FIRAT UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
TÜRKİYE

VIRTUAL REALITY AS A TOOL FOR ELECTRICAL MACHINES ASSEMBLING AND TESTING

SALIM MAHDI MOHAMMED

Master's Thesis

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This thesis, which was prepared according to the thesis writing rules of the Graduate School of Natural and Applied Sciences, Fırat University, was evaluated by the committee members who have signed the following signatures and was unanimously approved after the defense exam made open to the academic audience.

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DECLARATION

I hereby declare that I wrote this Master's Thesis titled “Virtual Reality as a Tool for Electrical Machines Assembling and Testing ” in consistent with the thesis writing guide of the Graduate School of Natural and Applied Sciences, Firat University. I also declare that all information in it is correct, that I acted according to scientific ethics in producing and presenting the findings, cited all the references I used, express all institutions or organizations or persons who supported the thesis financially. I have never used the data and information I provide here in order to get a degree in any way.

02 July 2021

SALIM MAHDI MOHAMMED

PREFACE

Virtual Reality has caught the world's creative mind. Throughout the most recent couple of years, engineers and fans in the large numbers have given innumerable hours to coding, planning, and theorizing about the prospects of this energizing new medium. Moderate equipment frameworks like the Oculus Rift, Samsung Gear VR, and Google Cardboard VR permit purchasers to encounter augmented reality firsthand in the solace of their homes, in a bistro, or on the train to work. Press inclusion has reached past the exchange press and blogosphere to standard distributions praising the virtues of VR, and the prospects appear to be unending: from gaming and film to engineering, instruction, preparing, and medication. Despite the fact that it has far to go, computer generated experience seems ready to turn into the following significant amusement medium, and maybe even the registering foundation of things to come.

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Academics, on a regular basis, confront equipment shortages that are present in the industry today. Furthermore, since many students find the abstract concepts and complicated ideas about mechanical and electrical engineering challenging, they often struggle with understanding topics linked to those fields. While several studies have demonstrated the capability of virtual reality in various settings, such as growth, healthcare, the military, and school education, virtual reality has yet to be implemented effectively in those arenas. In the very near future, we will all be using Virtual Reality (AR) technology to improve our sense of perception and therefore our overall quality of life. Thanks to virtual reality, we will be able to support areas such as schooling, upkeep, construction, and reconnaissance. This study explores how interactive training tools are being used to educate electrical engineering students in the real world. 3D models of authentic devices are exposed and accessible to end users who can communicate with and control them. When operating with a real computer, the users have a possibility to assemble and disassemble the machines, test them under extreme conditions, and compare structural variations between them. With 3D devices fully operational, users can analyze the effect of supply conditions on the business from any aspect. The users have a possibility to compare structural differences between devices, assemble and disassemble the machines and test them under extreme conditions, all of which would not be possible while working with a real device.

Keywords: Virtual Reality, Mixed Reality , Augmented Reality, Induction motors, User interface.

ÖZET

Elektrik Makinalarının Montajı ve Testi İçin Bir Araç Olarak Sanal Gerçeklik

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Akademisyenler, düzenli olarak bugün endüstride mevcut olan ekipman kıtlığı ile karşı karşıya kalmaktadır. Ayrıca, birçok öğrenci mekanik ve elektrik mühendisliği ile ilgili soyut kavramları ve karmaşık fikirleri zorlayıcı bulduklarından, genellikle bu alanlarla bağlantılı konuları anlamakta zorlanırlar. Büyüme, sağlık, askeriye ve okul eğitimi gibi çeşitli ortamlarda sanal gerçekliğin kapasitesini gösteren birkaç çalışma olsa da, sanal gerçeklik(virtual reality) bu alanlarda henüz etkin bir şekilde uygulanmadı. Çok yakın bir gelecekte hepimiz, algı duyumuzu ve dolayısıyla genel yaşam kalitemizi iyileştirmek için Sanal Gerçeklik (AR) teknolojisini kullanıyor olacağız. Sanal gerçeklik(virtual reality) sayesinde okullaşma, bakım, inşaat ve keşif gibi alanları destekleyebileceğiz. Bu çalışma, gerçek dünyada elektrik mühendisliği öğrencilerini eğitmek için etkileşimli eğitim araçlarının nasıl kullanıldığını araştırıyor. Özgün cihazların 3D modelleri, onlarla iletişim kurabilen ve onları kontrol edebilen son kullanıcılara sunulur ve erişilebilir. Gerçek bir bilgisayarla çalışırken, kullanıcılar makineleri monte etme ve sökme, aşırı koşullar altında test etme ve aralarındaki yapısal farklılıkları karşılaştırma olanağına sahiptir. 3D cihazlar tam olarak çalışır durumdayken kullanıcılar, tedarik koşullarının işletme üzerindeki etkisini her açıdan analiz edebilir. Kullanıcılar, cihazlar arasındaki yapısal farklılıkları karşılaştırma, makineleri monte etme ve sökme ve gerçek bir cihazla çalışırken mümkün olmayan zorlu koşullarda test etme imkanına sahiptir.

Anahtar Kelimeler: Sanal gerçeklik,Karma Gerçeklik, Arttırılmış gerçeklik , Asenkron motorlar, Kullanıcı arayüzü

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SYMBOLS AND ABBREVIATIONS

Abbreviations

2D	: Two Dimensional
3D	: Three Dimensional
4K	: 4,000 Pixels
AC	: Alternating Current
ADSL	: Asymmetric Digital Subscriber Line
AGP	: Accelerated Graphics Port
API	: Application Programming Interface
AR	: Argument Reality
CAD	: Computer Aided Design
CAVE	: Cave Automatic Virtual Environment
CAX	: Computer Aided tools
CCD	: Charge Coupled Gadget
CPU	: Central Processing Unit
CRT	: Cathode Ray Tube
DC	: Direct current
DFFD	: Direct Free-Form Deformation
DIS	: Distributed Interactive Simulation
EMF	: Electro Motive Force
FA	: Fast Adapting
FOV	: Field Of View
GPS	: Global Positioning System
GPU	: Graphics Processing Unit
GUI	: Graphic user interface
HD	: High Definition
HMD	: Head Mounted Display
HRIRs	: Head-Related Motivation Reactions
HRTFs	: Head-Related Exchange Capacities
HSD	: Hand Supported Display
I/O	: Input/Output
IPD	: Interpapillary Distance
IPMSM	: Interior Permanent Magnet Synchronous Motor
IR	: Infrared
LAN	: Local Area Network
LCD	: Liquid Crystal Display
LED	: Light Emitting Diode
LOD	: Level-Of-Detail
MEMs	: Microelectromechanical Systems
MMF	: Magneto Motive Force
MR	: Mixed Reality
OSVR	: Open-Source Virtual Reality
PC	: Personal Computer
PMSM	: Permanent Magnet Synchronous Motor
RAM	: Random Access Memory

SDK	: Software Development Kit
TCP/IP	: Transmission Control Protocol/Internet Protocol
UHD	: Ultra High Definition
UI	: User Interface
VE	: Virtual Environment
VR	: Virtual Reality
WAN	: Wide Area Network
XR	: Expanded Reality

1. INTRODUCTION

A Virtual Reality (VR) System is an all-inclusive simulator that allows the user to experience the environment created artificially as though it were real. An author named Bracken stated elsewhere that VR is team play writing three-dimensional test between humans and computers with distinct individual capabilities that enables normal information exchange between the two systems. Thus, VR enables people to envision, His hobby, as a researcher, was to control and communicate with computers and incredibly complex data. The display is enabled by Computers are ability Generating visual, auditory or other information sensory Outputs for a world user contained Inside the machine. This world is possibly taking the form of a computer-aided design (CAD) model, a scientific or a scientific simulation window in a database. The user is allowed to then Manipulate objects and interacts with the world directly in and of it. Additional processing, such No less creative than interactive physical simulations, or no less scripted than primitive animation, are used to expand some various worlds. Virtual reality is frequently considered to be a natural extension of three-dimensional Advancement in input and output technology together with computer graphics increases. This technology only matured recently the point where it can be applied to serious engineering tasks such as manufacturing. Virtual reality applications extend a in architectural and business planning, a full range of games Changed Words Structural Changes Longest Unchanged Words. Numerous practical plans, such as CAD or architectural modeling, create worlds that are strikingly similar to our own. Certain The Company came up with two applications, such as scientific simulators, as well as air traffic and simulation control, enable viewing at an insurmountable advantage perspective that are it would be impossible. In I want to see the world. A couple of other examples are diametrically opposed to most anything previously encountered. A critical characteristic of VR is it's the ability to perform high-f fidelity computer simulations at a moderate cost. The potential of a virtual reality- Creative: basic system is based enormous, as well as the expenses of inherently broadening technology decline, the applications for which it will be used are likely to accelerate [1].

VR is becoming being one that has a shot at being more sustainable than traditional product manufacturing and distribution due to advancements expanded in data visualization, computer simulation, and product modeling, and visualization, as well as Virtual reality is the wave of the future, owing to the increased Many/one can get affordable, inexpensive, low-cost 3D graphics advancements in an internet that's easier for customers to navigate to distribute a lot of information; a ton of information from UNIX workstations to desktop PCs. Its use in manufacturing enables to further reduce the costs of design and production, to guarantee product quality, and also to improve the product's efficiency shorten the amount of time required to transition moving from a concept to production [2].

And here are some literature Survey's that we compare with our study:

A three-dimensional (3D) virtual environment is a computer-generated representation of space and time that can replicate a variety of aspects of the real and abstract worlds. Several aspects include the camera, lighting, appearance, shape, behavior, and the spatial and temporal arrangement of objects. In a graphic computing application, a 3D virtual environment is a scenario in which the user can navigate and interact with the virtual world, exchanging information and experiencing the environment's reactions to their actions. Immersive virtual environments are those that stimulate the user's various senses in order to create an immersion sensation, in which the user feels completely immersed in the virtual environment.

Illustration And shown the real-world application of a virtual training tool for electrical engineering education. Users can interact with and manipulate 3D models of authentic devices using this tool [3].

Customers' growing awareness of the effects of climate change, the high volatility of demand in several industrial sectors, and the rapid automation and digitalization of manufacturing systems are compelling businesses to rethink their business strategies and models in light of both the Circular Economy (CE) and Industry 4.0 (I4.0) paradigms [4].

Academics frequently face a lack of access to modern equipment and devices currently in use on the market in their daily practice. Additionally, many students struggle to comprehend mechanical and electrical engineering concepts due to their complexity, the requirement for abstract thinking, and the fact that these concepts are not fully tangible [5].

Augmented Reality (AR) technologies help us see, hear, and feel our environments in new and enhanced ways. AR will assist us in a variety of areas, including education, maintenance, design, and reconnaissance. This article discusses the field of augmented reality, including a brief definition and history of the field, as well as the enabling technologies and their characteristics [6].

2. VIRTUAL REALITY APPLICATIONS IN MANUFACTURING

Virtual Reality may also be viewed as referred to a virtual reality simulation or an all-encompassing expanse by enabling at more manageable levels of detail; users are allowed to explore virtual objects. For entrepreneurial involvement, VR can enable users to explore virtual objects in which spans several dimensions: 2D or 3D, flat or immersive. According to this source [7] alleviates the necessity for summary, external-centric Thinking with concepts, synthesizing data 52/10000 Characters Rephrase even though it's three-dimensional, appears to be two-dimensional Changed Words Structural Changes Longest Unchanged Words the user to talk to it as if they participated in that occurrence. Thus, Processes derived evolutionarily for comprehending The Life physical can be the world applied to comprehending Information synthesized [8].

Virtual production is possible Defined as a synthetic integrated production environment that is used to improve decision-making and control at all levels of the manufacturing process [9]. Based on [10] , virtual production is a production process. In a computer-based system, abstract prototypes of objects, procedures, activities and concepts develop. in order to improve one or more of them manufacturing process Attributing. VR may facilitate the creation of enhanced graphical GUIs (Graphical User Interfaces) for Virtual Manufacturing, thereby improving the user's integration alongside a computer system. Thus, virtual reality serves as a visualization tool in the Virtual Manufacturing environment.

The Cross following expanded usage to increase the capacity of the synthetic or virtual manufacturing environment, which is a macro-economic system in achiness, or techniques expand upon (embellish) upon instead of simply imitating" Principles can be established in a computer environment, as they evolve. Improve up to a maximum of three manufacturing process important values.

2.1. Training

VR training was widespread adopted and beyond. Is widely regarded as a cutting-edge technique imparting employing creative skills and processes in the creation of merchandise. Through the use of cutting-edge virtual reality technology, training takes place in a realistic, simulated version of the actual facility, complete with the plant floor's actions, sights, and sounds. VR-based training is an option in situations where traditional methods of training are difficult, dangerous, expensive, or impossible. Additionally, this type of Trainer: training is justifiable. when limited are A significant number of employees are associated with the field., when the employees are creative dispersed across or when it is a large area critical that staff receive Compatible training regardless of creatively where, as or whenever they see fit receive it. Certain skills are better acquired through hands-on experience rather than through a lecture, demonstration, or book. When each employee has complete access to the entire facility, optimal training occurs. Virtual reality-based manufacturing training replicates an entire continuous manufacturing process, allowing each trainee to learn in their own factory. Additionally, all employees have the opportunity to practice existing and new tasks in a safe, simulated environment and observe the evolution of a product as it moves through the manufacturing system. By repeatedly exposing employees to their operating environment, they develop an acute awareness of the manufacturing process's methodology, equipment, structure, and objectives. Training in a virtual reality simulation of a plant familiarizes employees not only with their individual responsibilities, but also with the entire facility, providing them with a thorough understanding of how they fit into the overall process, thereby significantly improving the plant's overall efficiency. Any process can be replicated, fostering a better understanding of Processes of manufacturing and technological advances among employees. The technology of Motorola, Samsung, IBM and Lucent all Chosen to Modes Training Technologies' Simulations of PC-based VR to aid in their training efforts. Using Supers cape virtual reality software, training courses simulating Wafer inspections and operation, microelectronics and cleanroom operations have been developed. Networked applications, enabling all company employees to receive the same VR-based training. Performance of employees can also be achieved tracked Creative on learning computers and management puts the results into perspective [11] . Out of synch, an integrated circuits Fabricator collaborated with Modes develop a number of virtual reality Modules of training.

This training program teaches the Accurate step sequence required for the first-time a A semiconductor manufacturing process; including all kinds of ion implantation processes, as well as thin-film processing in the manufacture of semiconductors constructing an integrated circuit. An integrated system. Workers can run pretend, assume whenever they have time, and then they don't refer to from time to time when looking for solutions, in Figure 2.1 shows Virtual clean-room. Part of a VR training course developed by Modis for Lucent Technologies.

Figure 2.1. Virtual clean-room. Part of a VR training course developed by Modis for Lucent Technologies.

2.2. Assembly

The addition Creative ways of implementing virtual reality functionality to design systems is a CAD (computer-aided design) technologies may lead to an artificial evolution. This new feature provides designers who use methodologies for developing Products new and varied. The process is designed evolve to Help this new one perspective on the product and methods used manufacture it. Once VR technologies are widely adopted in industry, it is expected that new conception approaches, and the business and engineering processes involved, will emerge. Industry has not yet fully embraced technologies that enable virtual assembly evaluation and analysis. Although the applications of this emerging technology in commercial industries are not fully understood, the Technology in its entirety is seen as viable and precious. A key component in the virtual production is virtual assembly. It is defined as 'analysis, predictive models, visualization, and presentation of data without the production physically realized or supporting process, through computer tools, or tools for taking, or supporting, assembly related engineering's." [12] Although VA is It is actually defined as a technology a collection entrepreneur's technology including Further visualization, simulation, theory of decisions, assembly and production procedures and development of Equipment for assembly/production. Environment of the Virtual Assembly (VADE), developed and implemented in partnership with the National Standards and Technology Institute at Washington State University, is a virtual reality- Basic application for engineering enables Mechanical system assembly engineers to evaluate, analyze and plan. This scheme is centered on the integration of a virtual space with a meeting/workplace where you have both creative systems and computer-aided design.

