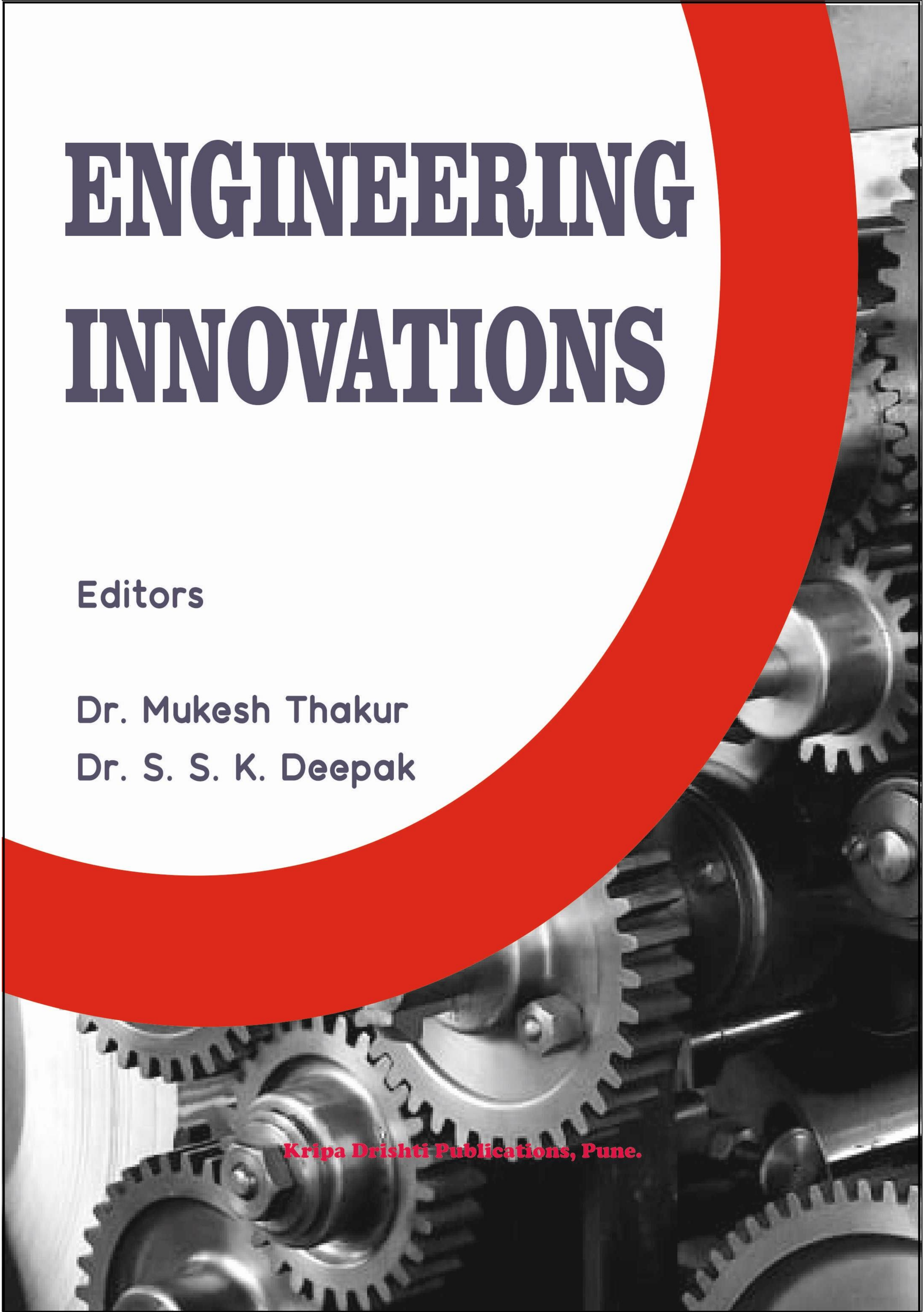
ENGINEERING INNOVATIONS

Editors

Dr. Mukesh Thakur
Dr. S. S. K. Deepak



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CONTENT

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1. Applications of Fuzzy Logic Systems: An Overview

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Abstract:

This document presents the application of fuzzy logic to chosen methods for quality control management and planning. The method applies when disputes arise when the issues in the brainstorming community are addressed. Each member of the brainstorming group may, for example, have their own opinion when deciding the timing of an action. The method of fuzzy logic was introduced in order to combine the views achieved without losing any minor details. The use of fuzzy logic allows all ideas appropriate, allowing the weight of each member of the brainstorming group to be taken into consideration.

Keywords:

Fuzzy Number, Fuzzy Parameter, Fuzzy Logic, Fuzzy Applications.

1.1 Introduction:

Fuzzy logic can be viewed as a classical logic generalisation. Lofty A developed Fuzzy logic in 1965. Zadeh, Computer Science Professor at Berkeley University in California. Problems relevant to imprecise data have been resolved and derivative rules formulated in a somewhat ambiguous fashion[1].

The foundation to establish fuzzy logic is that human thought components are not numbers. Instead, language words are not specified precisely. It cannot always apply to one object or another to a specific category or class. Language words may also be known as fuzzy sets. There are several artefacts associated with the various classes at the same time. This depends on a group 's standards. Criteria should be described correctly for one class or another. There is no classical logic that can describe such objects. Big house, gorgeous woman, or loud music, for instance, cannot be a clear community or class. A specific topic cannot always be referred to a certain group; according to the opinion of the expert the data differ. The fuzzy logic of these cases has been observed[2].

Fuzzy logic is a very broad field of application. The paper Application of fuzzy logic for the management of companies in the food industry provides a financial management software study for companies where the correct choice for the business is chosen and the optimal food commodity price based on the Mathsad 14 programme is determined.

The article Implementation of the fuzzy logic in machine repair tool management explains the foundations of the fuzzy logic approach for handling machine tool repair inventory. An example is presented to decide the best stock units with fuzzy logic. The paper explains the approach to measurement quality of the images and enhancement of the image and quality of the images through the use of fuzzy logic methods. The approach proposed uses fuzzy logic techniques, in particular the method for detecting object edges[3]. The article the development of a model decision system to help the rail transport explores ways of designing, on the basis of the fundamentals of the fuzzy sets and the fuzzy logic theories, a proper decision-making system of support for rail transport[29]. The article on the application of fuzzy logic in humanitarian research aims at showing that purely formalised quantitative analysis has their limitations, which are able to lose the consistency, scope and credibility of the perception of truth. Hence, the application of "flexible" approaches, like fuzzy logic[4], is important in humanitarian studies.

