IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

# EXPERIMENTAL STUDY ON HIGH ENTROPY FeNiTiCrCOZn ALLOY FOR THE APPLICATION OF BRAKE DISC

Sanjai kumar,
Department of mechanical engineering,
Kumaraguru college of technology,
Coimbatore

Vikash,
Department of mechanical engineering,
Kumaraguru college of Technology,
Coimbatore

Sujithkumar,
Department of mechanical engineering,
Kumaraguru college of Technology,
Coimbatore

**ABSTRACT:**

Brake discs are important components in automobiles because they dissipate the kinetic energy created when braking. Due to their excellent mechanical qualities, such as high hardness, strength, and wear resistance, high-entropy alloys (HEAs) have emerged as viable alternatives for brake disc applications. The tribological performance of a high-entropy FeNiTiCrCoZn alloy for brake disc applications was investigated experimentally in this study. The alloy was created via powder metallurgy and went through several heat treatments to improve its microstructure and mechanical properties. The alloy's tribological performance was tested against a commercial cast iron brake disc under varied operating conditions.

The results showed that the FeNiTiCrCoZn alloy outperformed the cast iron brake disc in terms of wear resistance and frictional stability. The HEA alloy's increased tribological performance is due to its fine-grained microstructure and the creation of a protective oxide layer during friction. According to the findings, the FeNiTiCrCoZn alloy has the potential to replace traditional cast iron brake discs in automotive applications.

**KEYWORDS:** Material ,Thermal conductivity, High entropy Alloy, HEA, Brake disc, Analysis

## INTRODUCTION:

High-entropy alloys (HEAs) are a novel type of material made up of five or more elements in equal or nearly equivalent quantities. HEAs have been demonstrated to have several distinct qualities, including great strength, hardness, and toughness. These characteristics make them appealing for a variety of applications, including braking discs.

During operation, brake discs are subjected to significant wear and strain. As a result, they must be composed of materials that are both powerful and long-lasting. HEAs can achieve these standards while also offering several advantages over typical brake disc materials, including:

- Increased strength and hardness, which can result in longer brake disc life.
- Better wear and tear resistance.
- Corrosion resistance has been improved.
- Weight reduction

Several research on the usage of HEAs for brake disc applications have been done. According to one study, a high-entropy FeNiTiNiCoCr alloy has a tensile strength of 1.2 GPa, which is much more than the tensile strength of standard brake disc materials such cast iron (0.5 GPa) and steel (0.8 GPa). The study also discovered that the FeNiTiNiCoCr alloy was harder and more resistant to wear than typical brake disc materials.

A high-entropy FeNiTiCrCoZn alloy with a tensile strength of 1.1 GPa and a hardness of 550 HV was discovered in another study. The study also discovered that the FeNiTiCrCoZn alloy outperformed typical brake disc materials in terms of corrosion resistance.

Overall, the findings indicate that HEAs have the potential to be employed as brake disc materials. HEAs outperform typical brake disc materials in terms of strength, hardness, wear resistance, and corrosion resistance. More research, however, is required to properly confirm the usage of HEAs in brake disc applications.

HEAs are quite inexpensive to create, in addition to the possible benefits outlined above. This is because HEAs may be manufactured from a range of recyclable

materials, including scrap metal. As a result, HEAs are a viable and environmentally benign option for brake disc applications.

**LITERATURE SURVEY:**

The ideology of this paper is to design and create a lightweight multi-utility electric scooter with hub motor gearbox. The suggested vehicle is capable of performing flexible activities in a variety of domains, including material handling in small-scale companies, hauling agricultural goods, and short-distance transportation. Hub motor power transmission, regeneration system, transportation, material handling, and goods carrier are all keywords [1].

The 'Single Wheel Hover-board' is a one-wheeled personal electric vehicle. The car is powered by a battery. The motor (DC 24V, 250W, High Torque) is coupled with the shaft of the wheel through a chain drive, and its speed will be regulated by a purpose developed 'Speed control' circuit, capable of currents up to 100 amps. Approximately 50A. The position of the people driving the vehicle controls the motor's direction. Intelligent sensors, such as the IMU, which has an accelerometer and a gyroscope, are used to monitor the person's posture, and the CPU signals the speed controller circuit appropriately. The Hover-board also has regenerative braking, built-in battery charging capability, and a power level indicator [2].

The study of this paper's main goal was to design and build an electric tri-wheel scooter for use as a multi-purpose transportation medium on the Bulacan State University Main Campus. The concept was created to alleviate stress in people from various walks of life and circumstances. The project was created using materials that were readily available in the area. Because it is intended to relieve the tension of certain people who walk a long distance, the project may be utilised both indoors and outdoors. It is especially beneficial inside, such as near a school, university, or shopping centre. It is solely meant for one rider [3].

Describes a traction system beneficial for an autonomous Electric Vehicle for individual usage. In the first method, the created system is made up of two separate power sources: one made up of batteries or fuel cells, and the other made up of supercapacitors. This study proposes a technical approach for integrating and using two energy storage systems in the same traction system. Supercapacitors are employed in the created system as a temporary energy storage element that may be used to retrieve energy [4].

The derivation of a set of four first-order nonlinear differential equations representing torque converter dynamics is provided, along with the appropriate bond graph representation. The bond graph is made up of an inertia field and modulated gyrators that connect mechanical and hydraulic ports. A dualization of this structure substitutes the original I-field with an IC-field, and all modulated gyrators with their partial duals—the modulated transformers. Further bond graph alterations result in torque converter—equivalent mechanical structures. The study finishes with examples of static torque converter model validation and comprehensive, dynamic model use in the design of shift quality controllers for discrete ratio electronic gearboxes [5].

Describes that Auto rickshaws are compact, three-wheeled vehicles that are widely utilised for people and cargo transportation in several Asian nations. The cars are compact and narrow, making them easier to manoeuvre in crowded Asian cities. Auto rickshaws are often utilised as taxis in India since they are affordable to operate. Despite apparent benefits in vehicle design, auto rickshaws cause significant pollution in major Indian cities. This is due to the use of an inefficient engine, usually a two or four-stroke with little or no pollution control. This study describes an ecologically friendly transportation system based on auto rickshaws [6].

