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CONTENTS

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EDITORIAL

A multidisciplinary approach to engineering

Anna Hnydiuk-Stefan*[1]*,

[1]*Opole University of Technology, Opole, Poland*
https://orcid.org/0000-0002-0694-5393

***Corresponding author:* editor@goldfieldsci.com**

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Editorial

On behalf of the entire Editorial Board, I am very pleased to announce the launch of a new journal called the Multidisciplinary Journal of Engineering Sciences. As the name suggests, it is a journal associating works in the broadly understood field of engineering. In today's world, advancements related to technology and engineering play a significant role in the lives of people around the world. Engineering data is becoming more complex, covering ever-larger areas of related disciplines and an ever-expanding time span. When considering a single, but very important part of engineering sciences, namely the environmental area, we can see that data solving the multidisciplinary problems confronting today's engineering researchers involves the knowledge to use available data and information to make their decisions [1]. Engineering issues that will be considered in the publishing process in the discussed journal include in particular such areas as chemistry and physics, which are the basis of engineering research. Therefore, already at the stage of education in the field of engineering, the curriculum should include issues related to chemistry [2]. It is similar to the field of physics, physics courses are among the main subjects for mechanical and electrical engineering students [3]. Therefore, conducting research in this area and publishing their results openly to everyone is extremely important nowadays. Advanced research on materials has seen the development of issues from the macro to the nanoscale. The creation of technology using nanomaterials is one of the greatest technical achievements that took place at the end of the 20 century. Currently conducted research is more and more advanced and developed. It is expected that scientific and technological progress in the current century will be very much determined by the achievements related to nanomaterials and their application in various domains of scientific and engineering studies [4]. Nanoscale is currently being used, for example, in a form of carbon-based nanomaterials where it has gained considerable importance for a number of usages. Their excellent physicochemical characteristics have prompted intensive research to assess their capability as gas sensing materials [5]. In turn, issues related to carbon will be an important part of the energy, environmental protection, and mining related to the extraction and exploitation of coal, and thus the release of significant carbon dioxide emissions. Coming back to the materials issue, in the last couple of decades, high-tech polymeric materials have become more common in developing environmentally friendly uses for the agricultural sector. Intelligent polymer solutions have made a huge contribution to the agro-industry by increasing the productivity of fertilizers, as well as pesticides and herbicides. [6]. Bioengineering is an important element in broadly understood engineering, as it is connected with agriculture and industry systems, which are valid subject of this journal. The digital intelligence industry is the frontline industry of social progress these days. Among other things, it plays a role in economic development and is also exposed to global competitive pressures [7]. Hence, this journal could not be complete without issues related to new information and electronic technologies and on existing problems in the development of electrical engineering. Another thematic group covering engineering issues in a related way includes engineering management, which concentrates on integrating scientific, engineering and management issues to successfully and effectively make a contribution to the operation of industry, society and organizations [8]. Current social and technological changes pose new challenges to researchers following the latest scientific discoveries. Commitment to the development of knowledge needed to design more efficient socio-technical systems is particularly important from an engineering point of view. The scope of this type of research includes industrial engineering and production processes, management engineering, and technological processes. This discipline brings together management, taking into account the technical nature of the managed processes, which makes up engineering management. The last of the important parts falling within the scope of the journal is the construction, operation, and modification of processes and technological products.

Types of articles, objectives, and scope

The new open-access journal, established under the title of Multidisciplinary Journal of Engineering Sciences, is an international peer-reviewed open-access journal, which allows readers to access the content of the articles free of charge, and consider for publication articles covering all the areas described above. We highly encourage academic authors from around the world to publish research results in this journal. All articles undergo a thorough review process to ensure the highest quality of published content for readers.

Conflict of interest:

The author declares no conflict of interest.

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OPEN ACCESS ARTICLE

FULL LENGTH ARTICLE

Electrical System Audit of a University Laboratory

Edgar P Cortes[1], Mary Grace T. Cortes [2]

[1]College of Engineering, Technology & Architecture, University of the Visayas, D. Jakosalem St, Cebu City, 6000 Cebu Philippines; https://orcid.org/0000-0003-3427-8687
[2] Graduate Student , Cebu Technological University, R. Palma St., Cebu Philippines; https://orcid.org/0000-0002-6656-2810

***Corresponding author:* edgar_cortes@uv.edu.ph**

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Abstract

An electrical system audit is important in every building or dwelling to ensure the safety of the occupants. The audit was conducted following the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) level 2 standard. In this study where the locale is a university laboratory, results found that there is a thermal anomaly in the main distribution panels, which is an indication of a loose connection or possible overload and leads to technical system loss, loss of energy and cause a fire in the long run. There are also multiple cable splices going to the distribution panel, which is a violation of the electrical code. The lighting in the area does not meet the required illumination for laboratory safety. Moreover live bus bars were exposed on the distribution panel.

Keywords: illumination; hot spot; safety; systems loss; electrical panels

1. Introduction

Many elements have affected the environment, and have directly affected people. Well-designed environments make people happy, energize and vice versa. These elements start with building structure and shape, and are complete with a color, light, electrical system, outside viewing, and furnish. Sometimes, the influence of light through a good electrical system in the environment is much more than other elements. Understanding the relationship between light, good electrical systems, and the environment can help designers or architects to improve interior designs for better performance (Samani S., 2011). Electrical system design has become increasingly significant to electrical designers and engineers. With the advent of high energy costs, designers have needed to become more aware of electrical systems. In an electric utility system, loss means the difference between the amounts of sent energy from a station and the building amount to customers in an electrical system. Invariably, laboratories, commercial buildings, schools, and households' electrical distribution systems are no exception on it.

In these important aspects of an electrical distribution system, electrical power, and energy lost when transmitted to customers can represent a significant expense to Cebu Technological University – Hitachi Robotics and Metrology Laboratory which is our locale of the study. Reducing electrical losses through the enhancement of the present installation will limit the associated economic burden. For Cebu Technological University – Hitachi Robotics and Metrology Laboratory, it is difficult to state in general terms what savings might achieve by implementing economically justifiable measures to reduce electrical system deficiencies. It has existing systems that already consist of low–loss components and configuration, but those old lines and equipment may discover numerous possibilities to achieve losses. In the process of eliminating electrical system deficiencies, this study proposes a defect identification methodology using Plan – Do – Check – Act and determined which component contributes greatly to the electrical system, therefore this study. The electrical grid that spans continents is typically made up of a few large networks. Within those networks, all hundreds of thousands of electricity flow freely among lines and distribution cables of many electrical systems following Kirchhoff's Law (IEEE Spectrum, Jul. 2003).

Bringing power from generation delivery points to the customers and transforming the same to lower voltage, electricity is dissipated or lost. The transmission of electricity results in some loss of electrical energy even in the most efficient systems (IEEE Spectrum, Jan. 2004). In the Philippines, the extent to which losses occur due to electrical installation deficiencies in any electrical distribution system is measured by the value called efficiency. The lost electrical energy is bought by the utility company and resold to the customer, this unpaid energy results in major operating costs. The components of cost are usually combined into a single figure either in terms of cents per kilowatt-hour of total energy loss or the amount per kilowatt-hour of peak loss. Expressing losses in terms of money per kilowatt is called capitalized cost of losses and in some advantages in that, it shows directly the amount of money that could be economically spent to save 1kw of losses (Hazan, 1982).

Department of Energy estimates that at least 154 TWh will be needed in the next decade as baseline consumption for end–use lighting. In this case, it is very important for Cebu Technological University – Hitachi Laboratory to determine the optimal levels of illumination requirements to save energy.

2. Research methodology

The researcher used acausal–the comparative research method. This study sought to determine particular, actual situations as they are. It involved an assessment of the electrical system of Cebu Technological University – Hitachi Robotics and Metrology Laboratory, analysis of data gathered, and interpretation of conditions that exist under the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) level 2 standard.

This study aims to assess the electrical system of Cebu Technological University – Hitachi Robotics and Metrology Laboratory, determine design deficiencies, and present corrective actions. Surveys are administered through actual site inspection, interviews, and functional group discussions of the administrators involved. The ocular inspection had been conducted to check the total connected load, evaluation through the use of a thermal imager and other electrical analyzing instruments to circuit breakers, circuit home runs, and electrical panels, grounding system protection, illumination, and observed violation to existing standards. Field interviews focusing on the practices, equipment failure incidents due to low or high voltage, breaker failure, and other related useful data had been conducted.

The data gathered through interviews and ocular inspections and from results through the use of electrical analyzing equipment were tallied and treated statistically. Recommendations, analysis, interpretation of data, and recommendations are patterned to a commonly used tool, the Plan – Do – Check – Act cycle. Figure 1. shows the research flow diagram using the PDCA cycle.

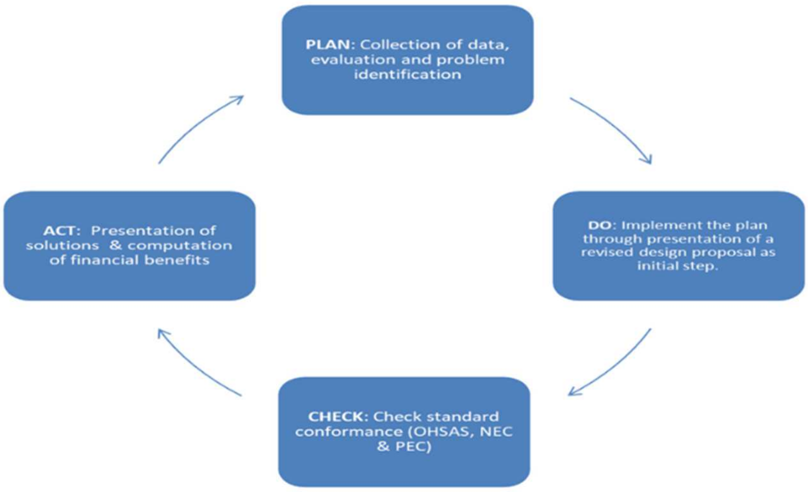

Figure 1. Flow of the study.

3. Results and discussions

Cebu Technological University – Hitachi Robotics & Metrology Laboratory is subdivided into four rooms, these are Mechatronics Laboratory No. 4, Mechatronics Laboratory No. 3, Lapping Area, and Office of the Dean. Mechatronics Laboratory No. 4 has a total area of 72.6 square meters, Mechatronics Laboratory No. 3 with a total area of 43.45 square meters, Lapping Area with 100.04 square meters, and Office of the Dean with a total area of 15.82 square meters. Finished floor level to ceiling has a total height of 3.70 meters while work plane to ceiling has a total height of 2.90 meters (measured from the top of the laboratory table to ceiling reinforced concrete slab).

Nine (9) identified locations were tested using an Illumination meter to test current illumination in each room at CTU – Hitachi Robotics and Metrology Laboratory, for the data collection. Figure 2 shows an estimated location where the test was conducted, the position of the instrument is above the work plane. The work plane is an estimated distance from the finished floor level to the tabletop where most of the equipment is positioned and of the same level. Table 1. shows the tabulated result taken at a selected significant location/room in comparison to the Occupational Health and Safety Standard as amended by the Department of Labor and Employment which states that: “A minimum of 300 lux (30-foot candles) shall be provided where close discrimination of details is essential”.

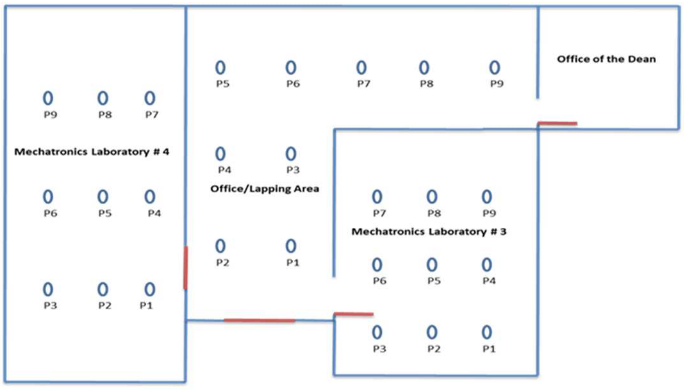

Figure 2. Measured illumination taken at different point at CTU – Hitachi Robotics & Metrology Laboratory.

Table 1. Tabular illumination in Lux using illumination meter.