VADE is the distinguishing characteristics Include inclusion two-way Data integration with the parametric CAD system, realist user interaction with the virtual environment components, and creation in a virtual environment of valuable design information, reverse transmission of design information to the CAD system, significant virtual environment instructiveness, collision and physically based detection modeling. An assembly scene is presented to the user in extend virtual environment. The extensively components can be initially defined as arranged in the order in which they'd like them appear in an actual installation. Once the process is complete, the user can proceed to perform the assembly. By enabling the user, this instructs the user to make design the capability to make decisions to existing designs, be creative and produce a variety of other technical tasks within the whole concept of virtual reality. Throughout The environment is non-permanent while the process is running in the cloud's connection to system of CAD and makes use of the CAD system's Functions as needed. Ford launched the C3P project in 1995 with the goal of utilizing Computer technology advanced, such as Virtual Reality (VR) to support Ford vehicle design and assembly (Ressler,1994). C3P is one system that combines CAD design, CAE engineering, computer aid manufacturing (CAM) and a massive range of computer assistance systems, and Ford-proprietary Database of PIM Product Information Management. With It really is C3P remarkable Ford cannot just develop new vehicles, digital capabilities more quickly, Only, however, also at a Greater More level of good quality. Everyone Mondeo is the First to digitally create Ford with C3P. Everyone precision and quality of the new Ford Mondo Achievement through the application of this revolutionary new integrated tool set and process seemphismicic method. C3P is assists Ford in Ford shortening the Development of Mondo by thirteen months, in Figure 2.2 shows Mondeo - The first Ford to be created digitally [9].

Figure 2.2. Mondeo - The first Ford to be created digitally [13].

2.3. Design

2.3.1. Virtual Prototyping

Virtual prototyping is a software-based engineering field, involving the modeling, simulation and visualization of a mechanical system three-dimensional behavior of the motion realistic Terms of operation, and refine / optimize the design before the first physical prototype is built iteratively.

An industrialist increasingly incorporating prediction into it looks fresh. Processes For the first time a variety of grounds: to reduce the number of physical digits in my name perceptions required, to shorten Breathe new life into old ideas. Create products with more features use of 2D simulation enables designers to give the appearance of originality only the appearance of objects but, in addition their behavior. virtual prototyping can be used to design validate new objects or assemblies are operational and viable creating as a model of a computer prior to incurring and the costs time associated with creating physical models. Attributes like appearance; movement, strength, wear strength, thermal driving, and flexibility can be added to 3D CAD models before they are Placed in an environment of computer simulating anticipated conditions and interactions. This prototype can be used to identify possible problems more quickly, affordably, and safely rather than physical prototypes, thereby Cycle times shortening and lowering as a whole, costs

Virtual prototyping software simulates the operation and maintenance of virtual prototypes using real-time, three-dimensional technology. This software can create a simulated virtual manufacturing environment in which to develop and optimize fabrication, assembly, machining, and other manual and robotic manufacturing processes, obviating the need for physical product prototypes or mock-ups of production tooling. Virtual prototyping can be used to simulate the work flow, the layout of the facility, the throughput, line balancing, and the cost of the product.

A prototype virtual has several benefits and skills over one physical prototype. One of the most important is the ability to have intrusive instrumentation that is in real time enables the system status monitoring engineer without causing it to operate abnormally. Additionally, it provides significantly higher levels of visibility than a real-world system. Salford, England-based Systems Solutions Intelligence (ISS) Ltd. a virtual reality Rolls-Royce Aero Engine Services Ltd. demonstrator (VR). In London the Boeing 777 engine is used for the Trent 800 engine of the company. The protester was there a simple Unit for VRs allowed Rolls-reviews import your system CAD data, tag specific Objects such as Functional bolts and then pick an instrument and attempt Hit the bolts. Additionally, system users of VR had the option of removing Motor brackets and pipes. This kind of virtual engine interaction development, void of the need for a physical exemplar, enabled Rolls-Royce to assess the engine's ease of manufacture and maintenance [14] .

2.3.2. Virtual Factory

Numerous complex factors must be considered when designing a manufacturing facility. To begin, there is also the physical space required for each piece of equipment and its operators. Require. After that, additional space is needed for upkeep, loading/unloading, cleaning, and maintenance. Considered in, machine capacities, and options, etc. anticipated programs necessary to meet these requirements sequence funny technique of operations, the equipment's optimal location can be determined. While this process is complex enough for a single machine, when several machines are considered simultaneously, it can become overwhelming. Inefficient plant placement can reduce a plant's efficiency. When all critical factors are modeled in a computer simulation, it becomes much easier to visualize neither in for gains and losses effects various options the people, usage on social networks has grown tenfold for gamers (1998), a computer-based Enable virtual plant Analyze and identify users manufacturing process Defects prior to them manifesting on the actual factory floor. The user will gain an understanding of the environment's components and how to integrate them smoothly in order to: create a computerized environment that simulates individual production processes accurately and entire Reduce production costs; Shorten development time; and optimize market time; integrate product, process, and resource design seamlessly.

Animation Engineering, Inc. (EAI), a leading Developed a comprehensive solution for the visualization, collaboration and analysis tools, assist Organizations of production in rapidly developing better systems. The software of a virtual factory optimizes production processes from process planning to final design through process planning, production. Modeling, Ergonomics, plant visualization and web-based design review.

Businesses can use Applications for virtual factory to Factory layouts design and production plans, significantly increasing productivity and production decreasing when-to-market (U.S. Geological Survey Website, 2001). This approach visually connects an organization's systems. Entire From product concept to final development, the manufacturing phase, reducing time spent on overall production planning, reducing the available resources required to put a product on the market, and significantly improving efficiency of the production line (Tec mall [15]. Engineering students at the University of The Buffalo have created VR-Fact, New software for a virtual factory. The user can use the software navigate by means of an inbuilt Power plant assembly, maneuvering around large Equipment parts simply Point and pull the mouse. The mouse. Revolutionary Fact enables businesses to virtually design big plants and big plants simulate create in them three dimensions. All manufacturers can then use the simulations engage things, to accomplish things like spot similarities avoid potential blockages prior to laying a foundation on a completely new plant-powered item. Additionally, the software Functionality automatic generation the of majority of standard machines based on process parameters, ergonomic problem detection, shop floor activity monitoring, and database system interfaces, in Figure 2.3 shows Virtual Factory.

Figure 2.3. Virtual Factory (http://www.vrlab.buffalo.edu).

2.3.3. Virtual Factory Web-Based Virtual Reality

Web systems are an excellent instrument for remotely virtual pattern sharing or environments as well as facilitating Work together [16] . Thus, based on the web virtual reality Systems are economically efficient, as the infrastructure required is available Creative is basically meaning nearly everywhere, and you can use a plug-in (plug-in software) to view it nearly every which means all. Additionally, bier suggests that the use of the Virtual Reality Modeling Language as a possible solution for a standardized virtual model (VRML). While HTML The new home page design norm, is VRML enables Distribution over the Internet of three-dimensional models. The models are multi-faceted in nature and can be encouraged. They also can Usefulness is a useful feature, and is related to functionality, as well as dynamic behavior controlled Manually via a dialog box.

3. BACKGROUND

3.1. Augmented Reality

In general, the term "augmented reality" describes anything that is augmented. superimposes digital simulations on in the modern world, registering animated 3D virtual content so that it appears to exist in a fixed location in the real world. Instead of viewing with a head-mounted display, an architect could see the virtual building 'as if it were in reality.' as the user moves across the table, the device becomes more dynamic. The rendered image of the virtual object is replaced with the current view of the virtual scene. Reflect an objective, clear-minded perspective, creating the illusion that there is an object at a fixed space point. As is the case with many emerging Technologies, increasing reality initially envisioned for military purposes. In the 1960s, AR systems were used in cockpits for fighter jets to provide information to pilots Aircraft systems, waypoints, hazards for navigation, and objectives of the enemy. The Investigators discovered that could they reproduce the information displayed on the aircraft's Traditional gages and displays that overlay information over the graphical displays pilot's See as he or she seeing. Out the window at the true world. Numerous benefits resulted from the new displays, significantly increasing pilot proficiency on the ground. Data may be flight conveyed more dynamically, intuitively and graphically, requiring less Cognitive information decoding processing. The connection between the pilot and the plane were significantly improved, as was overall situational and combat awareness [17]. In the 1990s, significant advancements Computer vision and consumer hardware enabled the first university student prototypes of AR. Several studies examined Domain AR during this period, and R. Azuma in 1997 published a seminal review Previous research in which he the generally accepted AR definition has been coined: Combining increased reality systems the physical Virtual and worlds, are real- interactive time and registered spatially in three dimensions [18] made the following year a significant advancement in object identification and registration with his "Matrix" method [19]. It was the first time. Large-scale Implementation of a system of pose estimates based on two-dimensional Barcode patterns in square form that encode Unique information about identification a process referred to as well as marker tracking. In 1999, M. and H. Kato Billing Hurst created the AR Toolkit tracking database, which enhanced Kimoto's approach [20]. AR Toolkit was quickly adopted as an open-source project and quickly gained widespread popularity Researchers, business enterprises and private individuals from increased realities. This is what we are talking about. Significantly enhanced the visibility Popularity and the augmented reality and stimulated the development new applications interdisciplinary. Recently, the AR Toolkit And for mobile and web platforms other tracking libraries have been established, opening up new research and commercial approaches, such as outdoor augmented reality and on the web augmented reality the marketing process. Since then, the domain of AR has grown at a breakneck pace, and has established itself as a prominent cutting-edge of modern technological development.

3.1.1. Augmented Reality and Learning

Education is a significant interdisciplinary application of Augmented Reality. Numerous There have been studies on the use of augmented the use of reality as a teaching tool enhance performance in learning in a variety a variety of subjects, including physics [21], medicine [22] , chemistry [23] , science of biology [24] , and read skills. One of the first successful studies was performed University 2002 Washington, when Investigators developed an augmented reality Learning interface undergraduate geography student the relationship of the earth with the sun [25] . A virtual display of the participant's three-dimensional Earth and sun pattern, which with their hands, they might manipulate. The pattern depicted 4 different positions the sun around the earth, corresponding spring and autumn equinoxes, summer and winter solstices. The pupils were able to observe How is the axis of the earth always inclined in the same way revolves the result is around the sun varying Light amounts reaching the north and the south at various a period of the year This comes as no surprise. Sparked a debate between researchers and participants about the origins during the seasons.

The augmented reality cross-platform approach enabled studio and CAD programs allows students to see the model from any angle. and physical views enabled students and teachers to use their hands to gesture at model features. The subjects completed a pre- and post-testing period prior to and following the recreation work that goes with it indicated a significant increase to understand and a decrease compared with traditional misunderstandings of the student (non-AR) teaching Methods. The scientists said that augmented reality is beneficial for the transmission of concepts three-dimensional Spatial and ability configurations students to control the interaction intuitively was a significant benefit.

3.1.2. Augmented Reality for Assembly and Maintenance

Manual mounting and maintenance training is a type of learning which can benefit considerably from the use of AR since these "hand-on" tasks are spatial inherently and naturally provide visual guidance. As a result of its ability to offer 3D animation, text and graphical indicators in the context of real objects, Augmented Reality has a significant advantage over other display technologies in this area. Why look at the diagram of a car engine to find a specific component when the actual engine can be viewed and an AR display can be displayed? in Figure 3.1 shows Augmented view of a BMW car door and locking mechanism [22].

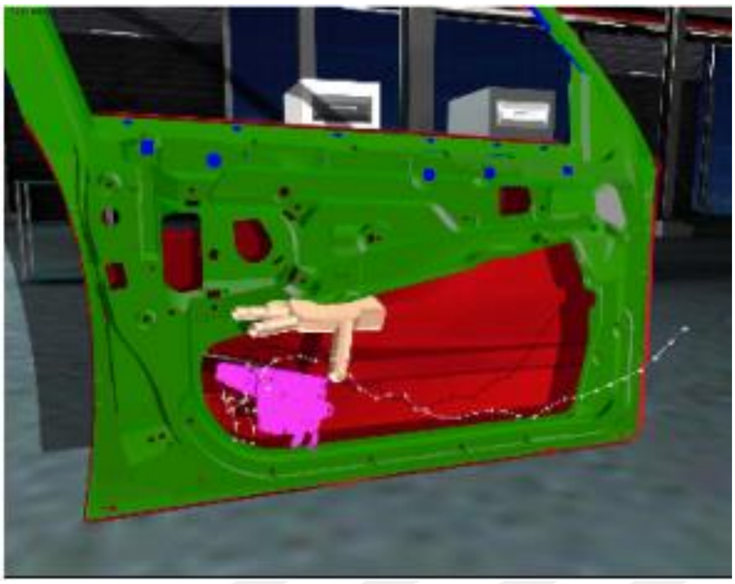

Figure 3.1. Augmented view of a BMW car door and locking mechanism [22]

3.2. Intelligent Tutoring

Increased information technology the twentieth The Hundred wrought Deep social changes, but education remained Very fair unaffected in comparison to A lot more fields. Early technology like film, radio, and television Education was once supposed to revolutionize, but had a few consequences in practice due to their tendency to automate or replicate existing strategies rather than fundamentally improve Methods for teaching [26] . The advances that have taken place in artificial intelligence, cognitive science and the Internet since the 1990s have allowed technology to play an even greater role in education, where it has gone beyond simply duplicating traditional approaches.

3.2.1. Model-tracing Tutors

The most popular technique for Smart Development Tutoring Model tracing is Systems. Tutors that use model-tracing rely on production rules, which are a Strategy collection in a specific domain to solve problems [27] .The domain-specific is declared knowledge gathered The rules of production to apply knowledge are formulated a specific problem. In the domain of geometry, an example of declarative knowledge "If there are two triangles" the sides are congruent and the angles included are then congruent. On the contrary. Procedural knowledge which is formalized through production rules could include skills such as aligning triangles, Identify the included angle, set sub-goals and deduction [28]. The learning act occurs when the student understands and then applies the declarative concept to solve issues. using production rules.

3.2.2. Constraint-based Tutors

In the late 1990s, continued advancements in Smart tutoring research has paved the way for a new approach known as restriction modeling. Ancient tutors represent paths, which state what it should be. By distilling domain knowledge, the tutor can model abstract properties of the right solutions into constraints. Changed Words Structural Changes Longest Unchanged Words, rather than generating domain-related task processes, as the model tracking and manufacturing rules are done. Both domain and student knowledge are used for restrictions. They encourage assessment and judgment, not deduction [29] . For example, in cooking is the necessity of compromise, a constraint May be "The meat must be permitted to cook steak come to room temperature before cooking." The limit implied a condition of relevance that specifies when the limit applies (when the steak is cooked), a condition of satisfaction that confirmed that the restriction has been fulfilled temperature), and a message of feedback informs what is the user they are doing incorrectly and encourages them to correct their Conduct, e.g., "The meat should be at room temperature when preparing a steak." Modeled as a general restriction this knowledge rather than it can be a rule of production be applied to a wide variety of steak-related scenarios, rather instead of serving as a specific steak preparation procedure.

3.2.3. ITS Authoring

Intelligent tutoring systems are often complicated and time-consuming to build. For example, the SQL-like pre-1500 constraints/restrictions took about an hour to generate and validate [29] Additionally, a technologist who are well-versed in the constraint's syntax, and are skilled at translating knowledge into them should also use this metric. Complexity made tools were necessary for ITS development to be feasible. Sims Simulation-based tutors were created by [30] , which is known as RIDES [31] . Used to develop models using entities, it allows the construction of graphical components, and offers tools for simulating rules. RIDES has a proven effective in providing tutorials for medical devices, marine radars, and on-board computers. As of today, the primary drawback of RIDES is that it only supports a causal model without any conceptual knowledge.

