Recent Development in Multidisciplinary Science and Technological fields

Volume I

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RECENT DEVELOPMENT IN MULTIDISCIPLINARY SCIENCE AND TECHNOLOGICAL FIELDS

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PREFACE

We're excited to release the first volume of our book, **Recent Developments in Multidisciplinary Science and Technological Fields**. This book is a collection of book chapters written by respected experts in the fields of multidisciplinary science and technology. The articles cover a wide range of topics and go deep enough to meet the need for a level that is both complete and interesting. It is a collection of information about progress and changes in the field of multidisciplinary engineering. We hope that students, teachers, researchers, scientists, and policymakers will find this book much more useful because it is focused on applications and inducements from different fields of study. The articles in the book were written by well-known academics and researchers. Our thanks and appreciation go out to the experts and researchers whose work helped make this book better. We'd like to thank our publisher, **Scientific Research Reports**, Chennai, India, for putting together this book with so much good information.

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CONTENTS

Chapter No	Chapter Title and Contributors	Page No
1	**Natural fiber-based Biomaterial used for Space Suit Manufacturing - A Review** *Ch.P. Rudesh, Nandan Kumar Jha, Bhakti Sachin Malve*	1-15
2	**Analysis of an Automated Radiator Panel using FEA** *Shaisundaram V.S , Chandrasekaran M, Karikalan L, Muraliraja R*	16-23
3	**Electric Vehicle Modeling and Simulation Using MATLAB SIMULINK** *Selvamuthukumar M, D.Vinay Kumar, Lokesh Madineni*	24-33
4	**Experimental Investigation of Fluidized bed Gasification with Agro-industrial waste** *S.Venugopal, R. Venkatraj, L. Karikalan, S. Sathish*	34-40
5	**Life Cycle Predictor of Lithium -Ion Battery Using Machine Learning for Electric Vehicles** *A K Boobalasenthilraj, Premnath S, Giridharan R, Solaiyappan S P, Nandagopal G*	41-48
6	**Impact of nanocoated heat exchanger with material behaviour of Silica nanoparticles/water nanofluid** *Ramasubramanian S and Yesu Chinnapparaj A*	49-55

Chapter 1

Natural fiber-based Biomaterial used for Space Suit Manufacturing -A Review

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Abstract

The use of biomaterial advancements to lightweight radiation protection, wound healing dressings, and microbe resistant surfaces becomes apparent. Understanding the space environment is essential for meeting human requirements in space. Design parameters must take into consideration both the environment's physical characteristics and its physiological adaptations. The space environment enables the creation of new biomaterials that are beneficial to Earth but cannot be manufactured there. Similar to this, developing a biomaterial to deal with a problem in space may result in new biomaterials that eventually help Earth. This article discusses various ongoing problems with human space travel, a range of biomaterials that may help, and a particular kind of space technology.

Keywords: Astronauts, Biomaterials, space based biomaterial, Space exploration, human health in the space.

1. Introduction

Both extremely new fields, biomaterials and human space flight, have the potential to promote the other. One of the most complex and challenging tasks ever is undoubtedly putting a human in space. It takes knowledge and materials that advance human health on Earth for human existence to last in space. Additionally, it necessitates the construction of life-sustaining habitats in settings that are uniquely hostile and that pose risks to human health and wellbeing that are not present on Earth. Everything launched into space, including equipment, supplies, and personnel, must adhere to strict weight, durability, resilience, and multi-functionality requirements. Whether the materials are employed in systems to support spaceship function or systems to support human health, these strict

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requirements push the design parameters of materials used for space. Pathological conditions on Earth can approximate physiological adaptation to the space environment, and these latter have benefited from biomaterials. There are significant prospects to tackle some of the more difficult issues in human spaceflight thanks to the developing ability to build biomaterials with particular qualities.

Here, the focus is on how biomaterials, in particular their properties, uses, and effects on mission accomplishment, might help both present and future human space travel. The bulk of biomaterials utilised in space to date have been used for scientific purposes rather than crew health care (example: 3D cell culture). Only a few newly developed biomaterials have undergone testing in space; none of them have been put to use for their intended purposes. This review's objectives are to:

1) Identify areas of present and upcoming space exploration where biomaterials might offer significant, distinctive advantages;

2) Examine current biomaterials and research that could be used for space travel;

3) Provide a framework for finding and improving crucial biomaterial properties that simultaneously minimise dangers associated with human space exploration and improve human health;

4) Suggest a new term, "space biomaterials," to encompass materials produced from living organisms and biomedical materials, as well as their future opportunities for assisting human space travel.

1.1 Defining Biomaterials for Space

The field of biomaterials science, which is only a little over 50 years old, defines biomaterials as any substance, whether synthetic or natural in origin, that is intended to be used in close contact with biological systems, tissues, and fluids and that has a medical purpose, such as assessing, treating, enhancing, or replacing any tissue, organ, or bodily function. However, they defined biomaterials as biologically derived materials and their focus was on materials for habitats that could be grown on an extra-terrestrial site when the Space Studies Board of the National Academies first held a workshop to identify biology-based technology to improve human well-being in space in 1997 [1]. There were no biomaterials sessions and just one presentation specifically discussing a biomaterial at the most recent Human Research Program (HRP) 2020 event [2]. If both materials are to be fully utilised in space exploration, it is imperative to address the difference in terminology between

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researchers looking to use biologically derived materials for space missions and those developing biomedical materials for use on Earth.

Each pound that is sent into space costs huge amounts of money and fuel [3], Any component that reduces the expense of launching more components is highly desired. Therefore, it is important to look for components that have several uses, can be recycled or repurposed, or may even be utilised to create new materials on the spot [4]. Biological systems are very adaptable in several ways. This explains the fascination in biological materials, but it does not deal with the disparity in language.

The way missions are imagined is the main reason for this difference in how biomaterials are defined. The human crew (and any other biological) is often modelled as one of the many component systems of a space mission utilising a specialised aerospace engineering systems approach, which is used to plan, build, analyse, and implement space missions. The 2020 NASA Technology Taxonomy which was just issued, [5], Additionally, for space applications, equipment, materials, or supplies may be categorised as either supplies that may be produced during the mission or components that must be launched.

Due to these factors, space systems designers must take into possible uses for both biologically produced materials and items related to biomedicine, especially where they intersect. however, for Earth-based applications determine whether or not a substance is a biomaterial, one substance during human space travel may or may not be Depending on the situation, a biomaterial. Thus, although the emphasis is This paper proposes for a new definition that includes both biological materials to aid human space travel and “Space biomaterials" encapsulates the necessity for biologically generated materials and biomedical materials to overlap in space.

1.2 The Environment in Space

Human life is unsuitable to space conditions. Therefore, a habitat capable of supporting life must be built for the duration of any mission that carries people or other higher biological systems. Important space environment features that need to be taken into consideration include: Gravitational variability, severe temperatures, particle pollution, and cosmic radiation are listed in that order **[6].** furthermore to 5) surroundings with no atmosphere or that are hazardous, and 6) limited and isolated habitats. Gravity, in example, may vary from 0 G (microgravity) on the International Space Station (ISS) to a fraction of Earth's gravity, such as on the Moon (16.7% G) or Mars (37.6% G), to several multiples of Earth's gravity, as experienced during

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spaceship acceleration and deceleration. Any biomaterial must be created to work or endure the full mission's acceleration/gravity profile.

Extreme temperatures ranging from very hot to very cold can be felt on other celestial bodies or during extravehicular activity (EVA) whether in full view of the Sun (121°C) or in the Earth's shadow (-157°C). It is necessary to provide an atmosphere, both for breathing and for creating atmospheric pressure. The given atmosphere, whether in the confines of an EVA suit or the larger spaceship, is often within a contained environment that may be composed of gases and pressures that differ from Earth's atmosphere and may entrap toxins from off-gassing equipment or respiratory waste processes, such as CO_2. The bulk of the materials used in the livable compartment were chosen because, among other factors, they have low harmful off-gassing, as these gases must be cleaned from the environment. Dust and other particles remain suspended as a result of the decreased gravity. These suspended particles need to be dealt with since in the atmosphere they might be swallowed by crew members and clog filtering systems, whether they come from crew activities, typical hair and skin shedding, or lunar dirt. Finally, no spacecraft has ever been able to completely protect cosmic radiation, subjecting both the crew and the supplies to radiation. Therefore, another desirable property in any biomaterials for space is resistance to cosmic radiation

1.3 Effects of Space Travel on Human Health: Current and Future

Every organ system in the body is impacted by the space environment (Fig. 1) [7]. Microgravity results in:

1. muscular atrophy caused by inactivity, particularly heart muscle;
2. resorption of weight-bearing bones, which can cause kidney stones and an increased risk of fractures as a result of the excessive excretion of calcium;
3. A fluid redistribution or headward shift that can cause visual abnormalities and causes baroreceptors to expel extra fluid, which causes a drop in blood volume, further cardiovascular alterations, and orthostatic intolerance upon landing on Earth. Other adjustments include modifications to: 4) the circadian, 5) the sensorimotor, 6) the reproductive, 7) the immune, 8) the reproductive, and 9) the wound healing systems.

Even while some of these modifications could be easily tolerated in a weightless environment, they become troublesome upon reentry to gravity conditions, such as landing on Mars after travelling there from Earth or coming back to Earth from the

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International Space Station. Not every adaptation takes place right away; some need time to reach a zero G set point while others advance during the course of the zero G experience. The traditional presumptions of normal physiology in an abnormal environment may no longer hold if space flight becomes affordable for everyone. The physiological health and fitness of passengers will probably vary more, necessitating closer monitoring and treatment of pre-existing disorders.

NASA researchers created the Integrated Medical Model (IMM) to guide mission planning, research funding, and medical kit optimization (Fig. 2). The IMM sheds light on the 100 most probable medical disorders that could manifest themselves across various space flight situations. The IMM offers medical issue incidence rates and treatment needs based on data from the Apollo, Skylab, Mir, Space Shuttle, and ISS flights as well as terrestrial space mission analogues. In reality, the Apollo, Mir, Space Shuttle, and ISS missions saw about 40% of IMM conditions **[8].**

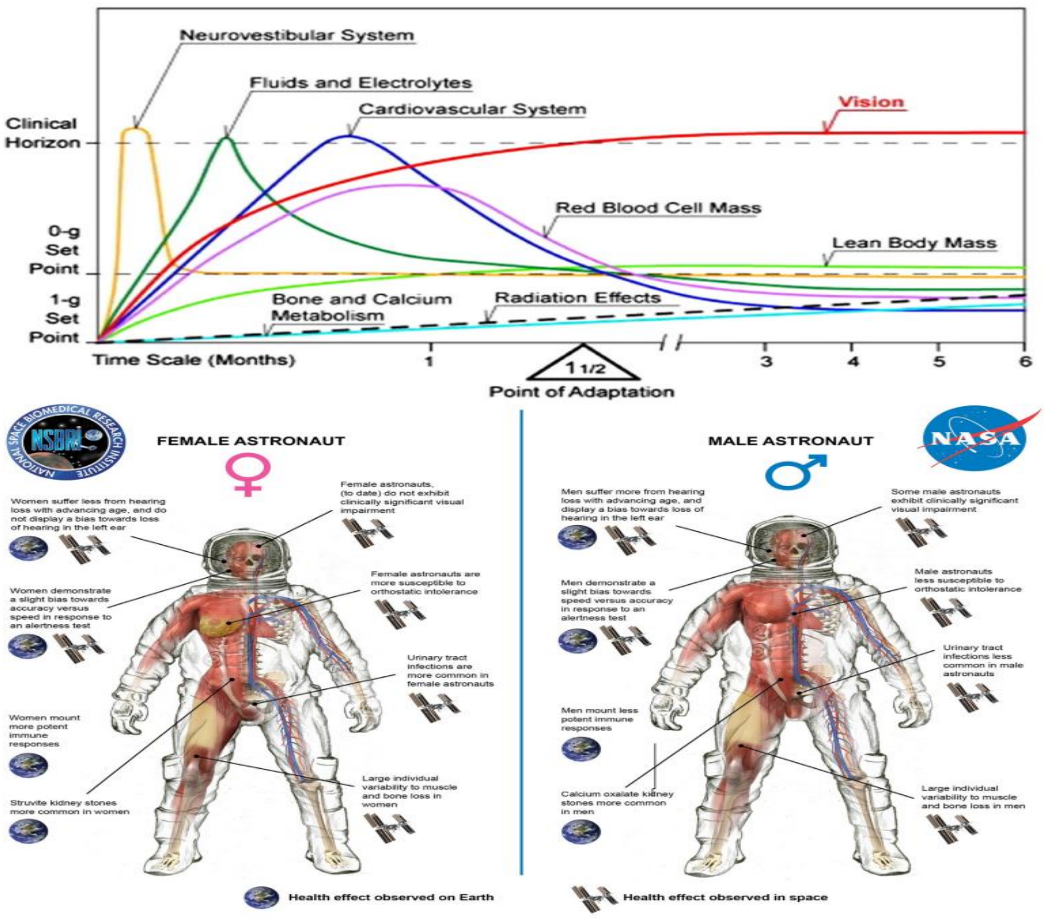

Fig.1. The timing and location of physiological changes brought on by microgravity. NASA and NSBRI provided the images.