Defines the method and device for simulating fluid torque converter properties such as torque ratio, capacity factor, and efficiency, the steps of determining a plurality of parameters including a fluid passage angle and a fluid passage resistance from a vane profile of a fluid torque converter's vane wheel and simulating the

properties of said fluid torque converter based on said parameters and an input and output torque relationship are performed [7].

Briefs on the electric vehicle stanch for personal automobiles and its related market, as well as background information on the subject. The study focuses on the existing scenario for purchasers as well as the less and more advantageous conditions in the Indian car sector. The primary focus of the paper is a comparison between electric and conventional automobiles. Furthermore, the study focuses on the overall cost of ownership of owning an electric car vs than a conventional vehicle in the Indian market. The study also focuses on the manufacturer's viewpoint by determining the optimal category in which to launch an electric car in India [8].

Helps to the production and sales Over the last decade, the global market for electric cars has grown at an unparalleled rate. We begin this article by discussing the scope and potential for Electric Vehicles in India. We also talk about the numerous policies and frameworks put in place by the Indian government. Then, we examine several case studies on the adoption of electric vehicles from throughout the world. Finally, we discuss how India might apply and profit from these tactics at both the local and national levels [9].

Briefly explains about the terms of energy generation, consumption, and vehicle emissions, future transportation is predicted to be sustainable. Embedded intelligent systems are critical in the electrification, autonomy, and deployment of automobiles. Though electric vehicle technology is predicted to lead automotive powertrain architecture in the future decades, a number of challenges are now impeding its adoption in the automotive sector. These impediments are broadly classified as battery technology, car performance, charging infrastructure, customer behaviour, and government assistance. As a result, a full investigation of these impediments, particularly for developing nations with low electric car adoption, is a source of worry [10].

Explains about Plug-in hybrid electric vehicles (PHEVs) have emerged as a potential technology for replacing gasoline usage in vehicle fleets. This article compares the expenses (vehicle acquisition and energy expenditures) and benefits (lower petroleum consumption) of plug-in hybrid electric cars to hybrid electric and conventional automobiles. A thorough simulation model is utilised to anticipate the petroleum savings and expenses of PHEV designs when compared to a midsize car as a baseline. According to the data, PHEVs with 20 miles (32 km) or more of energy storage can yield petroleum savings of up to 45% per car. The long-term additional expenses of these cars, however, are expected to reach US$8,000. A basic economic analysis is done to demonstrate that high petrol costs and low battery capacity accordingly [11].

Talks about the ubiquitous three-wheeled vehicles known as auto rickshaws are widespread in Asian cities, where they have been substantial contributors to the present air quality challenges that affect metropolitan areas due to their antiquated two-stroke engines. Recent improvements to four-stroke engines including those fuelled by diesel, compressed natural gas (CNG), or liquefied petroleum gas (LPG) minimise pollution and greenhouse gas emissions. However, due to the vast number of automobiles on the road, emissions from such vehicles remain a major concern. Recently, some research has been conducted on converting an internal combustion engine (ICE) rickshaw to an electrical or fuel cell rickshaw. Most rickshaw conversion experiments employed one of the basic urban driving cycles [12].

Research looked at the negative and positive effects of auto-rickshaws (Bajaj) on the Burao neighbourhood, as well as the personal characteristics of drivers. The research had three goals in this regard: to analyse the negative impact of auto-rickshaws on the Burao community, to examine the positive impact of auto-rickshaws on the Burao community, and to describe the characteristics of auto-rickshaw drivers [13].

Helps to understand the Fuel consumption targets set by numerous nations for the next years have pushed the development of hybrid passenger vehicles with ever-smaller internal combustion engines. Because fuel consumption is equally critical as engine packing and power density in such powertrains, two-stroke engines, which have a greater combustion frequency than four-stroke engines, may be a possibility. As a result, the current study looks at the air-fuel charging mechanism of a two-stroke overhead four-valve direct injection supercharged engine [14].

Research was discovered in which micro-hybrid technology with solar panels on top of the vehicle was utilised in an auto-rickshaw. This study is primarily concerned with the utilisation of solar energy in engine-driven auto-rickshaws, as well as micro-hybrid technology. The primary outcome of our suggested system is energy savings from the national grid. When this vehicle is used instead of a regular car, approximately 23% of energy is saved. According to feasibility studies, installing this system on a traditional one would pay for itself in 2-2.5 years, whereas a standard engine-driven auto-rickshaw may service for roughly 18 years under rigorous conditions [15].

Article examines the socioeconomic and environmental effects of battery-powered Auto Rickshaws in Rajshahi, Bangladesh. Bangladesh's unemployment rate is among the highest in the world. Bangladesh has seven lacks of jobless people. Auto rickshaws help to reduce unemployment by roughly 2%. In this thesis effort, numerous questions were posed to Auto Rickshaw drivers at various locations in Rajshahi. The data was then computed to determine their socioeconomic status [16].

Briefs about an amine (MEA)-based CO2 absorption system for post-combustion flue gas applications has been developed, and its performance and cost models have been linked with an existing power plant modelling framework that incorporates multipollutant control technologies for other regulated pollutants. The integrated model was used to investigate the feasibility and economics of carbon capture and sequestration at both new and existing coal-fired power stations. The cost of carbon avoidance was shown to be highly dependent on assumptions about the reference plant design, CO2 collection system specifics, interactions with other pollution control systems, and CO2 storage technology [17].

Explains about the efficiency of semi-flexible monocrystalline silicon solar panel used for a solar powered car called “Firat Force” and a solar powered minibus called “Commagene” was determined. Firat Force has 6 solar PV modules, a maintenance free long life gel battery pack, a regenerative brushless DC electric motor and Comma gene has 12 solar PV modules, a maintenance free long life gel battery pack, a regenerative brushless DC electric motor [18].