Point(s)/Location	Measured Illumination (Lux)	Standard Illumination (Lux)
Mechatronics Laboratory # 3		
1	112	300
2	134	300
3	225	300
4	60	300
5	86	300
6	45	300
7	90	300
8	48	300
9	114	300
Mechatronics Laboratory # 4		
1	56	300
2	237	300
3	40	300
4	95	300
5	61	300
6	59	300
7	207	300
8	194	300

Point(s)/Location	Measured Illumination (Lux)	Standard Illumination (Lux)
9	30	300
Office/Lapping Area		
1	134	300
2	60	300
3	103	300
4	98	300
5	227	300
6	23	300
7	285	300
8	226	300
9	178	300

The scatter graph in Figure 3. shows that there is a strong positive relationship between Mechatronics Laboratory No. 4 and the Lapping/Office area with the standard illumination for laboratories. These are indicated by the red and green regression line going up while strong negative relationship for data measured at the Mechatronics Laboratory No. 3 concerning standard illumination for laboratories as indicated by the black regression line going down. Data also show that no single point of reference in the three rooms being measured meets the 300 lux (30-foot candles) illumination requirement based on the standard. Overall these laboratories did not meet the required illumination standard for laboratories. The scatter plot indicates uneven illumination.

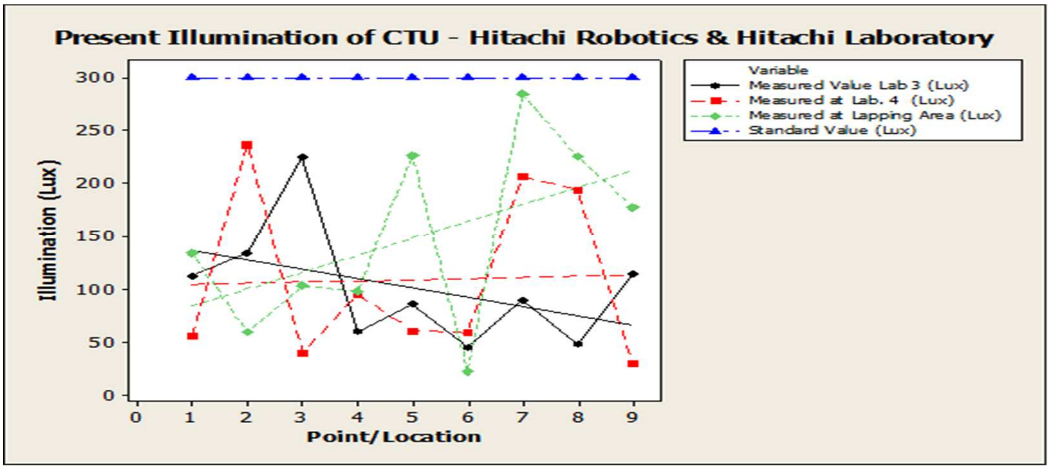

Figure 3. Scatter plot result on measured illumination vs. standard data illumination for Hitachi Robotics & Metrology Laboratory.

Cebu Technological University's main transformers are oil–immersed transformers located on the front of the building mounted in a transformer pad. The total installed capacity is 750 kVA, composed of 3 – 250 kVA individual transformers interconnected together in a wye-delta configuration. The primary voltage rating is 23,000 volts (23kV) and the secondary is 240 volts in a line-to-line configuration. The transformer location is too close to a building without space separation. The National Fire Protection Association (NFPA) 70 also known as National Electrical Code Handbook, 2002 Edition under article 450.27 requires that combustible materials, combustible buildings, and parts of the buildings shall be safeguarded from fires originating in an oil–immersed transformer installed to or adjacent to a building. In case the transformer installation presents a fire hazard, one or more of the following safeguards shall be applied according to the degree of hazard involved. These are space separation, fire-resistant barriers, automatic fire suppression systems, or an enclosure.

Figure 4. shows the thermal scanning images using Fluke Ti25 Thermal Imager. A temperature reading has an average of 40.2 degrees Celsius with a maximum of 45.5 degrees Celsius which appears to be normal. The object distance is 1.5 meters from the equipment taken at 2:20 in the afternoon; the weather is dry with an ambient temperature of 29 to 30 degree Celsius.

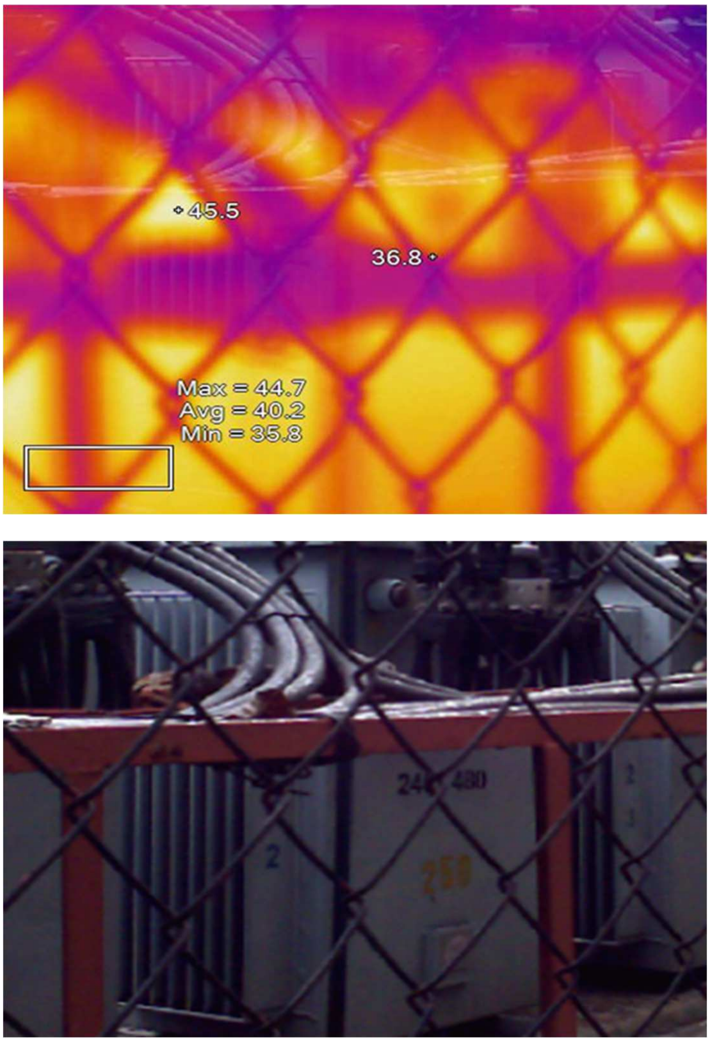

Figure 4. Thermal scanning and actual images of CTU 3 x 250kVA transformer

Four cables per phase of 250 square millimeters, THHN used as main conductors from the transformer to the main distribution panel. It was also observed that there are splices in between the transformer and 1,800 amperes main circuit breakers line side of the main distribution panel. The live bus bars in the panel board are exposed to dust accumulation. Figure 5. shows splices between two terminals. The National Fire Protection Association (NFPA) 70 also known as National Electrical Code Handbook, 2002 Edition under article 300.13(A) states that splices or taps are prohibited within raceways unless the raceway is equipped with a hinged or removable cover.

Figure 5. Cable splices from transformer towards main distribution panel

The main distribution panel is located inside the building with 1800 amperes, three-phase, and 240 volts main with four branches, these are 600 amperes, three-phase, 2 by 100 square millimeters in diameter THHN cable for College of Education; 400 amperes, three-phase, 2 by 100 square millimeters in diameter THHN cable for Administration Building; 400 amperes, three-phase, 1 by 100 square millimeters in diameter THHN cable for College of Technology Building and 125 amperes, three-phase intended as spare. It was observed that the bus bars of the main distribution panel are exposed and the entrance door has no restriction. Hotspots were also found on the load and line side of the breakers and a potential sign of a loose connection.

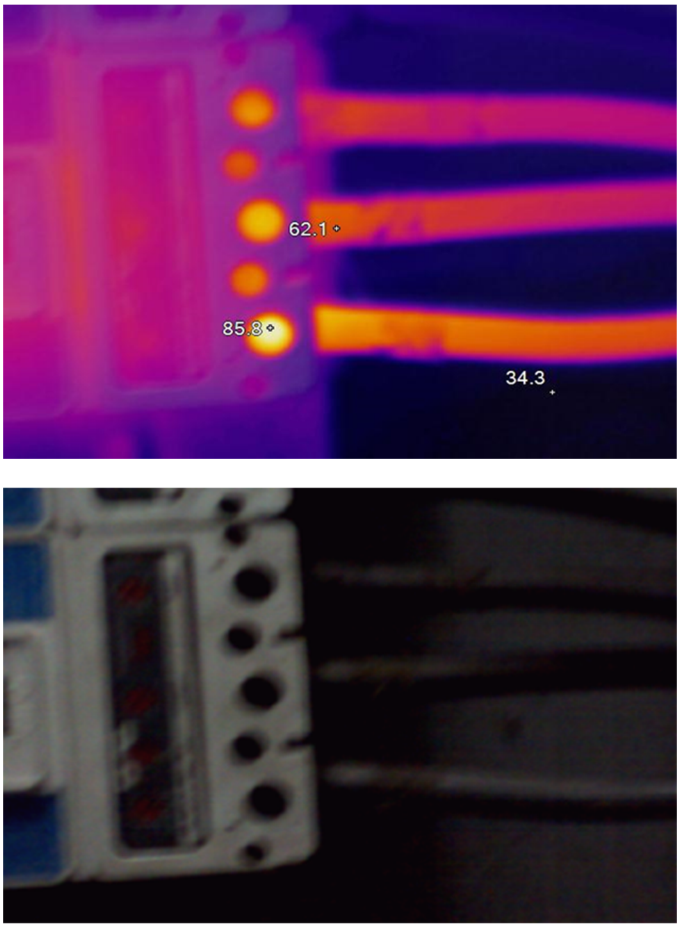

Figure 6. Hot spot at 400 Amperes supplying College of Technology

Figure 6. shows the thermal scanning images using Fluke Ti25 Thermal Imager. Temperature reading has a maximum of 85.8 degrees Celsius; object distance is 1.5 meters from the equipment taken 2:30 in the afternoon, weather is dry with an ambient temperature of 29 to 30 degree Celsius. Results show that there is t hot spot in the component and a sign of loose contact.

4. Summary and conclusions

Based on the results of the study, it was found that there is a hot spot in the main distribution panel which is an indication of loose contact and an overload system. Hot spot contributes to technical systems loss. There were no available barriers between the transformer and the main building which is a safety concern. Unenclosed multiple cable splices going to the main distribution panel which is a violation of the electrical code. Present illumination did not meet the Occupational Safety and Health Standard which requires a minimum of 300 lux for laboratory application. There are also exposed/unsecured live bus bars at the main distribution panel. The distribution panel/feeder located at the Hitachi Robotics and Metrology Laboratory is enclosed with a plyboard, a highly combustible material. Without a permanent power source tapping point for most of the laboratory equipment and no available 208Vac, 3 phases for two laboratory equipment located at Mechatronics Laboratory No. 3. Lastly, breakers used as overcurrent protection devices for laboratory equipment did not meet the ampere – interrupting requirements as per equipment manufacturer specifications.

With all of these findings, the institution must revisit/strengthen its maintenance program, and initiate immediate corrective measures, particularly on high-risk issues like a loose connection, poor illumination, unenclosed multiple splicing, safety barriers, unsecured live bus bars and removal of combustible materials within the power centers. For the equipment that needs a specialized supply of 208 Vac, this can be addressed by a transformer, breakers also can be replaced following machine/load ampere–interrupting capacity requirements.

Author contributions

Conceptualization [E.C.]; methodology [M.C.]; software [E.C.]; validation [M.C.]; formal analysis [E.C.]; investigation [E.C.]; resources [E.C.]; data curation [E.C.]; writing—original draft preparation [M.C.]; writing—review and editing [M.C.]; visualization [E.C.]; supervision (E.C.]; project administration [E.C.]; funding acquisition [M.C.

All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declares no conflict of interest.