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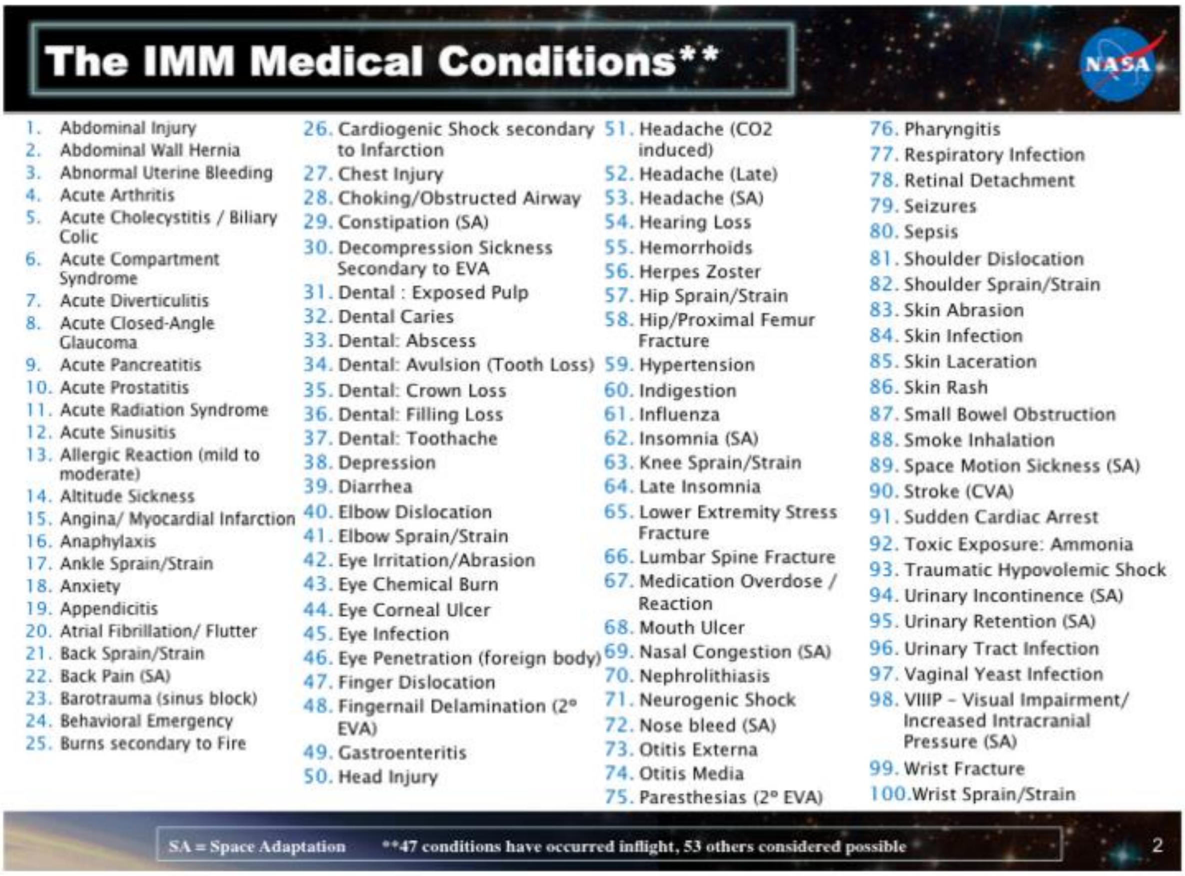

Fig. 2: NASA's Integrated Medical Model identified 100 possible medical issues that may arise during space travel (IMM). NASA provided the image in Ref **[8].**

2. Current and Future use of Biomaterials in Human Space Exploration

Biomaterial researchers can determine the biomaterials required for human space exploration using the criteria outlined by the IMM and the 2020 TX06 Human Health Life Support and Habitation Systems as well as general space flight operating restrictions. This analysis focuses on prospective biomaterials that might be used in space to support and improve human health, performance, and well-being as well as to treat potential diseases or medical crises. This article focuses on biomaterial applications that might in some way be specific to or helpful for human space travel. Once they are found, there is a huge possibility for new research directions, partnerships, innovations, discoveries, and financing sources.

2.1. Radiation Safety

Long-term human space missions are notoriously difficult due to radiation exposure. Strong barriers against the constant flow of cosmic radiation from protons and high atomic number high energy particles are provided by the magnetosphere and atmosphere of the Earth. Cosmic radiation at sea level is reduced to an annual

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average worldwide value of 0.22 mGy **[9].** For those who are exposed to altitude for extended periods of time, such as commercial airline pilots **[10–11]** and inhabitants of high-altitude cities **[12–13],** the incidence of cancer increases at high altitudes where the magnetosphere's protective shield is still in place but there is less atmosphere to act as a shield.

Despite as what is often believed, the answer is not as simple as coating the spaceship with lead, which only works for a certain band of high energy particles. For instance, whereas acrylic successfully blocks beta radiation, lead creates secondary Xrays when exposed to beta radiation. Lead is very good at preventing gamma or X-ray radiation. Furthermore, current shielding only partially shields astronauts from radiation—shields 5-7 cm thick may only block 30-35% of cosmic radiation **[14]—**and significantly increases the weight and launch costs of a spacecraft. Most critically, it does not totally shield people from radiation. In order to lessen the effects of ionising radiation, NASA is now looking into the use of pharmaceuticals and dietary supplements **[14].**

Here, biomaterials could provide an original answer. Comparatively speaking, biological radioprotective materials like melanin are both lighter and more adaptable in their prospective applications than radioprotective geology elements like lead. The kingdoms of plants, fungi, bacteria, and animals are all home to melanins, a category of heterogeneous biopolymers that operate as pigments and/or offer radiation protection **[15].** Researchers looked at the potential of melanin-coated nanoparticles to shield bone marrow from radiation treatment for cancer. By using the enzymes 3,4-hydroxyphenylalanine and/or 5-Scysteinyl-3,4-hydroxyphenylalanine to polymerize melanin, Schweitzer et al. coated 20 nm plain silica nanoparticles with a 15 nm-thick coating of the pigment **[16].** They irradiated healthy or tumor-bearing animals through intravenous injection of the melanin-nanoparticles and discovered lower hematologic toxicity and no tumour protection in the nanoparticle-treated mice.

Ju et al. overcame the problem by creating melanin nanoparticles through the straightforward oxidation of dopamine under straightforward conditions, which led to nanoparticles that were excellent free radical scavengers and showed high dispersion stability in aqueous solutions such as biological media **[17,18].** It was noted that silica nanoparticles persist in tissue and may not be ideal for human therapy **[17].** Melanin nanoparticles were examined by Rageh et al. in radiotreated mice given a dosage of 7 Gy -irradiation **[17].**

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They examined the blood count, spleen histology, and the comet test to evaluate cellular DNA damage in the bone marrow at 1, 4, 8, and 12 days after radiation to determine the effect of the intraperitoneally injected nanoparticles on radiation damage to peripheral blood, spleen, and DNA. They discovered that melanin nanoparticle therapy provided considerable radioprotection to hematopoietic tissues, preventing hematopoietic tissues from suffering radiation damage and increasing the life of mice in treated groups (40% survival) compared to controls (10% survival).

Instead of using melanin to coat nanoparticles, Cao et al. created a unique kind of melanin that they want to employ as a sunscreen on the skin **[15,19].** Although there are five multifunctional types of melanins (allomelanin, eumelanin, neuromelanin, pheomelanin, and pyomelanin), little is known about their structures or genesis. The scientists pointed out that pheomelanin's X-ray absorption coefficient may be superior to eumelanin's, despite the fact that allomelanin and eumelanin have received a lot of attention in radiation protection studies. Additionally, because the X-ray absorption coefficient is proportional to Z4 and selenium has a higher atomic number (Z) than sulphur, the researchers reasoned that selenium-enriched melanin would offer superior X-ray protection than pheomelanin, which contains sulphur **[15].** Since the amino acid selenocysteine is genetically encoded in 25 human proteins, the group emphasised the significance of selenium as an important vitamin. These findings prompted the authors to postulate the possibility of a selenomelanin that has not yet been identified in nature, one that would be superior than known melanin’s in protecting organisms from ionising radiation. They next created a unique selenomelanin by employing selenocysteine to create a selenium analogue of pheomelanin using a mix of chemical and biosynthetic processes. They discovered that selenomelanin formed perinuclear caps in neonatal human epidermal keratinocytes, which they called "micro parasols." These micro parasols effectively protected the cells from G2/M phase arrest when exposed to high-dose X-ray irradiation as opposed to control keratinocytes without the selenomelanin. To ascertain how melanin will respond to exposure to cosmic radiation, samples are now in space on the ISS **[20].**

2.2. *Surfaces with Microbe Resistance*

Current biomaterial research is focused on contact killing surfaces, which might have significant advantages in space. The majority of an astronaut's time in orbit is spent performing maintenance on the habitat. The crew habitat's systems are hampered by biofilms**.** Storage, weight, and possible toxins are constraints on

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cleaning products. Both Mir and ISS have a sizable microbial and fungal infestation. A microbial infection has been found in drinking water as well as on panels and workout equipment. Surfaces that may prevent microbiological contamination without needing staff cleaning might minimise payload (e.g., use fewer cleaning materials) and be advantageous for the productivity and well-being of the crew.

Equipment for space habitats may be significantly less contaminated if contact-killing surfaces are used. Biomimicry of topological features or chemical coatings are typically used in biomaterial techniques to generating these surfaces. Immobilized quaternary ammonium compounds, mechanobactericidal surfaces, surface coatings of selenium or silver, which restrict microbial contamination and are employed in contact lenses and urinary catheters, respectively, have all been demonstrated to kill a variety of bacteria.

2.2.1 Coatings for Surfaces

Silver's antibacterial capabilities have long been recognised; ancient civilizations used it to treat open wounds and sailors would dip silver coins into water to preserve its freshness. Its mode of action, however, has only lately been clarified. All 225 genes involved in silver toxicity or resistance in Escherichia coli (E. coli) were mapped by Gugala et al.. Their research supported earlier studies showing that some cellular redox enzymes and proteins with iron-sulfur clusters are disrupted as a result of silver's antibacterial action. The research also provided details on a more intricate mechanism of silver's antibacterial effect, including genes related to cell wall upkeep, quinone metabolism, and sulphur absorption. When silver is introduced, antibiotics that have lost effectiveness owing to antibiotic resistance restore it . Recently, stainless steel surgical and microsurgical equipment were coated with silver nanolayers (40 nm thick Ag/Al2O3 nanocomposite layers) using radio frequency reactive magnetron sputtering . Following coating, the instruments were cultured for 24 and 48 hours with E. coli or Staphylococcus aureus (13 106 cells each of S. aureus), two typical nosocomial infections acquired in hospitals. The germs were entirely dormant after 48 hours.

Sutures, wound dressings, and materials linked to orthopaedics and dentistry are now being investigated using surface-immobilized quaternary ammonium compounds. Quaternary ammonium compounds in orthodontic materials have been shown to be effective in vivo by a recent randomised, double-blind clinical experiment. In order to produce 48-hour multi-species biofilms, 32 humans wore specially manufactured retainers. The retainer was made with 5% weight quaternary

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ammonium methacryloxy silicate on one side but not the other. The experiment showed that the quaternary ammonium compounds had efficient biocidal action without endangering the individuals' oral mucosa or overall health.