Derivates about the rising number of hybrid and hybrid electric vehicles with high voltage lithium-ion batteries poses a variety of new safety risks. Although the risk for an electric shock for passengers is negligible even in severe accidents and the fire safety is generally better than in cars with internal combustion engine only, the high voltage battery poses new risks for car mechanics, breakdown recovery staff, and rescue personnel [19].

Gathered knowledge about A three-wheeled vehicle's front suspension system consists of the suspension arm, steering column, shock absorber, and suspension spring. One of the drawbacks with this vehicle is that it tends to drift to the right. It's because the suspension components are heavier. To address this issue, the front suspension must be redesigned and optimised to save weight. The goal of this study is to give information on the optimisation of a three-wheeled vehicle's front suspension system using Finite Element Analysis [20].

Helped When selecting an electric car motor, one must first evaluate the performance, operating circumstances, efficiency, comparable prices, and so on. A low-weight, high power density, and economical motor must be conceptualised in terms of functionality and economic feasibility in the Indian context for electric vehicles such as three-wheel auto rickshaws covering short-range driving cycles. The ultimate goal of this research is to discover the features of a variety of motors and decide which properties are most suited for large-scale deployment of electric auto-rickshaws in the Indian transportation context [21].

Exhibits the problem of hybrid vehicles Because of their low fuel consumption and minimal emissions, plug-in hybrid electric vehicles (PHEVs) have been identified as one of the most promising vehicle types today. Energy management is essential for optimising PHEV performance. This work provides a strategy to energy management based on the particle swarm optimisation (PSO) algorithm. The optimisation goal is to reduce overall energy costs (the sum of oil and electricity) from vehicle use. The fundamental disadvantage of optimum techniques is that they cannot be employed in real-time control [22].

An overview of the energy management issue with hybrid electric vehicles is provided in the dissertation. A consistent framework is offered along with a number of control mechanisms that have been documented in the literature. For the investigation of energy flow and simulation of vehicle performance, a thorough vehicle model is offered. Pontryagin's minimum principle, equivalent consumption minimization strategy (ECMS), and dynamic programming are three of the methodologies that are examined in depth and compared from a theoretical standpoint, illuminating the fundamental parallels. To illustrate how the tactics are used, simulation results are also given [23].

A new service-based electric car ownership model is now possible thanks to the development of electric vehicles with switchable batteries. According to this approach, network operators for electric cars will offer clients pay-per-mile contracts that include the battery's financing charges as well as charging and range-extension services [24].

These network operators will be able to address range concerns by installing and maintaining battery switching and charging infrastructure that offers customers a driving range that is greater than the 200 miles provided by the Tesla Roadster and comparable to that provided by the current petrol station network. Additional benefits of a network operator-centred system are discussed in this paper, including lower EV purchase costs, the removal of consumer concerns about battery longevity, and the centralization of the electricity purchase for charging EVs [25].

Focuses on the environmental problems brought on by auto rickshaws, which are compact, three-wheeled vehicles that are commonly utilised for transportation in Asian nations. Despite being affordable to operate, these vehicles increase greenhouse gas emissions and air pollution. The article suggests revamping the current auto rickshaws into a more effective micro cross type system in order to create an eco-friendly transportation system. To facilitate the use of alternative energy sources like solar electricity for charging the vehicle's power-packs, a recharging infrastructure is also recommended. The goal of the project is to create a lightweight, reliable, and reasonably priced hybrid system that can dramatically lower the fuel usage and emissions of auto rickshaws [26].

Through investigation and testing, it was discovered that there were numerous design flaws, as well as issues with ergonomics, comfort, and health and safety. Upgrades to the design were put in place to fix any issues. The present cycle rickshaw's testing revealed the power and energy needed. A 500 W 24 V DC motor and a battery with a 220 amp-hour capacity were utilised in an electric drive system, along with a pedal assist system, to provide a range of up to 52 km. To demonstrate the effective use of a pedal assist system, which was established as a viable design alternative, a conceptual prototype was constructed [27].

Globally, the transport industry has a large impact on carbon emissions and environmental degradation. Adoption of electric vehicles (EVs) has the potential to lower emissions while promoting the use of renewable energy sources. Through automated battery pack switching at battery sharing stations (BShS) in a battery sharing network (BShN), which is crucial for the smart grid, this study suggests a design idea and technique to increase EV adoption. A useful and creative technique is offered by examining current battery replacement procedures and taking into account technical and socio-economic variables. The proposed BShS/BShN addresses major obstacles to EV adoption and offers innovative solutions for broad adoption [28].

The electrification of three-wheelers, especially passenger auto rickshaws, is essential for urban mobility due to the alarming air quality in many Indian towns. The usage of e-auto rickshaws has been encouraged by the government through the provision of incentives, concessions, and exemptions. For these cars, electrification goals have been set. The establishment of charging infrastructure is the goal of programmes like Production Link Incentives (PLI), Phased Manufacturing Programme (PMP), reduced GST rates on EVs, components and batteries for OEMs and component manufacturers, Model Building Laws 2019, and National Energy Policy 2017 [29].

It suggests a grid-connected local energy system that takes into account a community battery energy storage system (CBESS) for e-rickshaw battery swapping and charging stations (BSCS). The HOMER Pro software was

used to mimic this system. The simulation results demonstrate that by integrating solar PV locally, such systems can assist communities in drastically reducing their reliance on the national grid. The suggested BSCS also demonstrates a chance for circular battery management and a decrease in battery demand for electric rickshaws [30].

As the transition to electric transportation is predicted, retrofitting, which is the customising and merging of current technology into existing systems, is being investigated in the majority of cars. In nations like India, auto rickshaws are frequently utilised as public transportation and can be upgraded with electricity. The upgraded electric auto rickshaw looks and feels the same as the original model. It has been investigated how auto rickshaws, e-rickshaws, and customised electric rickshaws operate. Significant environmental advantages result from this strategy's alignment with the reducing, recycling, and reusing guiding principles. The study investigates whether turning an auto rickshaw into an electric rickshaw is feasible [31].