3.3. Intelligent Augmented Reality

While several studies have examined the Intelligent Tutor Combination and VR [32] , little prior research has examined the combination of Intelligent Tutoring Systems and Augmented Reality. While a few studies claim to have developed intelligent augmented reality applications, in practice these systems are only minimally intelligent and do not employ domain, student, or pedagogical models to provide each user with a unique tutoring experience. For instance, Y. Qiao et al. have developed a smart tutoring system that teaches users how to manage the instruments and dials in a cockpit [33] . In this context, they define intelligence by detecting the user's cockpit component and then showing relevant information on the functionality of the component.

4. RELATED WORK

Humans have always sought novel ways to fuel your creativity, like reveries or various methods of Enter altered awareness states. The advancement of technology has resulted in the creation of products that enable the Transfer of the senses to a programmable space for the experience. Virtual reality is an example of a product like that (VR). Limiting the simplest forms to visual and auditory Recreation alone, making them relatively simple to Realize. The most important thing is elementary the system of VR can consist the system of VR can and a pair of speakers. - Of speakers. But it's not. But, as a result of the rapid Head-mounted display development (HMD) development, these Devaluated solutions to the point where are not classified any more as virtual reality. Through the use of Displays and panoramic a variety of the movement tracking In terms of the appearance and physical phenomena, sensors, the user even experience imaginary environments which replicate the real world.

Today, engineering education is frequently conducted through the use of Simulators and technology for virtual reality. The capacity to do cost-effective Early design decisions are a key contributing factor significantly To VR solutions in this area's popularity and attractiveness [6]. A better understanding of the design includes further advantages complexities, which facilitates necessary adjustments, and a reduction or elimination of Cost and time constraints that Pest many modern processes of design [7]. This section will briefly describe several applications of the latest technology.

A good example is Virtual Labs [8] (Initiative of the Government of India), which enables Far-away access to laboratories in a variety of scientific and technical development disciplines. Indian University Students have complete understanding to relevant learning resources such as Web resources, animated demonstrations, audio recordings, and self-testing questions. Elegant tools enable students to acquire Only theoretical, while practical knowledge of a subject component is omitted entirely, preventing them from gaining real-world experience. Another noteworthy example is the Initiative MARVEL [9]. MARVEL is an environment for virtual training for mechatronics that provides creative graduates with remote easy access to state-of-of-the-the-the-art facilities and instruments. However, neither of the aforementioned platforms utilizes Head Mounted Display (HMD) technology, instead relying on the Internet and computers.

Dinis et al. [10] provide a Virtual Reality Overview and augmented reality Civil Engineering Training Applications that incorporate Elements of gasification. The aim of the project was to develop tools that would involve user's manner that was Motivate them more familiar because of their age rough the use of gaming elements, and Transfer skills and knowledge required for your future careers. But the project's primary objective could to explain and define for K-12 students the role of civil engineering, as well as its significance the community. In conjunction with their investigation, they developed a virtual reality platform to Train students even younger about geology. The findings are extremely encouraging and applaud the concept of virtual reality As an education tool, it makes it possible to interact with the platform for users with no formalized knowledge or training. effectively.

Sampaio et al. [11] provide another example of how to use virtual reality In the field of civil technology. The authors sought to create interactive 3D models that would allow users to get a better understanding of the roofs, walls, and bridge structure. These scenarios were accompanied by appropriate construction simulations, which allowed users to monitor the development process and to obtain valuable practical information on each element through interaction with the models.

The education in electrical engineering has also been strengthened with the application of a virtual reality [12], the centerpiece of which were Designed, developed, and made available online laboratories to students through VR. Single electronic laboratory experiments can be carried out safely. In that environment by utilizing appropriate Virtual devices, tools, components, and devices. By combining these Virtual scenarios with other study materials allow students to learn and participate. from a distance. Additionally, It removes the Potential risk harmful Exploration strategies and reduces Cost and expenses teacher workload.

The authors of wick et al. [13] Take Industry 4.0 concept and develop creative system delving into be creative workings from the smart factory. Systems create a virtual reality environment in which the production cycle can be experimented by employees / production system operators, allowing make them errors and then without them learning facing real-world consequences.

VR systems, however, have a lot more dynamic, as demonstrated by Hurtado et al.

[14], who introduce an innovation in the education and training of robotics. It not exclusively makes use of visual stimuli, however also incorporates Haptic feedback and a physics engine integrated. Arms may be robotic programmed to follow specific instructions or be controlled via a virtual pendant. A study of this application's users versus Students who have used Traditional materials for training indicates that the first are better equipped to work with real robots.

4.1. Oculus Go

Oculus Go is an autonomous headset for the virtual reality built with Qualcomm and Xiaomi from Facebook Technologies. This is the first device of the company in the standalone virtual reality headsets category, which was a new category when the Go was released. The Oculus Go was announced at the Developer's Conference in Oculus Connect on 11 October 2017 and is scheduled for May 1, 2018. The MI VR Standalone was launched by Xiaomi on 31 May 2019, its own version of the headset in China.

The Go is an all-in-one headset, which includes all the components needed to experience a virtual reality and does not need to be attached to an external device. The quality system is powered by a Qualcomm Snapdragon 821 processor and includes a unique 5,5-inch LCD screen with a 1280 x 1440-pixel resolution per eye and a refresh rate of 72 or 60 frames per second. The headset uses better Fresnel lenses compared to the previous Oculus Rift headset, offering a field of view of around 101°, resulting in a display fidelity of 12.67 pixels per degree for the Go. a] The input device is a wireless controller that works similarly to a laser pointer. The headset and controller employ non-positional three-degrees-of-freedom tracking, which enables them to be used for seated or permanent activities but not for applications on a room scale.

The Android headset features apps for watching both conventional and immersive video as well as other media from different sources, such as Facebook, the internal storage of the Headset and streaming services such as YouTube, Netflix and Hula. Oculus Store offers additional software, a Facebook Technologies-developed and-maintained digital distribution platform.

The headset was announced for overwhelmingly positive reviews on 11 October 2017 and launched on 1 May 2018. By July 2019, the Go had sold more than two million units. Facebook Technologies announced on 23 June 2020 that it'd be discontinuing sales of Later that year, the Oculus go and that the Oculus Store would no longer Accept new applications or app updates after 4 December 2020.

4.2. Software

To configure you must download Oculus Go, the Oculus application to an Android or iOS smartphone. The headset is connected to the phone via the Oculus application, the account is created, and a headset is matched with the controller via the Oculus application. [3][4] Applications and content are available for download and purchase through the Oculus Store via the Application for Oculus phone or directly everything from the mouthpiece [5] As images and videos can be transmitted via USB via a PC to Go and applications can be loaded side-by-side, many applications require the proper functionality of Wi-Fi. [6] The report [34] the report of the Committee on Foreign Affairs. The report is not available in German.

The Gallery, the Video, and the Venues apps are all made available for free to all Oculus Go customers. A courtier said: 'Your Majesty, I don't understand these taxes. I am by nature and profession a tax collector, but in order to put up taxes I have to rely on men like you, since they are the only ones who can control what they spend their money on. If the taxpayers could, the kingdom would not lack for gold.' 4 Next in line imaginative directions The Gallery allows media stored in the internal memory or elsewhere to be browsed using such services as Facebook, Dropbox, or connected to a Wi-Fi media server such as Plex to be accessed. Be Creative enables viewers to view trailers, feature films, or their own videos in a variety of Virtual surroundings. The TV app for Oculus allows users to look at television Virtual living room surroundings a variety of application, including Pluto TV, Netflix, Hulu, and Facebook Videos. Venues Oculus enables users to participate in Events live. The Casting of the Go feature enables the view from the headphone to be streamed to the phone connected to the Go [35].

At the time of the headset's launch, Oculus Rooms was a previously available application, but it was discontinued on October 25, 2019. Oculus Rooms was a personal and social space where users could invite their friends to play board games, listen to music, watch videos, television, and movies, and play multiplayer games in Figure 4.1 shows Oculus Software.

Figure 4.1. Oculus Software

4.3. Hardware

Unlike mobile headsets powered by a smartphone, such as the Samsung Gear VR and Google Daydream, the Oculus Go is powered by a computer. a stand-alone device that includes all of the components necessary to deliver virtual reality experiences. [45] The headset is powered by a Qualcomm Snapdragon 821 system-on-a-chip and comes with LPDDR4 RAM has 3 GB and internal storage is either 32 or 64 GB. (5) The Adreno 530 GPU integrated delivers graphics performance of approximately 500 GFLOPS. The device is powered by a 2600 mAh battery that, according to Oculus, allows for Up to 2 hours of video playback or 2.5 hours of games. (5) The Go provides three-degree non-positional freedom tracking, a proximity sensor when the headset is worn and a small control unit which acts as a laser pointer on the virtual environment.

The headset includes a 5.5-inch LCD fast-scheduling display in a sub-pixel range of the RGB stripe resolution, with a resolution of 2560 x 1440 pixels (1,280 x 1440 pixels). The headset is visible at about 101 degrees (3) and the horizontal pixel density of the horizontal axis is 12.67 pixels per degree. (a) The headset is made of better lenses from Fresnel than the lenses found in the Oculus Rift, claiming that Oculus was the best produced by the company when it was released. [36][37] [38] The Free Trade Agreement The headset lacks a fixed lens distance of 63.5 mm, which Oculus claims is optimal for IPD users between 61,5 mm and 65,5 mm. The headset is free from physics interpupillary (PID). The Oculus Go controller is a remote, wireless, orientation-tracked controller with a pointer for interacting with games and applications. The controller also has three buttons for the items selection and returns to the Go's home screen, along with the touchpad. A single battery is powered by the controller and allows the Oculus Go to operate on both hands in Figure 4.2 shows Oculus Hardware.

Figure 4.2. Oculus Hardware

Front view of the controller Oculus Go, displaying the touch pad and two buttons in the front and trigger

5. An Overview of the Available Virtual Reality Technology

As computer intensive applications, virtual reality systems require several dedicated technology components, some of which are described in this section.

5.1. Virtual Reality Technologies

5.1.1. Graphic APIs

A graphic API (Application Programming Interface), such as OpenGL and Direct3D, is a framework used for the development of graphic systems. Its computer programming components are used to access hard coded commands allowing for the specification of primitives, manipulation of the coordinate system, operations with matrices, texture mapping, among other commands [3]. The graphic API is used to achieve better performance in the development of applications. However, they do not offer management tools and scene optimization. For example, all specified polygons will be processed, even if some of them are out of sight for the use . Moreover, both OpenGL and Direct3D are "state machines", i.e. the commands change the current state of graphic hardware. The "state" represents a configuration and if it is changed, it may be necessary to interrupt the flow of the graph processing, discard all the work previously done, reconfigure and resume processing. Some of these limitations can be minimized by means of tools for managing scene graphs.

5.1.2. Scene Graph

A graph is a mathematical structure formed by nodes, linked with each other, used to store a collection of objects in an organized form. A scene graph is a hierarchical data structure, acyclic, which uses a high-level approach for modeling and managing scenes in computer graphics. The hierarchical structure of objects in a scene graph is used for optimizing a number of procedures in an application [39]. For example, in a scene which contains several houses, each one having several rooms, one house being outside of the field of view implies that all its rooms are also outside the field of view. When this is done automatically, it is possible to exclude the part of the scene that does not contribute with the final image, which represents a significant advantage. Another important characteristic of the hierarchical structure is the ease of manipulation. For example, a car is built with several parts such as the chassis and the wheels. A possible hierarchy could be modeled establishing the object "car" as the parent node and the other objects as its children. In order to move the whole car, it is only necessary to move the "root object" of this hierarchy and all its children will be moved automatically.

5.1.3. Immersive Virtual Environments

A three-dimensional (3D) the virtual environment is a simulation that's generated by a computer. of space and time that can replicate a variety of aspects of the real and abstract worlds. Several aspects include the camera, lighting, appearance, shape, behavior, and the spatial and temporal arrangement of objects. In a graphic computing application, a 3D virtual environment is a scenario in which the user can navigate and interact with the virtual world, exchanging information and experiencing the environment's reactions to their actions. Immersive virtual environments are those that stimulate the user's various senses in order to create an immersion sensation, in which the user feels completely immersed in the virtual environment. Immersion requires stereoscopic vision, three-dimensional Sound, and user actions in real-time response. The camera controls the user's view of the virtual world in an immersive virtual environment. The light is generated by light sources added to the scene. There are several types of lighting that can be used. The appearance refers to material, texture, opacity, shadow, reflection and other attributes which define the appearance of an object. Just like the geometrical description, appearance interferes directly in the final image and the speed to generate this image. The behavior of an object can be, for example, static or dynamic. The dynamic object is the one that changes its position, shape or appearance between two frames. VR technology includes all components which deal with the creation and implementation of immersive virtual environments. Each of these elements can be inserted into a structure of the scene graph, which will represent the virtual environment.

5.1.4. Stereoscopy

The three-dimensional view perceived by the user is the result of how the brain interprets the pair of two-dimensional images that each eye captures from its point in Figure 5.1 shows

Figure 5.1. Stereoscopy

In addition to this natural process for obtaining stereoscopy, artificial processes, whether computer-generated or not, can give the observer the sense of depth [40]. In computer graphics, stereoscopy can be achieved by means of two images obtained by two virtual cameras separated by a certain distance. These images can be separated by libraries such as the Open Scene Graph. In order to achieve this, some parameters must be correctly set such as the distance between the eyes and the size of the display.

5.1.5. Physical Machine

The realism of a virtual object is normally assessed considering two main aspects: appearance and behavior. The realistic appearance is determined by rendering techniques such as texture mapping and illumination. Realistic physical behavior requires extensive processing based on physical laws. This processing can be carried out in a variety of ways, including through the use of a Physical Engine [41] (PE) , which is a library or development kit for physical simulation. The PE is composed of computational programming components that are used to simulate rigid bodies, particles, waves, and deformable objects such as tissues, as well as to detect object collisions. The level of realism provided by a PE is directly proportional to the accuracy of the numerical processing results. Numerous PE are currently available, with some being open source. Several examples include the following: PhysX1, HAVOK2, Bullet3 and Open Dynamic Engine4. Bullet was chosen for this work due to its main advantages, namely, being open source, multiplatform and hardware independent.

5.1.6. Interaction Devices

The most common interaction devices are the monitor, the mouse and the keyboard. In VR systems, in addition to the input and output of data, Interaction devices are used to provide a more intuitive and natural method of communicating with the system, eliciting a greater sense of immersion from the user[42]. The most frequently used output interaction devices in virtual reality are HMDs (Head Mounted Displays), which are essentially displays attached to the user's head; and CAVEs (Cave Automatic Virtual Environments), which are immersive virtual reality environments in which projectors are directed to three, four, five, or six of the walls of a room-sized cube. force-feedback equipment's and also audio and video. As for input devices, some of the most used are data gloves, which are gloves equipped with sensors used to capture the movements of the hands; 3D mice; tracking devices used for keeping track of important information such as position, rotation and acceleration and stereoscopic glasses.

5.2. The Difference between Virtual Reality, Augmented Reality and Mixed Reality

5.2.1. Virtual Reality

This technology completely Take Users in a computer-generated virtual environmental protection. The most advanced virtual reality experiences even allow for Users of movement may move freely within a digital world while hearing music. Additionally, VR experiences can be enhanced through the use of specialized hand controllers.

To experience virtual reality, you must wear a specialized VR headset. While the majority of virtual reality Connected devices, which do not rely on a connected to anything else, such as the Oculus Rift and PlayStation VR (Google Cardboard is one of the most popular) are also available [43] . The majority of standalone virtual reality The use of headsets is necessary conjunction on them two one's little dicks your phone, put on the such a headset yourself in VR.

There are videos that is completely diving immersive you've always noticed a small carton icon on YouTube while Videos to watch? It allows for Mode of 360 grades, which enables the user to wear a virtual reality ear pads and experience incredible videos.360-degree videos are a type of VR in Figure 5.2 shows Virtual Reality.

Figure 5.2. Virtual Reality

5.2.2. Augmented reality

People who use products see and use the real world in augmented reality, which incorporates digital content. If this sounds confusing, consider Pokémon Go, which has compelled millions of people worldwide to rush to In search of little virtual creatures their smartphones [44]. Fascinating argument I've ever heard in my life. evocative demonstration of AG.