1.2 Fuzzyfication:

The fuzzy theory says that a fuzzy set A is a special fuzzy subset of real numbers. The membership of the system $\mu A(x)$ is continuous mapping at intervals $^{[0,1]}$. Suzzyfication is a process which transforms crisp values into linguistic terms (language variables), later quantified using fuzzy sets by means of a fuzzy membership function (Figure 1.1). Fuzzyfication is the process whereby a real scalar value is translated into a fuzzy value and correct crisp values are translated into linguistic variables.

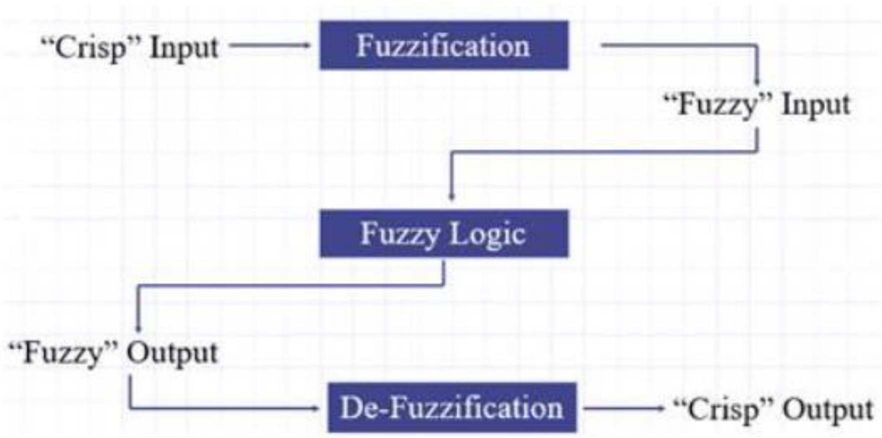

Figure 1.1: Fuzzy logic process

1.3 Defuzzification:

During fuzzification, crisp numbers are translated into fuzzy numbers, but the majority of acts or decisions made by humans or machines is binary or crisp in nature in a variety of applications. Therefore, the fuzzy results obtained through fuzzy analyses are after all essential. Defuzzification is said to be the method for transforming the fuzzy output to a crisp value.

A defuzzification process which produces crisp value from the fuzzy value in terms of membership of fuzzy sets is defined. In other words, this integration into a particular decision or true value of the membership degrees of fuszy classes. There are different methods of defuzzification, including the centre of gravity, the centre of gravity, and the average of maximums. The input for the defuzzification is the aggregate set and the output is only one number. In control engineering and process modelling, gravity centre is commonly used. The remaining approaches are discontinuous, primarily used to choose the alternative in decision-making and pattern recognition applications. Figure 1.2 demonstrates how membership function preach values are found [5].

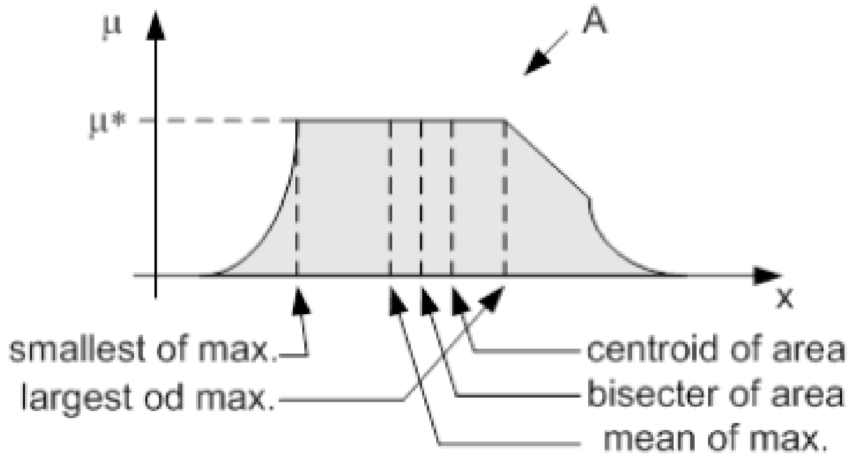

Figure 1.2: Graphical demonstration of results of defuzzification method

1.4 Contemporary Fuzzy Approach to Quality Control:

Quality management and risk analysis is a key component of any company's performance. However, under conditions of uncertainty, with increasing frequency businesses have to take decisions, which may result in unintended effects and thus adverse results and losses. The long-term decision, which is generally implied in the assessment of the projects, can be especially serious. There is, therefore, one of the most critical issues of modern quality control and risk analysis: recognition on time, appropriate and reliable risk and qualitative assessment.

Unfortunately, current risk analysis and quality management methods are not lacking in the subjectivity and significant assumptions leading to incorrect outcomes in the risk analysis and quality assessment process. A modern, complex approach to risk and quality management is philosophy of fuzzy logic. Fuzzy modelling has become one of the most successful and exciting fields of applied science in recent years in the area of quality management.

This chapter introduces a contemporary fuzzy approach to quality management, such as fuzzy failure mode and impact analysis, fuzzy fault tree system, fuzzy histogram, fuzzy management. In the previous chapters are listed both process definitions and the concepts of fuzzy logic. The current advantages and drawbacks of the flippant rational approach need to be oriented. There are some benefits of the use of fuzzy logic. It allows you to:

- Include in the study qualitative variables,
- Draws fuzzy data input,
- Through language requirements,
- Model and compare complex dynamic structures with a default degree of precision over a short period of time,
- To fix the deficiencies and limits of current project risk management approaches and solve problems of output quality.

1.5 Disadvantages of the Method:

- Subjectivity in the collection and establishment of futile rules on membership functions,
- Mangel of process knowledge and little consideration provided by professional organisations to the use of the process,
- Need for special tools and experts who work with it.

Despite flaws and shortcomings in theory, some of the major international enterprises (Motorola, General Electric, Otís Elevator, Pacific Gas & Electric, Ford) recognised the system of fuzzy sets as promising and reliable performance. Risk analyses based on statistical methods are not applicable to most newly established companies because statistical knowledge is not collected for objective assessment[6,7].

1.6 Contemporary Fuzzy Approach to Fault Tree Analysis:

Another reliability and safety analysis methodology are the Fault Tree Analysis (FTA). The idea was developed for the US Air Force in 1962 at Bell Telephone Laboratories. The Boeing Company was eventually adopted and applied extensively. FTA is a highly efficient method that is commonly used for process quality assessment.

The tool helps identify areas of concern for developing new products or enhancing current products. It also helps to describe corrections for resolving or reducing a number of problems.

FTA is useful for both the production of new products and the further resolution of the problem found that belongs to current products / services. The FTA will help to optimise the objectives and process characteristics and design for essential factors and human error as a major element for improving procedural efficiency.

Fault tree analysis is an overall failure analysis technique. The defect approach uses a Boolean algebra and logical modelling from the top event, to graphically depict the relationship between different failures at various levels of the operation.

The study is carried out by evaluating how individual or combined lower-level failures or events can trigger the top event (fault). The causes of the event are connected by logic gates as shown in Figure 1.3[8].