Quaternary ammonium compounds have shown promise and progress in creating anti-microbial surfaces, but before they are widely used, their biocidal effects that go beyond microbes must be addressed. Recent studies have shown that they are toxic and genotoxic to water fleas **[21]** and genotoxic to mammalian and plant cells in vitro, at concentrations reported in commercial nasal sprays , which have the potential to be harmful to the ecosystem and people's health. As opposed to what was previously believed, it has recently been shown in a number of mammalian cell lines that the cytotoxicity of quaternary ammonium compounds is caused by disruption of internal biochemical processes rather than membrane disintegration or cell lysis **[22].** Additionally, low concentrations of quaternary ammonium compounds result in mitochondrial malfunction, oxidative DNA damage, oxidative stressors, disruption of cellular energy systems, and the induction of apoptotic signals **[21,22].**

Quaternary ammonium compounds may build up in soil over time, and when mixed with other pollutants, they may change the ecology of the soil, which in turn may cause bioaccumulation in soil organisms and eventually pose biological dangers to other creatures. The enclosed space of a spaceship may increase these dangers. For instance, quaternary ammonium compounds and their degradation products have been found in surface water, sediment, and sludge-affected soil, which is alarming because quaternary ammonium compounds alone are toxic to aquatic organisms , soil organisms, animals , and humans in addition to microbes. To thoroughly evaluate the potential biological and environmental dangers of quaternary ammonium compounds and determine if certain formulations have more focused microbial activity, more toxicity studies are required. Theoretically, quaternary ammonium compounds cannot escape from quaternary ammonium-based materials; hence, greater characterization of the toxicity processes associated with quaternary ammonium may allow for the safe application of these materials. For instance, antioxidants have been utilised to scavenge reactive oxygen species in an effort to lessen the cytotoxicity of quaternary ammonium compounds caused by oxidative stress **[23].** Modifying the molecular structures of quaternary ammonium compounds has been one method of reducing their toxicity. For instance, completely preventing their hemolysis of human red blood cells by PEGylating (covalently attaching polyethylene glycol, PEG) quaternary ammonium compounds .

ISBN 978-819620980-3

2.2.2. *Surface Topography*

Long-term usage in both Earthly and space exploration may benefit from biomaterial strategies that modify surface topography to provide mechano-bactericidal characteristics. Despite having powerful antibacterial effects, selenium, silver, and quaternary ammonium compounds all run the danger of accumulating in the environment and contaminating it. Since it was discovered that the wing surfaces of cicada and dragonfly include nanopillar structures that may physically kill bacteria, research into and development of biomaterials with nanopatterned surfaces that display bactericidal capabilities have increased (Fig. 3).

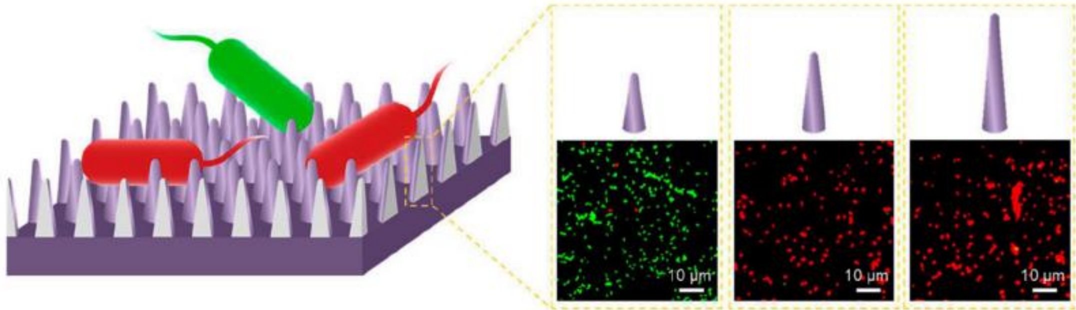

Fig 3: Fluorescence photos of E. coli that are alive (green) and dead (red) on various nanopillar heights.. American Chemical Society has granted permission for this reproduction.

2.2.3 Wearable Technology

Although clothing and other items that come into close contact with the skin while in space exploration are not typically thought of as biomaterials on Earth, this may be a crucial area for biomaterials researchers to focus on. This is in line with the idea that any material the crew comes into contact with frequently should have multiple functions, i.e., be biocompatible and support crew health. For instance, since there is no way to wash clothes or bedding in space, clothing and other items frequently come into touch with the skin. Unwanted clothes is thrown into the Earth's atmosphere to burn up while clean clothing is hauled up by a supply ship. A crew of six uses 900 pounds of clothes annually. For lengthy expeditions, replenishing clothing won't be an option. Currently, clothing may be worn for several weeks or even months at a time. Similar design considerations that would not generally be of concern on Earth, such as the possibility that comfortable clothes on Earth could become skin sensitizers in space, must be taken into account in specific places of the body where sustained contact can mirror that of a patch in many respects.

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Since EVA suits are complicated, independent mobile spacecraft that can now only undergo modest maintenance and repair while in orbit, they provide a unique problem. To fit various astronauts, suit components may also be switched out. Extravehicular activity (EVA) suits and gloves can cause abrasions; crew members may wear them for up to eight hours or more (Fig. 4). Crew members wear maximal absorbency clothing (adult diapers) when doing EVA chores to control waste. To direct pee, male crew members may use condom catheters. Form-fitting EVA coolant and pressure garments with tubing running throughout are worn over these. The crew must be hydrated and fed while on the hours-long trips, and the suit features filters that clean and renew the breathing gases. The selection of such materials is particularly critical under these conditions because 1) the user has little control over clothing within the suit during an EVA and 2) normal skin flora changes in space and diseases become more deadly **.**

Minimizing the burden of keeping clean or sterilised clothing or bedding is another unconventional possibility for using biomaterials to enhance human space travel. Carrying enough clean clothing for a protracted trip that cannot be resupplied is not practical due to the limited resources available for laundry. Additionally, astronauts come into frequent touch with the surfaces of the workout gear. Despite the fact that these are not life-or-death issues, biomaterials advancements may allow for the optimization of such system components, a considerable reduction in payload launch weights, and an improvement in crew performance. Superhydrophobic surfaces are one method that may be used. In lotus leaves, geckos' feet, and water striders' legs, superhydrophobic surfaces—defined as surfaces with contact angles >150° and contact angle hysteresis 5° for water—are present. These surfaces are also increasingly used in biomaterials to control protein adsorption, cellular interaction, bacterial growth, drug delivery, and diagnostics**.** Superhydrophobic surfaces offer the potential to produce apparel that is stain-free and does not require washing outside of biomedical applications.

Similar to this, wearable health and performance monitoring instrumentation is essential for ensuring astronaut health, although the amount of time these instruments are in touch with the astronaut may be longer than usual. The microbiological environment in which they must function is also changed. Ideal materials for such devices are those that are flexible, non-restrictive, and can be firmly connected to the body for a long period without leading to abrasions, sensitizations, infections, or functional declines **[5].**

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Fig 4: EVA suits being put on by astronauts and the skin abrasions that accompany a lengthy

3. Conclusions

The following goals were pursued, even though this is by no means a comprehensive review of all biomaterials that would be useful for spaceflight.

1) Take into account the potential of biomaterials to enable spaceflights of various lengths;
2) draw attention to the qualities of biomaterials required for space exploration;
3) demonstrate how some of the main barriers to long-duration spaceflight could be overcome by biomaterials;
4) Showcase the potential use of biomaterials to reduce human health risks for which there are neither ideal nor practical solutions.

In order for biomaterials to succeed in space, five crucial aspects of the space environment must also be taken into account when defining design requirements for the biomaterials performance: radiation, microgravity, microorganisms, fire resistance, and weight to launch. Numerous locations have made fascinating new findings. Even if they weren't used as surgical instruments, contact-killing surfaces would be useful for long-duration missions because the ISS has surfaces colonised with bacteria and fungi, which thrive in space and tend to become more dangerous. This review's goal was to show that the area of biomaterials has the potential to make a significant contribution to deep space exploration while also advancing technology on Earth.

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Chapter 2

Analysis of an Automated Radiator Panel using FEA

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Abstract

The proposed machine design consists of a steel support structure, similar to a crane, onto which purchased pre-manufactured components and drive systems are mounted. All drives are multi-axis modular systems designed to perform the required panel handling operations. The components and multi-axis modular systems are operated with the use of pneumatics, and have basic connecting and mounting assembly arrangements. All the modular drive systems proposed as part of the machine design are combined with similar interface systems. Solutions to required stroke, load and position specifications were met by selecting appropriate multi-axis drive systems. The use of modular drive systems offered numerous advantages and included the following: a simplified and time-saving design and project planning process, a rapid system assembly, a high mechanical rigidity and the availability of existing CAD drawings for standardized design. Three main pneumatic driven modular systems are proposed within the team's design. Two linear gantries allow for horizontal and vertical translation of the panels, two actuated swivel drive systems perform the 180° panel rotations and two gripper jaws serve to secure the panels during all handling operations.

Keywords: CAD; FEA; pneumatics; multi axis; load.

1. Introduction

MTM's current equipment design requires manual handling of each radiator panel by as many as two operators for transferring the panel from a roll form press, to the subsequent spot and seam welding operations. Current radiator panel assembly processes require that, from the roll press, the first of every two panels be manually rotated, placed and aligned on the next panel in preparation of the spot welding operation. A hydraulic arm is used to secure and push the joined panels at the indexing

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work station, in preparation for the final seam welding process. MTM requires a machine design capable of eliminating manual handling of the radiator panels, through the use of process automation. As a primary design project requirement, MTM needs and expects the team to develop a theoretical automated machine system to be used for orienting, aligning and indexing the radiator panels as they come out of the roll form press. The machine design requires 180° rotation about the horizontal axis on only the first of every two panels, the ability to accommodate varying panel dimensions and to be mechanically reliable. MTM also requires a machine design which provides a means to align paired panels before indexing them into a spot welder and in preparation of the ensuing seam welding operation. Finally, MTM requires a machine assembly design that can eliminate human panel handling and improve assembly quality through increased alignment precision. Throughout the design process, MTM needs the team to consider potential variations in assembly line infrastructure and building space, and to take into account the known various panel sizes and roll form process speed specifications. [1-5]

Figure. 1: Radiator panels

1.1. Design Overview

The automated panel rotation machine incorporates the use of a crane like design to rotate the first of every two panels that exits the roll former. This design essentially pulls the panel exiting the roll former from above, grabs the other end and lifts it up, rotates and places the panel back onto the bed. The next panel is picked up and placed onto the first panel at the end of the table. A variety of motions and components are used to enable the crane to achieve this task. A close up of the gripper and the pneumatic drive can be seen in figure 2.

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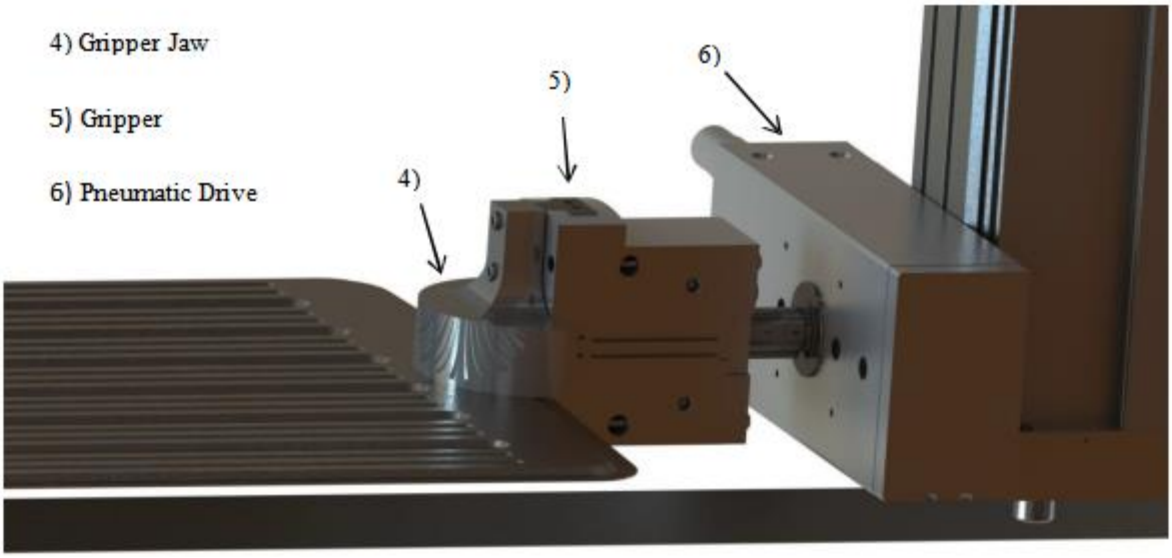

Figure. 2: Close up of gripper and pneumatic drive

The linear gantry is a newly developed product, there are limited specifications. A functional CAD model for the linear gantry, in the required length, was unavailable from FESTO, the manufacturer for a number of the components used within the design. The features missing are the connection plates and components between the two horizontal drives, the connection between the vertical drive and the pneumatic drive and also a detailed analysis of the connection to the structure. These are all things that a FESTO representative would have to further assist.