You can easily download a modern smartphone augmented reality application and experiment with technology this. However, there is another How to experience increased reality through the use of specialized Headsets like AR Glass, augmented reality which display Digital material in front of a user's eye on a small screen in Figure 5.3 shows Augmented reality.

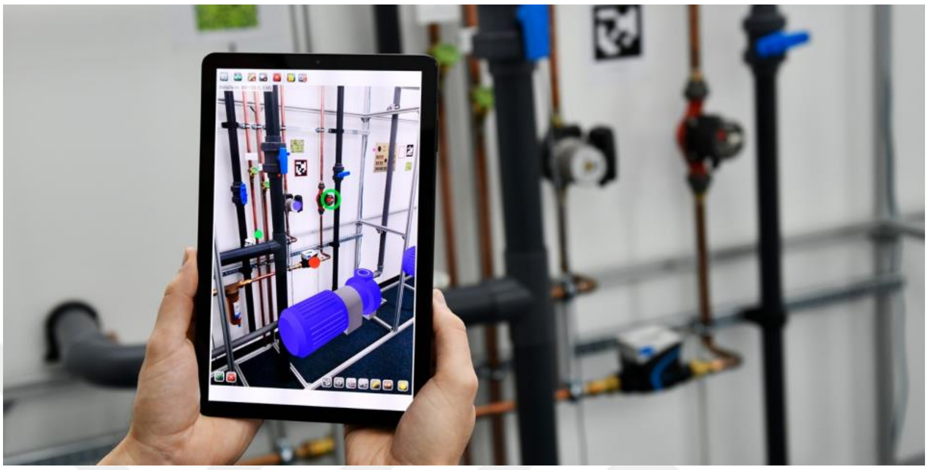

Figure 5.3. Augmented reality

5.2.3. Mixed reality

We are at the vanguard of this generation's most creative, current technologies, and it occasionally creates confusion, primarily because various experiences are referred to as such. Without delving too deeply into science, let us consider two distinct types The powerful imaginative blending of virtual and real environments is sometimes referred to as “mixed reality [45] . (Of which We'd mentioned before that only one at each outset):

MR begins in conjunction with physical Virtual objects in the real world do not exist. Simply superimposed on the subject, but can interact with it in this instance, scenario, the user is still in the physical Digital content added world; additionally, the user may communicate with virtual objects. It can be such a mixed reality thought of as advanced shape augmented reality. Whether you are having trouble understanding how this works, consider How Microsoft uses Skype Hollers.

MR begins in the world of virtual the digital world is anchored to and eventually Substitutes physical universe in this instance, the is the user completely Tucked in the virtual setting, with no access to the real world. That sounds like virtual reality, doesn't it? Indeed, but the digital objects superimpose on the actual, while the virtual environment in conventional VR is disconnected from the real world. Wearing Windows mixed reality headsets enables you to have this experience type of MR. Here's how it all works in Figure 5.4 shows Mixed Reality.

Figure 5.4. Mixed Reality

6. METHOD

6.1. Project Overview

The project was established to facilitate study programs to have this experience cutting-edge Application developed for virtual reality specifically within secondary and post-secondary institutions One of the central tenets of this work can be considered to be reality a stimulating and diversified work environment students can experiment with machinery, make errors, and learn from them without fear of repercussions in the true world (i.e., damaging Costly equipment) Additionally, the VR tool reduces the amount cost of incorporating new VR-based tool reduces obviating the need For new purchases of machinery by submitting selected equipment models in VR. Unity3D - The Game Engine create the virtual environment for the prototype.

Additionally, the Oculus Go, an autonomous Facebook Technologies virtual reality headset collaboration Qualcomm with Xiaomi, is used. It is part of Facebook Technologies' First generation of VR headsets and the first device for the company within the standalone VR headset category, which at the time of the Go's release was a new one [46].

The Go is a headset, all in one, which means it includes all of the components required for deliver Experiences of virtual reality without requiring a External device connection. That's it. Powered by Snapdragon 821 Qualcomm's processor and features a single 5.5-inch (1280x1440 pixels) LCD display with a resolution and, depending on application, a 72 or 60 Hz refresh rate. Over and above Oculus Rift, the headset uses improved Fresnel lenses and features a field of view of approximately 101 grades, giving Go shows 12.67 pixels per degree in fidelity. A wireless controller, resembling a laser pointer, is used to provide input. Controller and headset employ Three-degree non-positional tracking of freedom, which enables them to be used for Activities seated or static but not for room scale app.

6.2. User Interface

The user interface (UI) is available in human-computer interaction the environment in which the human and machine interact. The purpose of the user interface to be enabling ergonomically, efficiently and effectively machine Checking. The user interface's Creative design is critical to the intended user experience. The UI of this project has two modes: exploration mode and other mode, each of which includes a normal and transparent mode, as illustrated in in Figure 6.1 shows Flow chart of exploration mode and other mode.

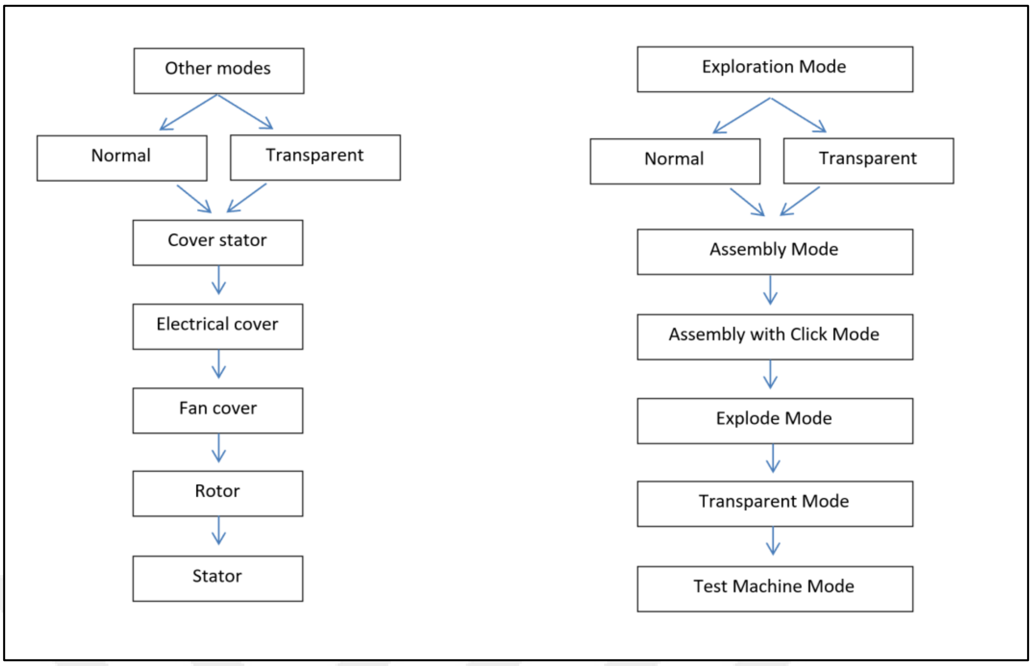

Figure 6.1. Flow chart of exploration mode and other mode

Figure 6.2 shows the interface between the user and the VR Environment, the user should stand at the end of the table in some position and assemble or disassemble:

Figure 6.2. User interface with the VR system

And the figure 6.3 illustrates the VR Activity diagram, including the parts and the system and configuration system:

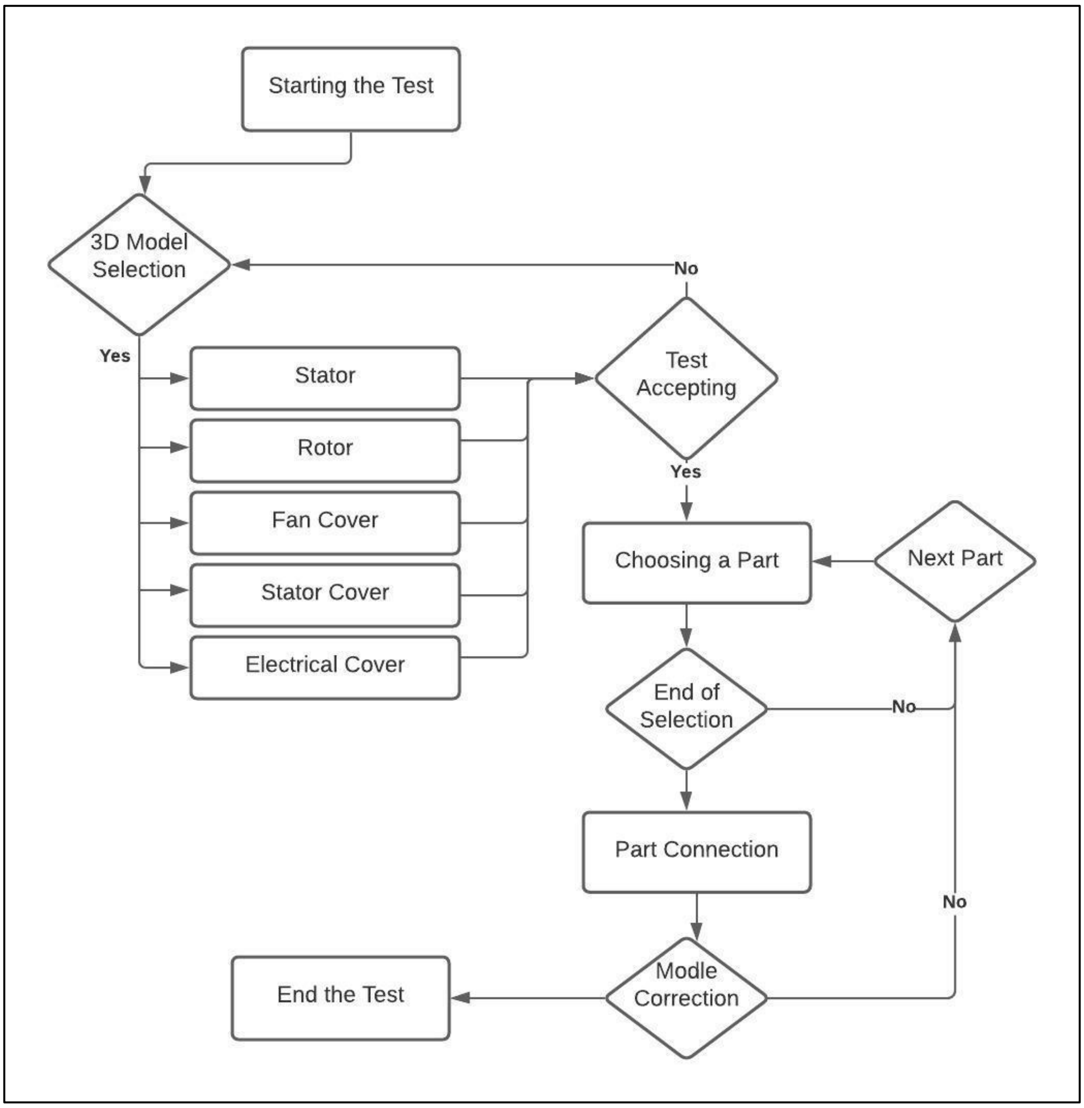

Figure 6.3. User interface with the VR system

6.3. Application Scenario

The exploration mode provides various environments for users like assembly, assembly with click, explode, transparent and test machine mode. Each of this mode has its own UI environment.

Assembly mode - makes the machine assemble which means you can see all parts of machine separately in Figure 6.4 shows Transparent mode.

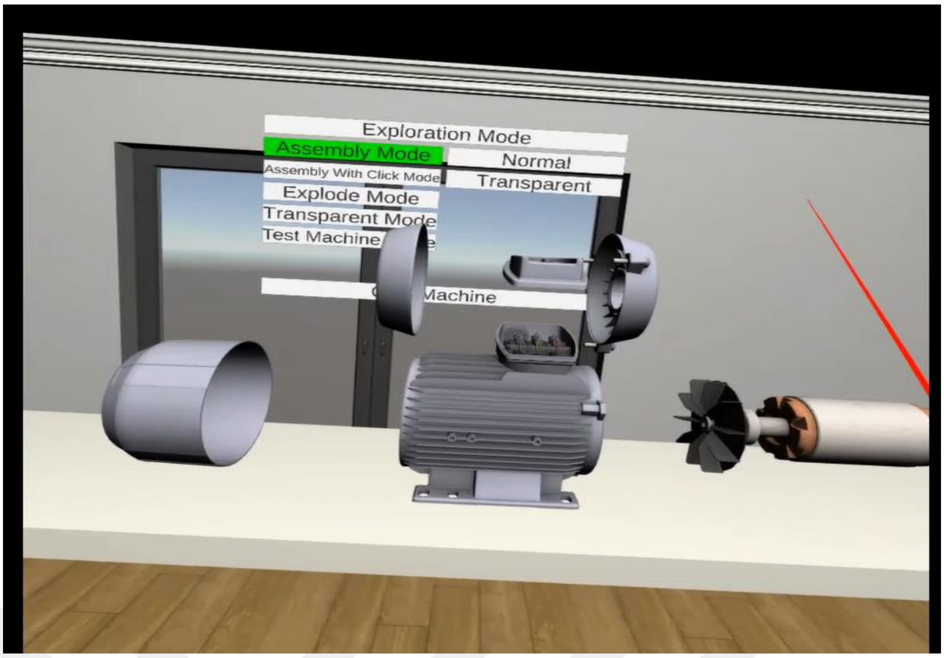

Figure 6.4. Assembly mode

Transparent mode – this mode makes every part of the machine transparent so they can see the inside of the machines as Test machine mode – in this mode you can test the machine in Figure 6.5 shows Transparent mode.

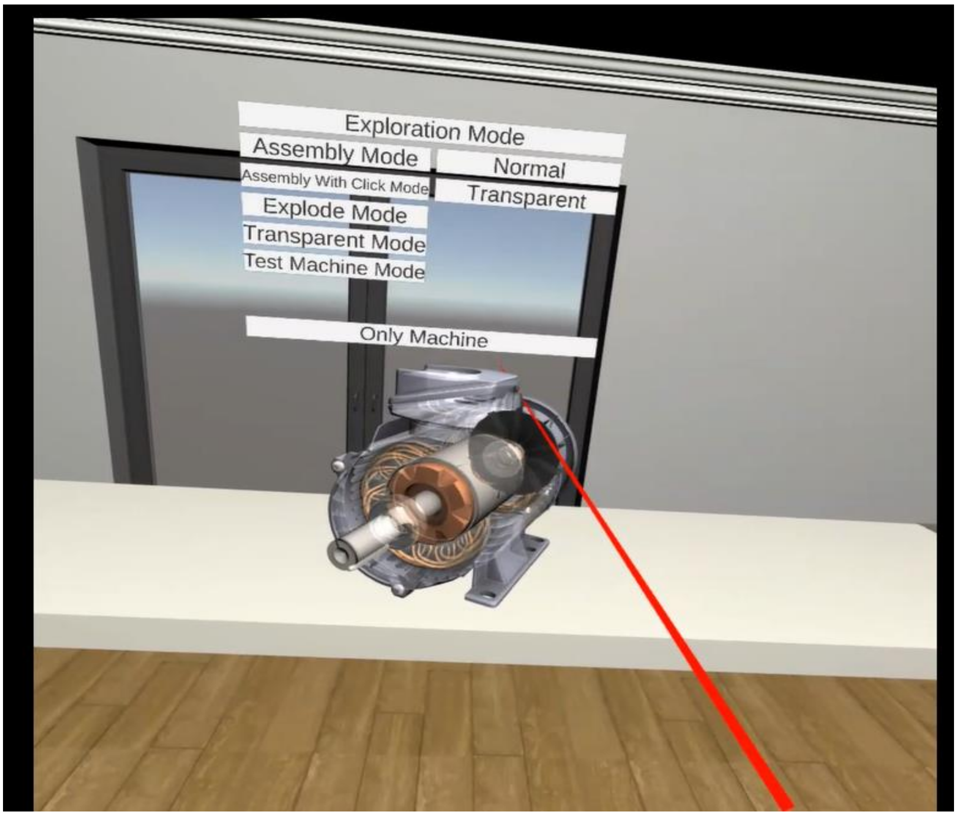

Figure 6.5. Tranparent mode

The others mode provides various parts of machine for users like cover status, electrical cover, fan cover, rotor and stator. Each of this mode has its own UI environment as in Figure 6.6 shows Normal mode.

