental Parameters

Following values are taken from an article “Development of polishing machine for preparation metallographic specimen with re-manufacturing” [5].

Table 4.8: Experimental Parameters

Material	Aluminum Alloy Ø25×L:25mm	
Time	3 (Minutes) for 60 Grit, 4 (Minutes) for 160 Grit	
RPM	2800	
Grit size	60	160

4.5.3.3 Reference Values

Table 4.9: Reference Values

Reference Values	60 Grit	160 Grit
Time (Minutes)	3	4
R_a (μm)	0.16	0.09

4.5.3.4 Achieved Values

Table 4.10: Achieved Values

Achieved Values	60 Grit	160 Grit
Time (Minutes)	3	4
R_a (μm)	0.2	0.08

4.5.3.5 Comparison Chart between Reference and Achieved Values

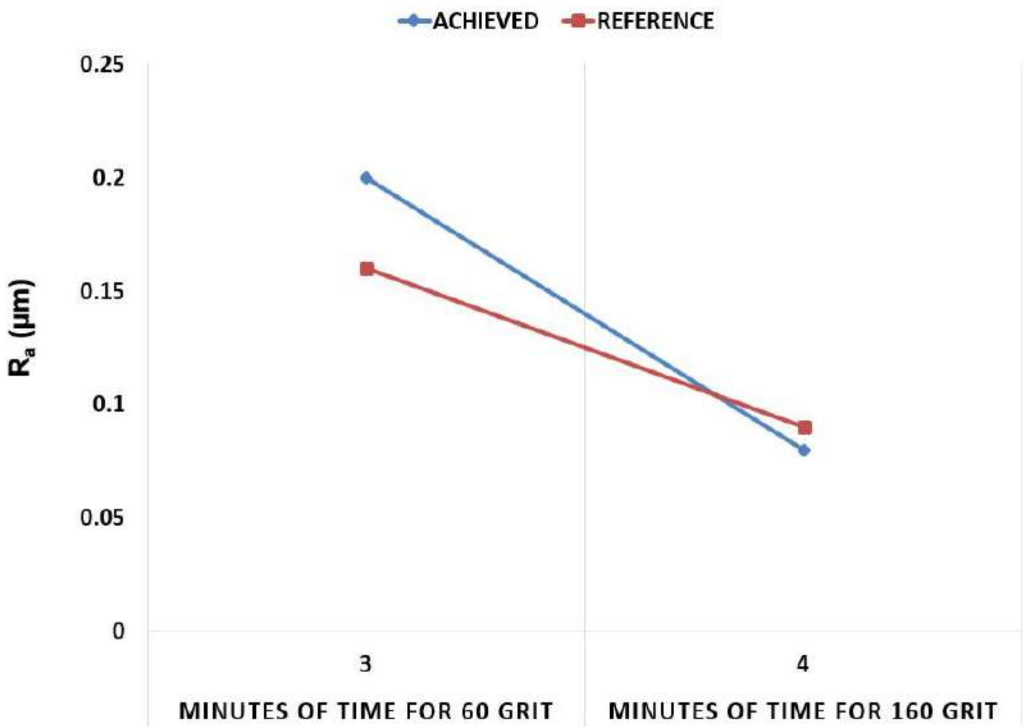

Figure 4.8: Comparison between Reference and Achieved Values

4.5.3.6 Discussion of Experimental Results

In this experiment there are 2 Type of Grits 60 & 160 to prepare polished surface of Aluminum Alloy for crack investigation. Parameters are given to perform this experiment. Then we are able to check that how much R_a values we get in µm during duration of 3 and 4 minutes of intervals. After getting results we conclude that we get better and close values by utilizing our machine and expertise as compared to reference parameters.

4.6 Conclusion

We have concluded that Metal Multi tool Linishing Machine is effective than conventional grinding machines. Abrasive belt, grinding wheel and buffing wheel combines many operations for efficient surface finishing. And it can fulfill the accuracy for super finishing of key which required for company as per their design. Also, we can use Metal Multi tool Linishing Machine to obtain the different super finishing quality with the help of using different grade abrasive belt. This Grinding machine has the versatile operations and achieve the operations of all other Belt grinding methods.