India's most prevalent means of transportation for both people and cargo is the three-wheeled auto rickshaw. However, using inefficient internal combustion engines has a negative impact on pollution control. A solar-assisted auto rickshaw with a powerful electric drivetrain is suggested as a way to modernise the vehicle and cut pollution. The project focuses on developing a solar-powered, three-wheeled auto rickshaw and adopting an energy management strategy appropriate for Indian road conditions. The suggested auto rickshaw is modelled, built, and tested in a variety of traffic scenarios using the Simulink software [32].

In both urban and rural settings, the tricycle rickshaw is a well-liked means of transportation for short distances. Rickshaws are the most popular three-wheeled vehicles in India. They are preferred due to their accessibility, practicality, and simplicity. There are two varieties of rickshaws: pedal-powered manual rickshaws and grid-powered electric rickshaws. Electric rickshaws are more expensive than manual ones. A brushless DC motor, battery controller, throttle, and other components are driven by solar panels in a solar-powered rickshaw designed exclusively for disabled people [33].

For both urban and rural areas of India, a motor-assisted battery-driven hybrid rickshaw offers a peaceful and non-polluting mode of transportation. The project's goal was to build an electric hybrid rickshaw while keeping its current rickshaw design. The proposed design saves energy while maintaining the functionality and aesthetics of antique rickshaws. It combines a battery-powered motor system with a solar battery charging system. As infrastructure for charging, a solar-powered battery charging station is advised. Reduced physical exertion, air and noise pollution, and easier motion control are all features of the hybrid car. It can create job opportunities in India's rural and urban locations [34].

E-rickshaws are becoming more and more well-liked in Indian cities as an economical and ecologically responsible means of transportation. They only account for 1% of the market for electric automobiles. For low-income people in urban and rural regions, operating e-rickshaws has developed into a reliable method of transportation and a lucrative vocation. The article examines the shift to more efficient and environmentally friendly e-technology, highlighting its potential as the transportation of the future. In addition, government initiatives and directives in favour of e-rickshaws are highlighted. The paper examines the development, advantages, and difficulties of e-rickshaws in the past, present, and future [35].

India is home to three-quarters of all autorickshaws in the globe. Autorickshaws make up 10–20% of daily motorised journeys but only make up a small portion of the total vehicle stock. The livelihood of almost 11 million people in India comes from autorickshaws. In India, there has been a slow transition to electric autorickshaws (e-autorickshaws) as a result of excessive pollution and rising fuel expenses. From 0.1% in 2013 to roughly 6.2% in 2022, e-autorickshaw sales as a percentage of total autorickshaw sales have climbed. The Intermediate Public Transport (IPT) category includes autorickshaws as well as shared tempos/vans, e-rickshaws, and microbuses. They meet the mobility needs of residents in urban, suburban, and rural locations and are used for a variety of commute reasons [36].

**HARDNESS TEST:**

The resulting Rockwell number represents the difference in depth from the zero-datum position because of the application of the major load. The entire procedure requires as little as a few seconds (up to 15 for plastics), so the major advantage The Rockwell hardness test is based on the measurement of the depth to which an indenter is forced by a heavy (major) load beyond the depth resulting from a previously applied preliminary (minor) load. The test follows the sequence, see Figure 23.4 to your right:

- Application of minor load. A ‘zero’ position is recorded.
- Gradual application of load until the major load is reached. The maximum penetration position is recorded.

Removal of load until the minor load is reached of the Rockwell test is that results are quickly and directly obtained without the need for a secondary, dimensional measurement requirement.

The hardness test was carried out for Cast iron using Rockwell hardness test and the result is shown below.

| | | |
|---|---|---|
| Cast Iron | 95 HRA | 95HRA |
| | 97HRA | |
| | 93HRA | |

Table 3.2 Hardness Values

Fig 1. Hardness test

**WEAR TEST:**

**Pin on Disc** is used for testing the wear of the material. A "pin-on-disc" test is a type of tribological test used to study the friction and wear characteristics of materials, lubricants, and coatings. The test involves a rotating pin

that slides against a stationary disc under controlled conditions. This setup allows researchers and engineers to evaluate the performance and durability of various materials and lubricants in sliding contact.

**The test is performed for Cast iron.**

Tribometers can be used to examine how material pairings wear and friction. A specified standard force (about 5 N) is applied to move a test object—such as a steel ball or pin—over the specimen in a circular motion (pin-on-disk). The coefficient of friction, also known as the friction force, is continuously monitored throughout the test. Measuring the test specimen's abrasion and wear track allows for the subsequent determination of wear.

**Fig 2. pin on disc setup**

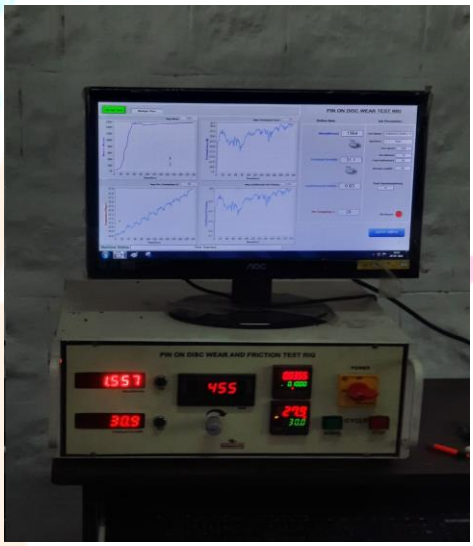

**Fig 3. wear test results**

The wear rate was exponential and increasing drastically up to **60 seconds** which was **1500** in microns, and it oscillates for 60 to 100 seconds, and it increases gradually and finally the wear in microns was **1770.94** in microns in **600 seconds.**