2. Design Methodology

The In order to accurately specify components, the forces that these components will experience must be known. The forces in the components are attributed to the deflection of the panel, which are large because the panel is very long and thin as well as being supported at only two end locations. An analysis of the static forces will be completed, followed by a dynamic analysis.

3. Static Force

The model that was used was a replica of the wide panel. It was analysed using Finite Element Analysis (FEA) because of the complex nature of the geometry. The thin nature of the panel required that a shell mesh was performed.

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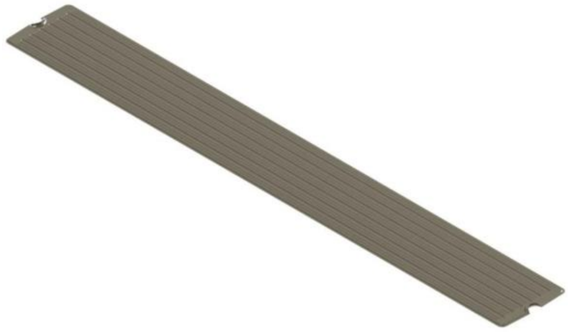

Figure.3: 520x4000mm panel CAD model used in FEA

Using Solid Works to perform the FEA, the first process was to define the shell features and mesh the panel. The default mesh relevance was selected for this model. The maximum and minimum face sizes where and respectively. Two fixed supports on both the flange risers on each end of the panel were used. The only force that is applied to the panel in all cases is gravity. The gravity force will result in a uniformly distributed load on the panel. The fixed supports have been placed on this face as this is the intended location for the top gripper jaw to rest against.

When the initial test was run with the small displacement option on, an error was received from the solver saying that it expects large displacements and that it advises the implementation of this option in the model. A simple hand calculation to obtain an approximation for the centre deflection of the panel was performed as follows, to verify the estimation of the FEA. Using the beam deflection equation for a simply supported beam, with a uniformly distributed load we are able to calculate the maximum deflection of the panel [5-8].

In the equation above is the uniformly distributed load, is the length of the panel, is the elastic modulus of the material and is the moment of inertia for the entire panel. The panel used was used because it will provide a worst case scenario as if there is play at the gripper end. The uniformly distributed load is calculated from the volume of the panel and the density. Since the panel is made from A36 steel which has a density of and a modulus of elasticity of, the distributed load and associated deflection are equal to the following. Now that the deflection of the panel is approximated, the models can be compared and a best representation determined. From the small deflection simulation run the maximum deflection of the panel was figure 4 represents this displacement [9].

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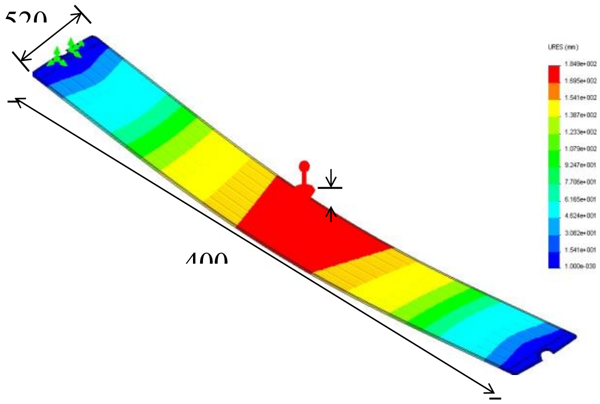

Figure.4: Displacement of 520x4000mm panel with small displacement setting

Since this is much larger than the analytical calculations, the large displacement model needs to be verified as a valid option. This is done by changing the fixtures of one end to a roller support so that one end is free to move. The displacement of this fixture can then be calculated using the large displacement option and determine what path to follow. The new model has one fixed support on the flange riser and one roller support on the flat surface of the flange riser.

3.1 Location of Roller Support

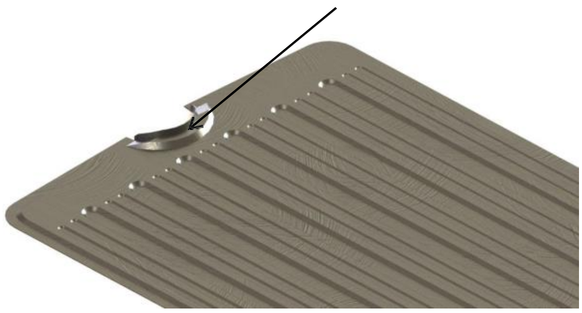

Figure.5: Location of roller support for proof of large displacement test

After performing this test, the roller support moves a distance of displacement. The displacement is large and for this reason the large displacements option within the solver will be used for the FEA.

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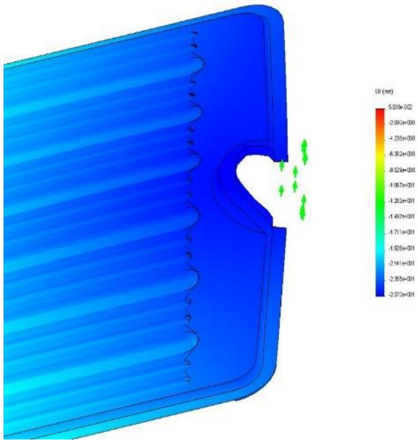

Figure.6: Displacement of panel relative to the roller support

It was determined that large displacements option is required, the displacement and associated stress and forces the panel will transmit through the system were analysed. With the fixed support back in place the maximum displacement of the panel was calculated to be this deflection can be seen in figure 7.

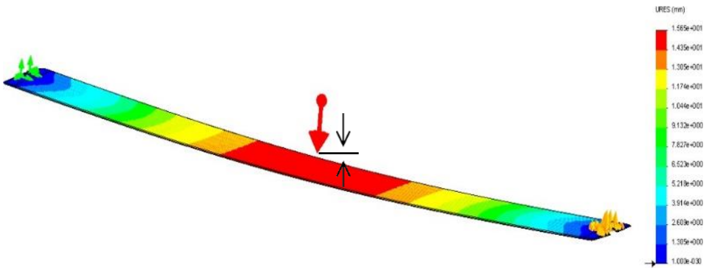

Figure.7: 520x4000mm panel displacement

The stress was analyzed to ensure that the panel will not fail or yield as this would result in misalignment and potential for leaking of the final product. Figure 8 shows the resultant stresses in the panel.

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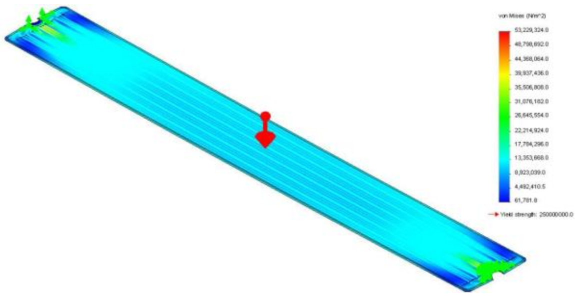

Figure.8: Stress distribution in the panel

From this test it was shown that the maximum stress that the panel experiences in since the Yield strength of the material is, there is no risk of yielding. Figure 3.6 shows the location of the maximum stress. The maximum stress appears on the fillet closest to the flange. The maximum stress in this location can be attributed to the moment that is passed through this area. It is also an area of stress concentration due to the change in geometry and the radius of the fillet. Next, the reaction forces were determined on the fixed support, the gripper, in both the directions. The reaction forces are important because these are the forces that the other operable devices on the gantry arms will experience in either axial or moment form [10].

4. Conclusion

During the design process, analysis of all panel handling induced static and dynamic forces were performed. The panel clamping static and dynamic forces were obtained and allowed determining correct gripper forces, motor torque and lifting force specifications. The static and dynamic force analyses were required to help determine whether the panel handling procedures and forces might potentially permanently deform the panels. The maximum forces generated by the panel handling processes were found to be below the panel material yield stresses and it was concluded that no permanent panel deformation would occur during any panel handling procedure.

An analysis of the gripper jaw properties and limitations was also performed. The gripper jaw components needs to be functional, strong and failsafe. In the final analysis, the gripper jaws were rated with a safety factor making them unlikely to fail. Because the top gripper jaw is designed with a bevelled edge, the gripper jaws can effectively and reliably centre and pick up the panels. The gripper jaws are also designed to accommodate those panels which might exit the roll former with a slight skew, or those that are slightly off axis. The proposed grippers are therefore, more than capable of performing the required tasks.

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Chapter 3

Electric Vehicle Modeling and Simulation Using MATLAB SIMULINK

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Abstract:

In this design, we design the electric vehicle model by using MATLAB SIMULINK tool blocks. Conventional vehicles give good performance and long range. But due to low energy frugality and exhaust gas emigrations causing environmental pollution, interest in electric vehicles is adding. The range of electric vehicles is short and they cannot reach high speed. Longer-distance vehicles are being produced as electric motor and battery technology advances. Thus, the performance of these vehicles can be optimized by opting for the motors and batteries depending on the region and the drive cycle. The dynamic model of an electric car was constructed utilizing MATLAB SIMULINK in this study. The energy consumption values of the electric vehicle and their range were determined for drive cycles similar to WLTP, NEDC, and HWFET. The factors of the Battery electric vehicle (BEV) frame were bandied then, and that model was dissembled on MATLAB SIMULINK and also the affiliated factors associated with the electrical systems.

Keywords: Electric vehicle, MATLAB SIMULINK, Simulation, Drive Cycles.

1. Introduction

Energy conservation is one of the most pressing issues confronting the world's climate. The global energy climate is also under threat. No one correctly predicts the future of energy; we believe that transportation will play a significant role in saving future energy. EVs are currently products of technological innovation that have contributed to making our lives easier and safer. EVs not only consume energy, but they also generate, store, and transport it. As a result, they are an excellent fuel vehicle option. The recent growth of hybrid and electric vehicles is strongly related to the need for highly efficient machines able to meet the most recent pollutant emissions regulations. In the automotive industry, electric propulsion is now a mature technology that is

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already available on the market and capable of meeting pollutant emission regulations based on the most recent testing process. In recent days, Electric vehicles represent the most viable alternative to the IC engines. Batteries can perform differently depending on the operating temperature, actual capacity, and aging state [1].

The MATLAB/Simulink software, which is capable of modeling complete EV powertrains at various levels of fidelity and detail, has proven to be an invaluable modeling platform. This software features a variety of shipped sample models for simulation of pure battery electric as well as hybrid electric vehicles of different configurations and types. The MATLAB/Simulink platform supports many add-ons which have been used in vehicle modeling, such as Super systems and SimDriveline, Advisor Sims cape, Powertrain Block set, etc. For vehicle modeling, Simulink supports an equation-based, data-driven, and physical modeling approach. Simulink also supports hardware testing and deployment code generation, testing and analysis frameworks for test case management, and report generation. The literature contains numerous studies of MATLAB/Simulink models. However, methodologies for validating these models in a research set within a real-world environment have not been adequately addressed in the existing literature [2-5].

1.1. Block Diagram of Proposed Model:

It consists the following main blocks, 1.)Vehicle body, 2.)DC Motor, 3.)Power converter, 4.)Battery, 5.)Drive controller, 6.)Drive cycle

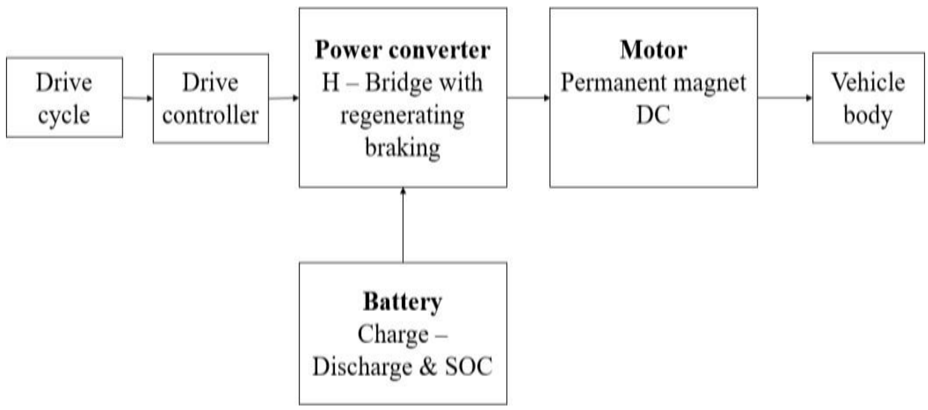

Figure 1: Block diagram of the proposed model

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2. Tool Blocks Used

Vehicle Body: The Vehicle Body block represents a straight-line moving two-axle vehicle body. For example, two front axle wheels and one rear axle wheel. For example, two front axle wheels and one rear axle wheel. The block considers body mass, aerodynamic drag, road incline, and weight distribution between axles due to acceleration and road profile. Optionally include pitch and suspension dynamics. The vehicle's axles are parallel and form a plane. The longitudinal direction, x, is perpendicular to the axles and lies in this plane. If the vehicle is traveling on an inclined slope, the normal, z, direction is never parallel to gravity but always perpendicular to the axle-longitudinal plane [6-8].