The results and discussion can be taken the first few conclusions, the advantages of Metal Multi tool Linishing Machine are in finishing work not in rough workmanship. Lastly, the disadvantage of this machine is that it is less effective in rough working and deep cutting of very thick metal plates which cause the weakness of the belt sandpaper which can be damaged if the rotation is less stable.

4.7 Safety Precautions

1. Safety glasses are required.
2. Don't wear loose clothing or gloves, keep long hair tied back.
3. Never remove guards unless authorized by supervisor.
4. Don't place hands or fingers under pieces during feeding to avoid potential pinch hazard.
5. Don't let hands come too close to top of opening on abrasive belt. This is also a pinch hazard.
6. Setups requiring anything other than the standard sander equipment must be approved by supervisor.
7. Sandpaper changes must be approved by supervisor.
8. Machine must be locked out for all adjustments other than table height.
9. Avoid kick out. Stand to the side of the belt.
10. Sanders will throw pieces if operated improperly. Be aware of what we are doing.
11. Don't sand anything that contains metal.
12. If machine is malfunctioning stop immediately and report to supervisor.
13. Place work piece onto feed belt so that it goes through the sander with the grain.
14. Emergency stop is used for emergencies and malfunctions.
15. Keep motor load at or below 50%. To keep below this limit, slow conveyor feed rate or increase the thickness the table is set on.

4.8 Operating manual

Please read this manual before using machine.

4.8.1 Pre-Operational Safety Checks

- ✓ Locate and ensure we are familiar with machine operations and controls.
- ✓ Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- ✓ Check workspaces and walkways to ensure no slip/trip hazards are present.

4.8.2 Operational Safety Checks

- ✓ Only one person may operate this machine at any one time.
- ✓ Use the front of the wheel only.

- ✓ Work only below the centre of the spindle.
- ✓ Hold work so the edges cannot catch.

4.8.3 Ending Operations and Cleaning Up

- ✓ Push Emergency Switch off the machine when work completed.
- ✓ Leave the machine in a safe, clean and tidy state.

4.8.4 Potential Hazards and Injuries

- ⓘ Work can be snatched if improperly presented to buff.
- ⓘ Hair/ clothing getting caught in moving machine parts.
- ⓘ Eye injuries.

4.8.5 Don't

- ✗ Do not use faulty equipment. Immediately report suspect equipment.
- ✗ Do not hold work piece with gloves, apron, material or clothing.
- ✗ Never leave the machine running unattended.
- ✗ Do not bend down near machine while it is running.

4.8.6 General Safety Precautions

1. Check all the components of the project in predetermined position.
2. Grinding wheel consists of several smaller parts which should be properly assembled and tightened together. Make sure that the right flanges are used and attached properly for a smooth movement.
3. Grinders must always be tested before beginning any kind of work. Test run the grinder in a safe enclosed area such as beneath the workbench to detect any kind of damage or fault in the wheel or the grinder.
4. Wear goggles for before starting the machine.
5. Never use machine without the grinding wheel guard which is provided for protection.
6. Check the grinding wheel for any kind of crack or damage before using it.
7. Only one person may operate this machine at any one time.
8. this machine, the motor is equipped with a thermal over-load switch to stop the motor if excessive wheel pressure is applied thus preventing the burning out of the motor.
9. Do not exceed recommended depth of cut for the grinding wheel or machine.

4.8.7 Hazard Types

1. Point of Operation
2. Nip Points and Rotating Parts
3. Flying Chips
4. Sparks

These hazards exist on the Metal Multi tool Linishing Machine and they need to be considered.

CHAPTER 5

ENVIRONMENT AND SUSTAINABILITY

5.1 Positive Effects of Project on Environment

The designing and manufacturing of a Metal Multi-tool linishing machine can have several positive effects on the environment. While any manufacturing process has some environmental impact, designing with sustainability in mind can significantly mitigate negative effects. Here are potential positive effects of the project on the environment:

5.1.1 Reduced Material Waste

A well-designed machine can minimize material waste during both the manufacturing process and the machine's operational life. Efficient material use and optimized design contribute to reduced waste generation.

5.1.2 Energy Efficiency

Incorporating energy-efficient components and systems in the machine's design can lead to lower energy consumption during operation. This results in reduced greenhouse gas emissions and lower energy costs.