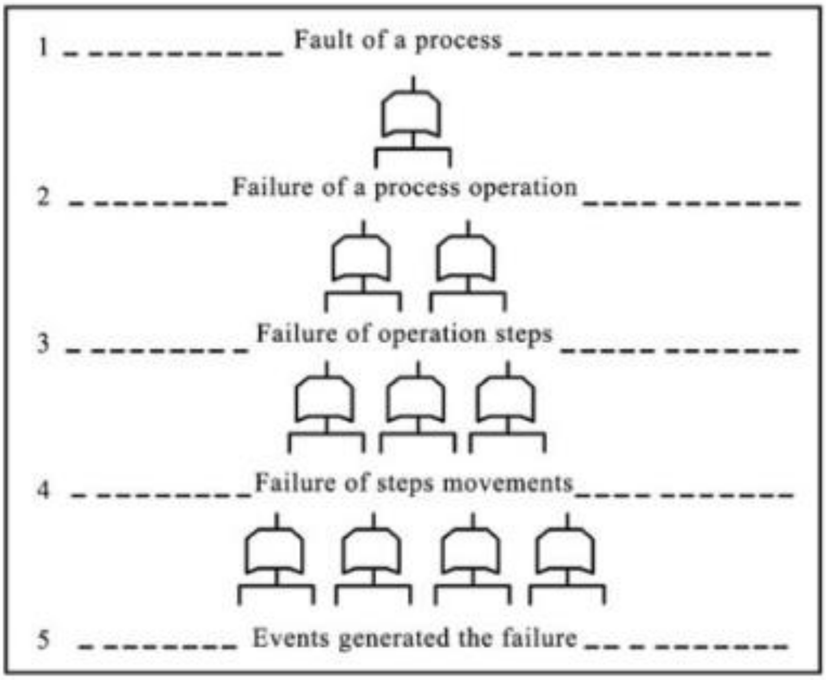

Figure 1.3: Typical Fault Tree

The deductive logic is used in this technology. It allows the root causes of a process' error events to be established. This kind of reasoning helps to create consistent and comprehensive relationships that can affect their consistency between the steps or events of the process.

The Fuzzy Fault Tree analysis paper offers a smart system of the fault diagnosis power transformer by means of the Fuzzy Fault Tree Analyse (FTA) and beta distribution for the estimation of fault possibility[7]. This is very important for ensuring continuous power supply. The authors have examined a series of potential issues (informat transmission errors as well as errors that have occurred during data processing in transformer survey and monitoring, uncertain and incomplete transformer information). By employing the technology, he suggests transforming the continuous attribute values into fizzy numbers to provide a reasonable estimation of the probability of failure of a fundamental event in FTA. It describes a new method to rate fundamental events according to their Fuzzy Signification index based on the Euclidean distance between fuzzy numbers.

1.7 Contemporary Fuzzy Approach to Histograms:

Histogram – a method for visually analysing the distribution of statistical data, clustered into a certain (predetermined) interval by frequency of occurrence data. A histogram is a graphical way to show a distribution 's form. It is especially useful if many observations are made. It is constructed using rectangles, and their area is proportional to the frequency at which the rectangle is formed.

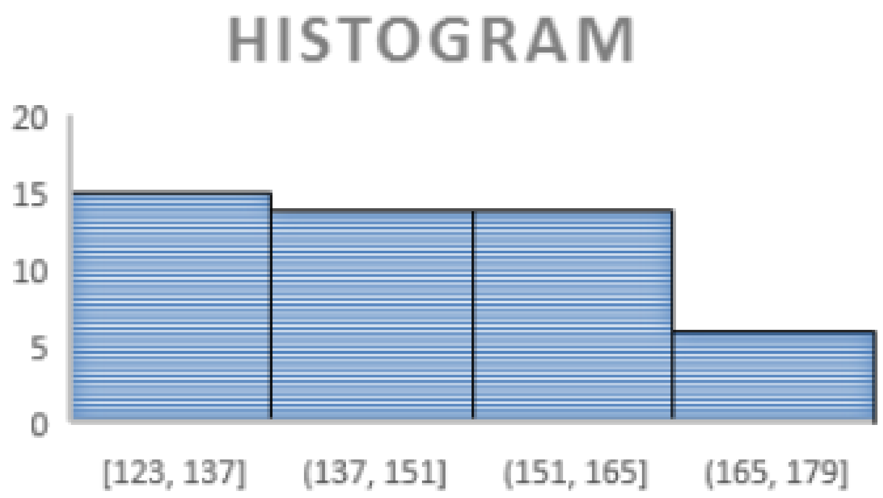

Figure 1.4: Example of a histogram

In the paper Fuzzyplogs it is reported that the statistical analysis is a gross generalization of a standard crisp histogram (Fuzzy histogram). Statistically, fluorescent histograms were analysed in the paper, compared to other nonparametric density estimators. Finally, it turns out that fluffy histograms can combine high statistical performance and a high degree of machine efficiency[9].

1.7.1 Fuzzy Approach to Control Charts:

The control diagram is used to analyse how a process evolves over time. In time, data is plotted. The average centre line, the upper line of the upper control limit and a lower line of the lower control limit are often present in a control map. These lines are based on historical details.

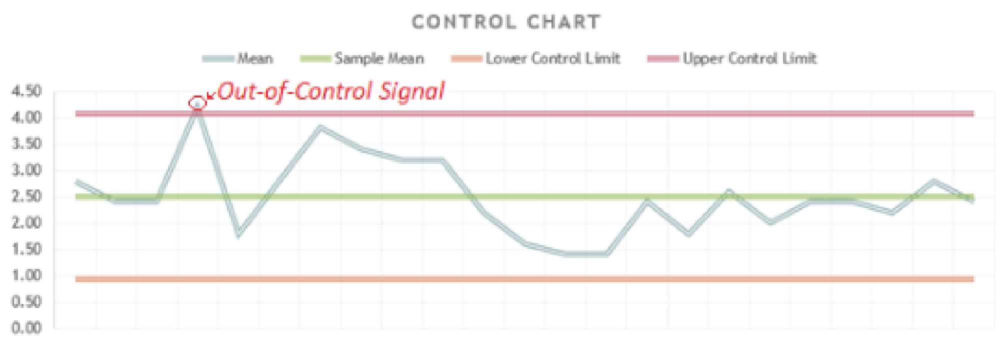

Figure 1.5: Example of a control chart built in Excel

Statistical control diagrams are useful tools for tracking production process status. Control charts are used to compare and compare process data with process limitations. Points outside these boundaries mean that they are out of control.

In his paper Fuzzy short-run check diagrams[60] the University of Alabama's USA D. J. Fonseca1 concluded that normal control diagram procedures are restricted because when the data is fuzzy it cannot be taken into compte.