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MULTIDISCIPLINARY JOURNAL OF ENGINEERING SCIENCES

REVIEW
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The Analysis of Future Robots in Japan: Review article

Momen Salah [1], ***Osama Elmowafy*** [2]

[1] *Graduate at High Institute for Computer & Management Information Systems, Department of Computer Science, Egypt*

[2] *Assistant professor in the Computer Engineering Department at High Institute of Engineering and Technology, 5th settlement, Egypt.*

Corresponding author: C1500144@cis.edu.eg

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Abstract

Human entertainment bots, androids, animal bots, social bots, guard bots, and many other types of robots are currently popular in Japan. Each sort of robot has distinct characteristics.

This paper aims to encompass the common achievements of robots and compare them in categories like length, width, ability to replicate human behavior, and other characteristics. Consequently, in that discussion, many questions will be asked; where is the future of robotic organisms heading? What is the likely sequence of robot innovations and their use of human technologies? What challenges do robots have to face in today's world?

Keywords: androids, astronaut robots, assistive robots, humanoid robots, human–robot interaction, domestic robots, personal robots, robot assistant, robot peers, robot societies, social robots, rescue robots, evolution of social robots, history of social robots

1. Introduction

The concept may have started in Japan in the 17th century when art and function were combined in the Karakuri puppets. The doll had a human-like aesthetic appearance whilst serving the function of serving tea [1].

The invention of the robot faced a multitude of challenges in imitating a human face or walking, entertaining, liking, shaking hands, speaking, gesturing, transmitting information, measuring distances, and running. Not to mention, it faced a challenge in all algorithms of emotion. For example, Keepon is a social robot created in 2003 for autism research by Hideki Kozima in Japan [2-8]

Our review paper discusses, how should the robot be in the coming decades, as we discuss the competitiveness and cooperation of robotic organisms and humans, and what was limited to the robot at the beginning of its manufacture, the establishment of its structure, and the modernization of its mechanism. In addition to emotional disturbances and trauma, the distinction between taste, smell, and touch, mastering the look of the robot between hope and pain, optimism and pessimism. Robots' occupations can in the coming years range from construction workers to astronauts.

2. Research methodology

The Historical, psychological, and social review has been conducted for all the robots covered by the research.

2.1 Brief history of robotics in Japan

The karakuri ningyo, or mechanical dolls, are among Japan's earliest robot precursors. Takeda-za established a mechanical-puppet theater in Osaka's Dtonbori district during the Edo period (1603-1867). [9] Hisashige Tanaka, known as "Japan's Edison," was a Japanese craftsman who created an array of extremely complex mechanical toys, some of which could serve tea, fire arrows drawn from a quiver or even paint a Japanese kanji character. In 1796, the seminal work Karakuri Zui (Illustrated Machinery) was published. [10] Figure 1.

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Figure 1. A karakuri automaton, c. 1800, British Museum and Tea-serving karakuri, with mechanism, 19th century. National Museum of Nature and Science, Tokyo.

[Source: File:KarakuriBritishMuseum.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:KarakuriBritishMuseum.jpg (accessed 2023-03-29)]

[Source: File:TeaAutomatAndMechanism.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:TeaAutomatAndMechanism.jpg (accessed 2023-03-29).]

Makoto Nishimura, a biologist, designed and built the Gakutensoku robot in 1928. [11] Astro Boy, also known as Tetsuwan Atomu in Japan, was a popular fictional robot. Osamu Tezuka created Astro Boy. Figure 2.

Figure 2. Makoto Nishimura (left of Gakutensoku) and one of his assistants, Bōji Nagao, pose with the robot. Atom and Osamu Tezuka appear in the eighth tankōbon book (Osamu Tezuka Manga Complete Works edition).

[Source: File:Gakutensokuold.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Gakutensokuold.jpg (accessed 2023-03-29).]

[Source: Astro Boy. Wikipedia. https://en.wikipedia.org/wiki/Astro_Boy#/media/File:Astro_Boy-08.jpg.]

[Source: Osamu Tezuka. Wikipedia. https://en.wikipedia.org/wiki/Osamu_Tezuka#/media/File:Osamu_Tezuka_1951_Scan10008-2.JPG (accessed 2023-03-29).]

Professor Ichiro Kato of Waseda University studied humanoid robots in the mid-twentieth century. He started the WABOT project in 1967 and finished the WABOT-1, the world's first full-scale humanoid intelligent robot, in 1972. WABOT-1 moved on two legs, had two arms, and two camera eyes. [12] As a result, it was the first android. Its limb control system enabled it to walk with its lower limbs and grip and carry objects with its hands via tactile sensors. Its vision system enabled it to measure distances and directions to objects by employing external receptors, artificial eyes, and ears. Its conversation system allowed it to communicate with a human using an artificial mouth in Japanese. [13-15] Since then, Japan has been at the forefront of robotics. [16]

2.2 Some types of robots in Japan

Humanoid robots are a key factor in the modern development chain, and Japanese companies have created distinct robots in imitating humans, especially in movements, verbal gestures, speaking, understanding, and fulfilling the requests of a human speaking to a robot. And Asimo (Advanced Step in Innovative Mobility), who ascended the throne in 1986 [17], was very distinguished from the first journey of its formation until the year of its production with the latest version. What distinguishes this robot is that its standards for updating and adding features took more than one experimental model from the first E zero in 1986 through E1, E2, and E3 from 1987 until 1991, and from 1991 until 1993, the development of E 3 to E4, E5, and E6. The first and most advanced and experienced model started from 1993 until 1997 with three types of p1, p2 and p3, and in the year 2000 ASIMO was born, going through several developments from walking to running to jumping with task performance capabilities and communication capabilities as well as sound and image recognition, sensing, situational estimation, behavior generation, and field experiments.

It is clear that the human robots did not stop at ASIMO, other successful attempts such as the second human model Toyota Partner Robot, a line of humanoid robots manufactured by Toyota. At the 2005 World EXPO in Aichi, Japan, they made their debut playing music on drums and trumpets. There are five robots in total, each with a unique movement system. Version 1 (bipedal robot), Version 2 (Segway-like wheels), Version 3 (Segway-like wheels), Version 4 (unique wire system), and the I-Foot are the five robots (mountable with 2 legs). Toyota released a video of their partner robot's running and standing abilities in July 2009. The robot can travel at a speed of 7 km/h, but it can only walk and run on level ground. T-HR3, Toyota's third-generation humanoid robot, was introduced in 2017 and will be utilized in space travel [18].

The T-HR3 is guided by a Master Maneuvering System, which enables the complete body of the robot to be operated automatically via wearable controllers that map hand, arm, and foot movements to the robot. Furthermore, a head-mounted display that allows the user to observe the world through the eyes of the robot. It was developed to look into the prospect of supporting humans at home, in medical facilities, on building sites, in disaster zones, and even in space.

Before we get into the more contentious types, the term "robot" has evolved to apply mostly to mechanical humans, animals, and other beings. [19] The name "android" can refer to either of these, [19], but a cyborg ("online organism" or "robot") is a creature made up of organic and mechanical parts.

While the term "android" refers to robots with human-like appearances in general (not necessarily male-like robots), a female-looking robot is also known as a gynoid. Furthermore, anthrobots or anthropoids can be used to refer to robots without alluding to their sexual appearance. (Short for humanoid robots; the term humanoids is inappropriate because it is already used to refer to organic, human-like species in the context of Science Fiction, Futurism, and Speculative Astrobiology).

The term "android" was used by the writers in a variety of contexts other than that of a robot or a cyborg. In certain works of fiction, the distinction between a robot and a robot is only apparent, as robots are designed to resemble humans on the surface yet have robot-like internal mechanisms. [19] In other stories, the term "android" refers to a completely organic, yet artificial, entity. [19] Other fictional Android graphics can be found somewhere in the middle.

According to Eric G. Wilson, who defines a robot as a "artificial human being," there are three categories of robots based on their body composition:

Mummies, dolls, puppets, and figurines are examples of "dead things" or "solid, inanimate, natural matter."

Golems and homunculi are examples of golems, which are constructed of flexible, possibly organic substance.

Robot type - made up of both living and dead elements, such as robots and automatons [20].

This mechanical humanoid type as we now call it was the Actroid Woman with a great visual resemblance. Osaka University created it, and Kokoro Company Ltd manufactured it. (the animatronics division of Sanrio). It was first shown at the International Robot Show in Tokyo, Japan, in 2003. It has completed its development process since then, and the appearance of the robot reflects a young Japanese woman of average age. It is capable of imitating natural activities such as breathing, blinking, and speaking. and it is one of the robots that has an interactive ability to speak, process it, and respond to it [21-26].

Internal sensors allow Actroid models to react naturally through air actuators placed at various places of articulation in the upper torso. Early models have 42 points of articulation, whereas later models have 47. So far, lower-body movement has been restricted. The operation of the robot's sensory system in concert with its air propelled movements enables it to react to or avoid intruding actions such as a slap or a poke. It can respond differently to softer types of touch, such as a pat on the arm, thanks to artificial intelligence [21-26].

The Actroid may also imitate human behavior by adjusting its position, moving its head and eyes, and breathing in its chest. Furthermore, the robot can be "taught" to emulate human actions by confronting a person wearing reflective dots at critical spots on their body. This motion can then be "learned" and repeated by the robot by using its visual system to track the dots and computing limb and joint movements to match what it sees [21-26].

The HRP-4C, often known as Miim, is a feminine-looking humanoid robot developed by Japan's National Institute of Advanced Industrial Science and Technology. (AIST).

Miim is 158 centimeters' (5 feet, 2 inches) tall and weighs 43 kilograms' (95 pounds) when equipped with the power pack. She has the head and face of a typical young Japanese female, as well as the figure of a typical young Japanese female. (Based on the 1997–1998 Japanese body dimension database). Thanks to 30 body motors and additional eight for face emotions, she can move like a human. Miim can also recognize and respond to environmental sounds and voice using speech recognition software [27].

The Open Robotics Platform (OpenRTP), which includes OpenRTM-aist and OpenHRP3, is used to build the robot's software. [28]

On March 16, 2009,[29] a public demonstration was held, followed by another at Tokyo's Digital Content Expo in 2010 to demonstrate current enhancements that allow HRP-4C to mimic human facial and head movements, as well as perform dance steps [30 - 31].

Mimi's human-like walking abilities was upgraded in 2011, as exhibited in a WAIST film, and has been described as "super-realistic"[32].

The entertainment business and a human simulator for device evaluation could be among the applications for the HRP-4C.

Due to the history of natural disasters in the past decade. According to the Center for Research on the Epidemiology of Disasters, the impulse to construct lifesaving robots arose after scientists realized the enormity of the destruction. (CRED).

This resulted in the creation of the T-52 Enryu robot, which is designed to rescue humans in natural disasters such as tsunamis, earthquakes, etc. In addition, the robot rescues them from a man-made tragedy like a fire or a car accident [33].

The robot works hydraulically through the wreckage to travel a certain distance for the same rescue operation in the aftermath of an earthquake or other calamity.

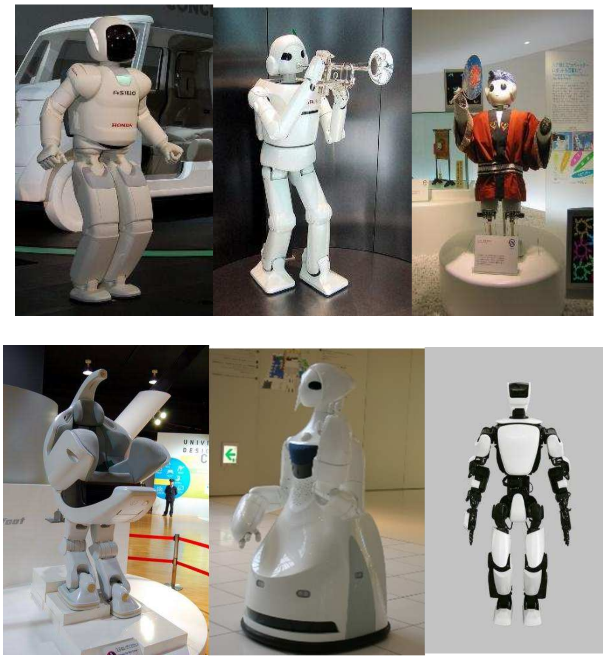
In 2006, the robot successfully lifted from a snowbank during a performance test at Nagaoka University of Technology.