- The vehicle motion is a result of the net effect of all the forces and torques acting on it.
- The weight *mg* of the vehicle acts through its center of gravity (CG).

$$m\dot{V}_x = F_x - F_d - mg * \sin\beta$$

$$F_x = n(F_{xf} + F_{xr})$$

$$F_d = \tfrac{1}{2} * C_d \rho A (V_x + V_w)^2 \cdot \mathrm{sgn}(V_x + V_w)$$

- The normal force on each front and rear wheel.

$$F_{zf} = \frac{-h(F_d + mg\sin\beta + m\dot{V}_x) + b \cdot mg\cos\beta}{n(a+b)}$$

$$F_{zr} = \frac{+h(F_d + mg\sin\beta + m\dot{V}_x) + a \cdot mg\cos\beta}{n(a+b)}$$

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- Pitch acceleration depends on three torque components and the inertia of the vehicle

$$a = \frac{(f \cdot h) + (F_{zF} a) - (F_{zr} b)}{J}$$

Where:
a is the pitch acceleration.
f is the longitudinal force.
h is the height of the center of gravity when measured parallel to the *z*-axis.
J is inertia.

Tire: The tire's longitudinal direction is the same as its motion as it rolls on the pavement. Based on the Tire-Road Interaction (Magic Formula) block, this is a structural component. You can specify tire compliance, inertia, and rolling resistance to improve the fidelity of the tire model. These properties, however, add to the complexity of the tire model and can slow down the simulation. If you are simulating the model in real-time or preparing it for hardware-in-the-loop (HIL) simulation, consider ignoring tire compliance and inertia.

DC Motor: The DC Motor block uses the following equivalent circuit model to represent the electrical and torque characteristics of a DC motor. The resistor R is equivalent to the resistance specified in the Armature resistance parameter. The inductor L is equivalent to the inductance specified in the Armature inductance parameter.

- The permanent magnets in the motor cause the armature to experience the following back emf vb.

$$v_b = k_v \omega$$

where k_v denotes the Back-emf constant and angular velocity motor produces the following torque, which is proportional to the motor current I

$$T_E = k_t$$

Where, k_t is the Torque constant

2.1 Power Controller:

The tool blocks in a DC motor power controller are (a) H-Bridge and (b) Controlled PWM Voltage.

H-Bridge: The H-Bridge block represents an H-bridge motor driver. The block's simulation mode options are as follows: 1) PWM, 2) Mean The H-Bridge block's output is a controlled voltage determined by the input signal at the PWM port. When the input signal exceeds the Enable threshold voltage parameter value, the H-Bridge block

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output is activated and has a value equal to the Output voltage amplitude parameter value. The averaged model is the other mode. Smoothed and unsmoothed load current characteristics are available in this mode. The Smoothed option assumes that the current is nearly continuous due to load inductance.

Controlled PWM Voltage: A pulse-width modulated (PWM) voltage source is represented by the Controlled PWM Voltage block. Select either electrical or physical signal input ports in the Modeling option parameter. The block calculates the duty cycle by using the reference voltage across its ref+ and ref- ports. You can directly specify the duty cycle value by using an input physical signal port [9-10].

Drive Cycle: A standard or user-specified longitudinal drive cycle is generated by the Drive Cycle Source block. The output of the block is the specified vehicle longitudinal speed, which can be used to

- Estimate the engine torque and fuel consumption required by a vehicle to achieve the desired speed and acceleration for a given gear shift reference.
- Create realistic velocity and shift references for vehicle control and plant models' closed loop acceleration and braking commands.
- Study, tune, and optimize vehicle control, system performance, and system robustness over multipledrive cycles.
- Identify the faults within tolerances specified by standardized tests, including EPA dynamometer drivingschedules

Battery: A high-fidelity battery model is represented by the Battery block. The block computes no-load voltage as a function of charge level and includes several modelling options. 1). Self-discharge, 2) Battery Fade, 3) Charge Dynamics, and 4) Charge Dynamics Ageing by the calendar. The Battery (Table-Based) block has four modelling variants, which can be accessed by right-clicking the block in your block diagram and then selecting the appropriate option from the context menu, which can be found under Simscape > Block choices. Uninstrumented Instrumented No thermal port, Unistrumented show thermal port, Instrumented show thermal port. The instrumented models have an additional physical signal port that outputs the internal state of charge. Use this functionality to change load behaviour as a function of charge state without having to build a charge state estimator. The fundamental battery model, the self-discharge resistance RSD, the charge dynamics model, and the series resistance R0 comprise the battery equivalent circuit [11].

Simple Gear: The Simple Gear block represents a gearbox that constrains the connected driveline axes of the base gear, B, and follower gear, F, to corotate with a

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specified fixed ratio. You can specify whether the follower axis rotates in the same direction as the base axis or in the opposite direction. The angular velocity of the follower, ωF, and the angular velocity of the base, ωB, have the same sign if they rotate in the same direction. ωF and ωB have opposite signs if they rotate in opposite directions. Backlash, faults, and thermal effects can be easily added and removed [12-13].

- The kinematic constraint that the Simple Gear block imposes on the two connected axes is

$$rF\ \omega F = rB\ \omega B$$

where:

rF is the radius of the follower gear.

ωF is the angular velocity of the follower gear.

rB is the radius of the base gear.

ωB is the angular velocity of the base gear.

3. Proposed Model

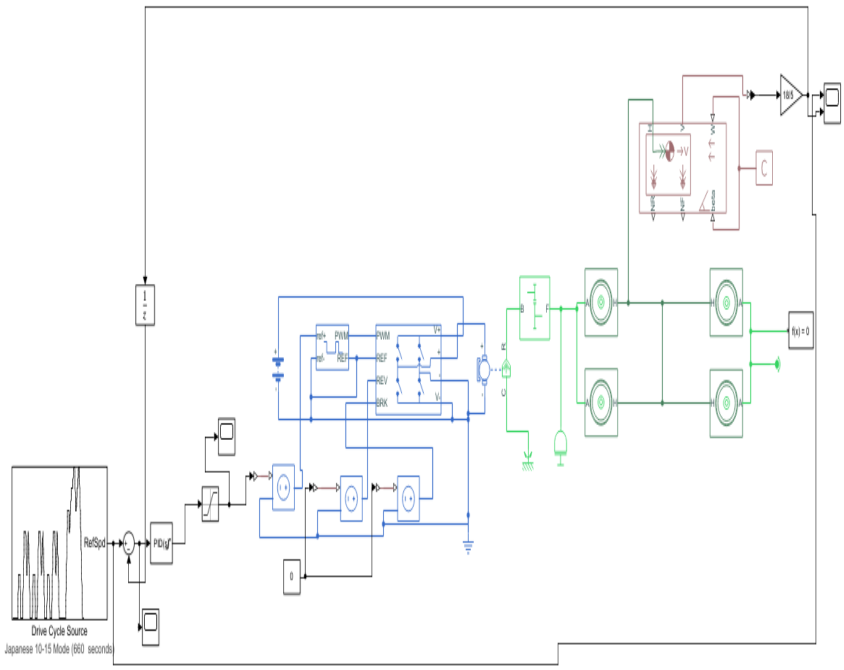

Figure 2: MATLAB SIMULINK MODEL of an Electric Vehicle

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3.1. Simulation Results

After designing and modeling the MATLAB SIMULINK was used to create an electric vehicle. Some simulation has to be performed in order to assess the electric vehicle battery capacity, range, speed, and timefor acceleration and deceleration, idle time, and cruise time. Also, according to the model, the main parameter is to plot the difference in the rated speed of the vehicle and the actual speed of the vehicle by taking feedback from the vehicle body [14].

- Simulation results of given input drive cycles are shown in figures A1 and A2.
- Simulation results of the PWM voltage signal are shown in Figures B1 and B2.
- Simulation results of the velocity of rated and actual velocity for a given input drive cycle are shown in FiguresC1, and C2

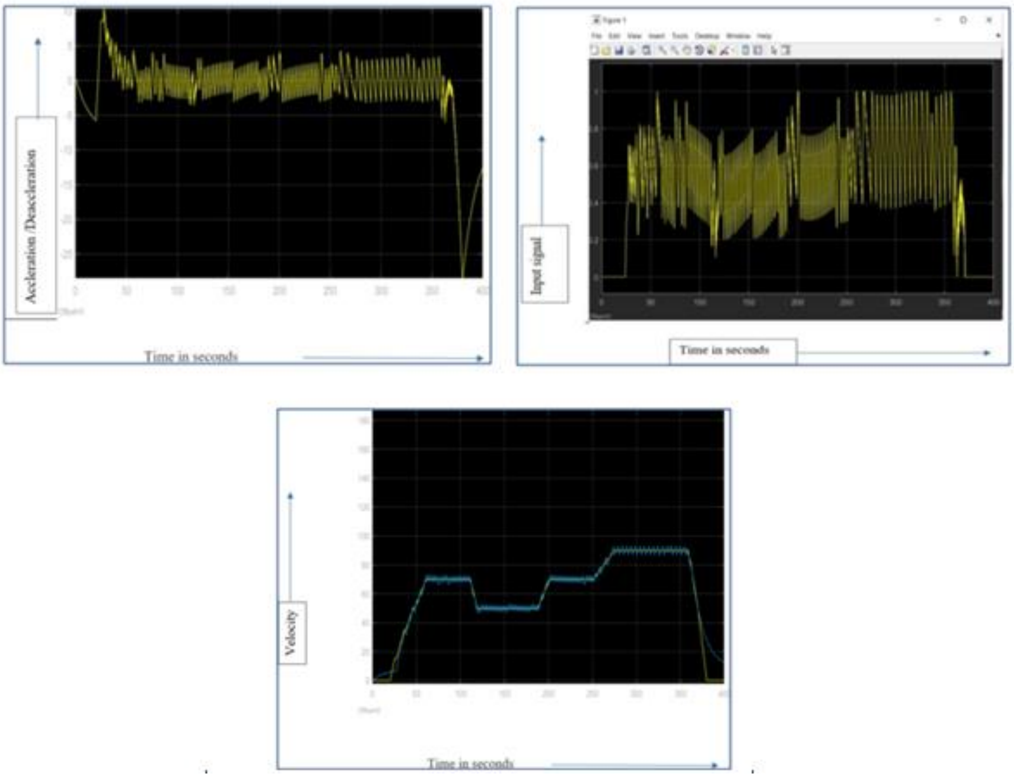

Figure 3: Extra Urban Drive Cycle

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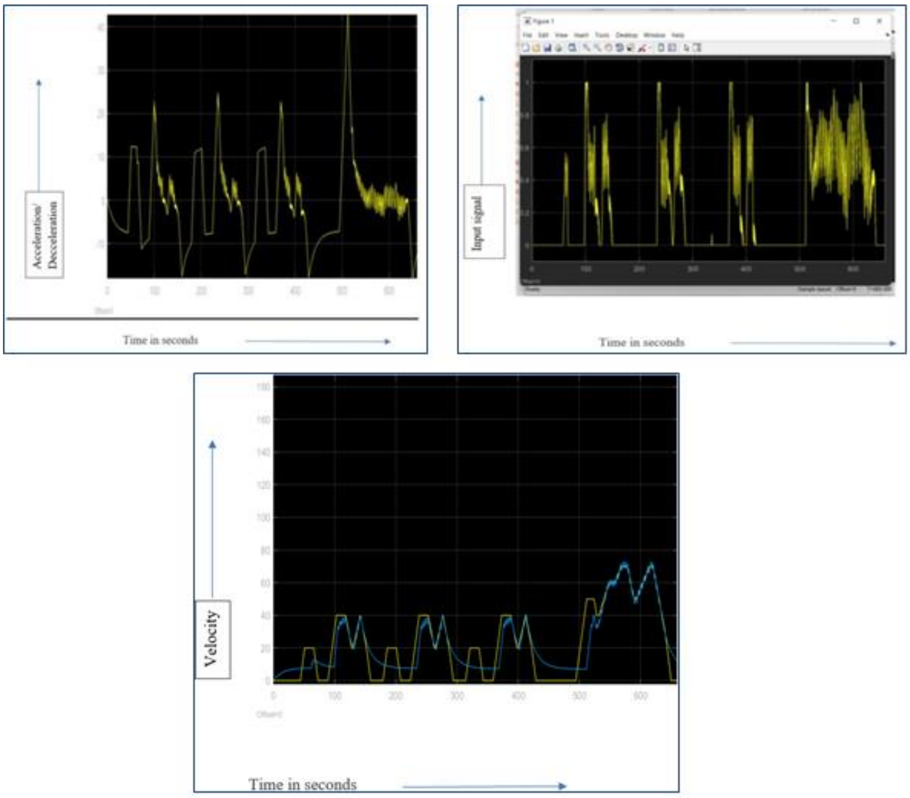

Figure 4: Japanese 10-15 Mode Driving Cycle

4. Conclusion

Modeling an electric vehicle system makes it simple to figure out how much battery capacity an electric car with specified specifications needs to travel a certain distance.