1.7.2 Fuzzy Approach to the Affinity Diagram:

The text is based on the application of fuzzy logic in the process affinity diagram to improve the accuracy of process affinity diagrams by means of a standard approach in comparisons with the process affinity diagram format[10]. Each phase can involve one or more failures. A structure of the affinity diagram (Figure 1.6) may explain the operation.

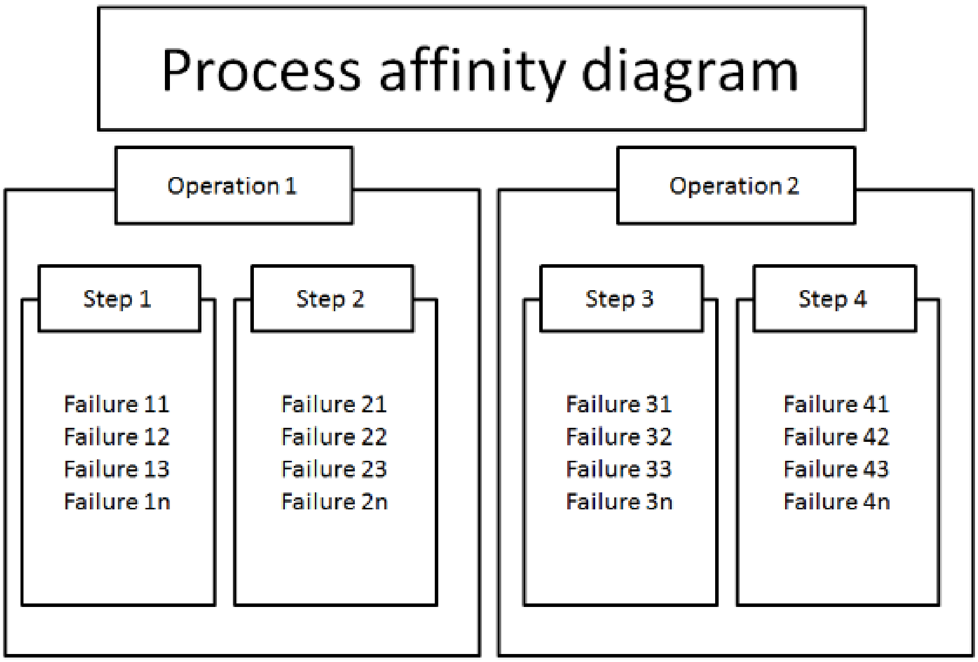

Figure 1.6: Structure of the process affinity diagram

1.8 Basics of the Process Decision Program:

The Chart Phase Decision Chart (PDPC) is designed to recognise and carry out proactive measures to remove possible concerns during the implementation of the Work Plan.

If a working plan is ready, PDPC helps define threats and develop countermeasures (preventive actions). In general, it is developed if the threats are not recognised or if there may be severe consequences.

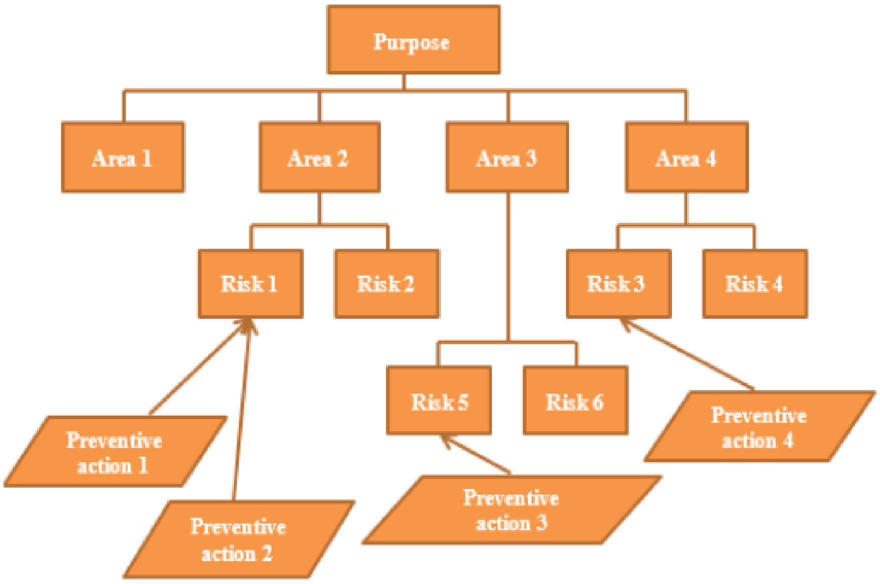

Figure 1.7: Defined structure of PDPC Chart

When indicating the importance of the risks in the creation of the PDPC table, the use of fuzzy logic is presented. The major risks are then defined by the fuzzy approach and placed in the PDPC table.

1.9 Conclusion:

The quality standards increase in combination with advances in new materials, processes and applicable diagnostics. The quantity of data collected from standard quality management tools such as Ishikawa or quality control management and planning tools also ceases to be enough. A diagram of affinism to the adhesive assembly was developed with the help of Fuzzy logic based on electrically conductive adhesives. The subject was decided at the start of the study. Fuzzy logic solves this issue and helps to quantify failures that occurred during the testing, triggered by combining failures in prior phases. It will help to schedule preventive measures in time and will, eventually, render fewer defective goods.

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2. Computer Engineered Chair-Side Dental Ceramic Restorations

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Abstract:

Digital dentistry is replacing traditional methods in dental practice. Computer-aided design (CAD) computer-aided manufacturing (CAM) system is a restorative process (CAD/CAM) that can be fabricated chair-side. In three steps CAD/CAM restoration is about data acquisition, design and manufacturing. This chapter is an overview of CAD/CAM processes in restorative dentistry with emphasis on scanners, designing, milling machines, sinter furnaces for restoration finishing. The computer engineered (Machin able) materials used to fabricate these restorations are discussed with a comparison between traditional and digital work flow patterns.

Keywords:

CAD/CAM, Chairside restorations, materials, composite, zirconia, PMMA.

2.1 Introduction:

Digitization is the order of the day, in all walks of like. Dentistry is no exception. For decades, the skills of dentists and laboratory technicians provided patients with a wide range of dental restorative options. Traditionally restorations have been fabricated using the lost wax technique, which dates back to the twelfth century. Integration of technology such as computer-aided design/computer-aided manufacturing (CAD/CAM) has changed the way restorations are planned and executed in the dental office. Computer-aided design (CAD) computer-aided manufacturing (CAM) systems were developed in 1950 by United States Air force for the defense sector. This technology was applied in dentistry by Francois Duet who developed a dental CAD/CAM device which included an optical impression of the abutment tooth and a numerically controlled milling machine. Werner Mormann is well known for the first commercial chair-side ceramic restoration using CEREC, using computer-aided design/computer-aided manufacturing (CAD/CAM) technology in 1985[1]. This revolutionized concept was possible in dentistry with introduction of industrially made ceramic material for chairside fabrication with the aid of milling devices1. The use of computer engineered technology is nearing four decades. A series of software and hardware advancements have taken place since inception. Simultaneous introduction of newer Machin able materials like lithium disilicate brought out more natural looking restorations. Further research has led to the development of adhesively bonded restorations in addition to the already available cemented restorations.