TMSUK created the robot in partnership with Kyoto University, the Kitakyushu Fire Department, and Japan's National Fire and Disaster Research Institute in Tokyo. The 3.5m long robot may be commanded remotely or from a cockpit at the front. It, like its cousin Banryu, features numerous CCD cameras that broadcast to the remote driver - in this case, seven 6.8MP CCD cameras mounted to the "head," "torso," and "arms."

While we are touching on the most advanced species in our digital age, let us discuss the astronaut robot named Kirobo who is the first Japanese astronaut who achieved world records after an 18-month stay aboard the International Space Station. Thus, it was the first robot in space and the first robot to be at such a height while having a conversation [34].

Developed by the University of Tokyo and Tomotaka Takahashi, the first of its kind, Kirobo arrived at the International Space Station on August 10, 2013 from Japan's Tanegashima Space Center. A twin of Kirobo, named Mirata, was also created with the same characteristics, and remained on Earth as a backup member of the crew. The word "kirobo" itself is a portmanteau of "kibō" (希望), which means "hope" in Japanese, and the word "robo" (ロボ), used as a generic short word for any robot [35].

We attach pictures of the robots on which we put a spotlight in sequential order. Figure 3.



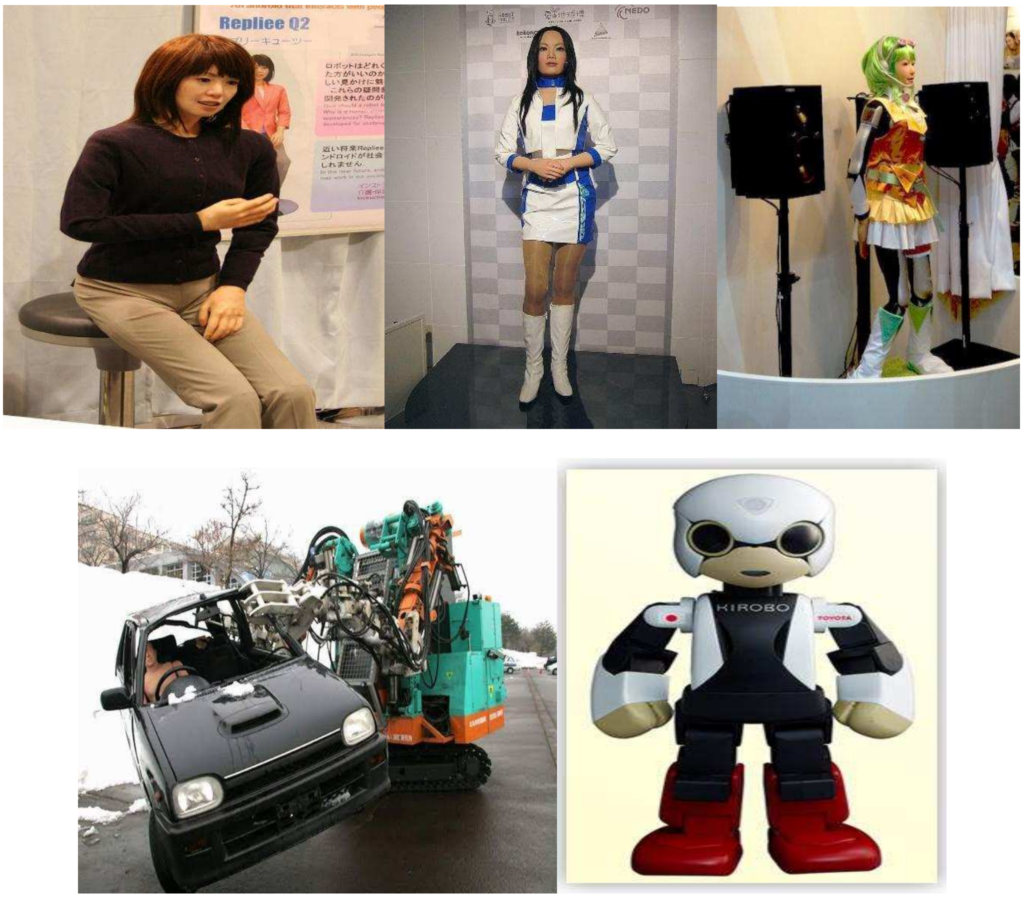


Figure 3. ASIMO, Toyota pranter robot & T-HR3, actroid & HRP-4C, T-52 Enryu and Kirobo.

[Source: File:Honda ASIMO (ver. 2011) 2011 Tokyo Motor Show.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Honda_ASIMO_(ver._2011) _2011_Tokyo_Motor_Show.jpg (accessed 2023-03-29).]

[Source: File:Toyota Robot at Toyota Kaikan.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Toyota_Robot_at_Toyota_Kaikan.jpg (accessed 2023-03-29).]

[Source: File:Toyota robot.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Toyota_robot.jpg (accessed 2023-03-29).]

[Source: File:Toyota i-foot.JPG - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Toyota_i-foot.JPG (accessed 2023-03-29).]

[Source: File:TPR-ROBINA.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:TPR-ROBINA.jpg (accessed 2023-03-29).]

[Source: CORPORATION, T. M. T-HR3. Toyota Motor Corporation Official Global Website. https://global.toyota/en/download/34530991 (accessed 2023-03-30).]

[Source: File:Repliee Q2.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Repliee_Q2.jpg (accessed 2023-03-30).]

[Source: File:Actroid-DER 01.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Actroid-DER_01.jpg (accessed 2023-03-30).]

[Source: Wikimedia.org. https://upload.wikimedia.org/wikipedia/commons/4/45/Vocaloid_%2B_HRP-4C_Miim_collaboration_%28clip%29%2C_Yamaha_booth%2C_CEATEC_JAPAN_2009.jpg (accessed 2023-03-30).]

[Source: Redd.it. https://i.redd.it/z2n5ydkfpcu21.jpg (accessed 2023-03-30).]

[Source: Technewsworld.com. https://www.technewsworld.com/images/article_images/78364_250x460.jpg (accessed 2023-03-30).]

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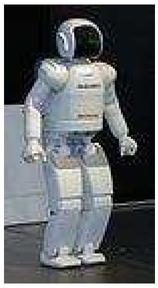
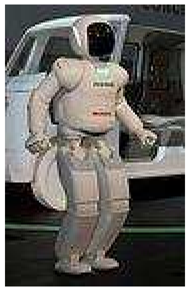
2.3 Asimo's comparison [36 – 40]

Table 1. Shows a comparison between Asimo's launches, up until 2011.

This comparison discusses mass, height, width, language, etc.

Table 1. Parameters comparison of Asimos versions.

<table>
<tr><td>Model</td><td>2000, 2001, 2002</td><td>2004</td><td>2005, 2007</td><td>2011[41-42]</td></tr>
<tr><td>Mass</td><td colspan="3">54 kilograms (119 lb.)</td><td>48 kilograms (106 lb.)[43]</td></tr>
<tr><td>Height</td><td>120 centimeters (47 in)[36]</td><td colspan="3">130 centimeters (51 in)</td></tr>
<tr><td>Width</td><td colspan="4">45 centimeters (18 in)</td></tr>
<tr><td>Depth</td><td>44 centimeters (17 in)</td><td colspan="2">37 centimeters (15 in)</td><td>34 centimeters (13 in)</td></tr>
<tr><td>Walking rate</td><td>1.6 kilometers'/hour (0.99 mph)</td><td>A speed of 2.5 km per hour (1.6 mph)</td><td colspan="2">2.7 kilometers'/hour (1.7 mph)</td></tr>
<tr><td>Running rate</td><td>—</td><td>A speed of three kilometers' per hour (1.9 mph)</td><td>6 kilometers per hour (3.7 miles per hour) (straight) 5 kilometers' per hour (3.1 miles per hour) (circling)</td><td>A speed of 9 km/h (5.6 mph)</td></tr>
</table>

Airborne time (Running motion)	—	0.05 seconds	0.08 seconds	
Battery	38.4 V, 10 Ah, 7.7 kg Nickel metal hydride (17 lb.) It takes 4 hours to fully charge.	51.8 V lithium ion battery, 6 kg (13 lb.) It takes 3 hours to fully charge.		
Continuous operating period	Thirty minutes	40 minutes to an hour (walking)		Continuous operating period
Degrees of Freedom	26 (head: 2, arm: 5×2, hand: 1×2, leg: 6×2)	34 [44] (head: 3, arm: 7×2, hand: 2×2, torso: 1, leg: 6×2)		Degrees of Freedom
Languages	_____	___	Languages	_____
Images	 *[Source: File:Asimo.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Asimo.jpg (accessed 2023-03-30)]*	 *[Source: File:2005 Honda ASIMO 01.JPG - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:2005_Honda_ASIMO_01.JPG (accessed 2023-03-30).]*		 *Source: File:Honda ASIMO (ver. 2011) 2011 Tokyo Motor Show.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Honda_ASIMO_(ver._2011)_2011_Tokyo_Motor_Show.jpg.]*

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2.4 Different model comparison

Table 2 shows comparison other between asimo, T-HR3, kirobo, and T-52 Enryu in terms of type, first appearance, mass or weight, height, width, features, languages.

Table 2. Asimo, T-HR3, kirobo, and T-52 Enryu comparison

Name	Asimo	T-HR3	Kirobo	T-52 Enryu
Types	Humanoid robots	Humanoid robots	Astronaut robots	Rescue robots
First appearance	On October 31, 2000	On November 29, 2013	On August 10, 2013	2006
Mass or weight	48 kilograms (106 lb.)[43] Mass.	75 kilograms (165 lb.) weight.	1 kilogram (2.2 lb.) weight.	5 tons weight.
Height	130 centimeters.	1.54 meters tall (154 centimeters.	34 centimeters.	350 centimeters.
Width	45 centimeters.	___	18 centimeters.	240 centimeters.
Features	Recognize moving objects. Postures gestures. Surrounding environment. Sounds and faces, which enables it to	Flexible Joint Control. Whole-body Coordination. Balance Control. Real Remote Maneuvering.	Voice recognition Natural language processing. Voice (speaking) composite. Information and communication operations.	Save people during disasters. Joint training exercise with the Fire Department rescue team. Tests against snow disaster.

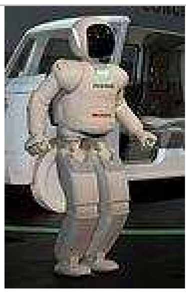
	interact with humans. Detect the movements of multiple objects.		Facial recognition camera. Camera for recording.	Soil surveying by remote control.
Languages	English & Japanese	___	Japanese	___
Images	 *[Source: File:Honda ASIMO (ver. 2011) 2011 Tokyo Motor Show.jpg - Wikipedia. commons.wikimedia.org. https://en.wikipedia.org/wiki/File:Honda_ASIMO_ (ver._2011) _2011_Tokyo_Motor _Show.jpg (accessed 2023-03-29).]*	 *[Source: Toyota Gets Back Into Humanoid Robots With New T-HR3. IEEE Spectrum. https://spectrum.ieee.org/toyota-gets-back-into-humanoid-robots-with-new-thr3.]*	 *[Source: Robot Astronaut Kirobo 003. Toyota USA Newsroom. https://pressroom.toyota.com/image/robot-astronaut-kirobo-003/ (accessed 2023-03-30).]*	 *[Source: Techeblog.com. https://media.techeblog.com/images/rescuerobot.jpg (accessed 2023-03-30).]*

Table 3. presents comparison of robots of same type.

Table 3. Comparison of robots of same type.

Name	Actroid	HRP-4C
Types	Androids	Androids
First appearance	2003	2009

Features	The Actroid may also imitate human behavior by adjusting its position, moving its head and eyes, and breathing in its chest. Furthermore, the robot can be "taught" to emulate human actions by confronting a person wearing reflective dots at critical spots on their body. This motion can then be "learned" and repeated by the robot by using its visual system to follow the dots and computing limb and joint movements to match what it sees.	HRP-4C can imitate human facial and head movements as well as perform dance steps. 2011 upgrades to Mimi's human-like walking ability were shown in a video released by AIST, and have been called "super-realistic".
Languages	Japanese	Japanese
Images	 [*Source: Actroid*. Wikipedia. https://en.wikipedia.org/wiki/Actroid#/media/File:Actroid-DER_01.jpg (accessed 2023-03-30).]	 [*Source: HRP-4C*. Wikipedia. https://en.wikipedia.org/wiki/HRP-4C#/media/File:HRP-4C_UCROA.jpg (accessed 2023-03-30).]