- This model can be used to measure the performance of a vehicle throughout the starting process or when running at a constant speed, as well as to estimate how long the battery can be utilized.
- In this project, we model an Electric Vehicle while taking in to consideration its all the basic system of vehicle body parameters, DC motor, H Bridge, PID Controller, Driver Cycle input.
- We get the feedback input from vehicle body and we sorted it by using descret PID controller.

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Chapter 4

Experimental Investigation of Fluidized bed Gasification with Agro-industrial waste

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Abstract

The present study examines the potential of groundnut shell to engender combustible gas in a fluidized bed gasifier. A fluidized bed gasifier combined of stainless steel tube with inside diameter of 100 mm and a height of 1500 mm, stretch into a 310 mm inside diameter and 400 mm high expanded free board section was fabricated with cleaning and cooling system of cyclone, hydrogen monoxide scrubber and dry filter. A drilled holed distributor plate of 100 mm ID and 200mm OD was utilized for air distribution. The goal of the study is to investigate the effects of reactor temperature and steam to biomass ratio on gas composition of the product gas with gas yield. The experiments are performed in the temperatures range of 550°C to925°C and Steam to biomass ratio of 0 to 1.2. The Equivalence ratio was employed in this study. The most important factor in gasification performance is gasification temperature. The higher the temperature, the greater the gas yield. As the temperature increases, the yield of methane decreases, and that of carbon monoxide and hydrogen increases. The process is influenced by the temperature. The higher the temperature, the better the gas and hydrogen yield. A too-high S/B will lower reaction temperature, and then will cause hydrogen yield to decrement. The highest hydrogen yield per kg of biomass is achieved at the condition of

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temperature 775°C, S/B of 0.81 and parity ratio of 0.17. It is shown that under opportune operating parameters biomass air - steam gasification in a fluidized bed is one efficacious way for the generation of hydrogen-opulent gas.

Keywords: Bio-mass; fluidized bed gasifier; hydrogen-rich gas; carbon monoxide and hydrogen.

1. Introduction

The term refers to all of the products of photosynthesis. In Energy Engineering, the term biomass is only utilized for the portion of plant matter from which thermal energy or mechanical energy is derived. The resulting bio residues are the result of various benefits from all types of flora. The thermal energy is produced by using these bio residues.There are a number of techniques that can be utilized for energy conversion. They are generally classified as (i) thermo chemical conversion methods and (ii) biochemical conversion methods. The methods under the first category are combustion, gasification and pyrolysis. The design of the project is to use bio residues to make mechanical energy. The use of biomass for provincial purposes will be a point of contention [1-2].

India is a developing nation. An important factor in a developing country is energy. Rapid depletion of reserves and flaring consumption of fossil fuels are earnest concerns in the country. The utilization of renewable energy sources could aid relieve these constraints. It stands out as a promising source of energy. The term refers to all the products of photosynthesis [3].

The biomass only refers to the portion of plant matter from which thermal energy is derived. The benefits from all types of flora can be found in the resulting bio residues. The bio residues can be used to trick the productivity of thermal strength or habitual strength. Diminution of glass house gases, reclamation of wastelands, and involvement of agricultural populate can be achieved through the utilization of biomass [4-5].

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There are several ways to convert wood to energy. They are broadly classified as (i) thermo chemical conversion methods and (ii) bio-chemical conversion methods. The aim of the project is to make mechanical energy using bio residues. It's a good idea to convince a fire to burn. When it is burned in a gas burner, it can be used for heating applications. The strength of the gasoline can be used in a workout absorbing design if it is burned in an internal combustion engine.

2. Literature Review

E. M.H.Khater have described on gasification of rice hulls, have discussed the behaviour of a downdraft gasifier of 30cm diameter and140cm height using rice hulls as a fuel. Feeding rates of 1.3-5.1kgh-1 and airflow rates of 2-4.44m^{3}h-1,which corresponds to 26-55% of the stoichiometric amount needed for complete combustion, were used. The minimum fluidization speed is the basic information required for the design and development of fluidized bed processes [6].

Valentino M.Tiangco have published a paper titled on optimum specific gasification rate for static bed rice hull gasifiers, have explained the experimental determination of the optimum specific gasification rate for static bed rice hull gas producers which was conducted for reactor diameters of 16-30cm.The paper was titled. Determination of reactor scaling factors for throat less rice husk gasifier. Four open core throat less batch fed rice husk gasifier reactors having internal diameters of 15.2,20.3,24.4and 34.3cm were designed and manufacture [7-9].

Gasification of hazelnuts in a gasifier was described by M.Dogruetal. A pilot scale downdraft gasifier was used to investigate gasification potential. A filled a mass counter balance has been reported with the tar productivity be rate as well as the gasoline as a situation of send berate [10-11].

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3. Modification of gasification system and experiments

3.1 Fluidized bed gasifier test setup

A bubbling fluidized bed gasifier system was fabricated for an experiment. The installation consists of a fluidized bed gasified, a steam engender, cleaning and sampling system, temperature control system, and the quantification equipment. A fluidized bed system with screw feeder and automatic control unit was fabricated for analyzing the fuel gas deportment and distribution of product yields of different agricultural samples. A control unit with temperature designation was included in the system. The product gas from the gasifier was cleaned and then put into a gas analyzer. The fuel gas from the fluidized bed was used to abstract the dense particles in the storm. After the passage through the typhoon, the gasoline still cools soot particles and tar, so it was cleaned through a dihydrogen monoxide scrubber. The dry and clean product gas was then analyzed in a gas analyzer to quantify the composition of CO, CO_2, CH_4, N_2 and H_2 presence in the fuel gas.

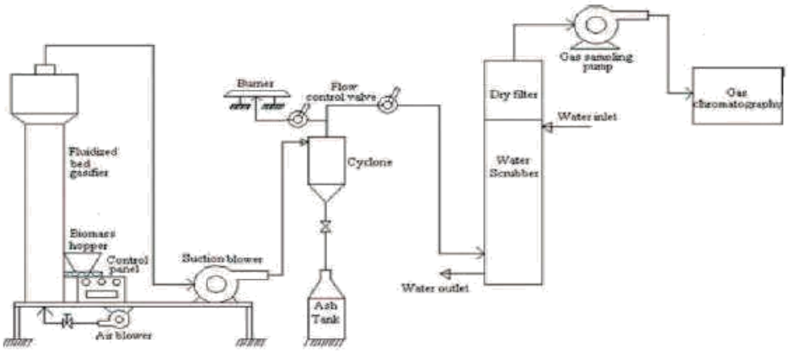

Figure.1: Fluidized bed gasifier setup

4. Result and Discussion

The raw biomass material was then fed through the screw feeder into the chamber. The feed rate was controlled by a motor drive.The supply of air was step by step stopped and the superheated steam at 250ºC was enclose at the lower most of the reactor vessel. The bed was runny as a fluidizing medium. The control panel system was utilized to standard the temperature of the gasifier. Cold gas efficiency is related to HHV gas and HHV biomass. Where the HHV is calculated.

$$\text{HHV biomass} = (H_2\% \times 31.52 + CO\% \times 20.18 + CH_4\% \times 90) \times 4.1868 \ (MJ/Nm^3)$$

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Table 1: Experimental results of different temperatures

Temperature(°C)	550	625	700	775	850	925
H_2%	30.6	31.8	30.3	30.6	30.7	31.2
CO_2%	20.6	20.2	20.4	20.9	20.4	20
CO%	19.3	19.1	19.4	19.2	19.1	19.4
CH_4%	5.8	5.7	5.65	5.9	5	5.7
N_2%	48	49.8	50.9	50.5	48.2	48.8

During the gasification of rice straw and sugarcane bagasse, the frequence of gas composition with bed temperature is analyzed. The temperature of the reactor is varying from 550 to 925°C and the corresponding engendered gas composition is noted. The results were shown in a table. The concentration of hydrogen and carbon monoxide is lower because the amount of volatilizes present is less.

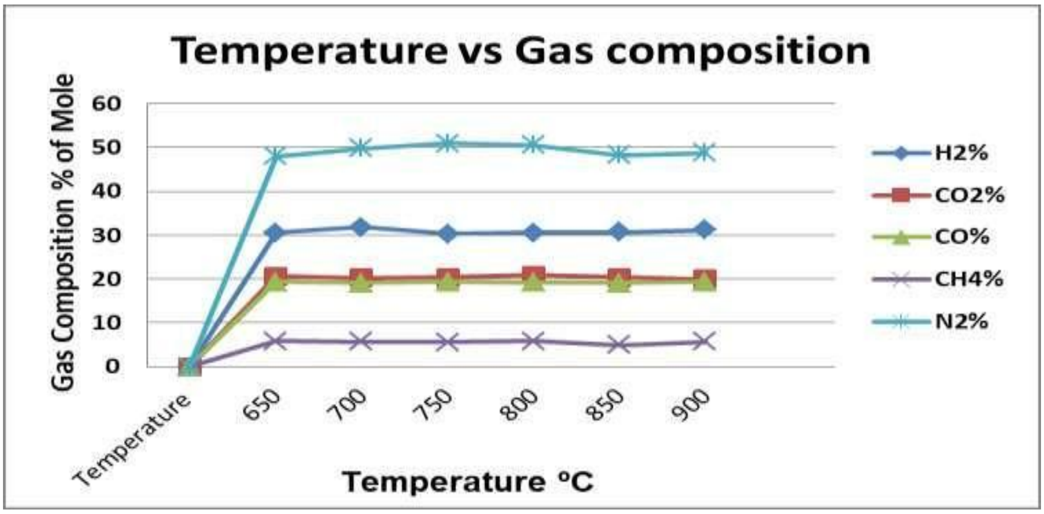

Figure.2: Effect of Temperature on gas composition

The composition of CH_4 varies between 5.02 to 5.9% and the concentration of H_2 is found to be in the range of 30.1 to 32 %.The concentration of CO lies in the range of 19.1 to 19.4 %and the concentration of CO_2 lies in the range of 20.1% to 20.9%. The concentration of N_2 lies in the range of 48 to 50.9% The experimental conditions and data of fluidized bed gasification of rice straw against temperature at fine-tuned steam biomass ratio of 0.40 and biomass victual rate of 10 kg/h are shown in Table 1.

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Table 2: Experimental results of different S/B ratios at bed temperature of 775 °C

S/B	0	0.2	0.4	0.6	0.8	1
H_2%	33.6	34.2	33.6	34.1	34.3	34
CO_2%	29.1	32.8	32.2	33.3	33.4	31
CO%	29.2	29	28.4	27.3	27.2	27.3
CH_4%	5.5	5.2	5.02	5.6	5.5	5.1
N_2%	44.5	40.8	44	42	42.3	43

The effect of steam on gas composition obtained from the gasification of rice straw. The test results were shown in table 2. The extent of decrementation in concentrations was much less than the situation with hydrocarbons release. No consequential changes were observed for CO_2 amounts. The formation of H_2 seems to be favoured for steam/biomass ratio of about 0.6–0.7w/was maximum values were obtained for this range.