2.2 CAD/CAM Restorations:

Early versions of CAD/CAM systems were used to fabricate inlays, on lays, single crowns. Currently this technology permits fabrication of inlays, on lays, crowns, veneers, and implant abutments, fixed and removable dental prostheses for partial and completely edentulous patients (Fig 1.1). Subtractive milling process is predominantly used today; additive technology like three-dimensional printing is applied to print models, surgical guides, impression trays, orthodontic aligners, dentures, provisional restorations etc. Future may well be taken over by the additive manufacturing processes. Any CAD/CAM dental restoration follows a few standard sequences namely

1. Scanning: Scanning involves recording the intraoral tissues to a computer software program utilizing an intraoral scanner (camera) or by digitizing the impression using Laboratory Scanner

2. CAD: Computer aided designing of the restoration: Designing of the restoration to desired contour, occlusion and contacts is done through a software program

3. Milling: Designed restoration is fabricated using a subtractive milling process based on the volumetric design created with the software program

2.2.1 Tooth Preparation:

From the clinician point of view, tooth preparation to receive a restoration fabricated indirectly utilizing CAD/CAM involves a few basic requirements. Since the restorations are milled, parameters like the size of the milling bur greatly affect internal fit of the completed restoration. Tooth preparation should provide adequate space for the final restoration, otherwise it may lead to fractures; and the preparation should be well rounded. Sharp corners and edges would not be represented in the final restoration[2]. Tooth preparation guidelines are specific for full veneer ceramic restorations whether they are fabricated in office or laboratory. Bonded ceramics do not require retentive preparation forms as they rely on adhesion to enamel/dentin.

2.2.2 Scanners:

3D scanners are used to capture 3D shapes utilizing a combination of cameras and light projection. Intraoral scanners scan directly inside a patient's mouth and are used in a clinical setting. Dental Laboratory scanners/ desktop scanners capture dental casts or impressions (negative imprints of patient's teeth/gums); they are used in a laboratory setting. Laboratory scanners work with cameras, light and different axes for the work to be moved. They can be two to five axis machines.

2.2.3 Dental Lab Scanners/Desktop Dental Scanners/Bench Top Scanners:

These are machines used to scan impressions and models (Fig 2.2). They use structured light technology in which a series of patterns is projected onto the surface of the dental model and then photographed by one or more cameras to determine the shape of the part. Some scanners use a laser line instead of structured light. The laser line appears bent on the surface contours and sensors detect the lines to determine the shape of a particular region. Most of them can scan models and the newer ones can capture impressions as well.

Desktop scanners are more like an alternative to casting. They allow a dentist to turn a traditional impression into a digital model, which can then be used to fabricate prostheses. Laboratories scan a stone model with a digital scanner (Lab scanner) [3].

2.2.4 Intraoral Scanners:

The intraoral scanners are devices that appear like a wand (Fig 2.3). These hand-held devices have refined with present day scanners being smaller, user friendly and patient friendly. Intraoral scanners are small portable handheld scanners used to examine the inside of a patient's mouth during a clinical checkup or prior to a procedure. Like desktop scanners, intraoral scanners use structured light or laser technology, but without the ability to rotate and manipulate the scanned object (here, patient's teeth and gums).

Intraoral scanners are used in dental clinics and are called a chair-side solution. Scans captured with an intraoral scanner can be processed instantaneously. An intraoral scanner is a digital alternative to traditional impression making. By using a chair-side scanner, dentists gather information faster and without waiting for materials to dry. Impression is a primary requisite to fabricate any restoration outside the mouth (indirect technique). When the same is obtained digitally it is a digital impression of the teeth and the surrounding tissues. A five-tooth quadrant model can be constructed in less than 20 seconds with five or fewer images. A full-arch scan can be obtained in 60-90 seconds owing to improved software algorithms that construct virtual models rapidly. Dentists can design most restorations in 5-7 minutes using the database provided in the software with minimal editing.

Intraoral Scanners function by projecting structured light (white, red or blue)[4]. This is recorded as images or videos and compiled by the software after recognition of specific points of interest. X and Y coordinates of each point are evaluated on the image and the third coordinate (Z) is calculated based on the distance of each object to the camera. A 3D model is generated by matching the points of interest taken under different angles.

Time taken for a digital impression is less than that for a conventional impression. Recent literature does not support the use of intraoral scanners for long span restorations on teeth or implants as slight deviations can occur with respect to cross-arch accuracy.

This is an area of future research. Photogrammetric imaging allows high accuracy for full arch implant restorations also. Intraoral scanners were connected to mobile carts earlier. Recent versions are directly or wirelessly connected to a laptop.

2.2.5 CAD/CAM Design Software:

Digital impressions can be visualized immediately after scanning. Errors if any can be detected immediately unlike conventional impressions wherein the flaws can be detected only after a master cast is made. Specific software can detect errors such as inadequate clearance, undercuts, unclear margins, sharp corners, rough surfaces etc.

Clinicians who incorporate digital impressions in their practices and send the work for milling and finishing outside can review and send the scanned images electronically to the laboratory to fabricate the restorations. The laboratory can then use compatible lab specific software for the design and manufacturing (Ex, Exocad, Exocad GmbH, and Darmstadt, Germany).

Digital scans can be stored and archived virtually without any issues with storage space. With most systems, CAD data are handled and transmitted in an STL format, which is a standard file format in 3D printing and rapid prototyping. Other formats currently used are PLY. DCM and UDX. These file formats are translated into mill able data file formats (CNC) to communicate with the milling machine. STL files describe only the surface geometry of a 3 D object without any representation of color, texture or other common CAD model attributes.

2.2.6 Chair-Side Milling Machines:

Milling units indicated for dental offices are usually compact. They can be used to scan, mill and deliver restorations in single appointment. This type is usually a 4-axis mill, which means that the milling bur moves in 3 axes x, y, z and the material block can rotate in 1 additional axis (termed as 3+1 axis milling machine). Some units use 2 burs on 2 separate motors to mill the material block. Accuracy and milling time are determined by number of axes, spindles, bur size, abrasiveness, milling speed and the material used. Silica based ceramics are typically milled in a wet environment. Composite and zirconia blanks are dry milled. Milling machines provide wet and dry milling options or just dry milling option.