5.1.3 Resource Conservation

Using durable and high-quality materials ensures the machine's longevity. This minimizes the need for frequent replacements and conserves resources over time.

5.1.4 Modularity and Upgradability

Designing the machine with modularity in mind allows for easier upgrades or replacements of specific components. This approach extends the machine's lifespan, reducing the frequency of complete replacements.

5.1.5 Improved Process Efficiency

The multi-tool nature of the machine can streamline linishing processes, reducing the time required for each task. This efficiency improvement translates to lower energy consumption and reduced waste.

5.1.6 Precision and Quality

A precise and accurate machine ensures that linishing tasks are performed correctly in fewer attempts. This reduces material wastage and enhances overall process efficiency.

5.1.7 Emission Reduction

Implementing efficient dust extraction and cooling systems can minimize airborne particles and pollutants that could harm the environment or pose health risks to operators.

5.1.8 Eco-Friendly Materials

Prioritizing the use of eco-friendly materials, such as recyclable metals and non-toxic coatings, reduces the environmental impact of the machine's manufacturing and disposal.

5.1.9 Recyclability

Designing the machine for ease of disassembly facilitates the recycling of its components at the end of its life cycle, reducing the burden on landfills.

5.1.10 Lifecycle Considerations

When designing the machine, consider the entire lifecycle, including its manufacturing, usage, and end-of-life stages. This holistic approach ensures that environmental impacts are minimized at every stage.

5.1.11 User Education

Including information in user manuals about proper usage, maintenance, and responsible disposal can encourage users to adopt environmentally friendly practices.

5.1.12 Local Manufacturing

If feasible, manufacturing the machine locally can minimize the environmental impact associated with long-distance transportation of components.

5.1.13 Innovation and Inspiration

The project's focus on environmentally conscious design can serve as an example to other industries, inspiring them to consider sustainability in their own projects.

By considering these factors and actively implementing sustainable design practices, the project can contribute positively to the environment by reducing waste, conserving resources, minimizing energy consumption, and promoting responsible manufacturing and use of the Metal Multi-tool linishing machine.

5.2 Solution of Existing Problem

A Metal Multi-tool Linishing Machine can solve several existing problems in the metalworking industry, especially in processes like grinding, sanding, and polishing. Here's how such a machine can address common challenges:

5.2.1 Efficiency and Time Savings

Existing manual or single-purpose machines might be time-consuming and less efficient. The multi-tool nature of this machine allows operators to perform various linishing processes in a single setup, reducing the need for multiple machines and setups. This results in significant time savings and increased productivity.

5.2.2 Space Optimization

Traditional machines for different linishing processes can occupy substantial space on the shop floor. A Metal Multi-tool Linishing Machine combines multiple functions into one, freeing up valuable space for other equipment or processes.

5.2.3 Cost Reduction

Operating and maintaining separate machines for grinding, sanding, and polishing can be costly. By consolidating these functions into a single machine, operational costs are reduced through shared resources and streamlined maintenance.

5.2.4 Consistent Quality and Operator Safety

Manual linishing processes can lead to variations in quality and finish due to operator skill and fatigue. A machine offers consistent precision and quality, ensuring uniform results across all workpieces. Manual linishing processes can be physically demanding and pose safety risks to operators. The machine's automated features and safety mechanisms minimize direct operator contact with the workpiece and reduce the risk of injuries.

5.2.5 Environmental Impact

By optimizing processes and reducing material waste, the machine contributes to a reduction in the overall environmental impact of linishing operations.

In summary, a Metal Multi-tool Linishing Machine addresses existing challenges by streamlining processes, improving efficiency, enhancing safety, reducing costs, and ensuring consistent and high-quality results in various linishing tasks.

5.3 Reliability and Sustainability of Project

Reliability and sustainability analysis for the Metal Multi-tool Linishing Machine project involves assessing its economic, environmental, and social impacts to determine its overall contribution to sustainable practices. Here's how we can conduct a sustainability analysis:

5.3.1 Economic Sustainability

5.3.1.1 Cost Savings

Evaluate how the machine's efficiency and reduced material waste lead to cost savings over its lifecycle compared to traditional machines.

5.3.1.2 Return on Investment (ROI)

Analyze the projected ROI based on increased productivity, reduced operational costs, and longer equipment lifespan.