**METHODOLOGY:**

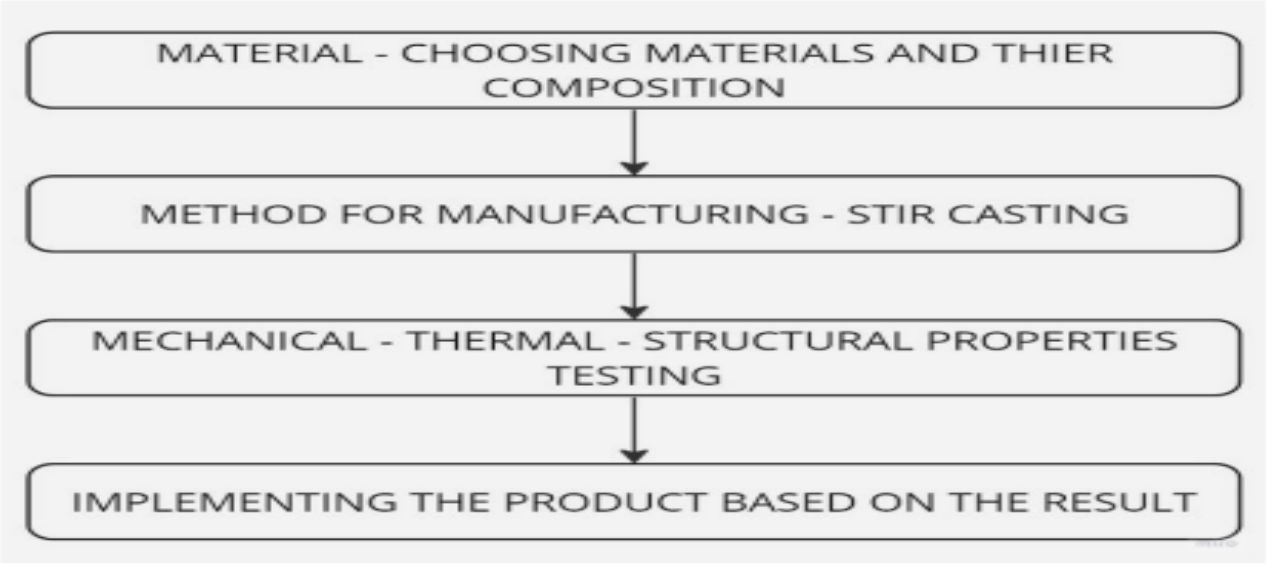


Fig 4. Flow chart

- ✓ The powders are purchased, and ball milled to minimize the size of the powders to microns.
- ✓ These refined powders are allowed to compact to get desired shape and then it is sintered to form HEA.
- ✓ This Fabricated HEA allows testing to compare the properties such as mechanical, Structural, and behavioral properties.
- ✓ Coating the HEA in gear and analyzing its performance.

**MATERIAL COMPOSITION:**

The two essential components' material makeup matters:

The balls known as grinding media (balls) are what smash and grind the material you want to grind. Usually, they are composed of:

- Ceramics: Alumina (ceramic oxide) and zirconia are popular options because they provide good wear resistance and chemical inertness for a variety of materials.
- Steel: Can introduce iron particles into the finished product; used for grinding harder materials.
- Flint Pebbles: An inexpensive, natural solution for less demanding uses.

The material that is being processed is what you wish to blend, mill, or make. Many materials can be processed with ball milling, such as:

- Grind minerals and ores to extract important components.
- Pharmaceuticals and chemicals: lowering particle size and producing homogenous mixes.
- Paints and Pigments: pulverizing unprocessed ingredients to achieve uniform colour and texture.

To prevent contamination and get the intended results, the material being processed determines the kind of grinding medium to use. For example, grinding something that is susceptible to iron contamination would not be done with steel balls. To prevent contamination and get the intended results, the material being processed determines the kind of grinding medium to use. For example, grinding something that is susceptible to iron contamination would not be done with steel balls.

**BALL MILLING:**

Ball milling is a mechanical process that uses high-energy collisions to grind, combine, or even create new materials. Envision a revolving drum that is loaded with your material and balls. The material is broken down into finer particles as the balls tumble and crash against the spinning drum.

Here's how it works in general:

• A horizontal or slanted axis is used to rotate a cylindrical chamber, or shell.

• There are grinding balls made of steel, ceramic, or even stones inside.

• The grinding medium and your material are halfway full in the chamber.

• The balls are raised by rotation, then they fall and strike the material, wearing it down.

FIG 5. BALL MILLING

**Ball mills come in two major varieties:**

- Tumbling Ball Mills: Continuous, large-scale mills for continuous processing.
- Planetary Ball Mills are a type of lab-scale mill that is perfect for small batches and study.

**Ball milling is useful in a wide range of applications:**

Grinding ores to extract valuable minerals is known as mineral processing.

Grinding and combining raw ingredients to create paints and powders, as well as pigments.

- Pharmaceuticals: Crushing and combining medicinal components.
- Nanotechnology: mixing components at the atomic level to create new materials.