Milling machines with 5 or more axes can rotate the material block in additional axes, which enable milling of more complex designs like implant superstructure where implant screw access opening may be angulated in different directions. Rotary cutting instruments with a smaller diameter led to greater accuracy but require longer milling times. Compact chair side milling units can accommodate material blocks of 20mm, 40mm and 85 mm. Five-axis milling units can process polymer, hybrid ceramic, glass ceramic, silicate ceramic and zirconium oxide from discs of 98.5 mm in diameter and up to 30 mm thickness. With a multi block holder, they can also mill up to 6 blocks at the same time for maximum productivity and efficiency. Laser milling of dental restorations uses millions of short, high intensity laser pulses to remove small amounts of material from a standard block. The small laser spot size allows higher resolution, resulting in improved morphology and micro texture on the restorations. Laser milling reduces cost by eliminating cutting tools and coolants. The integrated 3D scanner has the ability to perform in-process quality control before the restoration is finished.

2.2.7 Sintering Furnaces:

Most restorations require sintering or ceramic glazing before completion. Chair side furnaces popular like CEREC Speed fire (DENTSPLY Sirona) and the Program mat CS4 (Ivoclar Viv dent) can be used for sintering zirconia, glazing ceramics and crystallization/processing of lithium disilicate.

2.2.8 Chair-side CAD/CAM Materials:

Chair-side CAD/CAM represents the fabrication process, but the clinical outcome of the restoration is influenced more by the restorative material and how well it is handled. The material range for chair-side CAD/CAM technologies includes acrylics, indirect resin composites, ceramics (Fig 2.4, 2.5). Features unique to all CAD/CAM materials are that they are monolithic and industrially processed. This results in a dense, single homogeneous material throughout the restoration. Presently, CAD/CAM materials are available as monochromatic blocks in a variety of shades and as polychromatic blocks with Chroma/translucency that simulates shade transition from cervical to incisal as in natural dentition. Types of Materials for chair-side digital dentistry are as follows [5] (Table 2.1)

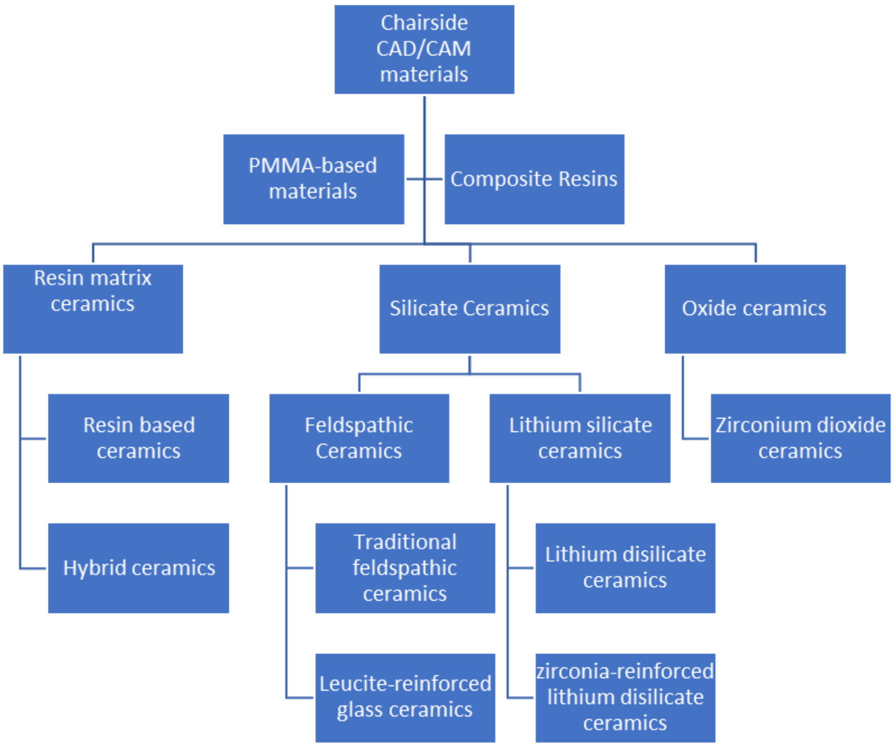

Table 2.1: Types of Chair-side CAD/CAM Materials

PMMA BASED MATERIALS: Cross linked PMMA CAD/CAM blocks are used for provisional restorations. Acrylic blocks are also used for milling copings, frameworks and restorations that burn out without any residue for casting with metal alloys. Examples of PMMA Based Materials: Telio CAD (Ivoclar Vivadent); VITA CAD-Temp (Mono color/Mutli color blocks) (VITA Zahnfabrik)

COMPOSITE RESINS: They are easy to use clinically. Polishing and application of stain/glaze is all that is needed. Examples of Composite Resins: Paradigm MZ100 (3M ESPE); BRILLIANT Crios (Coltene)

CERAMICS: There are three groups of ceramic CAD/CAM materials namely, resin matrix ceramics (RMCs), silicate ceramics and oxide ceramics.

Resin Matrix Ceramics (RMCs): RMCs are divided into two subgroups, resin-based ceramics and hybrid ceramics. Compared to silica-based ceramics this group can take up higher load capacity, better modulus of elasticity, favorable milling properties.

VITA ENAMIC: Hybrid ceramic block is a hybrid ceramic for chairside applications. They contain a ceramic network infiltrated with a polymer. The resin based ceramics subgroup, contains a polymer matrix with at least 80% Nano sized ceramic filler particles. They are Cerasmart (GC International AG, Luzern, Switzerland), Lava Ultimate (3M ESPE). Resin matrix ceramic restorations only require polishing like composite resins. They can be glazed and customized with light cure stains, making finishing simple and fast without need for a firing furnace. An important difference between hybrid and resin matrix ceramic is in the bonding procedure. Ceramic structure of hybrid ceramic requires hydrofluoric (HF) acid etching, ideally for 60 seconds and silane application. Resin based ceramics should not be acid etched and must be penetrated with aluminium oxide air -particle abrasion and then silanized.

SILICATE CERAMICS: They are divided into feldspathic and silicate ceramics. They are mainly nonmetallic inorganic ceramics that contain a glass phase. Glass offers high translucency, optimal esthetics and a natural appearance. They have low fracture strength and they are brittle. Hence, need adhesive bonding.

HF etching and application of a silane coupling agent is required. The etching time and concentration of the etchant depends on the crystalline content of the ceramic. Conventional feldspathic ceramics are acid etched with 9.8% HF acid for 2 mins. Leucite-reinforced feldspathic ceramics is etched with the same concentration for 1 min. Lithium disilicates are etched with 4.6% for just 20 seconds.

Traditional feldspathic ceramics are the most translucent, esthetic; highly popular for full coverage restorations. They are now available in polychromatic, multilayer blocks for enhanced esthetics to simulate the shade and translucency layers of natural teeth.