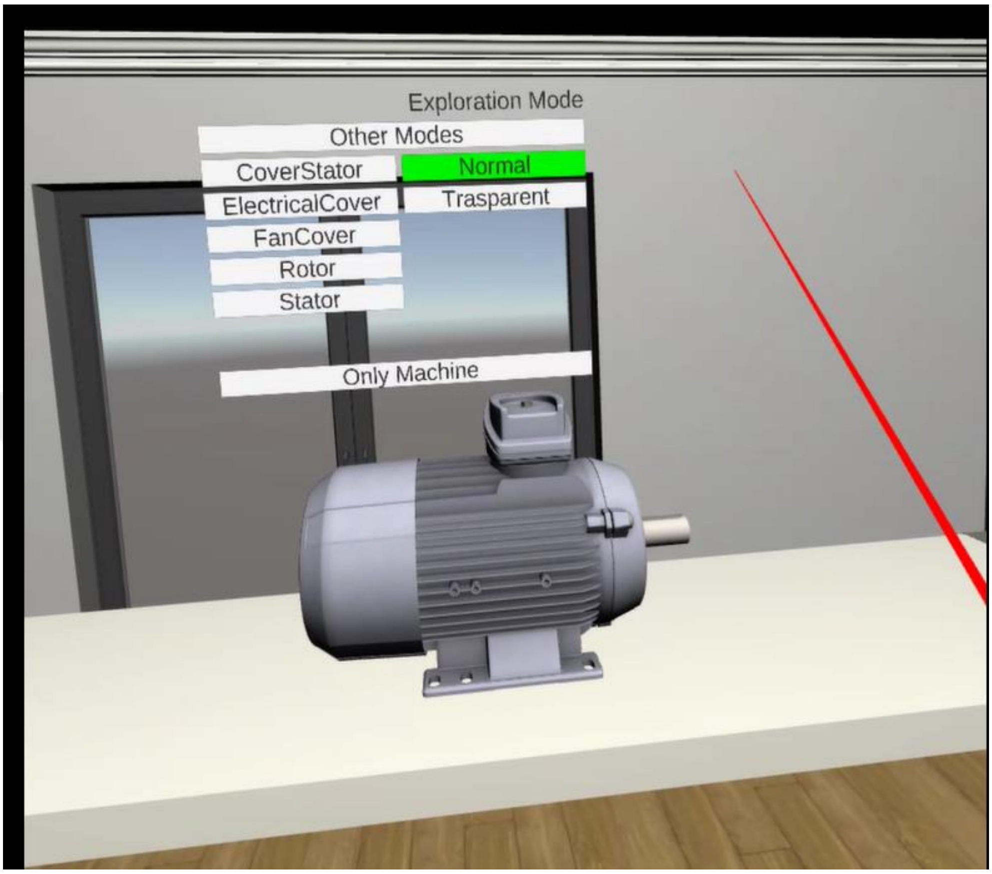

Figure 6.6. Normal mode

Assembly with click mode – makes the machine assemble with the ability for clicking on any part of it, so can be easily accessible in Figure 6.7 shows Assembly with click mode.

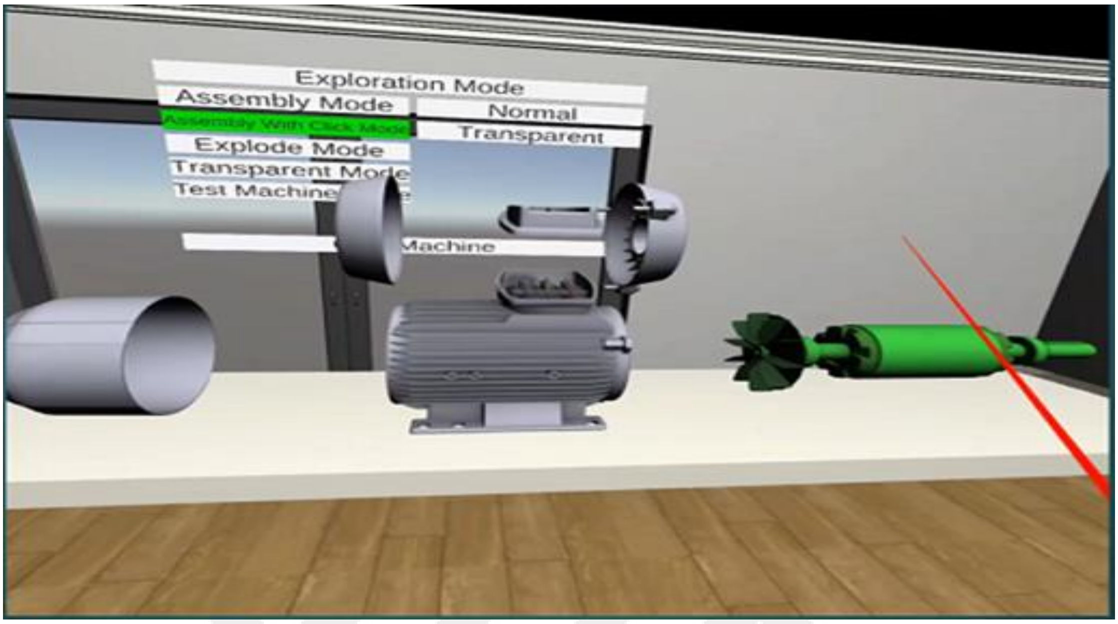

Figure 6.7. Assembly with click mode

Explode mode – this mode makes each part of the machine independent in Figure 6.8 shows Explode mode.

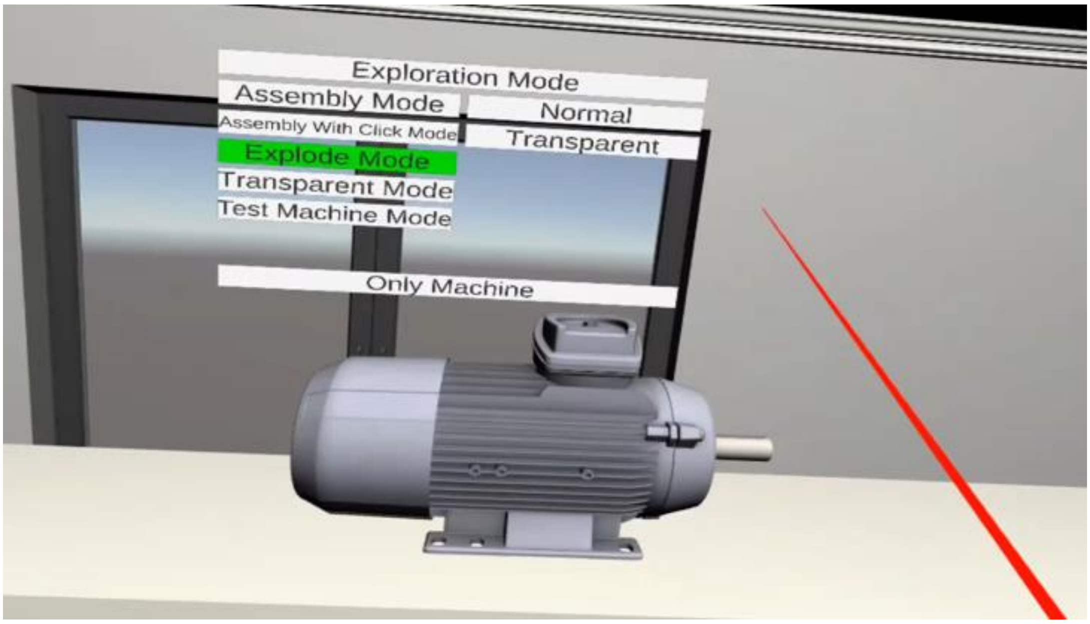

Figure 6.8. Explode mode

Test machine mode – in this mode you can test the machine like this, as you can see all angle of the machine and here, we can see the machine working transparently and also, we can see the machine walking by normal mode in Figure 6.9 shows Test machine mode.

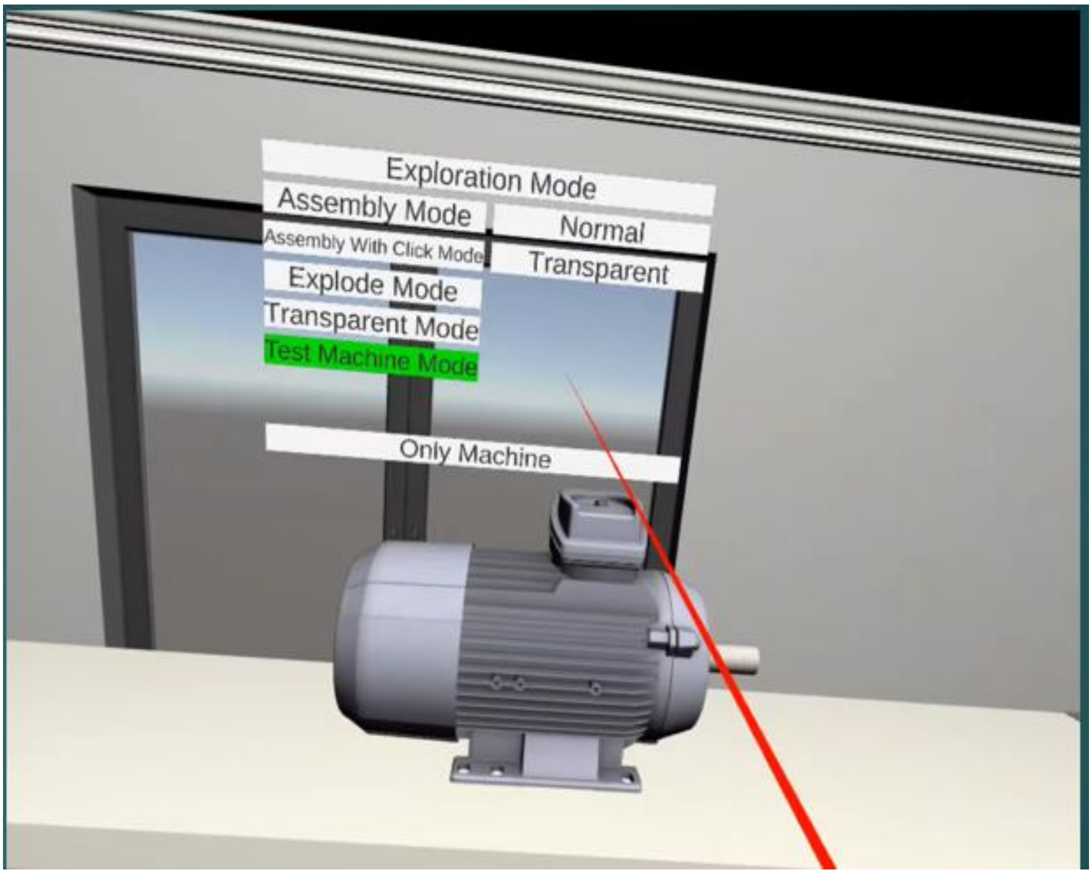

Figure 6.9. Test machine mode

If we click on cover stator, we can see the cover of the machine only by normal mode and transparent mode in Figure 6.10 shows Cover Stator Normal Test machine mode.

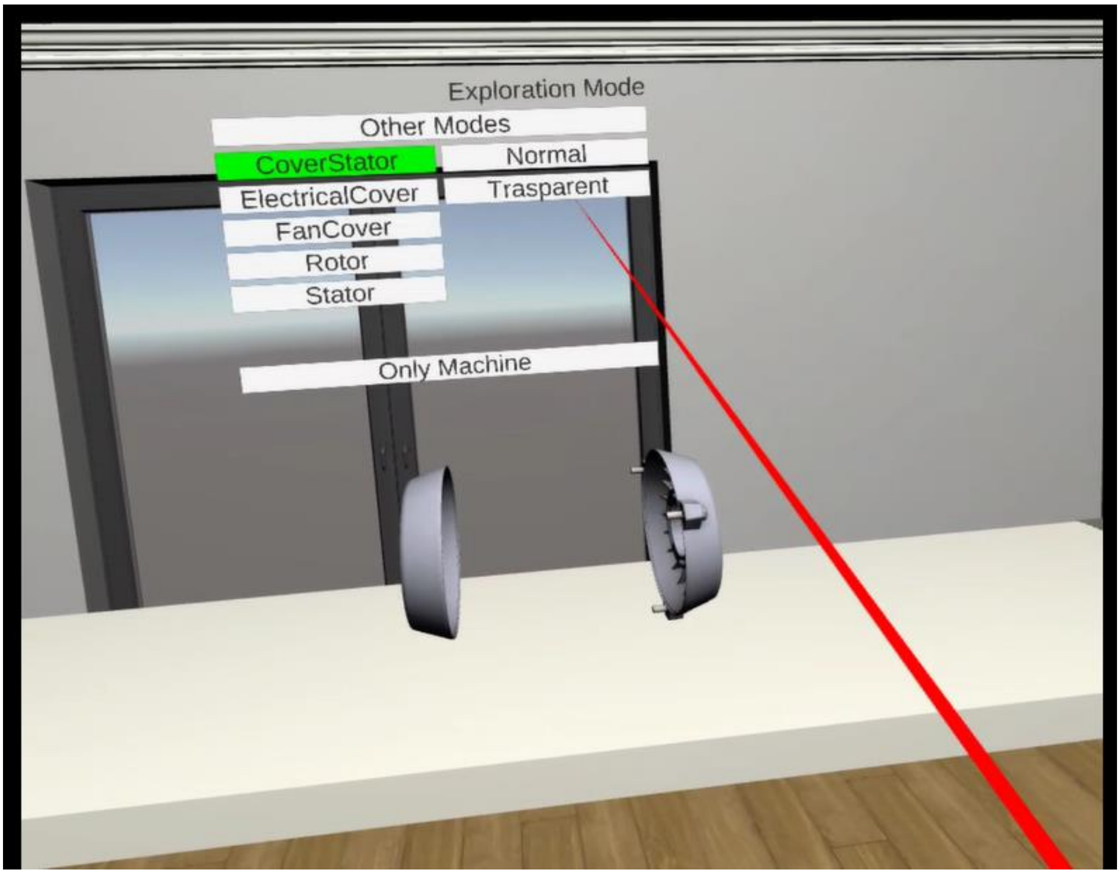

Figure 6.10. Cover Stator Normal

If we click on cover stator, we can see the cover of the machine only by transparent mode in Figure 6.11 shows Cover Stator Transparent Mode:

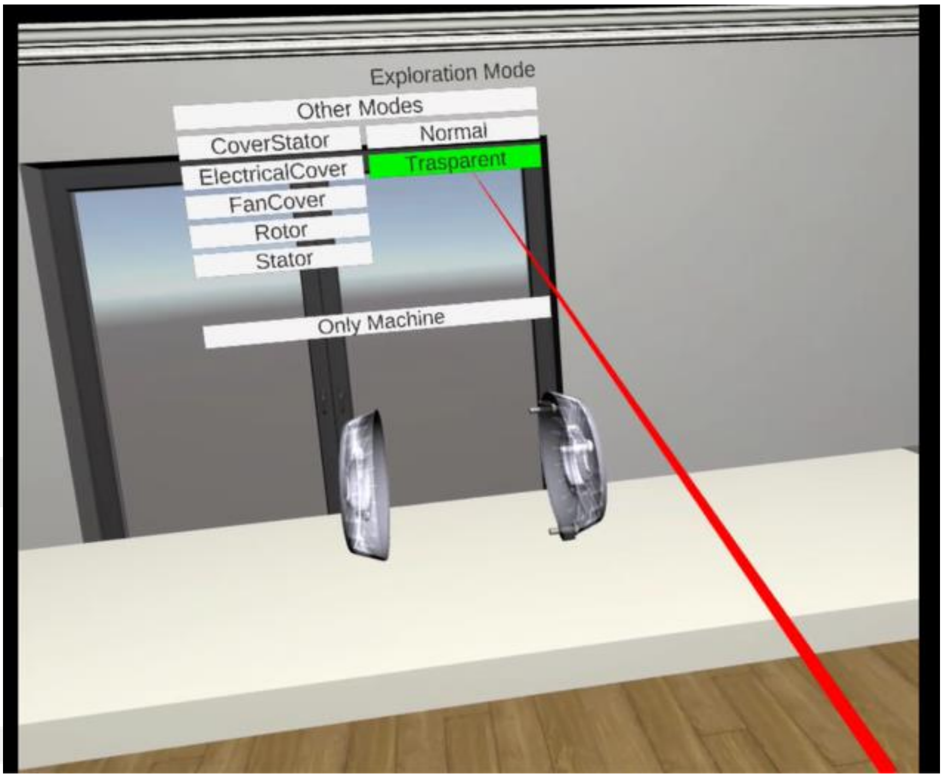

Figure 6.11. Cover Stator Transparent Mode

If we click on Electrical cover, we can see this cover of the machine only in Figure 6.12 shows Electrical Cover Normal.