2.5 Advantages and disadvantages

There are two sides to every coin. As this proverb suggests, to each advantage there is a disadvantage. Brief look at some of the benefits and drawbacks of robots are presented below.

All six types of robots advantages and disadvantage are presented in Table 4.:-

Table 4. Comparison of advantages and disadvantages.

Name	Advantage	Disadvantage
Asimo	The Asimo has a laser sensor that detects the ground's surface. It also has an infrared sensor with automatic shutter adjustment based on brightness that detects pairs of floor markings to confirm the navigable paths of the planned map. Other advantages include the Asimo's ability to recognize people's faces and voices, address them by name, and move in the ways they indicate. In addition, the shape of Asimo resembles an astronaut robot It also responds to questions by nodding. It is fluent in several languages and can recognize and address around ten different faces.	The disadvantage here is that it will cost many people their jobs. It is also expensive to build an Asimo on your own, let alone buy one with your own money. If the Asimo is not serviced on a regular basis and properly monitored, its operation can go haywire, resulting in destruction and injuries. It is best to proceed with caution. Asimo also has limited maps of his surroundings and has the big advantage of being an astronaut but he can't go into space!

T-HR3	It can safely assist humans in a variety of settings, including the house, medical facilities, building sites, and disaster-stricken areas and even outer space. Flexible Joint Control, which allows the robot to control the force with which it makes contact with any individuals. Robots in its environment; Whole-body Coordination and Balance manipulate, which allows the robot to keep its balance if it collides with things in its environment; and Real Remote Maneuvering, which allows humans to manipulate the robot in a smooth and intuitive manner.	Robot can only do what they are told to do – they can't improvise Although robots can be superior to humans in some ways, they are less dexterous than humans, they don't have such powerful brains, and cannot compete with a human's ability to understand what they can see.
Kirobo	Voice and speech recognition, natural language processing, speech synthesis, and telecommunications are among the capabilities of the robot, as are facial recognition and video recording.	It could not climb into the spacecraft on its own.
T-52 Enryu	Preparing for rapid rescue operations under any catastrophic circumstance. It also helps to clear the road for other vehicles to pass. Finally, T-52 Enryu	Because it is controlled by a human, the robot does not have a programme. Installed in it, does not need to be taught how to operate, and does not

	can rip doors off cars, allowing people to exit. It is mostly used in areas where people might be too afraid to go. [47] Master-slave control: This method transmits human movements directly to the machine from a control center, giving the machine more human-like motion. This method is very efficient when there is a risk of further collapse in the damaged area. To control the robot, the operator does not need to be inside it. [33]	have any sensors to assist it in seeing. It does have a camera to help the human see where it is going when the human is controlling it with a remote.
Actroid	Nonverbal methods are used to increase interactivity. When addressed, the interactive Actroids use "floor sensors and omnidirectional vision sensors" to keep eye contact with the speaker. Furthermore, the robots can respond to body language and tone of voice in limited ways by changing their own facial expressions, stance, and vocal inflection.	The skin is made of silicone and appears to be very realistic. The compressed air that powers the robot's servo motors, as well as the majority of the computer hardware that powers the A.I., are located outside of the unit. This is one of the reasons for The robot's inability to move around. The Actroid is always represented seated or standing, with substantial support from behind.
HRP-4C	She can move like a human, thanks to 30 body motors and another eight for facial expressions. Miim can also recognize	She is unable to move her hands flexibly and comfortably while dancing.

	ambient sounds and respond to speech using speech recognition software.	

2.6 Similarities and differences

Table 5. Illustrates similarities and differences between robots.

Table 5. Similarities and differences between robots.

Name	Similarities	Differences
Asimo	Bots are similar in that they carry out their own operations in their own environment. The vocalization process in bots is similar.	Robot algorithms differ in the programmed analysis of performing tasks related to each robot separately, as well as the method of performing tasks, and each robot differs from its robot friend in terms of shape, color, type, weight, and size.
T-HR3		
Kirobo		
T-52 Enryu		
Actroid		
HRP-4C		

3. Results of the review

In total, the comparisons resulted in a study of the differences, similarities, advantages, and disadvantages between the robots, in addition to presenting a brief history of robots in Japan, and their communication with humans. However, in this era, robots did not communicate with robots like them! Here we suggest adding an algorithm for the robot to recognize its robot friend, for example, the robot T-HR3 talks with the robot Kirobo about the data recorded by Kirobo at the space station. A person intervenes in their conversation by participating, not by interrupting, or by programming codes that will impose dialogue between them. The dialogue will be similar to the process of identifying, then perceiving the recipient, and finally transmitting the analyzed data through the dialogue.

And perhaps the machine should be freed from its maker so that it can improvise automatically by asking and answering, which will take a random time in the journey of the cameras that express the sight.

So we draw the process of talking between the robot and its robot friend, whether they are of the same type or different from each other. Creating possibilities for collecting and analyzing previous data and storing its information, then creating an increasing relationship between the two parties and engaging them in a dialogue, so the programmed algorithms will intertwine, and the dialogue between them will flow into an acquaintance with the types of experiences available to robots. Thus, a whole world of robots capable of communicating with each other and with humans will be created.

Then, the study of the behavior of machines with each other, their pattern of thinking between each other and humans, the method of making the necessary decisions, as well as their support for each other and their dealings in certain situations by transmitting verbal information and the ability to improvise and simulate the thinking of algorithms that recognize the surrounding world through them, will be achieved.

From here, the sequence paths start to form the robot's journey in the future, and indeed it will include three abilities: the first: the ability to learn, which results in observation, conclusion, and analysis, and second: the ability to recognize, which results in distinguishing between physical objects, and making names and familiar gestures. Third: The ability to discover the surrounding world, and Herein lies the problem of determining the place, as the robotic maps of places are still confined to certain places, and only open specific horizons for the robot, because the robots need huge data to identify the surrounding place, deal with them, and solve them in the coming years. It results in an ability that every robot lacks, which is improvisation, and so the robot will come to recognize data outside of its framework around it.

Algorithms are the building block of a robot, and an algorithm is a map that defines how a specific, well-defined task can be accomplished. It is a way to solve a problem. It depends on a set of mental and mathematical operations, whether simple or complex. Takes into account a specific value or set of values as input, and outputs a specific value or set of values as the final output.

Simply put, the algorithm is a problem-solving skill, and it is a set of steps that can be taken to solve a specific problem or finish a specific task.

A robot algorithm's main objective is to explain a process for manipulating a portion of the real world—the workspace—in order to accomplish a specific objective, like the spatial arrangement of several physical objects.

The robot's thinking brain is generated by algorithms, and the functions of the algorithms are to prioritize and draw attention to specific things. Similarly, to be able to classify and associate variables in certain categories, find relationships between variables, and then filter by extracting the required information.

4. Discussion on projects future

4.1 Feelings, emotions and sensations

Sometimes feelings fuel actions and sometimes feelings have nothing to do with actions.

Several kinds of reception are expressed through sensation: smell, taste, touch, sight and hearing. All of these convey to humans information.

Sensations come directly from the senses and are somewhat limited. If you feel love for a person, you should embrace or kiss him, but if you love him and you don't, this does not mean that you do not love him. So, love is a feeling and its sensations must be felt physically, such as smelling the scent of your loved one, the smell of your parents, your wife, or your grandfather's house. The sense of smell is connected to feelings. For instance, if you see someone who resembles someone you prefer, you can love them in principle, even if you do not know him. Philosophers say this is similar to love. Similarly, the sound of music or singing, whether with preferred or disliked music, is what determines or instigates feelings. Love, as a model, is a symbol, representing many feelings. However, it is separate from life. For example, if someone we love dies, and we still love him after his/her death.

Emotions are the key controllers of people. They are a direction or inclination of feelings towards a specific thing that may be love or hate. Emotion pushes a person to do a certain behavior in favor of the thing he loves or hates. Emotion is also a relatively stable emotional regulation that is accompanied by some pleasant experiences. What is hated and what revolves around it is the emotional outbursts that may be an image, a person, a group or an idea.

The above does not define the feelings, emotions, and sensations of the robot, because the robot does not have the senses of taste or smell yet. Rather, we can plan for storage, that is, we keep juice, water, a drink, or a plate of food that accepts storage in the robot.

Love is instinctive for a robot because it is a friend to any human being who recognizes it, and this results in a serious defect with time. The robot does not recognize its real owner. And the questions here will be as follows: Can a robot feel an urgent need to communicate when loneliness permeates it? Can a robot be in complete need of safety when it is overwhelmed by fear? Does the robot rebel against its owner's request by completely rejecting it if it had a choice between acceptance and rejection? Can a robot tolerate emotional turmoil if it exists in its algorithms?

4.2 Robot race

The ASIMO was first shown running in 2004 [48, 49]. Since then, it has increased its running speed year after year, and the 2011 model ASIMO can travel at a speed of 9 km/h. making a humansized robot like ASIMO run, to move forward by kicking and jumping against the floor like a human being, is a huge challenge.

To address these issues, a new technology was applied to the hardware as well as the gait generation technique [50-53]. High-speed processing circuits, highly responsive and powerful motor drive units, and lightweight, highly rigid leg structures were all part of the hardware. These changes improve the system's overall responsiveness to situational changes.

Honda could create a racing challenge for robots called ASIMO to retrofit the robot and it's not-so-distant return.

4.3 Flexing the hands

The problem of flexing the hand occurred with HRP-4C during her dance in the digital content expo. She was able to make acute angles in the first minute and six seconds. Hence, she both needed stretchable material on her elbow to fix programming matters within the tissues of the robot. [SOM 1-2]

4.4 Building Construction Robotics

Robotic technology research and use in the construction business has been a promising trend.

By simplifying assignments, establishing a safer work environment, enhancing end product quality, and making the entire process more cost effective, this technology can increase the productivity and efficiency of numerous construction jobs [54-55]. Construction robotics research began in Japan in the 1980s with the introduction of single-purpose robots to answer concerns about Japanese construction labor shortages [56].

Following that, robotic technologies were developed progressively and employed to conduct some building activities [54]. Single-task construction robots can conduct a single construction operation such as excavating, concrete leveling, or concrete finishing. Because these robots can only operate in an environment apart from construction workers, they cannot be incorporated into a broader network, rendering the bulk of them incompatible with the construction process. As a result of the advancement of integrated systems, the employment of single task robots gave way to the adoption of parallel robots [56].

The question here is whether this robot can save the building itself from destruction, whether in natural disasters or disasters based on human error?

And could he be able to build on his own without the direct or indirect intervention of humans as well as restoration?

4.5 Reach the moon

The robot can go up to the moon accompanied by an astronaut as long as the robot is on top of a spacecraft, it can reach the moon decisively and land on it. For example, the shape of Asimo, the features of Kirobo, and the characteristics of the T-HR3, after the appropriate update of the lunar atmosphere, all can make a full landing on the surface of the moon.

4.6 Suicides prevention

In Japan, suicide (自殺, jisatsu) is seen as a big social concern. [57-58] in 2017, the country had the OECD's seventh highest suicide rate, at 14.9 per 100,000 inhabitants, [59], and in 2019, it had the G7 developed nations' second highest suicide rate. [60] However, on a global scale, Japan ranks 49th in terms of suicide rate, having a lower suicide rate than several other wealthy nations. [61]

Suicide rates skyrocketed after the 1997 Asian financial crisis, increasing by 34.7% in 1998 alone and remaining quite high for more than a decade. [57] Suicide rates have consistently fallen since peaking in 2003, reaching their lowest level on record (since 1978) in 2019. [62] Suicide rates in Japan increased by 16% between July and October 2020, attributable to a combination of COVID-19-related variables. [63] Suicide is the primary cause of mortality in men aged 20-44 in Japan [64], accounting for 70% of all suicides [65]

The robot will play an active role in preserving the life of his friend, and perhaps a robot will be made that represents a rescue web in the form of a cobweb under Mount Fuji to save what can be saved.