Examples of Traditional Feldspathic Ceramics are VITABLOCS Mark II (VITA Zahnfabrik), VITABLOCS Real Life ceramic blocks (VITA).

Leucite reinforced glass ceramics possess increased strength compared to traditional felspathic ceramics, and they exhibit more translucency; they are indicated for anterior crowns, posterior inlays/on lays. Resin bonding with composite resin luting agents is a need.

An example of Leucite -reinforced glass ceramics is IPS Empress CAD (Ivoclar Vivadent)

Lithium silicate ceramics are indicated for monolithic crowns, inlays, onlays. Lithium silicate ceramics have a crystalline phase consisting of lithium disilicate and lithium orthophosphate, which increases fracture resistance without affecting translucency. They need to be crystallized in a sintering furnace after milling. They can also be stained and glazed. IPS e.max CAD (Ivoclar Vivadent) is an example of Lithium disilicate Ceramics.

VITA SUPRINITY PC (VITA Zahnfabrik) and Celtra Duo (DENTSPLY Sirona) are examples of Zirconia -reinforced lithium disilicate ceramics.

OXIDE CERAMICS: are high strength polycrystalline metal oxide based CAD/CAM ceramics like zirconium dioxide (zirconia). They are characterized by excellent mechanical properties substantially higher than silica-based ceramics. Pre-shaded multilayer high translucent zirconia materials are now available that offer greater light transmission. Higher translucency is achieved by slight changes of the Y2O3 content (5 mol% or more instead of 3 mol %) resulting in a higher amount of cubic-phase particles. More cubic zirconia offers higher light transmission but lower flexural strength values than conventional zirconia.

The restorations are milled from pre-sintered blocks with slightly enlarged dimensions compensating for the 20%-25% material shrinkage during final sinter step after milling. Conventional cements can be used for luting restorations. Resin-modified glass ionomer or self-adhesive resin cements are preferred. They provide a certain level of adhesion to both teeth and ceramic without additional time consuming and technique sensitive bonding and priming steps. However, for zirconia restorations that are less strong, thin, lacking in retention or relying on resin bonding with composite resin luting agents for retention a three-step approach is recommended (APC-zirconia-bonding concept):

a. Air-particle abrade the bonding surface with aluminium oxide(A)
b. Application of special zirconia primer(P)
c. Use of dual-cure or self-cure composite resin cement(C)

The restoration must be cleaned; zirconia should be air particle abraded with alumina or silica-coated alumina particles. Small particles (50-60 µ m) at low pressure (<200kPa (2bar)) are sufficient for air abrasion process. Next step is to apply special ceramic primer (Clearfield Ceramic Primer Plus, Kuraray Noritake) that contains special adhesive phosphate monomers. The monomer MDP (10-methacryloxydecyl dihydrogen phosphate) is effective to bond to metal oxides. Dual cure or self-cure composite resins should be used to ensure adequate polymerization/conversion (Panavia V5, Kuraray Noritake).

CAD/CAM technology is the only way to create zirconia restorations as the design program adjusts precisely for the shrinkage caused by sintering. Examples of Zirconium dioxide ceramics are CEREC Zirconia/Zirconia meso (DENTSPLY Sirona), Lava Zirconia Blocks

(3M ESPE), IPS e. max Zir CAD (Ivoclar Vivadent). Silicate and oxide-based ceramics need to be crystallized (lithium silicates) or sintered (zirconia) either with or before staining and glazing. Both these steps require a special sinter furnace.

2.3 Three Dimensional Printing:

Chairside CAD/CAM systems when combined with 3D printers, can provide more clinical applications and appliances, like night guards, occlusal splints, orthodontic appliances, surgical guides, provisional restorations and study models. Current research in metal and ceramic printing may result in 3D printing becoming the manufacturing method of choice in the future. Digital restorations have the ability to stream line processes that can be cumbersome via the analog way. Data storage is digital and the practitioner can evaluate the dentition and discuss with patient on a 3D model versus having to wait to pour the impressions, mount on an articulator and discuss the finding. The down side of newer technology is that startup costs are high, standardized work flows are lacking. Certain scanners use stl format while others may have their own native scan files such as PLY-polygon file format or in 3 shape system file is exported as digital imaging and communications in medicine format (DCM), which will need to be converted to the still format. Intraoral scanners /camera size can be an obstacle especially in distobuccally cusp of maxillary second molars or a limited size oral cavity. A learning curve and an adjustment for scanning, scanning sequence, and digital work flow present other challenges when integrating digital impressions in any dental practice. Deep margins/finish lines can be more challenging. Digital dentistry as a restorative process (CAD/CAM) can be in summarized in three steps, Data acquisition, design and manufacturing. There are three categories of systems: Scan only-stand alone; Scan, design and output to a third party mill; all-in-one ecosystem[6]. A comparison of traditional work flow and digital work flow is presented in (Table 2.2)[7]

Table 2.2: Work flow comparison

Work Flow (Steps)	Traditional	Digital
Impression making	10 minutes /arch	2 minutes/arch
Laboratory prescription	Handwritten	Digital prescription on screen
Submission of case to lab	Courier:1-3 days	Electronic portal; seconds
Design/Fabrication	Additional day for model work	Completed from digital model
Mode fabrication	Die/sectioning-potential for error	Stereo lithography models built overnight during framework creation
Restoration finishing	Work flow varies depending on selected materials (Ex: Monolithic/ Veneered material)	Work flow varies depending on selected materials (Ex: Monolithic/Veneered material)

2.4 Conclusion:

Digital dentistry and its integration into practice is more than just the piece of equipment. It is important to understand more than how to use the device, nuances of the technology, processes involved and how the technology fits into the existing practice system. Ceramic restorations will continue to evolve as the demand for high quality natural looking restoration increases. Single visit dentistry, chair side dentistry and invasion of technology in every aspect of practice from treatment planning to execution and final restoration are inevitable. Digital dentistry would be a great addition in any dental practice. It has its own drawbacks. Incorporating digital workflow into a dental office is a daunting task with endless workflow options. They can provide increased levels of communication, predictability and improved patient care.