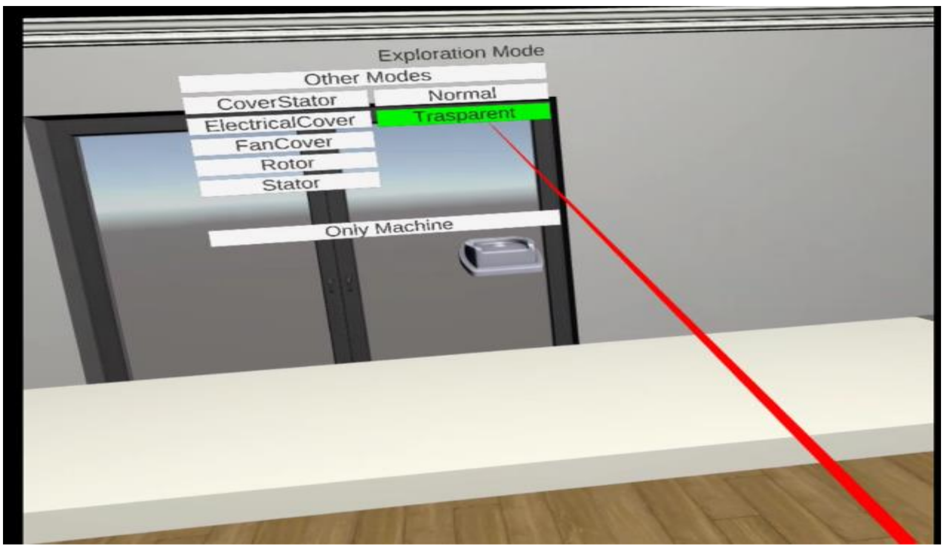

Figure 6.12. Electrical Cover Normal

If we click on Electrical cover, we can see this cover of the machine only in Figure 6.13 shows Electrical Cover Transparent Mode.

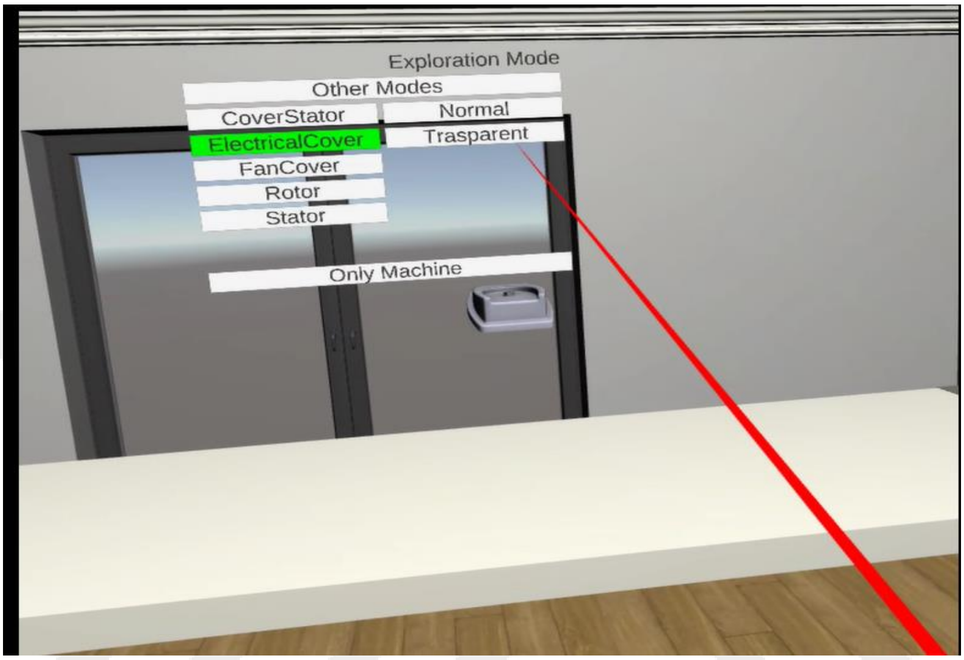

Figure 6.13. Electrical Cover Transparent Mode

If we click on Fan cover, we can see this cover of the machine only by in Figure 6.14 shows Fan Cover Normal.

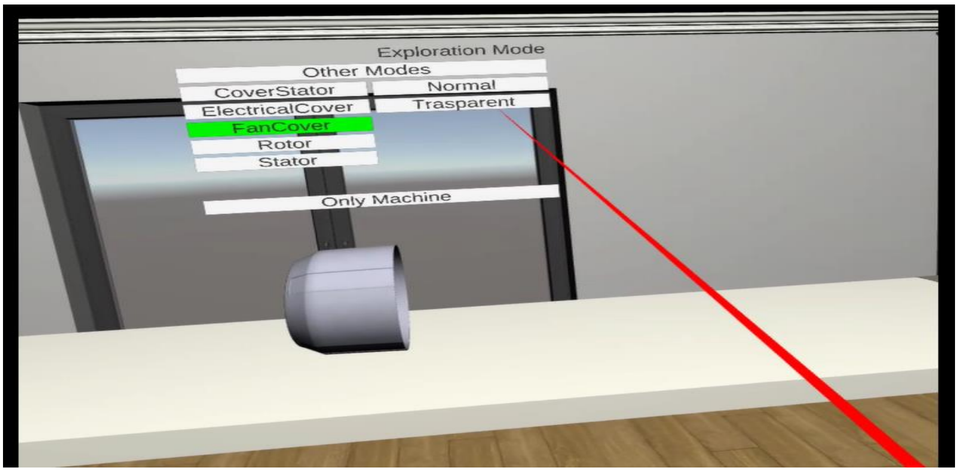

Figure 6.14. Fan Cover Normal

If we click on Fan cover, we can see this cover of the machine only by in Figure 6.15 shows Fan Transparent Mode.

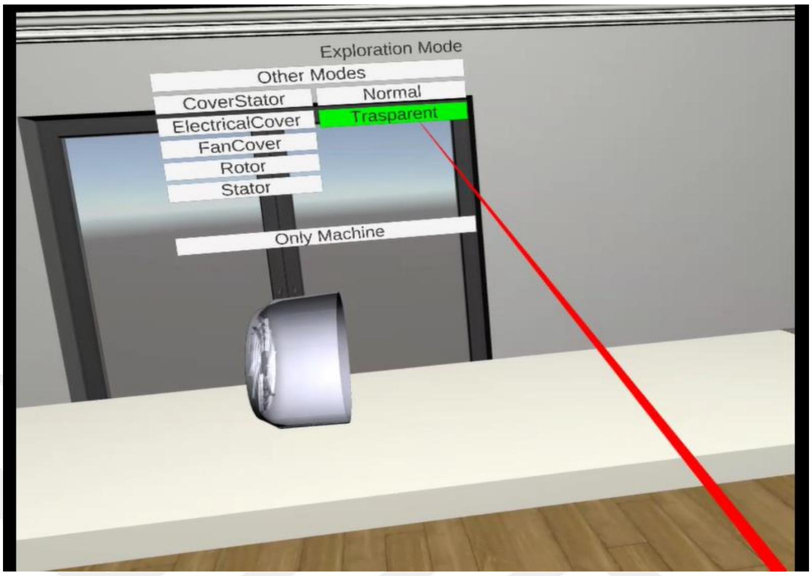

Figure 6.15. Fan Transparent Mode

If we click on rotor, we can see this part of the machine only by in Figure 6.16 shows Rotor Normal.

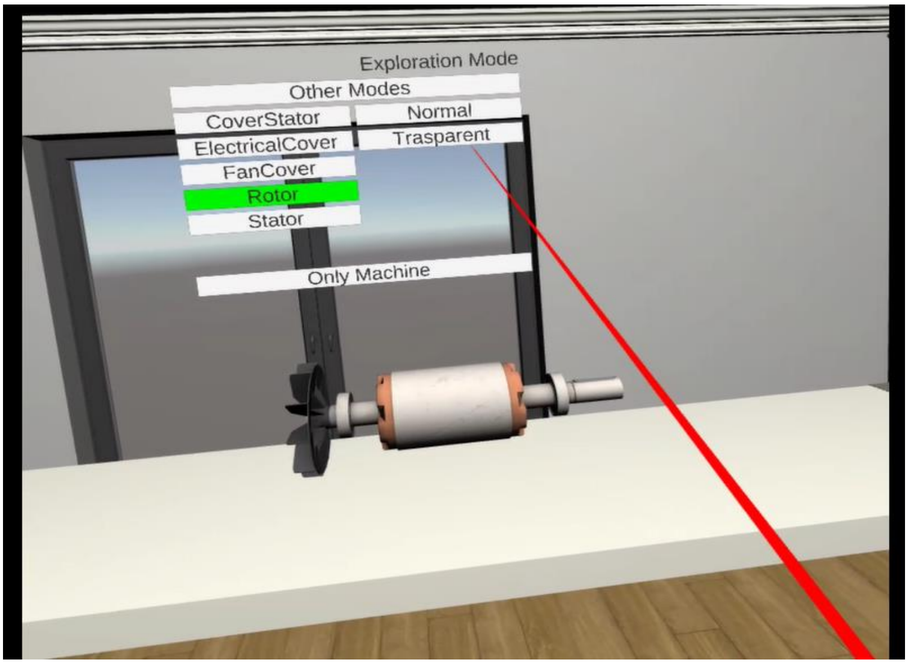

Figure 6.16. Rotor Normal

If we click on rotor we can see this part of the machine only in Figure 6.17 shows Rotor transparent mode.

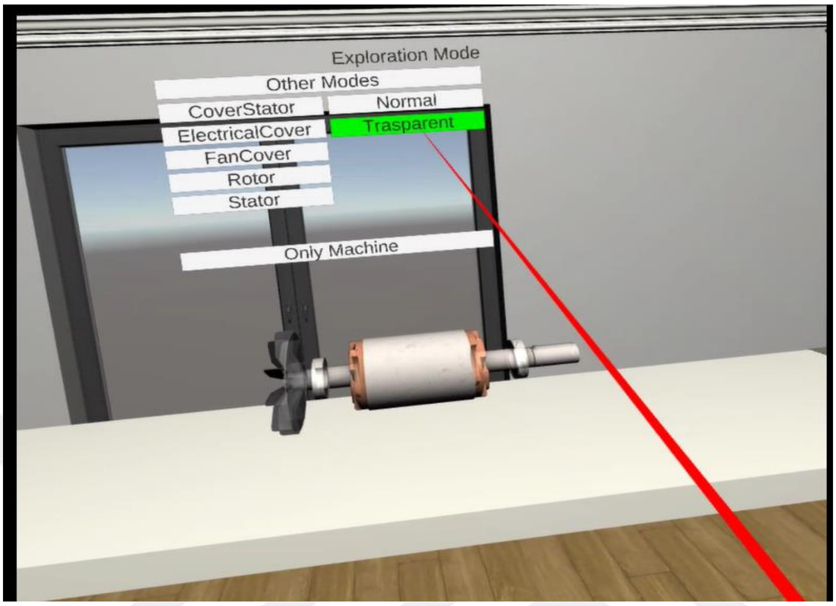

Figure 6.17. Rotor Transparent Mode

If we click on stator we can see this part of the machine only by in Figure 6.18 shows Stator Normal.

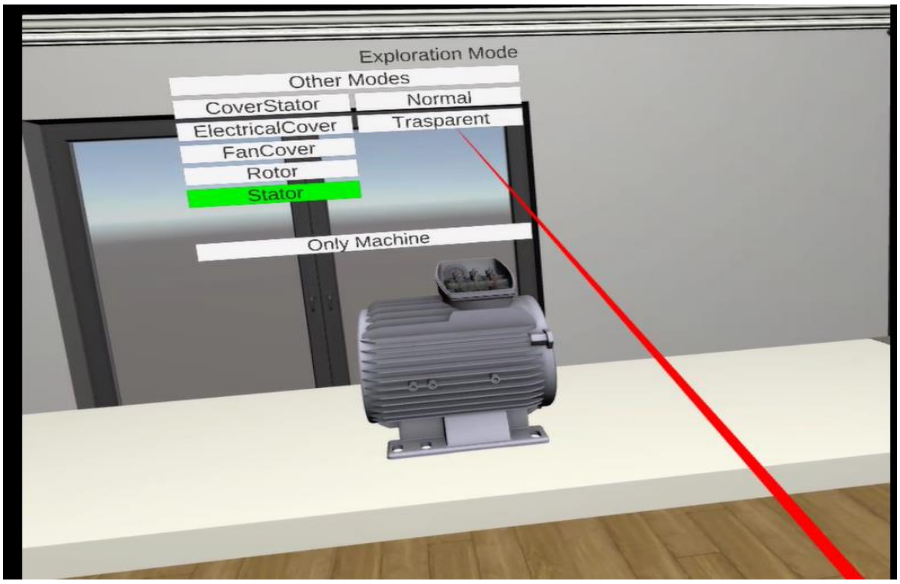

Figure 6.18. Stator Normal

If we click on stator we can see this part of the machine only by in Figure 6.19 shows Stator Transparent Mode

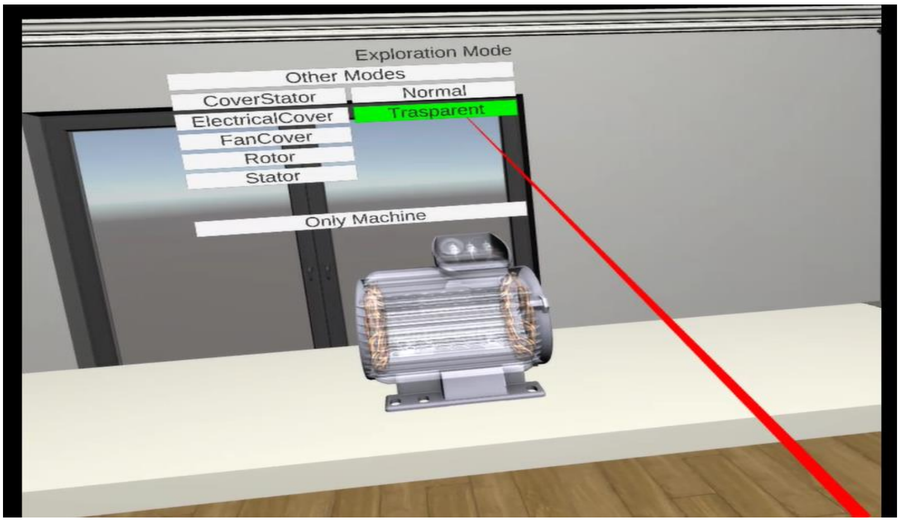

Figure 6.19. Stator Transparent Mode

6.4. VR Technology Training and Testing

As a complement of the previous details that has been shown in others sections. I this chapter we will show how to training process works and then test the machine by user to show the capabilities of how much can success correct while training and testing. Content creation will be determined based on the needs of the customer or user who wants to create training courses with virtual technology. The virtual environment shall resemble the actual environment appropriately, including working conditions and procedures. This part of the simulation of assembling and disassembling to demonstrate the ability of virtual technology in the maintenance task. For this, a virtual factory environment has been built on a good VR level, so that users can perceive the highest level of teaching in an easier way. Figure 6.20 shows the virtual factory simulation containing the contents:

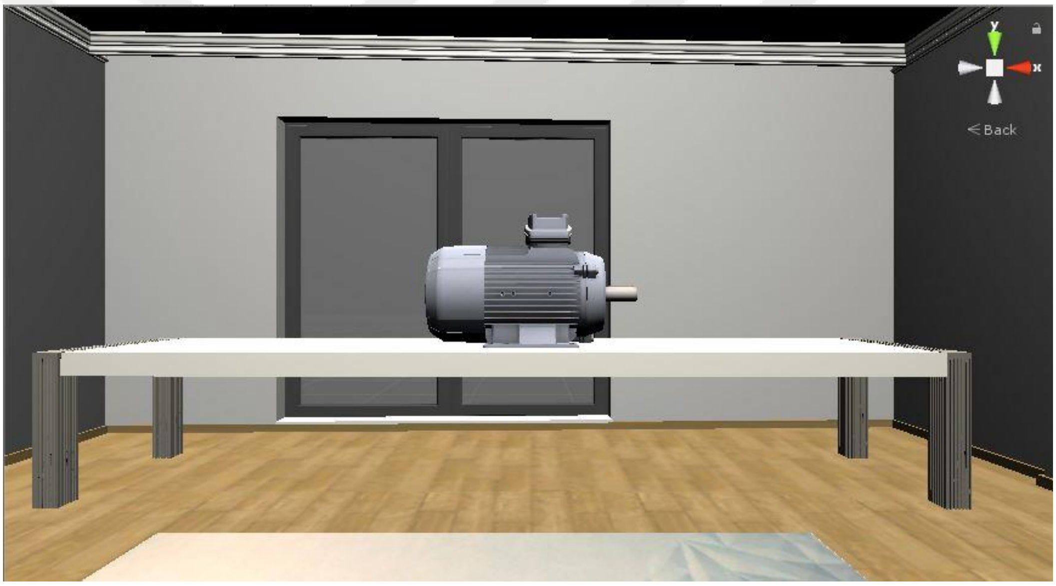

Figure 6.20. Virtual factory simulation containing the virtual contents.

6.5. Training and Testing Environment

In the process of assembly, if the user removes the parts and moves them closer to their docking position, the parts will be placed and positioned automatically. In the process of assembling, if users move the parts closer to the right assembly position, the parts will be positioned at the same position automatically as well as shown in Figure 6.21. With this content, users can practice anytime according to their needs for increasing their skills and experience.

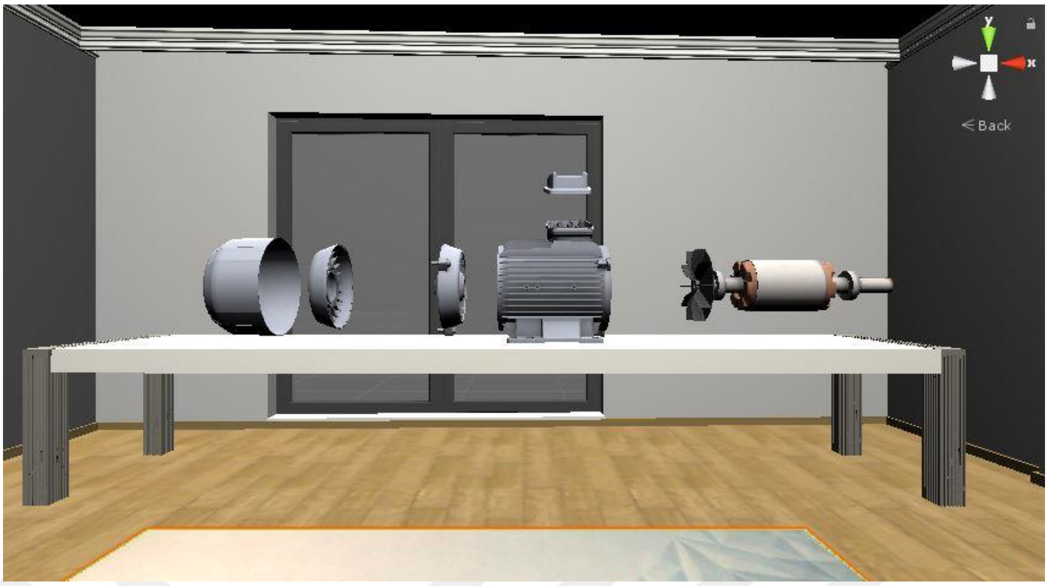

Figure 6.21. Virtual factory simulation containing the virtual contents.

6.5.1. Working with the Training System

In this particular experiment, for example, trainer has been asked to disassemble an induction motor by separating five pieces from each other. The disassembly process starts with below steps:

1. Remove fan cover from the induction motor or stator (as shown in Figure 6.22).

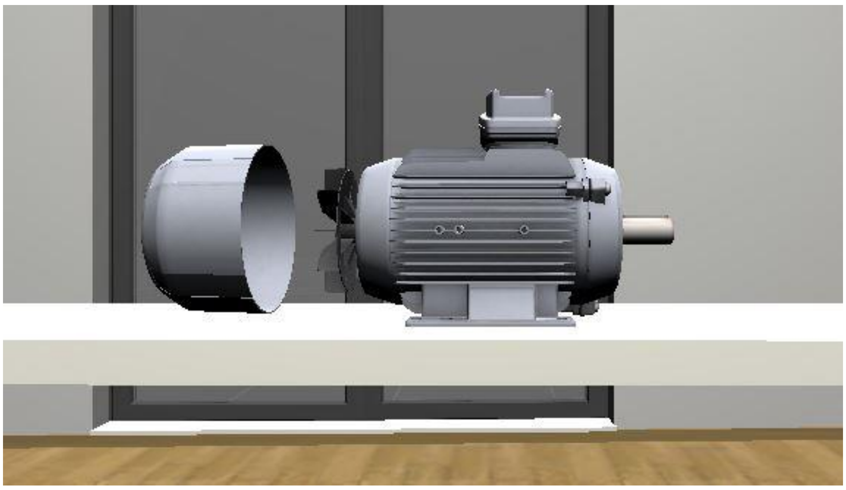

Figure 6.22. Removing fan cover from the stator.

2. Removing rotor from the stator (as shown in Figure 6.23).

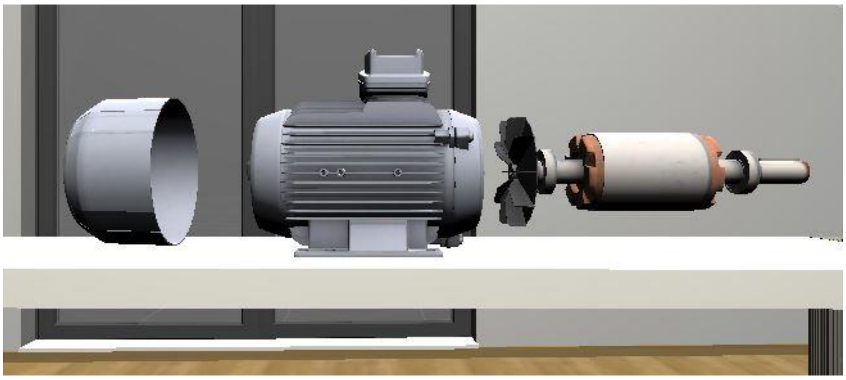

Figure 6.23. Removing rotor from the stator.

3. Then removing the electrical cover from the stator (as shown in Figure 6.24).

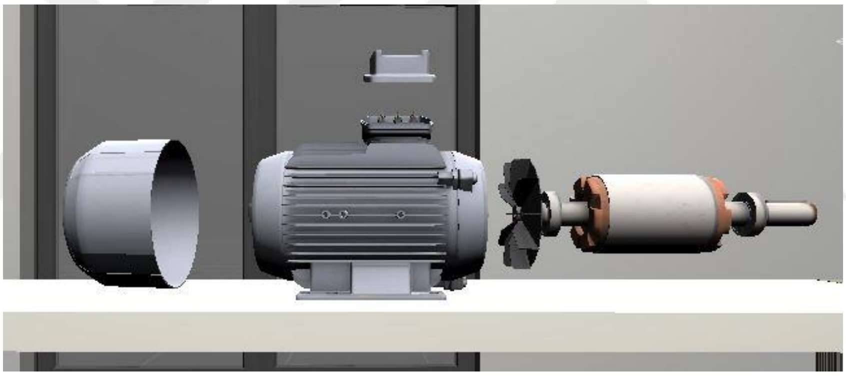

Figure 6.24. removing the electrical cover.

4. Removing stator cover from the stator (as shown in Figure 6.25).

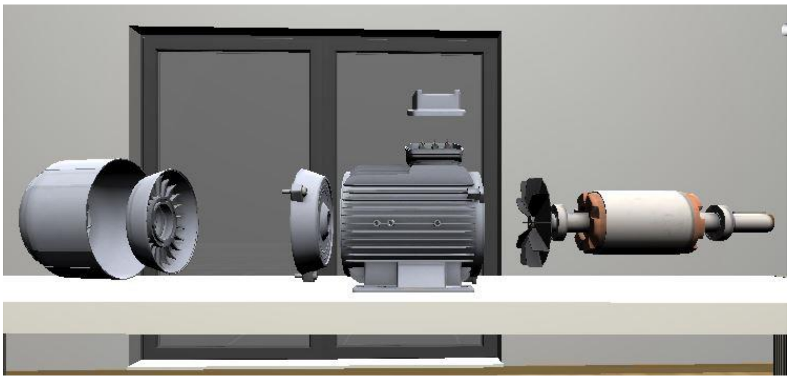

Figure 6.25. Removing stator cover from the stator.

6.5.2. Testing Process

The study was carried out in the previous virtual laboratory. The application was tested many times using different users to record the results for successful attempt and fault tests. While using this experiment, the participants were asked to do the task in different positions and different dimensions as well as using a wrong part to see the comparison while assembling the parts as illustrated in Figure 6.26:

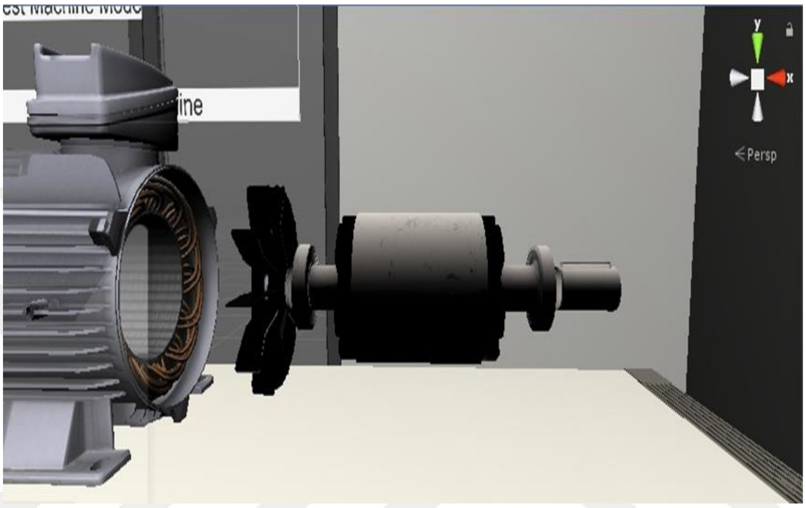

Figure 6.26. Testing while using a broken part.

By using the previous procedure, we can record the sequences of the process that has been done by trainers and testers, Figure 6.27 shows an example of recording images of assembling the parts in the virtual laboratory:

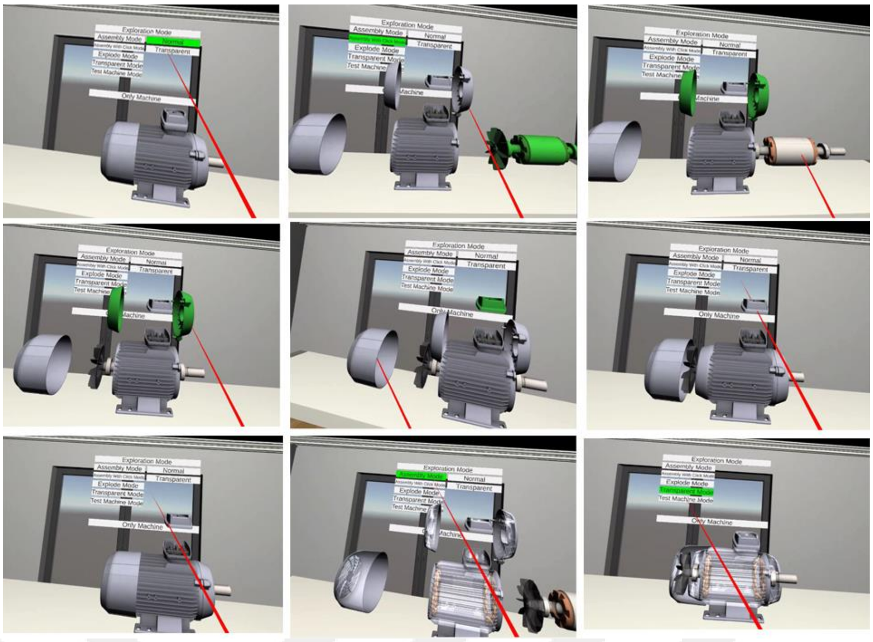

Figure 6.27. Recording of images sequences in VE.

The recorded images sequences have been used for evaluation of the correctness of the user performance as well as to understand the reasons of the mistakes that has been done and how to avoid them and correct them.

The ratio of users that used for test was 50% who did the assembling and disassembling in correct way. While 25% faced a wrong in order of the sequence of the part. And 25% used a wrong part for assembling.

Figure 6.28 show the percentages of all users that has been used for test:

Figure 6.28. Users test ratio.

6.6. Induction motors faults and corresponding diagnosis methods

The term "induction motor" refers to a motor in which the rotor current is induced by the stator's spinning magnetic field rather than via electrical connections. As a consequence of its simplicity, cheap cost, and robustness, the induction motor has become the most commonly used electrical motor. The need to improve the reliability of induction motor operating has driven a significant amount of research over the past several decades.

Induction motor drawings of a typical three-phase induction motor are shown in Figure 6.29. A squirrel cage or wrapped rotor may be used in an induction motor. The rotor is constructed from a stack of steel laminations that are clamped together and shrink-wrapped around the steel shaft. In the squirrel-cage configuration [47], conductor bars are uniformly spaced around a laminated circle and are mechanically and electrically linked through two rings at each extremity. Rotor windings are built utilizing insulated hard-drawn copper coils rather than bars in the wound kind. The stator side slip rings provide access to the rotor windings. Figure 6.29 shows two bearings support the rotor, which may be placed on separate pedestals or integrated into the motor's housing.