Note:

In all discussions of future projects, there is competition between robots and humans. However, on the contrary, what prevails in the image is cooperative, because the number of robots is still few compared to the population of Japan only.

Competition is not possible unless the number of bots increases dramatically.

The collaborative scene is what has dominated the world of robots and humans.

5. Conclusions

In this paper, there are various scenarios from the first robot formation journey in the brief history of robots until reaching a proposal for the expected results of including an algorithm that introduces the robot to its robot friend, and allows for ideal communication between them.

Previously, we have discussed various comparisons, analysis, and informative details related to the robot planet in Japan. Thus, we have achieved a comprehensive review of what will happen in the psychology of the robot and the expected sequence for the production of robots. Furthermore, we have understood its use of human technologies such as feelings, emotions, sensations, and the challenges we face in the cooperation between it and humans so far.

Author contributions

Conceptualization [M.S.]; methodology [M.S.]; software [M.S.]; validation [O.E.]; formal analysis [M.S.]; investigation [M.S.]; resources [M.S.]; data curation [M.S.]; writing—original draft preparation [M.S.]; writing—review and editing [M.S.]; visualization [M.S.]; supervision (O.E.];

project administration [M.S.]; funding acquisition [M.S.]

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Conflict of interest

The authors declares no conflict of interest.

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Numerical investigation of unsteady flow and heat transfer of a free convective second-grade fluid passing through exponentially accelerated vertical porous plate

***Ashirbad Kumar Rath* [1] *, *Itishree Nayak* [1], *Sukanya Padhi*[1]**

[1] *Veer Surendra Sai University of Technology, Burla 768018, Odisha, India*
**** Corresponding author:** akrath_phdmath@vssut.ac.in*

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Abstract

The constitutive equation considered here exhibits the heat transfer and unsteady flow of a second-grade fluid past through a long porous wall vertically. The discretized form of equations is obtained by implementing the method of finite difference of Crank -Nicolson type and solved numerically by resorting highly convergent method called “damped Newton". Two different cases are taken into consideration i.e the plate is accelerating differently at (n = 0.5) and constant acceleration (n = 1) and a comparative study is performed for the obtained results. Influence of various parameters g_r, R, P_r and α on the temperature and velocity field are studied through several graphs. The significant finding of the study is that for large P_r values, increases in the viscoelastic parameter α cause a rise in the velocity, Still, a contradicting effect is observed for comparatively smaller P_r values.

Keywords: second-grade fluids, free convective flow, exponentially fitted scheme, damped-Newton method, finite difference method

1. Introduction

In the present scenario, study of non Newtonian fluid rheology is intensified owing to its numerous applications in industrial mechanisms, chemical engineering and medical sciences. It is not possible to analyse all the diversified complex properties of non Newtonian fluid through a single model and therefore many researchers have proposed different fluid models. The second-grade fluid is known as one of the simplest visco-elastic fluid structure exhibiting peculiar properties that fascinate numerous researchers for its importance in the technological application and composite mathematical features [18, 21]. Beavers and Joseph [6] established a practical method of viscometry to study the characteristics of non Newtonian fluids. Teipel [20] obtained the stagnation point of the second-order fluid and resolved using a similarity approach. Bandelli and Rajagopal [5] analysed various unidirectional second-grade fluids in the finite dimension domain with the help of different integral transformations. They derived the Existence and Uniqueness of second-grade fluid flow for slip boundary conditions. Mohapatra et al. [15] obtained a solution numerically for MHD free convective flow of second-grade fluid passing over an infinite vertical plate. Massoudi and Maneschy [13] also found the numerical solution employing quasi-linearization for a second-grade fluid past a stretching sheet. Ariel [2] acquired the perturbation and asymptotic solution to second-grade fluid passing through a radially stretched sheet. Ariel [3] discovered a precise solution of fluid of second-grade flowing with in a parallel channel in geometries of two different types. Tan and Masuoka [19] discussed the exact solution of the second-grade fluid in a porous half space on a heated flat plate. Fetecau and Fetecau [8] used the Fourier sine transform for cosine and sine oscillations on an infinite plate to offer the precise solution for the second-grade fluid.

Hayat et al. [10] solved the steady electrically conducting second-grade fluid flow within a porous channel using the analytical method HAM. Hayat et al. [9] used modified Darcy's law for modelling the fluid model of second-grade and analysed the effect of porous media and magnetic field for some unidirectional second-grade fluid flows. Massoudi et al. [14] studied the natural convective flow for second grade fluid with variable viscosity within parallel vertical plate applying the collocation method. Ayub and Zaman [4] derived the exact momentum equation for second-grade fluid. Kecebas and Yurusoy [12] numerically examined an incompressible unsteady modified power law fluid of second grade. Abbasbandy et al. [1] obtained the HAM solution of power-law fluid of second grade passing through an infinite porous plate and a comparison was made with a numerical solution. Rana and Latif [17] obtained an analytical solution to study three-dimensional free convective second-grade fluid flow in a porous medium subjected to constant suction and variable permeability.

Most of the above studies have adopted the analytical methods that are appropriately described for small parametric values physically and monotonous calculation is needed for any exchange in boundary conditions. The rapid convergence and flexibility for all types of physical parametric values of the employed numerical damped-Newton method motivated the present study. In this study, a fully implicit FDM is used to analyse the unsteady free convective flow of a second-grade fluid passing through a porous vertical plate with uniform suction provided close to the wall. The recent work progress is in the following way.

The flow geometry is discussed in section 2. The finite difference discretization with its numerical solution is described in section 3. Analysis of obtained results through graphical representation is done in section 4. Section 5 summarizes the conclusion..

2. Mathematical analysis

Consider the heat transfer and unsteady flow of a grade two incompressible fluid past an infinitely long porous vertical wall. Here x^*-axis is taken parallel to the vertical plate and y^*-axis is perpendicular to it. Initially, at time $t^* = 0$, the plate is at rest but suddenly starts moving in direction of x^*-axis with a velocity $U(t)$ when $t^* > 0$. While zero temperature is maintained at $t^* = 0$, for time $t^* > 0$, it is expected that the plate will be exposed to an oscillating temperature. Due to the indefinite length of the plate, the purely physical characteristics are functions of only y^* and t^*. The equation governing the flow with above assumptions is obtained as

$$\rho\left(\frac{\partial u^*}{\partial t^*} - V_0\frac{\partial u^*}{\partial y^*}\right) = \mu\frac{\partial^2 u^*}{\partial y^{*2}} + \alpha_1\left(\frac{\partial^3 u^*}{\partial y^{*2}\partial t^*} - V_0\frac{\partial^3 u^*}{\partial y^{*3}}\right) + \rho\beta g(T^* - T^*_\infty), \tag{1}$$

with conditions

$$\begin{cases} t^* \leq 0: & u^* = 0, \quad \text{for every } y^*, \\ t^* > 0: & u^* = U(t^*) = \frac{U^{2n+1}}{\nu^n}e^{a^*t^*}t^{*n}, \quad \text{for } y^* = 0. \\ t^* > 0: & u^* = 0, \quad \text{for } y^* \to \infty. \end{cases} \tag{2}$$

The corresponding energy equation was obtained as

$$\rho C_p\left(\frac{\partial T'}{\partial t^*} - V_0\frac{\partial T^*}{\partial y^*}\right) = k\frac{\partial^2 T^*}{\partial y^{*2}}, \tag{3}$$

conditional to

$$\begin{cases} t^* \leq 0: \text{when} & T^* = 0, \quad \forall\, y^*, \\ t^* > 0: \text{when} & T^* = T^*_\infty + (T^*_w - T^*_\infty)\cos\omega^* t^*, \quad \text{at } y^* = 0. \\ t^* > 0: \text{when} & T^* = T^*_\infty, \quad \text{for } y^* \to \infty. \end{cases} \tag{4}$$

The joule and vicious dissipation are ignored, due to little effect on free convective flow. Furthermore, the velocity of suction indicates by $V_0 > 0$ and x^* and y^* are the axis of fluid velocities with u^* and v^* respectively. Here We select $U(t^*) = \frac{U^{2n+1}}{v^n}e^{a^*t^*}t^{*n}$ for computing.
We present the subsequent dimensionless quantities:

$$u = \frac{u^*}{U}, \quad \theta = \frac{T^* - T^*_\infty}{T^*_w - T^*_\infty}, \quad y = \frac{y^*U}{\nu}, \quad a = \frac{a^*\nu}{U^2}, \quad t = \frac{t^*U^2}{\nu}, \quad R = \frac{V_0}{U}, \quad P_r = \frac{\nu\rho C_p}{k}, \quad g_r = \frac{\beta g\nu(T^*_w - T^*_\infty)}{U^3}, \quad \alpha = \frac{\alpha_1 U^2}{\rho\nu^2}, \quad \omega = \frac{\omega^*\nu}{U^2}.$$

Implementing the above non dimensional parameters in equations (1) and (2), the required governing model results as

$$\frac{\partial u}{\partial t} - \frac{\partial u}{\partial y} = \frac{\partial^2 u}{\partial y^2} + \alpha \frac{\partial^3 u}{\partial y^2 \partial t} - R\alpha \frac{\partial^3 u}{\partial y^3} + g_r \theta, \tag{5}$$

along with the boundary and initial conditions

$$\begin{cases} t \leq 0 : & u = 0, \quad \forall\, y, \\ t > 0 : & u = e^{at} t^n, \quad \text{for } y = 0, \\ t > 0 : & u = 0, \quad \text{for } y \to \infty. \end{cases} \tag{6}$$

The governing heat flow equation so developed is represented as

$$\frac{\partial \theta}{\partial t} = R \frac{\partial \theta}{\partial y} + \frac{1}{P_r} \frac{\partial^2 \theta}{\partial y^2}, \tag{7}$$

along with the boundary and initial conditions

$$\begin{cases} t \leq 0 : & \theta = 0, \quad \forall\, y, \\ t > 0 : & \theta = \cos \omega t, \quad \text{for } y = 0, \\ t > 0 : & \theta = 0, \quad \text{for } y \to \infty. \end{cases} \tag{8}$$

3. Solution procedure

Subsequently, the PDEs are transformed into a system of coupled algebraic equation after discretising the derivatives with the help of implicit finite differences. The flow domain is divided by determining $\triangle y$ as the uniform mesh step and $\triangle t$ as time step. The grid points so generated are of the type
$(y_h, t_k) = (h\triangle y, k\triangle t)$,
$h = 0, 1, ..., N^* + 1$ and
$k = 0, 1, ..., M^*$.

The technique of minimising the PDEs (5) and (7) to a system of algebraic equations utilising a finite difference scheme(FDM) is discussed in the next subsections, and the numerical approximation solution of this system is obtained through a method called Damped-Newton[7].

3.1. Finite difference scheme

By adopting an implicit finite difference method(FDM) and a uniform space of mesh h and the time step $\triangle t$ the equations (5) and (6) are discretized, resulting in grid points of the form
$(y_h, t_k) = (h\triangle y, k\triangle t)$,
$h = 0, 1, ..., N^* + 1$ and
$k = 0, 1, ..., M^*$.