5.3.1.3 Market Competitiveness

Consider how adopting sustainable practices improves the project's competitiveness by attracting environmentally conscious customers.

5.3.1.4 Life Cycle Assessment (LCA)

Conduct a detailed LCA to quantify the environmental impacts of the machine throughout its lifecycle, from raw material extraction to disposal.

5.3.1.5 Energy Consumption

Assess the machine's energy efficiency, considering both its operational phase and the energy used during manufacturing.

5.3.1.6 Material Efficiency

Analyze how the machine's design minimizes material waste, reduces resource consumption, and promotes sustainable material use.

5.3.1.7 Emission Reduction

Evaluate the machine's contribution to reduced emissions through energy-efficient operations and effective dust extraction mechanisms.

5.3.2 Social Sustainability

5.3.2.1 Occupational Safety

It will highlight how the machine's features improve operator safety by reducing direct contact with hazardous tasks.

5.3.2.2 Community Impact

Consider any positive effects the project might have on the local community, such as reduced environmental pollution or enhanced safety standards. Analyze the potential for job creation in manufacturing, maintenance, and support services related to the machine's production and operation.

5.3.2.3 Mitigation Measures and Improvements

Identify areas where the project's sustainability performance can be improved and propose measures to mitigate any negative impacts.

Consider how feedback from users and stakeholders can inform future iterations of the machine, making it even more sustainable.

5.3.2.4 Comparative Analysis

Compare the sustainability performance of the Metal Multi-tool Linishing Machine with traditional machines or other alternatives, showcasing its advantages in terms of economic, environmental, and social benefits.

By conducting a thorough sustainability analysis, we can demonstrate how the Metal Multi-tool Linishing Machine aligns with sustainable practices and contributes to a more environmentally friendly, economically viable, and socially responsible manufacturing process.