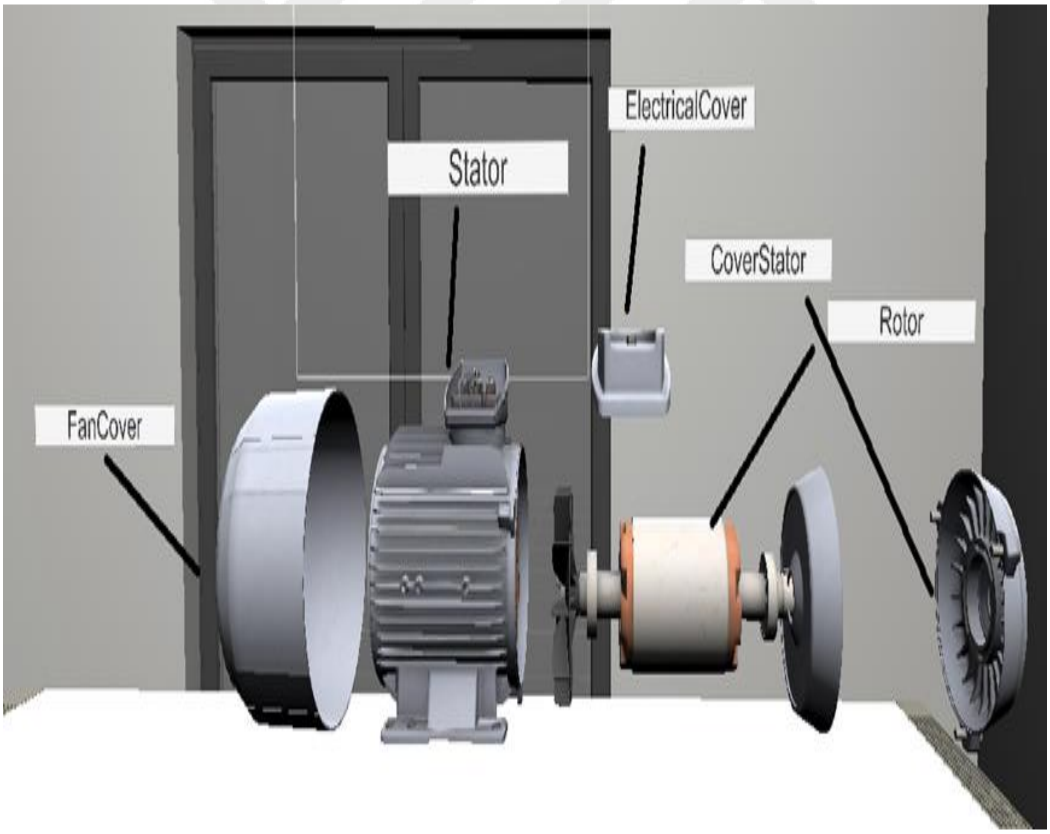

Figure 6.29. induction motor

The stator is composed of two major components: the stator and the cover stator. The stator protects and strengthens all of the induction motor's internal components. It must be robust and stiff in order to sustain both the stator core and field winding. Due to the limited distance between the stator and rotor, the eccentricity of the stator and rotor will result in an imbalanced magnetic force. The stator core's primary purpose is to conduct alternating current. Thus, it must be vibration-free while transporting the magnetic flux and have adequate cohesiveness to transfer the load torque reliably. To minimize eddy current loss, the stator core is made of insulated lam inactions.

Induction motor problems are usually divided into four types based on their location: bearing faults, rotor faults, stator faults, and eccentricity faults. Induction motor problems are usually divided into four types based on their location: bearing faults, rotor faults, stator faults, and eccentricity faults. The first work on induction motor problem diagnostics comes from the 1970s to 1980s. Since the 1990s, it has witnessed significant advancements in this field. The race to develop cost-effective and accurate fault diagnostic solutions continues, owing to the limits of prior-art techniques and the new paradigm presented by sophisticated motor control systems, which conceal certain fault-related signals. Numerous articles have been published on the subject of induction motor status monitoring and problem diagnostics. The following subsections summarize the techniques for diagnosing bearing, rotor, and eccentricity-related problems. Then, the techniques for diagnosing stator-related problems are described in depth, focusing on those that are most pertinent to the findings given in this dissertation.

6.6.1. Rotor related faults

Rotor failures include fractured rotor bars and end-ring failures. Faults account for about 5%–10% of overall induction motor failures. Excessive thermal, magnetic, residual, or dynamic stresses may result in defects; corrosion induced by chemicals or moisture; and mechanical stress produced by unfastened laminations and tired parts. Speed oscillations and abnormally frequent components in the current spectrum are caused by the faults. When a rotor bar or end-ring becomes fractured, current cannot pass through it, resulting in an imbalanced rotor flux[48]. Thermal strains resulting from thermal overload and imbalance; hot patches, excessive losses, or sparking (mainly fabricated rotors) Magnetic stresses are generated by electromagnetic forces, an imbalanced magnetic field, electro-magnetic noise, and vibration. Residual tensions as a result of manufacturing issues Dynamic stresses are those caused by shaft torques, centrifugal forces, and cyclic loads. Environmental stressors, such as rotor martial contamination and abrasion induced by chemicals or moisture Mechanical pressures caused by missing laminations, worn-out components, or bearing failure Due to the fact that 97 percent of induction motors are squirrel-cage type, particular attention must be paid to bar faults. Indeed, the typical failure mechanism for cage type rotor defects is a breaking or cracking of the rotor bars at the point where they connect the end ring. On the other hand, rotor type defects result in speed fluctuation, torque pulsation, changes in the frequency component of the motor's providing current, increased temperature, rotor arcing, and machine vibration. These collateral effects may be used to aid in the detection and classification of this kind of problem. However, the majority of induction motor rotor defects begin with a tiny fracture or a high resistivity area in the rotor bar. This area of damage heats up and deteriorates until the rotor bar is completely destroyed. After a broken bar occurs, the rotor current is transferred to another bar, resulting in an excess current and eventually a greater number of broken bars. Rotor cage defects may result in shaft vibration, which can result in bearing failures and air gap eccentricity, for example, while bar breakage results in increased current in neighboring bars, which can result in additional bar breakage and stator problems. As a result, early identification of rotor asymmetry is critical not only for rotor protection, but also for minimizing certain other kinds of motor failures.

Figure 6.30 shows the process of using illegal or damaged part, it will not work and will break the system down. So, in this way we can test the parts that has to be merged. This is a fault point and this is used for testing while assembling.

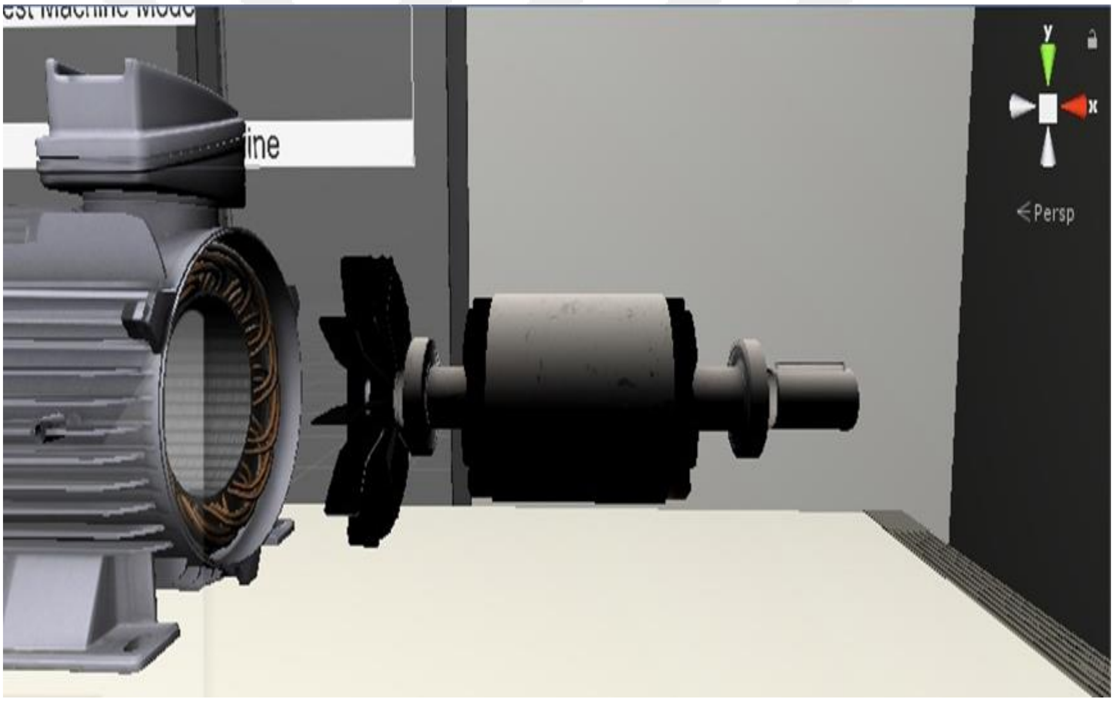

Figure 6.30. Burnt out routor

While Figure (6.31) shows another part working normal and it is legal part. It will work successfully and will not show any fault error:

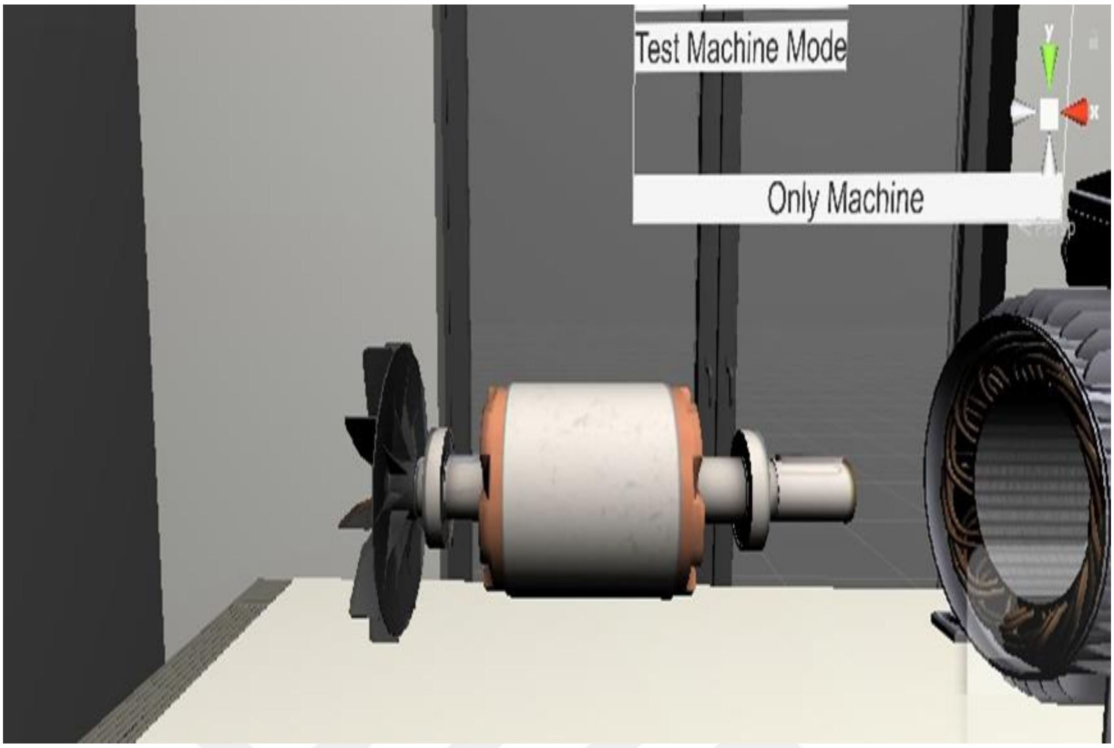

Figure 6.31. Regular rotor

We conclude from Figures (6.30) and (6.31) that we can test the parts of the machine and show if it works or not. That will make our working easier by comparing the two states.

6.6.2. Stator Related Faults

Typically, stator problems are caused by insulation failures. Numerous studies have shown that stator winding failures account for 30% to 40% of induction motor failures. Stator windings are made up of coils of insulated copper wire that are inserted into stator slots, and stator winding faults occur when the insulation breaks down between two adjacent turns in the same phase of a coil; this is referred to as a turn-to-turn fault or inter turn short circuit. As a result, this kind of defect generates more heat and creates an imbalance in the machine's magnetic field[49]. The additional local heat generated by two or more shorted turns will deteriorate the insulation of the adjacent boring turn until a catastrophic failure occurs, such as phase failures, phase to phase failures, phase to ground failures, or phase to phase to ground failures. Nonetheless, stator defects may be generally classified into two categories:

• Defects in the laminations (core hot spot, core slackening, etc.) and the frame (vibration, circulating current, coolant loss, earth faults, etc.)

• Stator windings defects: the most often found stator windings problems include either the end winding or the slot section. End winding part faults include localized insulation damage, insulation fretting, and insulation contamination by moisture, oil, or dirt; connector damage, turn-to-turn faults (whereas slot portion faults include insulation fretting), and conductor displacement. Indeed, the bulk of these faults are caused by a variety of stresses occurring on the stator, which may be classified as thermal, electrical, mechanical, and environmental. Inter-turn short circuits in stator windings are the most frequent kind of failure in induction motors[50]. Typically, short circuits in stator windings occur between single phase turns, between two phase turns, or between all phase turns. Additionally, short circuits occur between the winding conductors and the stator core.

The interterm short circuit of windings is a common precursor to failure. Localized heat generated by these shorted windings will spread to neighboring windings and to the stator core, resulting in stator core-ground insulation breakdown. When the insulation's breakdown temperature is achieved, this process usually propagates in as little as 1-2 seconds from turn-to-turn short circuits to phase-to-ground or phase-to-phase faults. As a result, accurate early identification of an interterm short circuit defect would prevent further damage to neighboring windings and stator cores.

6.6.3. Bearing Faults

As previously stated, about 40% of defects in induction machines are due to bearing failures. A rolling element bearing consists of an inner and outer ring, separated by a set of rolling elements. Rolling components come in a variety of standard forms, including ball[51], cylindrical roller, tapered roller, and needle roller. Typically, a bearing's rolling components are organized or steered inside a cage to maintain consistent spacing between elements and to avoid mutual contact. The many defects that may develop in a rolling-element bearing are classified by the damaged element as ball defect, inner raceway defect, and outer raceway defect. The rolling element bearing is a crucial component for spinning induction motors, since the majority of failures occur due to bearing failures. Thus, both the detection and diagnosis of mechanical problems in rolling element bearings are critical for an induction motor to operate reliably.

6.6.4. Other types of faults

Another kind of defect is air-gap eccentricity, which refers to an uneven air gap between the stator and rotor[52]. The presence of this defect results in an imbalanced magnetic pull or an unbalanced radial force, both of which may cause damage to a motor via rubbing between the stator and rotor.

Eccentricities are classified into two types: static and dynamic.

• Eccentricity that is static

A static eccentricity may be produced by the oval form of the stator core or by the rotor or stator being installed incorrectly during commissioning. The degree of static eccentricity does not vary if the rotor-shaft system is sufficiently stiff. This may result in a twisted rotor shaft or excessive bearing wear and strain. Additionally, it may result in some degree of dynamic eccentricity. Static eccentricity occurs when a rotor is moved from its bore center yet continues to rotate around it.

• Excessive dynamic eccentricity

In this instance, the rotor's center of rotation is offset from the rotation's center, and the location of the minimal air gap spins in lockstep with the rotor. Due to the presence of an imbalanced magnetic field, static eccentricity may result in some degree of dynamic eccentricity. At critical speeds, mechanical resonance may also result in dynamic eccentricity.

7. CONCLUSION

This research discusses the meaning and application of VR industrialization. The advantages of virtual reality Production and some potentials were highlighted applications of virtual reality in industrialization had been debated. VRML (Virtual Reality Markup Language), was created in order to the WWW and the Internet, is now the majority of significant method for delivering the three-dimensional matter to the display of any a user It makes it possible the presentation of three-dimensional things with an artificial demeanor. Numerous industrialization enforcement agencies can benefit from VRML's features, which include the ability to present new samples, optional styling, and a variety of objects with varying operations (Christmas, 1992). That's it. Critical to recognize that virtual reality isn't that just for the first time. Entertainment Applications; rather, it demonstrates enhanced Interaction and visualization methods which can be used for problems relating to real engineering.

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CURRICULUM VITA

Salim Mahdi Mohammed

[redacted]

[redacted]

[redacted]

RESEARCH EXPERIENCES

- ✓ Computer Programming languages available (C#, C++, MATLAP, LABVIEW, vb., Unity)
- ✓ Computer programs you can use (CAT/CAM, PROTEUS, CALCULUS, vb.)

[redacted]