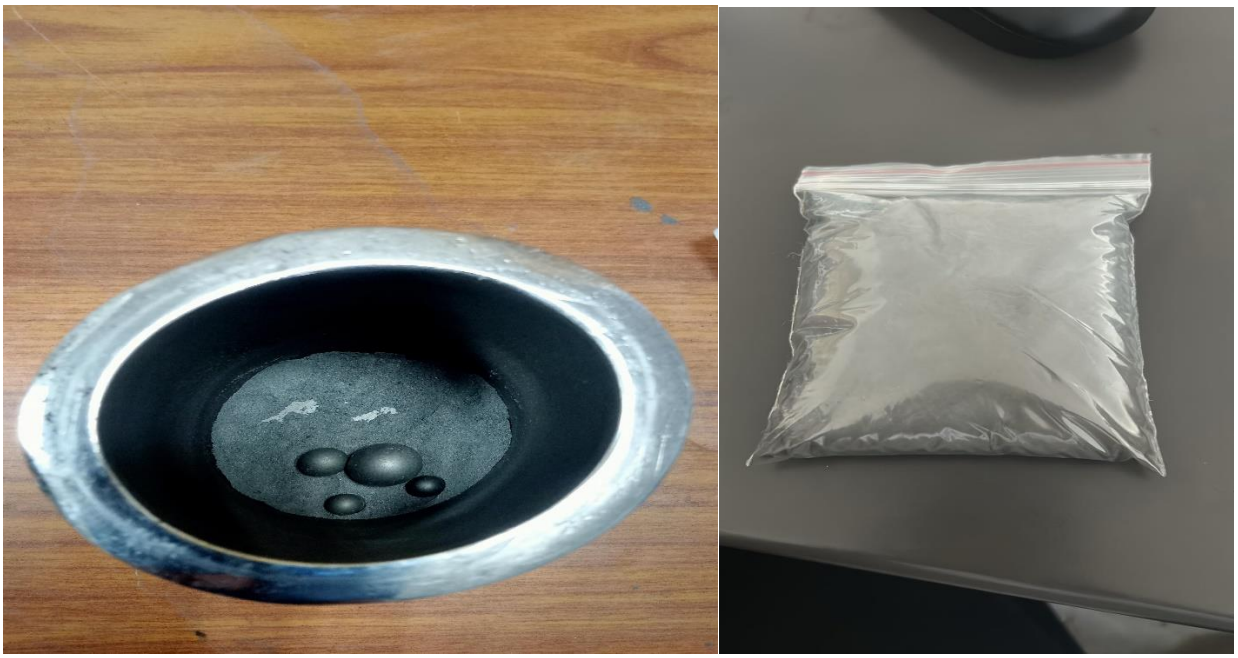

FIG 6. MATERIAL COMPOSITION

**Ball milling has several benefits:**

- Adaptable: Manages a range of materials, from pliable to robust.
- Scalable: Comes in various sizes ranging from little lab models to massive industrial systems.
- Controlled Particle Size: To obtain the required particle size, modifications can be made to the grinding media, speed, and processing time.
- Simple Design: Dependable and low maintenance.

In many different sectors, ball milling is an essential procedure that is used for grinding, mixing, and even for the creation of new materials.

**CASTING:**

A liquid material is often poured into a Mold that has a hollow chamber with the appropriate shape during the casting manufacturing process, and the Mold is then let to solidify. To finish the process, the hardened portion, often referred to as a casting, is ejected or broken out of the Mold.

Metals or different time-setting materials, such as epoxy, concrete, plaster, and clay, are commonly used as casting materials. These materials cure after mixing two or more components together. Most of the time, casting is utilized to create intricate shapes that would be costly or impossible to create using other techniques.

**FIG 7. CASTING**

Heavy equipment, such machine tool beds and ship propellers, can be easily cast to the desired size, saving assembly time from many small parts. Casting has been a craft for 7,000 years. A copper frog dating to 3200 BC is the oldest casting that is still extant.

**MACHINING:**

Machining is a manufacturing technique where a piece of material is shaped to the final desired shape by carefully removing material.

In contrast to additive manufacturing, which includes the carefully regulated addition of material, machining operations are generally referred to as subtractive manufacturing processes since they include the use of machine tools like machining centers and function by removing material.

- A cutting tool is formed of a tougher substance than the work material and has one or more sharp cutting edges. The chip is separated from the parent work material by the cutting edge. The tool's two surfaces—the flank and the rake face—are joined to the cutting edge.

- The angle at which the rake face is angled to control the flow of the newly created chip is known as the rake angle, or "α." In relation to the plane that is perpendicular to the work surface, it is measured. Either a positive or negative rake angle is possible. The tool's flank acts as a buffer between the newly produced work surface and the tool, preventing abrasion that could deteriorate the finish. The relief angle is the angle formed between the work and flank surfaces. Basic cutting tool kinds are as follows:

The single cutting edge of a single-point tool is used for planing, boring, and turning. The point of the device penetrates below the initial work surface of the work part during machining. There are instances where the fact is rounded to a nose radius.

Many cutting-edge tools have many cutting edges, and they often rotate to produce motion in relation to the work piece. Multiple cutting-edge instruments are used in drilling and milling operations. Many aspects of the geometry of these instruments are comparable, despite their shapes differing from those of a single-point device.

The two main machining techniques are milling and turning, which are explained here. Occasionally, other procedures complement basic ones or are carried out using separate equipment. For example, a drill bit can be put in a drill press or mounted on a lathe for turning. There used to be a difference between turning, in which the component turns, and milling, in which the tool revolves. With the development of machining centres and turning centres that can combine all the functions of several machines into one, this has become less clear.

### 3.10. TURNING:

A lathe is used to accomplish the machining operation of turning, which involves spinning the workpiece while the cutting tools are moving across it. The cutting tools produce cuts with exact depth and width by moving along two axes of motion. There are two varieties of lathes: the automated, computer numerical controlled (CNC) kind and the conventional, manual variety.