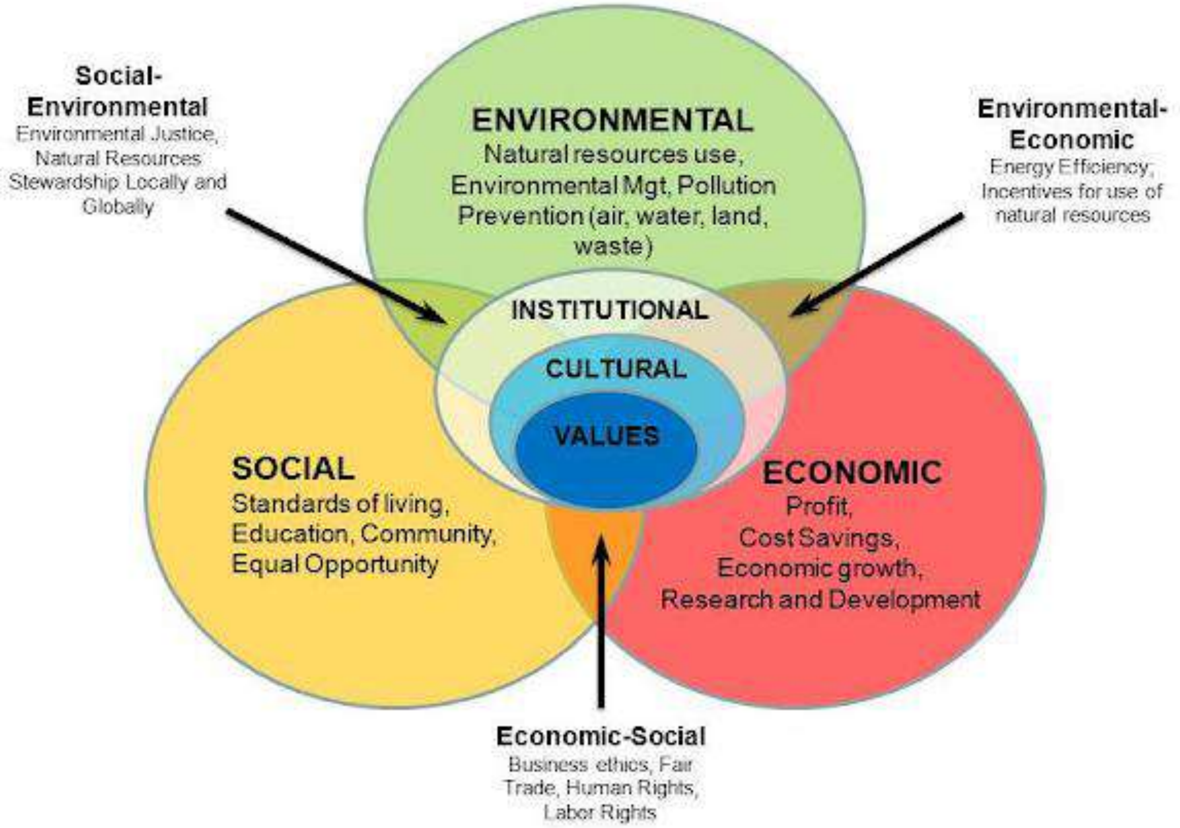

Figure 5.1: Environmental and Sustainability of Project

CHAPTER 6

CONCLUSION & FUTURE RECOMMENDATION

6.1 Conclusion & Future Recommendation

The successful completion of the project marks a significant milestone in advancing metalworking technologies and enhancing production techniques by validating its testing and achieved results. The comprehensive development process has resulted in a multifunctional capability, efficient, and user-friendly machine that offers numerous benefits to users. This machine greatly reduces human effort and improves accuracy.

The project design has potential future enhancements and upgrades. Feedback from users provides valuable improvement and innovation, allowing for continuous development and optimization of the machine. For the future enhancement of the Metal Multi-tool Linishing Machine, consider the following recommendations to improve its performance, safety, and versatility.

6.1.1 Variable Speed Control

Add variable speed control for the main roller and abrasive belts. This allows users to adjust the linishing speed based on the material type, workpiece size, and desired finish, providing more flexibility and control during the linishing process.

6.1.2 Enhanced Safety Features

Continuously improve safety features by incorporating advanced interlocks, emergency stops, and real-time monitoring systems. Ensure compliance with the latest safety regulations and standards to protect operators from potential hazards.

6.1.3 Modular Design for Customization

Design the machine with a modular approach, allowing for easy customization and upgrades. This enables users to adapt the machine for specific applications and future technological advancements.

6.1.4 Compatibility with Industry Standards

Ensure that the Metal Multi-tool Linishing Machine is compatible with industry-standard tooling and accessories. This allows users to leverage existing tooling and integrate the machine seamlessly into their existing workflows.

6.1.5 Feedback from Users and Industry Experts

Seek feedback from end-users and industry experts who regularly work with metal linishing machines. Incorporate their insights and suggestions to address pain points and enhance the machine's performance based on real-world applications.

By implementing these future recommendations, the Metal Multi-tool Linishing Machine can become a more efficient, user-friendly, and adaptable tool that meets the evolving needs of the metalworking industry.

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(Appendix-A)

Standard Operating Manual

METAL MULTI TOOL LININSHING MACHINE

DO NOT use this machine unless you have been instructed in its safe use and operation and have been given permission

PERSONAL PROTECTIVE EQUIPMENT

Safety glasses must be worn at all times in work areas.

Long and loose hair must be contained.

Gloves must not be worn.

Sturdy footwear must be worn at all times in work areas.

Close fitting/protective clothing must be worn.

PRE-OPERATIONAL SAFETY CHECKS

✓ Locate and ensure we are familiar with machine operations and controls.

Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.

OPERATIONAL SAFETY CHECKS

✓ Only one person may operate this machine at any one time.

✓ Use the front of the wheel only.

Work only below the centre of the spindle.

ENDING OPERATIONS AND CLEANING UP

✓ Push Emergency Switch off the machine when work completed.

✓ Leave the machine in a safe, clean and tidy state.

POTENTIAL HAZARDS AND INJURIES

ⓘ Work can be snatched if improperly presented to buff.

ⓘ Hair/ clothing getting caught in moving machine parts.

ⓘ Eye injuries.

DON'T

✗ Do not use faulty abrasive belts. Immediately report suspect equipment.

✗ Do not hold work piece with gloves, apron, material or clothing.

✗ Never leave the machine running unattended.

✗ Do not bend down near machine while it is running.

(Appendix-B)

ISO/TS 128-71 Technical Product Documentation (TPD), general principles of presentation and Part 71 simplifies the representation for mechanical engineering drawings.