The discretized form of the velocity equation with corresponding initial and boundary conditions is obtained as

$$\frac{u_h^{k+1}-u_h^k}{\triangle t}-\frac{R}{4\triangle y}\left(u_{h+1}^{k+1}-u_{h-1}^{k+1}+u_{h+1}^k-u_{h-1}^k\right)-\frac{1}{2(\triangle y)^2}\left(u_{h+1}^{k+1}-2u_h^{k+1}+u_{h-1}^{k+1}+u_{h+1}^k-2u_h^k+u_{h-1}^k\right)$$
$$-\frac{\alpha}{\triangle y^2\triangle t}\left(u_{h+1}^{k+1}-2u_h^{k+1}+u_{h-1}^{k+1}-u_{h+1}^k+2u_h^k-u_{h-1}^k\right)+\frac{R\alpha}{2(\triangle y)^3}\Big(\left(-u_{h-2}^{k+1}+2u_{h-1}^{k+1}-2u_{h+1}^{k+1}+u_{h+2}^{k+1}\right)$$
$$+\left(-u_{h-2}^k+2u_{h-1}^k-2u_{h+1}^k+u_{h+2}^k\right)\Big)-g_r\left(\frac{\theta_h^{k+1}+\theta_h^k}{2}\right)=0, \tag{9}$$

and

$$\begin{cases} u_h^0=0, \text{where} \quad h=0,1,\ldots,N^*+1,\\ u_0^k=e^{(a\triangle y\triangle t)}(\triangle y\triangle t)^n,\\ u_{N^*+1}^k=0, \text{where} \quad k=1,\ldots,M^*, \end{cases} \tag{10}$$

here for the nodes $(1, h\triangle t)$, we implement $\frac{\partial^3 u}{\partial y^3}\approx\frac{1}{2h^3}\left(d_{3h}^{\prime k+1}+d_{3h}^{\prime k}\right)$.
where $d_{3h}^{\prime k}=-3u_{h-1}^k+10u_h^k-12u_{h+1}^k+6u_{h+2}^k-u_{h+3}^k$.
and for the nodes $(N, h\triangle t)$, we implement $\frac{\partial^3 u}{\partial y^3}\approx\frac{1}{2h^3}\left(d_{3h}^{\prime\prime k+1}+d_{3h}^{\prime\prime k}\right)$.
where $d_{3h}^{\prime\prime k}=u_{h-3}^k-6u_{h-2}^k+12u_{h-1}^k-10u_h^k+3u_h^k$.
The difference approximations for time and space used here attain second-order convergence. The discretized form of energy equation with use of exponential fitted scheme as referred in [16] with corresponding initial and boundary conditions

$$\frac{\theta_h^{k+1}-\theta_h^k}{\triangle t}-\frac{1}{P_r(\triangle y)^2}\left(\theta_{h+1}^{k+1}-2\theta_h^{k+1}+\theta_{h-1}^{k+1}\right)\frac{R\triangle y}{2}\left(\frac{1+e^{-P_rR\triangle y}}{1-e^{-P_rR\triangle y}}\right)-\frac{R}{2\triangle y}\left(\theta_{h+1}^{k+1}-\theta_{h-1}^{k+1}\right)=0, \tag{11}$$

and

$$\begin{cases} \theta_h^0=0, \text{where} \quad h=0,1,2,\ldots,N^*+1, and\\ \theta_0^k=\cos(\omega\triangle y\triangle t), \text{where} \quad k=0,1,2,\ldots,M^*, \end{cases} \tag{12}$$

where u_h^k,θ_h^k are approximations of velocity and temperature respectively at nodes $(h\triangle y, k\triangle t)$ for $h=0,1,2,\ldots,N^*+1$, and $k=0,1,2,\ldots,M^*$.

3.2. Numerical solution

The above coupled system of algebraic equations is resolved to adopt the quadratic convergence numerical scheme damped-Newton method described in [7]. The residuals R_h, $h=0,1,2,...,N^*$ is assessed alongside the components of the Jacobian Matrix $J=\left(\frac{\partial R_h}{\partial u_k}\right)$, $h=1,2,3,4\ldots,N^*$ and $k=1,2,3,4\ldots,M^*$ that are not zero. An appropriate initial guess for velocity leads to a convergent solution that is obtained here by solving the tri-diagonal system of equation on setting $\alpha=0$ and $g_r=0$ in (9). The advanced level temperature is obtained from (11) by means of (12). Thereafter, advanced level velocities are upgraded from a system of equation $Jh=-R_h$ using suitable damping. This coupled procedure continues upto the maximum iteration limit N^*, where the difference between two consecutive approximation solutions is assumed be lower than a necessary tolerance value ϵ. Because of a sufficiently accurate initial guess, the results obtained here are correct up to five decimal places.

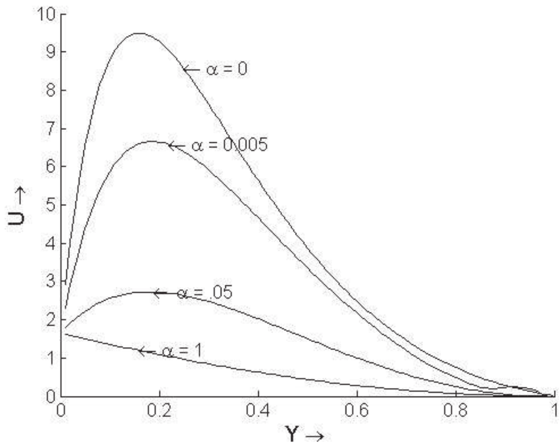

Figure 2: *Variation of* α *when* $g_r = 10, R = 9, P_r = 0.5.$

4. Result analysis

The above system of coupled algebraic equation is numerically solved by adopting a finite difference scheme implicitly and then simulated using MATLAB programming. The results so obtained are depicted through graphs. If not otherwise specified, the flow parameter values $\omega = 0.1$, $dt = 0.01$, and $a = 0.5$, $hl = 0.01$ is kept fixed for all plots. Results are examined for various velocity and temperature field parameters, primarily for two situations., $n = 0.5$ (variable acceleration), and $n = 1$ (constant acceleration).

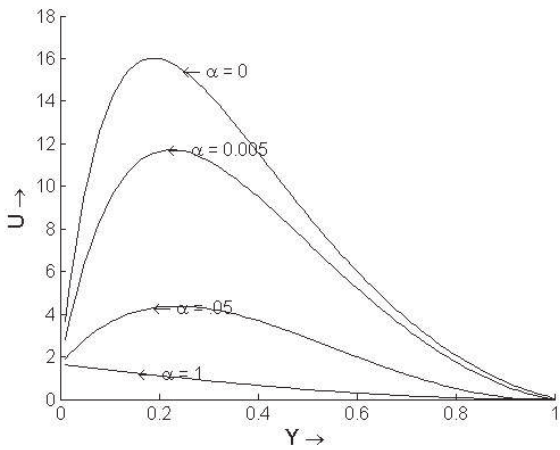

Figure 3: *Variation of* α *when* $g_r = 10, R = 9, P_r = 0.05.$

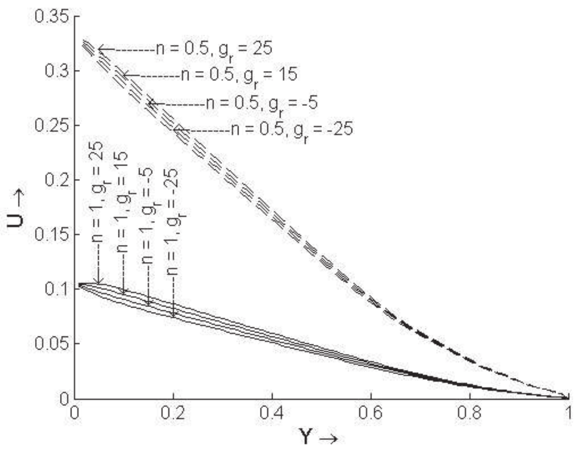

Figure 4: *Variation of* g_r *when* $(n = 1, 0.5)$, $\gamma = 0, \alpha = 1, R = 10, P_r = 10.$

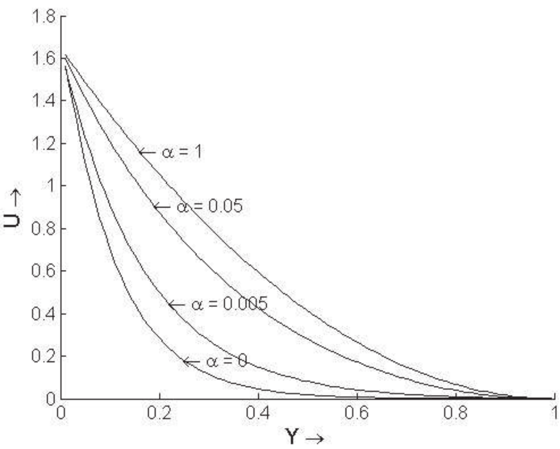

Figure 1: *Variation of* α *when* $g_r = 10, R = 9, P_r = 10.$

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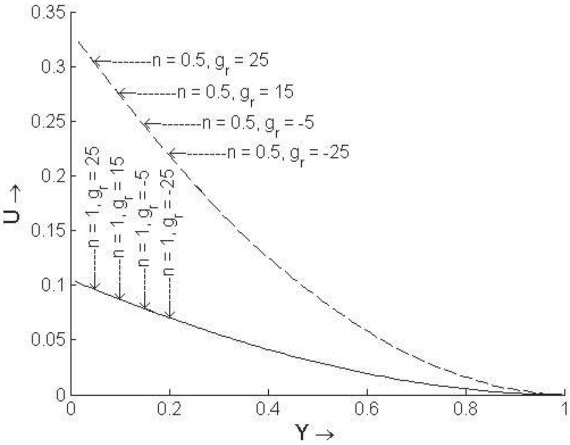

Figure 5: *Variation of g_r when,*
$\gamma = 0, \alpha = 1, R = 10, P_r = 10.$

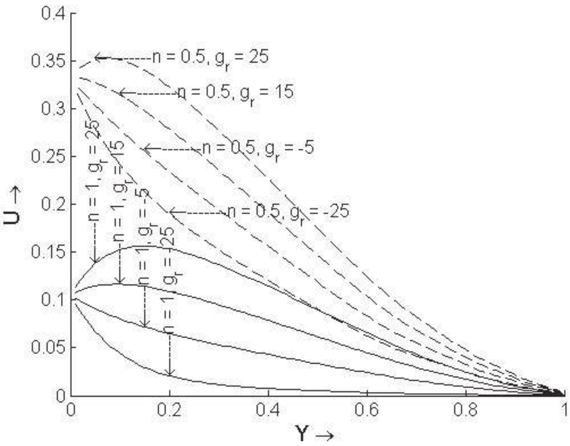

Figure 6: *Variation of g_r when,*
$\alpha = 1, R = 10, P_r = -10, \gamma = 0,$

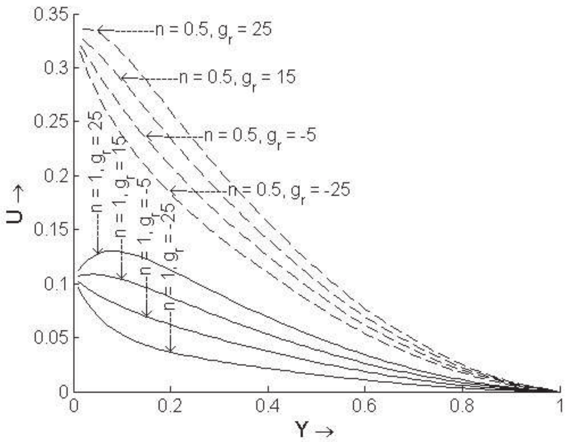

Figure 7: *Velocity variation of g_r .*

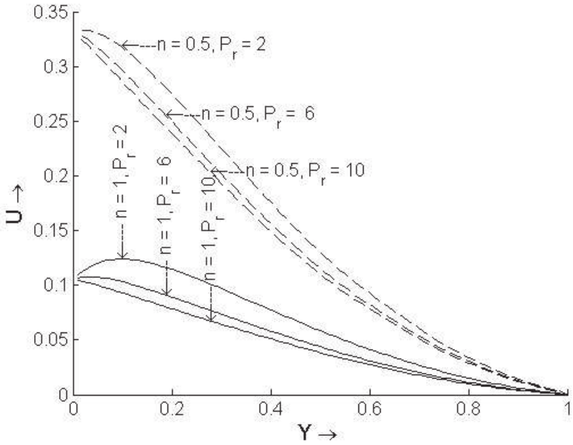

Figure 8: *Velocity variation of P_r.*

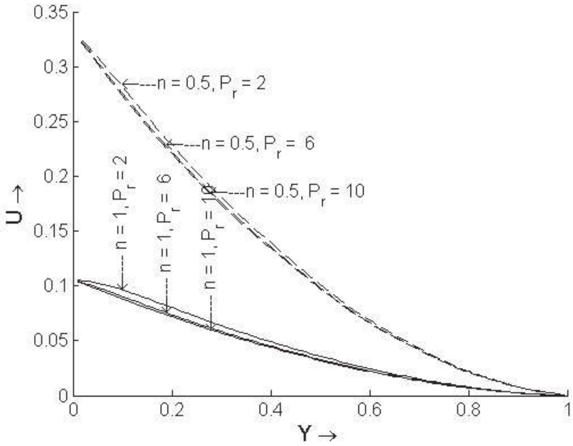

Figure 9: *Velocity variation of P_r.*

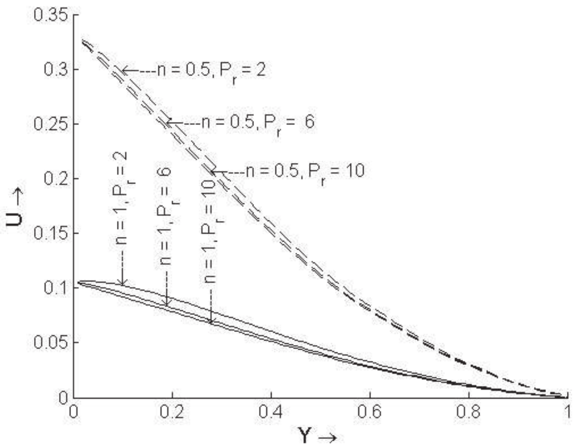

Figure 10: *Velocity variation of P_r.*

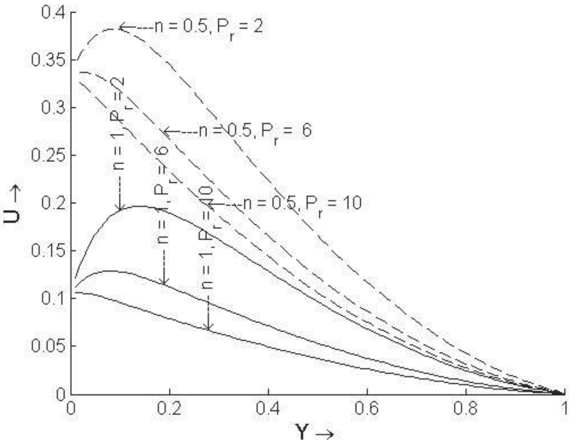

Figure 11: *Velocity variation of* P_r.