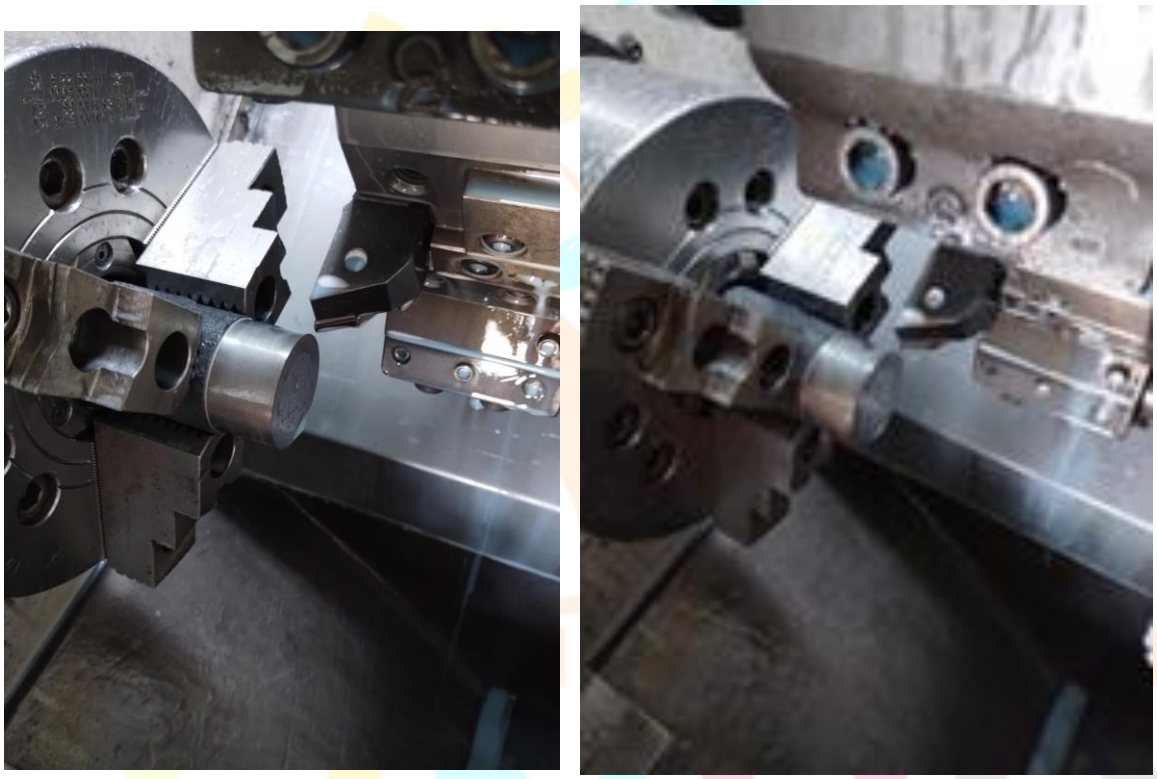

FIG 3.13. TURNING

It is possible to flip a material on its inner or outside. It is called "boring" when done on the inside; tubular components are the most popular use for this technique, which can be horizontal or vertical depending on the spindle's direction. "Facing" is another step in the turning process that happens when the cutting tool passes over the workpiece's end. It is usually done in the start and ending stages of the turning process. Applying facing is limited to lathes with fitting cross-slides. It was used to provide a datum perpendicular to the rotating axis on the face of a casting or stock form.

### 3.11. PLANING PROCESS:

Planing is a material removal industrial technique where a workpiece is reciprocated against a stationary cutting tool to create a sculpted or planed surface. Shaping and planning are similar. The tool reciprocates across the fixed workpiece during shaping, which is the primary distinction between these two procedures. Shaping motion is the reverse of planning motion. Milling is quickly taking the position of shaping and planing.

FIG 8. PLANING

A planer is the mechanism that is employed in this operation. The largest workpiece that can be machined on the planer determines its size. The cutting tools are like those used in facing and turning, and they are typically composed of high-speed steel or have carbide tips.

**RESULTS AND DISCUSSION:**

Electric auto rickshaws have gained popularity in recent years due to their low cost of operation, zero emissions, and low noise levels compared to their gasoline counterparts. Here are some key results and discussions on electric auto rickshaws:

Energy Efficiency: Electric auto rickshaws are much more energy-efficient than traditional gasoline-powered rickshaws. Studies have shown that electric auto rickshaws can achieve energy efficiency of up to 80% compared to gasoline rickshaws, which have an energy efficiency of only around 20%.

Cost Savings: The use of electric auto rickshaws can result in significant cost savings for both drivers and passengers. Electric rickshaws have lower operating costs as they require less maintenance, and electricity is typically cheaper than gasoline. Additionally, electric rickshaws have lower noise levels, which can make for a more pleasant passenger experience.

Environmental Benefits: Electric auto rickshaws have zero emissions, which can have a significant impact on air quality in urban areas. Traditional gasoline rickshaws emit pollutants such as carbon monoxide, nitrogen oxides, and particulate matter, which can be harmful to human health and the environment.

Challenges: While electric auto rickshaws have many benefits, there are also some challenges associated with their adoption. One of the main challenges is the availability and accessibility of charging infrastructure. Charging infrastructure must be widely available and easily accessible to ensure that drivers can recharge their vehicles quickly and easily. Additionally, there may be a need for government policies and incentives to encourage the adoption of electric auto rickshaws.

Prospects: The electric auto rickshaw market is expected to continue to grow as more drivers and passengers recognize the benefits of electric vehicles. There is also potential for innovation in battery technology and charging infrastructure to make electric rickshaws more efficient and convenient to use.

**REFERENCE:**

[1] Sharath Kumar M H, Nikhil B R, Prashanth Salimatt, Vikas B, Prof. Firoz Khan, "Design and Development of Light Weight Multi-Utility Electric Scooter using Hub. Motor Transmission," IJERT, Vol. 5, Issue 7, pp. 21-24, July 2016.

[2] A. Geetha, Vishwanath Kannan, Akhil Sai Vontimitta and Indraneel Patha, "Design and Development of a Self Balancing Mono Wheel Electric Vehicle," IJAREEIE, Vol. 6, Issue 5, pp. 4088-4097, May 2017.

[3] Ronaldo B. Asuncion and Warlito M. Galita, "Development of an Electric Tri-Wheel Scooter," Open Access Library Journal, Vol. 2, June 2015.

[4] D. M. Sousa, P. J. Costa Branco, J. A. Dente, "Electric Bicycle Using Batteries and Supercapacitors," IEEE, pp.1-10,2007.

[5] D. Hrovat and W.E. Tobler, "Bond graph modeling and computer simulation of automotive torque converters," Journal of the Franklin institute, Vol. 319, No. 1-2, pp. 93-114, 1985.

[6] Srdjan Lukic, Priscilla Mulhall, Ali Emadi, "Energy Autonomous Solar/battery Auto Rickshaw," J-Stage, Vol. 6, Issue 2, pp. 1135-1143, December 2008.

[7] K. Iwasasa and H. Abe, "Simulation method and device for aiding the design of a fluid torque converter," 23 January 1996, U.S. Patent 5,487,003.

[8] Comparison of Electric and Conventional Vehicles in Indian Market: Total Cost of Ownership, Consumer Preference and Best Segment for Electric Vehicle Akshat Bansal Akriti Agarwal2.