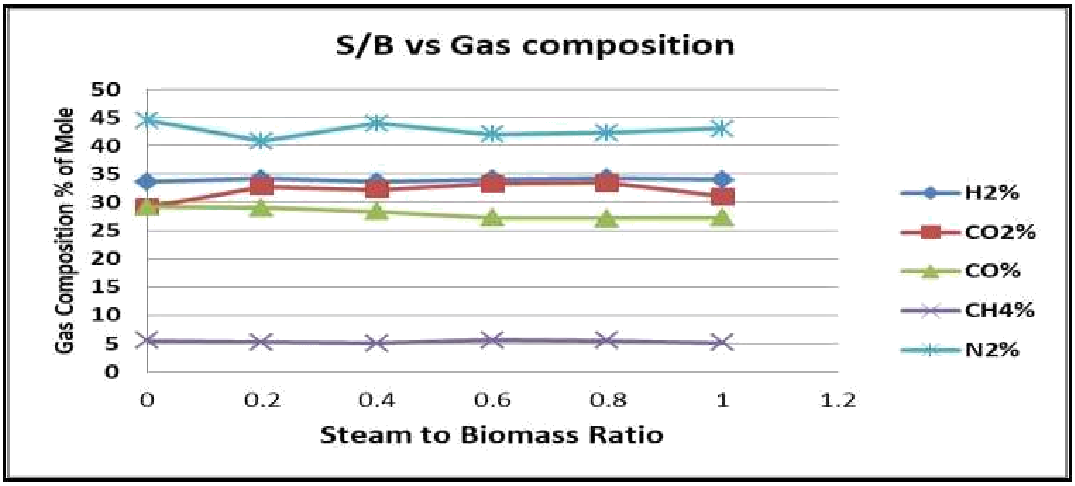

Figure.3: Steam to biomass ratio vs gas composition % of Mole

5. Conclusion

The potential of rice straw and bio gases to create gas in a fluidized bed gasifier is studied in the present study. The experiments are performed in the temperatures range of 550°C to 925°C and steam to biomass ratio of 0 to1.2. The best options for gasification is sugarcane bagasse.

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Chapter 5

Life Cycle Predictor of Lithium –Ion Battery Using Machine Learning for Electric Vehicles

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Abstract

Growing usage of Electric Vehicle calls for the invention of new technologies to increase the effective utilization of the Electric Vehicle and battery technology. The battery is the soul of the electric vehicle, so proper utilization of the battery is very important. This project is decided to predict the Lifecycle of the Lithium Ion Battery with the help of Machine Learning Software. The aging of the battery will increase the operating costs, reduce the service life of the equipment, and affect the safe operation of the equipment. There is no ideal solution for the recycling of Li-ion batteries and it is not environmentally friendly. So, predicting the lifecycle of the battery plays a vital role. With the help of data driven linear regression process, the lifecycle is predicted in a shorter span of time than the conventional methods in practice. This is done with the help of Edge Impulse software which is a development platform for embedded machine learning. Predicting the lifecycle of a battery will be useful for battery manufacturers, people buying used batteries and to operators who own a large fleet of electric vehicles. By knowing the lifecycle of a battery, they can be effectively used for the required application.

Keywords: Electric Vehicle, Lifecycle Prediction, Lithium-Ion battery, Machine Learning, Edge Impulse.

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1. Introduction

Lithium-ion batteries are one of the most widely used batteries today mainly because of their continual dropping price in industry, high energy densities, high cell working voltage, and good power capability. Companies and consumers need to know the cycle lifetime of the battery, defined as the number of charging and discharging cycles after which the battery capacity drops below 80% of the nominal value, primarily for commercial and technical reasons relating to warranty and remaining useful life of the product overall. Manufacturers using lithium-ion batteries ranging in applications from mobile phones to electric vehicles need to know how long batteries will last for a given service life. To understand this, expensive testing is required. The main objective of this paper is to predict the lifetime of lithium-ion battery using data driven method. This paper utilizes the data and methods implemented using edge impulse software, thus reducing the time taken to predict the life cycle of batteries.

2. Methodology

To predict the Life cycle of Lithium-Ion battery, there are many methods are available. One of the common methods is by linear interpolating the discharge capacity to the life cycle. In a conventional method, to estimate the life cycle using discharge capacity method, it takes 2 hours 30 minutes of time for 2500mAh- single Lithium-Ion cell. In data-driven method, a TinyML model is developed using Edge impulse based on Linear regression method to predict the life cycle of a battery in 1-hour time period. This could save 90 minutes of time compared to normal conventional method. This type of method is very useful in fleet management industry having battery swapping technology. Simple Linear Regression is a type of Regression algorithms that models the relationship between a dependent variable and a single independent variable. The relationship shown by a Simple Linear Regression model is linear or a sloped straight line, hence it is called Simple Linear Regression.

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The Simple Linear Regression model can be represented using the below equation:

$$y=a0+a1x+\varepsilon \qquad (1)$$

Where,

a0= It is the intercept of the Regression line (can be obtained putting x=0)

a1= It is the slope of the regression line, which tells whether the line is increasing or decreasing.

ε = The error term. (For a good model it will be negligible)

3. Literature Riview

In the paper produced by Ayon Dey [1] on Machine Learning Algorithms: A Review various machine learning algorithms were discussed. These algorithms are used for various purposes like data mining, image processing, predictive analytics, etc. The main advantage of using machine learning is that, once an algorithm learns what to do with data, it can do its work automatically. With abundance of dataset in existence which can be positively used to teach the machine how these data can be used in an effective way to train themselves to provide better, accurate results. The Supervised machine learning algorithms are those algorithms which needs external assistance. The input dataset is divided into train and test dataset. The train dataset has output variable which needs to be predicted or classified. The unsupervised learning algorithms learns few features from the data [3].

The Data-driven prediction of battery cycle life before capacity degradation by Kristen A et al [2], paper deals about Data-driven modelling which is a promising route for diagnostics of lithium-ion batteries and enables emerging applications in their development, manufacturing and optimization. It covers the development cycle life prediction models using early-cycle discharge data yet to exhibit capacity degradation, generated from commercial LFP/graphite batteries cycled under fast-charging conditions. In the regression setting, an overall test error of 9.1% using only

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the first 100 cycles is obtained; in the classification setting, an overall test error of 4.9% using data from the first 5 cycles is obtained [4].

4. Architecture And Model Setup

The data of standard charging and discharging cycle of a lithium-ion battery is taken by referring journal papers and these graphs are plotted using MATLAB signal builder. Then these values are fed to the edge impulse software as training data. Now the model is trained using linear regression model and this is ready for testing purpose. After creating the prediction model, the voltage of the battery is sensed using voltage sensor [5-6]. Then these analog values are given to Arduino Nano 33 BLE board and these data are used as testing values for predicting the life cycle of the battery. Here the data from 30 to 60 minutes of discharge cycle is considered for training purpose. Different discharge cycles with different load are considered for training data for better accuracy. Hence more the data given more accurate the model will be.

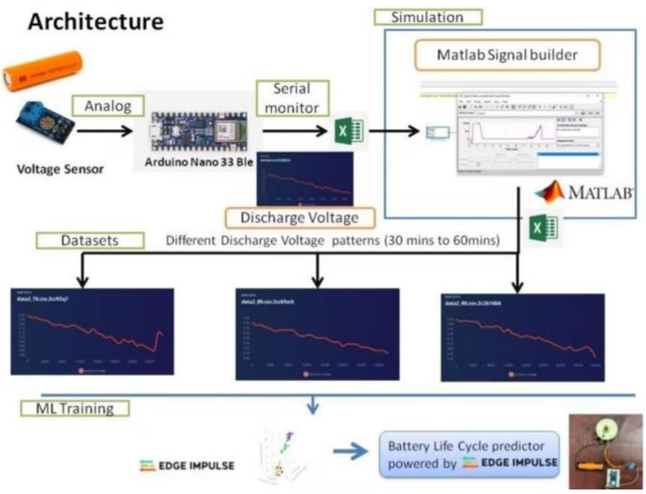

Fig.1: Process Flow

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4.1 Data Acquisition:

For carrying out Machine learning in edge impulse data was needed for training as well as testing the model. Thus data is needed to be collected for it. The voltage data and timestamp value taken from the journal and reference images were added in the excel sheet (timestamp in column x, voltage data in column y). Each graph data was added as a separate dataset by entering the data in separate sheets in the given format below.

	A	B
1	timestam	data
2	0	3.67
3	60	3.67
4	120	3.56
5	180	3.52
6	240	3.49
7	300	3.48
8	360	3.45
9	420	3.42
10	480	3.41
11	540	3.37
12	600	3.37
13	660	3.35
14	720	3.34
15	780	3.34
16	840	3.34
17	900	3.3
18	960	3.3
19	1020	3.24
20	1080	3.23

Fig-2: Timestamp and Data Column in Excel Sheet

The excel sheets were saved in the CSV format type such that it can be uploaded in the edge impulse interface. For getting data from MATLAB, a model was created.

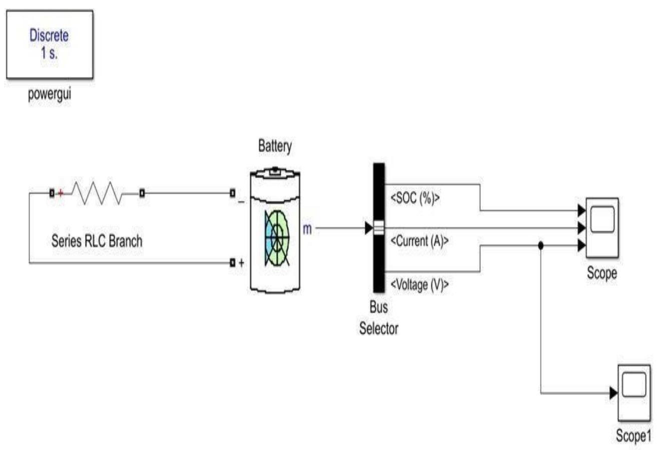

Fig-3: MATLAB Model of Li-Ion cell

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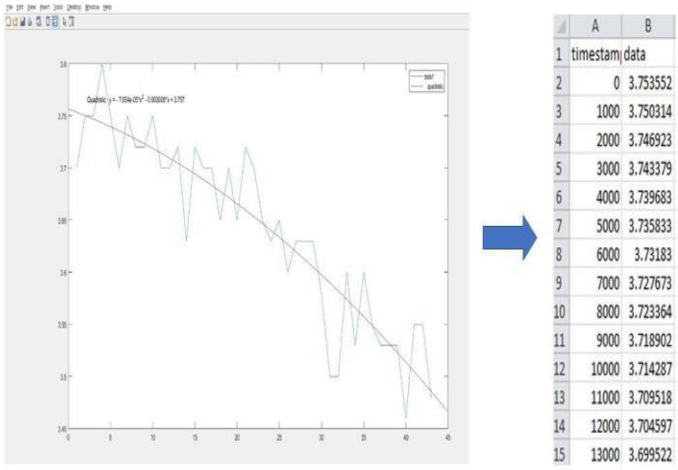
The value obtained from the voltage sensor in the Arduino interface is transferred to the excel sheet. The fluctuation in the voltage values is removed by curve fitting [7-8]. In edge impulse software every minute is considered to be 1000ms.



	A	B
1	timestam	data
2	0	3.753552
3	1000	3.750314
4	2000	3.746923
5	3000	3.743379
6	4000	3.739683
7	5000	3.735833
8	6000	3.73183
9	7000	3.727673
10	8000	3.723364
11	9000	3.718902
12	10000	3.714287
13	11000	3.709518
14	12000	3.704597
15	13000	3.699522

Curve fitting CSV Format

Fig-4: *Testing Data conversion according to Edge Impulse*

5. Results and Discussion

The results obtained are as follows:

- Predicted Voltage: **2.73295 V**
- Predicted Capacity: **1943 mah**
- Predicted Lifecycle: **667 cycles**

Results obtained are analysed

- By varying the time of testing data.
- Repeating the same procedure for the same time of testing data.

The time for testing data is varied in the testing data tab of the edge impulse software. Different input timings were given (10 minutes, 20 minutes, 30 minutes, 45 minutes,1 hour and 1 hour 30 minutes) and their results were compared.