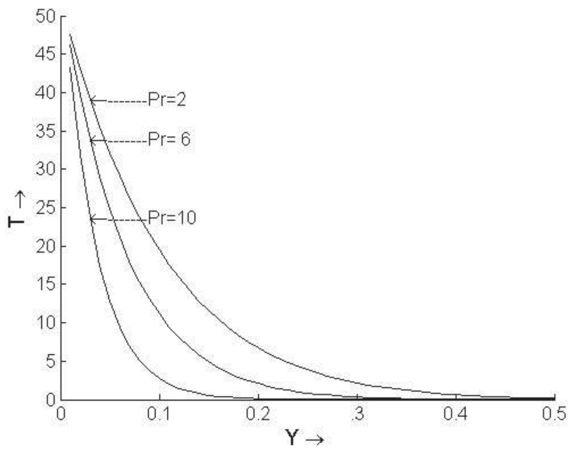

Figure 12: *Temperature variation of* P_r.

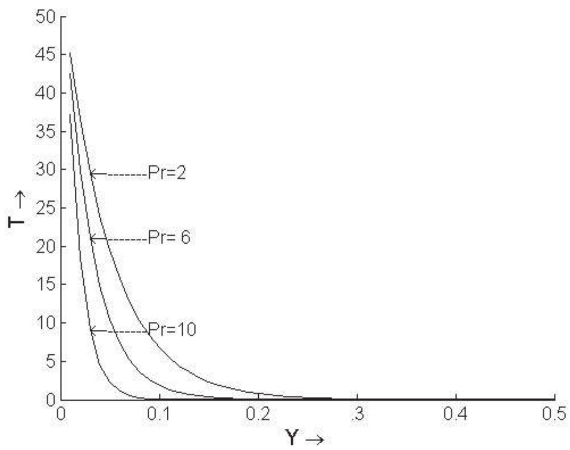

Figure 13: *Temperature variation of* P_r.

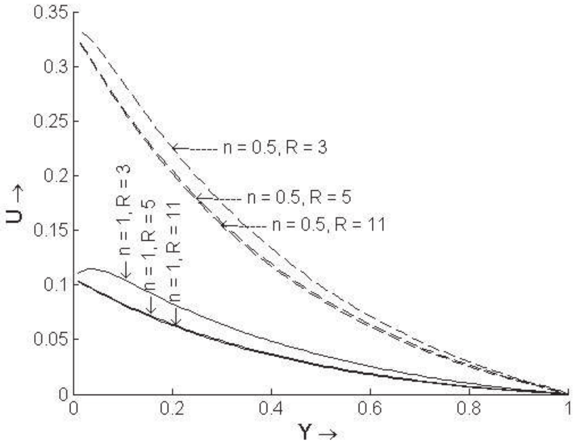

Figure 14: *Velocity variation of* R.

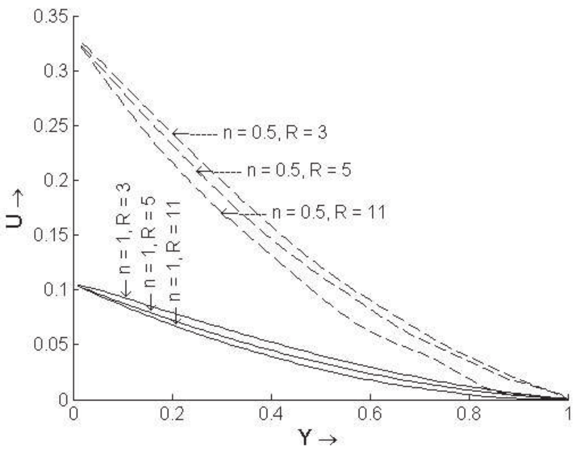

Figure 15: *Velocity variation of* R.

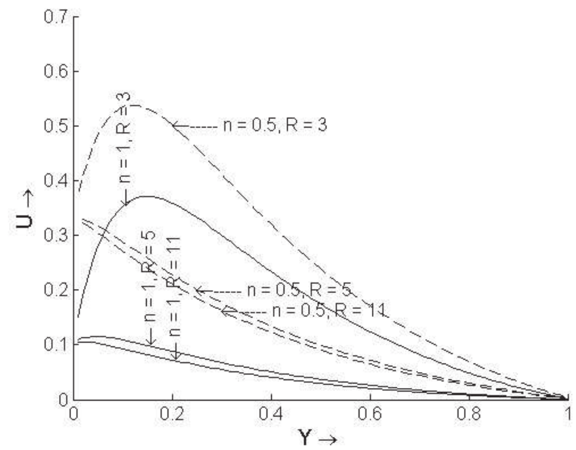

Figure 16: *Velocity variation of* R.

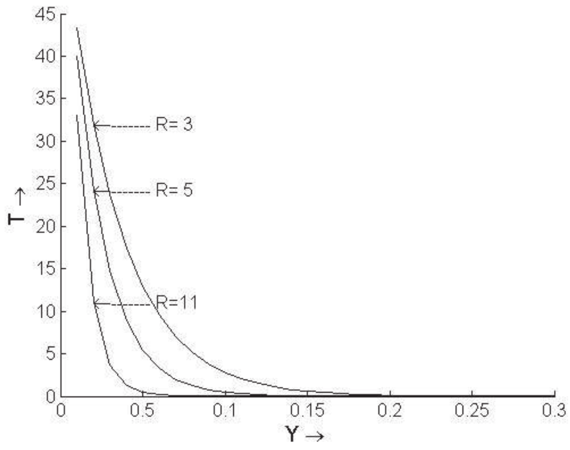

Figure 17: *Temperature variation of R.*

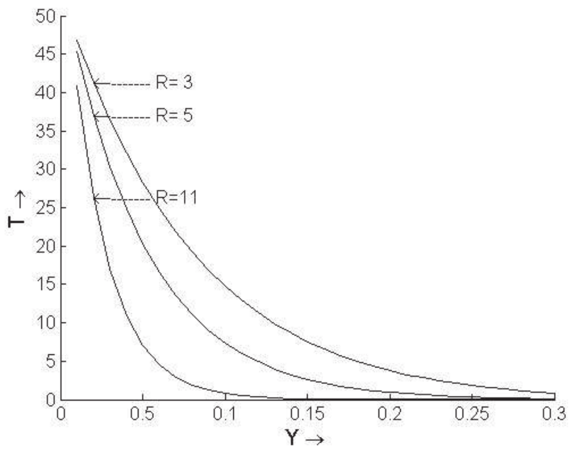

Figure 18: *Temperature variation of R.*

Figure 1 - 3 demonstrates the effect of values for the second-grade elastic factor α on the velocity profile, on variation of different emerging flow parameters. The velocity profile is found to be increasing with increase of elastic parameter value α when $P_r = 10$, but when P_r value is reduced to 0.3, a reverse effect is experienced in the profile. An exponential growth of velocity profile is observed near the plate surface and gradually boundary level thickness decreases away from the plate. Further reducing P_r values it is analysed that velocity profile decreases at a faster rate than the previous case.

Figure 4 - 7 describes the effect of grashof number g_r on velocity profile for various flow parameters, both for constant and variable acceleration case. Because of free convention, positive grashof number means cooling of the vertical plate and negative grashof number represent heating of the plate. In all situations, it is shown that the velocity profile rises as the g_r values climb, which is due to a reduction in dynamic viscosity as g_r increases, and that intensifies the velocity flow. Maximum velocity is attained near the wall which gradually seems to decreases. But this increasing behaviour diminishes as we go on to increase the value of suction parameter to $R = 8$ that leads to an increase in internal viscous forces of the fluid. In addition to it, as we reduce the P_r values diffusive heat of fluid decreases which allows more fluid to pass, hence a profound increasing flow behaviour is observed.

Figure 8 - 13 expresses the effect of prandtl number P_r on flow and energy profiles on varying different physical flow parameters. It is perceived that velocity profile initially rises exponentially close to the wall surface and then a steady decrease through out the flow domain is noticed. But when the suction parameter R is slightly increased, the momentum boundary layer thickness declines significantly due to rise of additional inertial forces within fluid. A similar behaviour is observed as we increase α values. With reduction in the elastic parameter values, an instant hike of velocity profile occurs near the plate which decreases remarkably. Temperature profile is found to be a decreasing function of P_r both for $g_r < 0$ and $g_r > 0$.

Figure 14 - 18 depicts the impact of the suc-

tion parameter R in the scenarios of $n = 1, 0.5$. It is witnessed that as R values rise, the velocity profile across the whole flow domain decreases. This effect is slowly diminished far away from the surface of the wall. As the elastic parameter values increase, a pronounced decreasing behaviour is seen through out the flow domain for both the cases i.e when either a constant or variable acceleration is suddenly applied to the vertical plate. As the suction parameter value increases, the temperature profile similarly drops.

5. Conclusion

In present work a numerical study of heat transfer and flow of a free convective second grade fluid passed through porous plate vertically is analysed for different non-dimensional flow parameters. The quadratic convergence numerical scheme adopted here to obtain appropriate stable results for small and large flow parameter values and overcomes persistent assessment of the entire problem for any modification in boundary conditions. Some significant findings of present analysis are noted hereby:

- For large P_r values velocity profile increases with increase in second-grade elastic parameter, but has a contrary effect on velocity for smaller P_r values.
- Velocity profile seems to increase for $g_r < 0$ and $g_r > 0$ for both smaller and comparatively larger P_r values. But the effect is insignificant when suction parameter value is more than 8.
- As P_r values increases, with an increase in the suction parameter, the velocity profile slows down even further, however as the elastic parameter value is decreased, a significant decline is observed.
- Both velocity and temperature field decelerates with an increase in R values, while other flow parameter values are also altered.

Nomenclature:

1. ρ = Density.
2. g = Acceleration due to gravity.
3. μ = Dynamic viscosity.
4. ν = Kinematic viscosity.
5. V_0 = Velocity of suction.
6. T^*_∞ = Temperature of a fluid at a distance from a plate.
7. t^* = Time.
8. C_p - Cpecific heat under a certain pressure.
9. k = The fluid's thermal conductivity.
10. β =Volume expansion coefficient.
11. u^*, U = velocities of the fluid.
12. g_r = Thermal Grashof number.
13. R = Suction parameter.
14. α_1 = Material constant with dimension ML^{-1}.
15. P_r = Prandtl number.
16. α = Elastic parameter.
17. ω = Frequency of oscillation.
18. a' = Constant having dimension T^{-1}.

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