[9] Opportunities and Scope for Electric Vehicles in the Indian market janarthan Prasad Kesari[1], Yash Sharma[2], Chahat Goel[3]

[10] Critical analysis on the implementation barriers and consumer perception toward future electric mobility Kannan Chidambaram[1] , Bragadeshwaran Ashok[2], Rajasekar Vignesh[1] , Chirag Deepak[1] , Rathan Ramesh[1] , Tharun MV Narendhra [3], Kaisan Muhammad Usman[4] and Chellapan Kavitha.

[11] Simpson, Andrew. Cost-benefit analysis of plug-in hybrid electric vehicle technology. No. NREL/CP-540-40485. National Renewable Energy Laboratory (NREL), Golden, CO., 2006.

[12] IMPACT OF AUTO-RICKSHAW (BAJAJ): A COMPREHENSIVE STUDY ON POSITIVE AND NEGATIVE EFFECTS ON BURAO SOCIETY, SOMALILAND Research, development and innovation department of University of Burak Mohamed Ahmed Kunle [1]Mohamed Jama Farah[2],

[13] A Study of Fuel Cell Hybrid Auto Rickshaws Using Realistic Urban Drive Cycles Mohammed Abu Mallouh [1], Bradley Denman b[2], Brian Surgenorb[3] , Brant Peppley[4]

[14] Ferguson, Colin R., and Allan T. Kirkpatrick. Internal combustion engines: applied thermosciences. John Wiley & Sons, 2015.

[15] Solar Assisted Micro Hybridized Auto-Rickshaw (Engine Driven)Md. Arman Arefin,Avijit Mallik 2016

[16] Rahim, M. A., Joardder, M. U. H., Houque, S. M., Rahman, M. M., &Sumon, N. A. (2013, February). Socioeconomic& environmental impacts of battery driven auto rickshaw gas control." Environmental science & technology36.20 (2002): 4467-4475.

[17] A Technical, Economic and Environmental Assessment of Amine-based CO2 Capture Technology for Power Plant Greenhouse Gas Control Edward S. Rubin Anand B. Rao Carnegie Mellon University Center for Energy and Environmental Studies Pittsburgh, PA 15213-3890

[18] Practical Efficiency of Photovoltaic Panel Used for Solar Vehicle tKoyuncu

[19] Electrical accident risks in electric vehicle service and repair – accidents in Finland and a review on research Vesa Linja-ahoa

[20] Optimization of Key Parts of Front Suspension System of Three Wheeler
Mr. Kumbhar Sandeep Janardan Mr. Runwal Nitin Jalindar Mr.KhodesSwapnil Sunil
Dr. Pradip Tatyabhau Kale

[21] Techno-Economic Assessment of Various Motors for ThreeWheeler E-Auto Rickshaw: from Indian Context Vaidehi[1] , S Dhar[2] , Arunkumar Jayakumar[3] , R Lavanya[4] , M Dinesh Kumar

[22] Chen, Zeyu, et al. "Optimal energy management strategy of a plug-in hybrid electric vehicle based on a particle swarm optimization algorithm." Energies 8.5 (2015): 3661-3678.

[23] Serrao, L.; Onori, S.; Rizzoni, G. A comparative analysis of energy management strategies for hybrid electric vehicles. J. Dyn. Syst. Meas. Control 2011, 133, 1–9.

[24] Becker, Thomas A., Ikhlaq Sidhu, and Burghardt Tenderich. "Electric vehicles in the United States: a new model with forecasts to 2030." Center for Entrepreneurship and Technology, University of California, Berkeley 24 (2009).

[25] Mallik, Arijit, Mohammad Arman Arefin, and Sabir Ahmad. "A Review on Waste Management Options to Lessen Greenhouse Gas Emissions from Paper." American Journal of Applied Scientific Research 3.2 (2017): 7-13.

[26] MALLIK, AVIJIT, MD ARMAN AREFIN, and SUJON KUMAR PAL. "Solar Based Micro Hybridized Auto-Rickshaw and its Feasibility Analysis for Bangladesh."

[27] Cochrane, C., Muneer, T., & Fraser, B. (2019). Design of an Electrically Powered Rickshaw, for Use in India. Energies, 12(17), 3346.

[28] Adegbohun, F., Von Jouanne, A., & Lee, K. Y. (2019). Autonomous battery swapping system and methodologies of electric vehicles. Energies, 12(4), 667.

[29] Dalvi, G., & Pharande, V. (2021). Rechargeable Electrical Energy Storage System Development for an Electrical vehicle Retro fitment kit.

[30] Hasan, A. M. (2020). Electric rickshaw charging stations as distributed energy storages for integrating intermittent renewable energy sources: a case of Bangladesh. Energies, 13(22), 6119.

[31] Kokate, V. L., Uttekar, S. S., Karandikar, P. B., & Holmukhe, R. M. (2020, January). Retrofitting of auto rickshaw to e-rickshaw-a feasibility study. In 2020 First International Conference on Power, Control and Computing Technologies (ICPC2T) (pp. 229-234). IEEE.

[32] Gorantla, S., Attuluri, R. V. B., & Sirigiri, S. N. R. (2018). Design and development of an affordable plug in/solar assisted electric auto rickshaw. Modell Meas Control A, 91(2), 41-47.

[33] Dalvi, G., & Pharande, V. (2021). Rechargeable Electrical Energy Storage System Development for an Electrical vehicle Retro fitment kit.

[34] Saha, S. C., Goswami, A., & Ehsan, M. (2011, December). Design and development of an electric hybrid rickshaw. In Proceedings of the International Conference on Mechanical Engineering (pp. 18-20).

[35] Kokate, V. L., Bankar, D. S., Vispi, R. H., & Karandikar, P. B. (2018, July). E-Rickshaw Present Past and Future with Reference to Current Transportation in India. In International Conference on Recent Innovations in

Electrical, Electronics & Communication Engineering-(ICRIEECE), Kalinga Institute of Industrial Technology (KIIT), Bhubaneswar, India (Vol. 1, No. 01, pp. 1-15).

[36] Harikumar, A., Anand, R. M., Jain, H., & Phillip, S. India's EV Transition.