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Table 1: Comparison of First and Second Iteration

Parameters	First Iteration	Second Iteration
Predicted Capacity	1943 mah	1949 mah
Predicted Lifecycle	667 cycles	660 Cycles
Predicted Voltage	2.73295 V	2.73496 V

6. Conclusion

Electric Vehicles are environmentally-friendly and energy-efficient to meet the requirements of green and energy conservation with the help of green energy power sources, namely, battery systems. The reuse of Lithium Ion battery will have huge market demand in future. The main aim of the project is to predict the life cycle of the battery so that it can be reused effectively based on the application. The prediction of life cycle of the Lithium-Ion cell is done with the help of a machine learning model in a software named Edge Impulse. To do this, the voltage values of lithium-ion cell was obtained while discharging the cell under constant load condition. These values were used as the testing dataset in the ML model. The training dataset needed were obtained from MATLAB model and reference journal papers. These datasets were trained in edge impulse interface and were deployed in Arduino CLI to infer the results. The resultant value (667 cycles) of battery life cycle was found out to be within the range (500-700 cycles) as per the battery manufacturer specifications. So this kind of ML model can be used to reduce the time taken to find the life cycle of the battery when compared to conventional methods. The ML model proposed was found out to be accurate and time saving in predicting the life cycle of the Lithium-Ion battery cell.

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Chapter 6

Impact of nanocoated heat exchanger with material behaviour of Silica nanoparticles /water nanofluid

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Abstract

Engineers use of nanofluid in TES system, heating and cooling system, space heating and modern building, and smart fabrics for the comfort of the human has recently received a lot of attention. The role that nanofluid-based energy systems can play in reducing global gas emissions and saving energy is now in focus. Studies show that nanofluid based on SiO_2 has physical characteristics that make it interesting fluid, particularly in industrial settings where there is substantial heat flow. SiO_2 nanofluids based on the water were studied for potential applications in heat transfer. Commercial nanofluids were used to create dispersed solutions of the cited nanofluids in three distinct concentration of 0.01% vol., 0.05% vol., and 0.1% vol.. The produced nanofluid density, viscosity, and thermal conductivity were measured.

Keywords: Nanofluid; thermal conductivity; viscosity; SEM; concentration.

1. Introduction

At the moment, heating represents one of the most significant and challenging technical challenges facing the industry. Traditional cooling methods that make use of extended surfaces (fins, microchannels) are beginning to reach their limits as the demand for faster and smaller devices continues to grow. This is leading to an increase in the amount of thermal load that must be cooled. As a direct consequence of this, there is an immediate requirement for advancements in heat removal technologies [1]. Because the nanofluid has been developed and, in some cases, demonstrated to have excellent potential for improved heat transfer capabilities, it is an appropriate candidate for the current cooling challenges. It has been reported, for example, that the effective thermal conductivity of ethylene glycol or oil contains Because the nanofluid has been developed and, in some cases, demonstrated to have excellent potential for improved heat transfer capabilities, it is an appropriate

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candidate for the current cooling challenges. For example, it has been reported that ethylene glycol or oil containing less than 1% volume concentration of nanoparticles increases effective thermal conductivity by 40% and 150%, respectively, over the base fluid [2]. This is in comparison to the thermal conductivity of the base fluid. The thermal conductivity of a SiO_2-water nanofluid increased by 30% and 10% when nanoparticles with diameters of thirteen nanometers and forty nanometers were suspended in the base fluid at a volume fraction of four point three percent, respectively. This was the case when the volume fraction was 4.3 percent.

The thermal conductivity of the nanofluid increased by up to forty percent when copper particles with a diameter of ten nanometers were suspended in water at a concentration of three percent, which is much lower than the original concentration. The original concentration was much higher than 3%. In the presence of less than 1% nanoparticles, the volume concentration increases by 40% and 150%, respectively, over the base fluid [3]. When nanoparticles with diameters of thirteen nanometers and forty nanometers were suspended in the base fluid at a volume fraction of four point three percent, the thermal conductivity of a SiO_2-water nanofluid increased by thirty percent and ten percent, respectively. Furthermore, when copper particles with a diameter of ten nanometers were suspended in water at a concentration of three percent, which is much lower than the original concentration, the thermal conductivity of the nanofluid increased by up to forty percent.

The nanofluid thermal conductivity has been attributed to a wide variety of causes and mechanisms, all of which have been put forward as potential explanations. In their proposal, Eastman and colleagues discussed the properties of heat transport in nanofluid as well as the impact of nanoparticles clustering and the Brownian motion of nanoparticle. Liquid layering is the process of aligning fluid molecule along the surface of a nanoparticles in order to create a more ordered structure. This is done in order to make the nanoparticle more stable. In spite of the fact that a great deal of research has demonstrated that nanofluids have increased thermal conductivity, more recent research has shown that the opposite is true. Nanofluids were found to be ineffective as heat transfer fluids based on the findings of a benchmark study of their thermal conductivity, which found no anomalous increases in thermal conductivity [4-5].

The utilisation of nanofluids in thermal energy storage systems, heating and cooling microelectronic systems, space heating or cooling in contemporary buildings, and smart textiles for the purpose of energy harvesting and distribution are all examples of promising applications of this technology [6-7]. The contribution of nanofluid-

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based energy systems to energy savings and the reduction of global gas emissions is of interest now. The produced nanofluid density, viscosity, and thermal conductivity were measured.

1.1 Nanofluid preparation

The creation of nanofluid can either be accomplished in a single step or in two distinct stages, depending on the method that is chosen. The second method results in the production of nanoparticles, which are then distributed throughout the fluid. However, the latter method is less advantageous because the nanoparticles have a tendency to aggregate before dispersing[8-10]. In the one-step method, nanoparticles are made and spread in the same step. This keeps the nanoparticles from getting oxidized.

1.2 Benefits of nanofluids

The following advantages of nanofluids over traditional fluids make them suitable for a variety of heat transfer and heat exchange applications.

- By adjusting the particle size, shape, material, and concentration of nanoparticles, it is possible to maximise energy absorption.
- Because of the extremely small size of the nanoparticles suspended in the fluid, the surface area and heat capacity of the fluid increase.
- The increased thermal conductivity caused by the nanoparticles in suspension improves the efficiency of heat transfer systems.
- The fluid's transverse temperature gradient is flattened by the dispersion of nanoparticles.
- By adjusting the nanoparticle concentration, fluid characteristics can be altered to make them suited for various applications.
- The produced nanofluids density, viscosity, and thermal conductivity were all measured.

2. Literature review

Pak and Cho found that using 1.34% and 2.78% particles increased the heat transfer coefficient by 45% and 75%, respectively. An increase in thermal conductivity is not the only possible explanation for this rise in temperature. The opposite was found to be true which compared the enhancement of heat transfer for a constant average velocity, the output showed a decrease in the heat transfer coefficient ranging from

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3% to 12%. Yang et al. show that there is only a very low level of enhancement, which is in line with the finding that no abnormal increase in the heat transfer coefficient.

An analogous experiment was carried out by Xuan and Li, but this time with larger copper nanoparticles. According to the results of their investigation, the coefficient of heat transfer increased by 40 percent when the velocity was held constant. Heris et al. arrived at the same conclusions when they dispersed CuO and SiO_2 particles in water. People assert that the improvement in HTC was brought about by Brownian motion, chaotic movement of particles, particle dispersion, and other processes in addition to these.

Ding et al. looked into the thermophysical characteristics of metallic oxide particles that had been dispersed in water. Both SiO_2 and TiO_2 For the purpose of determining the thermal conductivity of nanofluids, the transient hot wire method was utilised. It was discovered that the thermal conductivity of the nanofluids is noticeably higher than that of the base fluid. At a volume concentration of 4.34%, the thermal conductivity of SiO_2-water nanofluids and TiO_2-water nanofluids was approximately 32% higher than that of the base fluid, while the conductivity of TiO_2-water nanofluids was approximately 11% higher.

3. Nanofluid Preparation

The creation of nanofluid is the first critical step in using nano-phase particles to change the heat transfer rate of conventional fluids. The nanofluid refers to more than just a mixture of liquid and solid. The main components of nanofluids, which can be easily dispersed in heat transfer fluids including hydrocarbons, water, EG, and fluorocarbons with the addition of stabilising agents, are carbides, oxides, metals, and carbon nanotubes. Several other processes, such as gas condensation, mechanical attribution, or chemical precipitation, can also result in the production of nanoparticles. These nanoparticles can be created in cleaner environments and with the surface shielded from any unanticipated coatings that can develop during the gas condensation process. The demerit of this approach is the particles produced by it occasionally lack the potential to form pure metallic nanopowders. Direct evaporation and condensation procedure can help to reduce the emergence of such a problem. This method produces particles for stable nanofluids without the use of surfactants or other electrostatic stabilisers; however, it has issues with pure metal oxidation. Because viscosity increases with volume fraction, increased pumping

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9 788196 209803

power is required to circulate the nanofluid. It is obvious that this will have a significant impact on how well heat is transferred in non-still fluids.

3. Results and Discussion

3.1 SEM Image

SEM image analysis from a scanning microscope presented in figure 1 and revealed that depending on the anodizing conditions used, multiple structures of the oxide layers' surface morphology can be obtained.

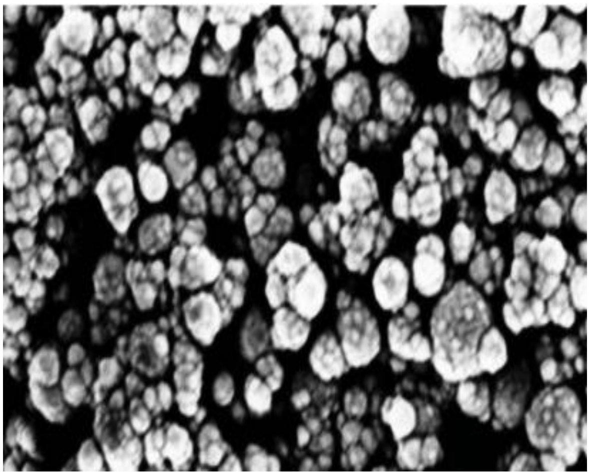

Figure. 1: SEM image of SiO_2 nanoparticles dispersed in water

3.2 Water-based SiO_2 nanofluid viscosity characteristics

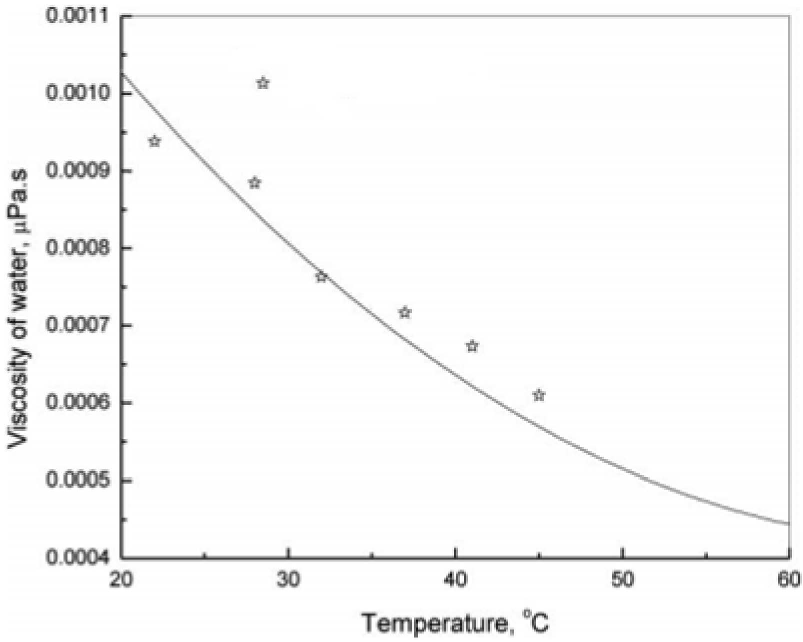

Figure. 2: Measurement of viscosity with water

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Aqueous alumina nanofluids were subjected to tests to determine their rheological characteristics in the particle vol. proporation range of 0.01%-1% and in the temperature range of 20 to 45 °C. Water was used as the sampling fluid in calibration experiments for the viscometer, which was done at various temperatures. This could be caused by the nanoparticles from nearby fluid particles adhering to the surface and creating clusters, which would raise relative viscosity. Other potential explanations for the discrepancy between experimental results and theoretical predictions include pH, surfactant, or inter molecular force changes, all of which have a substantial impact on how viscous nanofluids are. Additionally, Figure 2 shows that viscosity increases non linearly as particle concentration increases.

4. Conclusion

The thermal conductivity and viscosity of a nanofluid containing SiO_2 nanoparticles have both been examined in this research, with and without the use of surfactant. Temperature, surfactant type, and loading have all been carried out prior to measurement, as well as the synthesis and characterization of the nanofluid. Studied the properties of nanofluids at five different concentrations of particles (0.1%, 0.5%, 1.0%, 1.5%, and 2.0%) at temperatures ranging from 20 to 60 °C. To test how stable the nanofluid (water) is different surfactants, like SDBS, SDS and cetyl trimethyl ammonium bromide have been added to the base fluid.

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