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Figure 2.1: Chair-side CAD/CAM System (Sirona)

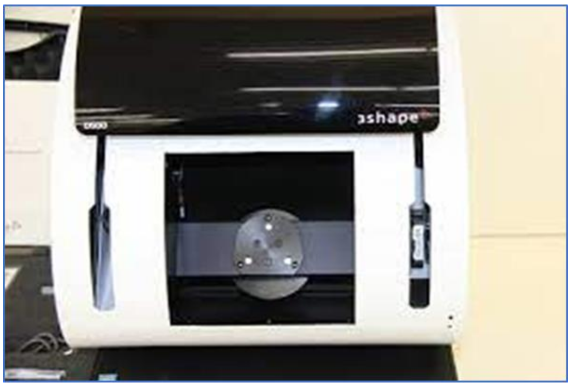

Figure 2.2: Laboratory Scanner (3 Shape)   **Figure 2.3: Intraoral Scanner (Sirona)**

Figure 2.4: CAD/CAM Blocks

Figure 2.5: CAD/CAM disk after milling

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3. A study on Multi Scale Sensors and Systems

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Abstract:

Many different sensors are now available for structural monitoring, but the total number of degrees of freedom (DOFs) that can be measured is still far less than what is currently possible. The efficiency of structural monitoring may be hindered if the structure does not respond structurally in all of its essential sections.

Structural monitoring objectives can only be met if multi-scale response reconstructions are performed in areas where sensors are unavailable. With a prototype multi-sensor fringe projection system for sheet-bulk metal inspections in mind, current optical system measurement processes are discussed in detail. A novel concept for finding the orientations and positions of the sensors' measuring ranges in a single coordinate system is devised as a result of the disclosed processes' shortcomings. Measurements outside the sensor's range are now possible thanks to an automated technique that determines geometrical relationships between the features being measured.

Keyword:

*Sensor, Multi Scale, Sensor System, Multi Sensor***.**

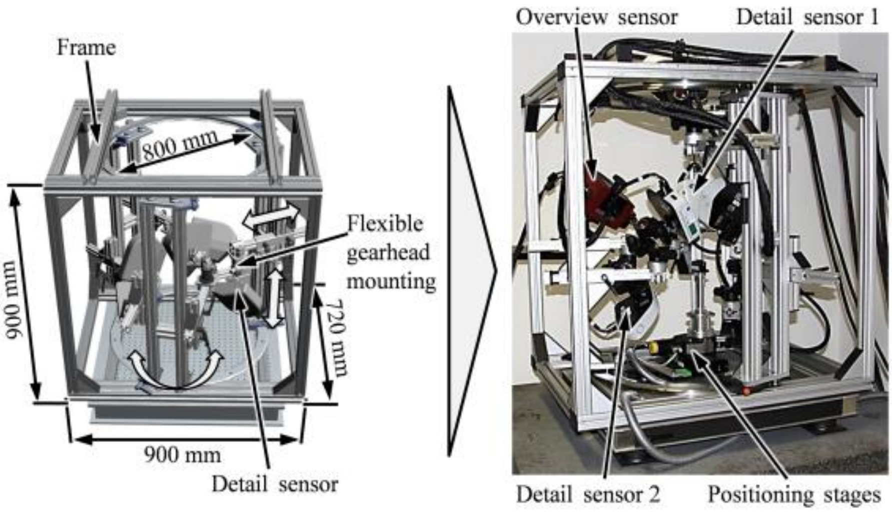
3.1 Introduction:

Sensors and systems research at the Multi-Scale Sensors and Systems research group focuses on the design and manufacture of devices that are physically and functionally compatible on a variety of dimensions.

They are prepared to revolutionize technology across the board thanks to their decades of multi-scale research and expertise. [1]

It is necessary that nano/micro size building blocks complement and strengthen new engineering methodologies in the relevant technology fields, including sensors, materials, systems, devices and components, as a result of recent breakthroughs in nanotechnology Consequently, it is necessary to create new computational approaches and tools aggressively to deal with phenomena at micro and nanoscale structures, interfaces and bulk samples that are mechanical, structural chemical and electrical in nature.

Multi-sensor fringe projection system prototype developed for production-related applications. [2]



Sketch of the idea without an overview sensor (left side) and realized setup of the prototype multi-scale multi-sensor fringe projection system are shown in Fig 3.1 (Right side).

This type of transducer is referred to as a BioFET (biologically sensitive field-effect transistor). Aqueous solution containing the analyte replaces the gate structure, which is analogous to a MOSFET. The conductance of the transducer is modulated by the binding of the analyte to receptors on the surface. Biologically sensitive field-effect transistors (BiFets) are miconductor transducers with field-effect biosensors. [3] Biofunctionalized surfaces in aqueous solution and an electrode replace the gate structure of conventional mosfets (metal-oxide-semiconductor field-effect transistors). Furthermore, the BioFet idea has been shown to function for a wide range of bio molecular sensors by appropriately functionalizing the transducer's surface. It is possible to identify single-nucleotide polymorphisms (SNPs) on the transducer surface by immobilizing complementary DNA strands on the transducer surface. The surface of the transducer is coated with monoclonal antibodies in order to detect various proteins, such as tumour markers. [4]

It is necessary that nano/micro size building blocks complement and strengthen new engineering methodologies in the relevant technology fields, including sensors, materials, systems, devices and components, due to recent breakthroughs in nanotechnology. To address the mechanical, structural, chemical, and electrical phenomena encountered in micro- and nanoscale structures, interfaces, and bulk specimens, new computational approaches and tools are needed. As one of the most effective methods for uncovering complex physical phenomena at the nano- or atomic scale, molecular dynamics (MD) has emerged. [5]

Improved sensor technology has made high-resolution photographs more widely available. Because of this, new methods have been developed to better utilise the data that is already out there. Thus, texture traits became a feature in the classification of Remote Sensing Image data because of these studies (RSIs) [6]

3.2 Review of Literature:

An interchangeable fringe projection sensor with a measuring range of the size of the workpiece is mounted to get an overview of the workpiece and also to measure large features simultaneously (Ohrt et al., 2012) [7]. Cortical bone was analysed using a hierarchical multiscale modelling approach by Ghanbari and Naghdabadi [8]. They used computational homogenization to link two boundary value problems: one at the macroscale and one at the microscale. A microscale boundary value issue is established and addressed at each material position where the constitutive model is required. They were able to measure the mechanical characteristics of cortical bone with varying mineral volume factions (MVFs) using this method, and the results were in good agreement with the available experimental data. For two-phase flow in extremely heterogeneous porous media, Aarnes et al. [9] proposed a hierarchical multiscale technique based on a mixed finite-element formulation. In order to increase the precision of the multiscale solution, they also devised adaptive techniques for coarse grids, which resulted in very flexible coarse-grid cells in terms of size and geometry.

Non-supervised and supervised classification procedures were combined in a high resolution RSI classification system developed by Gigandet et al. [10]. Support Vector Machines and Mahalanobis distance were used to classify regions in this method (SVM). For land cover change detection, both Ouma et al. [11] and Wang et al. [12] suggested methods based on multiscale data. In [11], Ouma et al. used an unsupervised neural network for vegetation analysis to provide multi-scale segmentation. In contrast, Wang et al. [12] proposed a method for detecting changes in urban areas. Based on a mixture of means for each pixel, the approach combines feature from multiple scales. In the end, a new image is created that represents the sum of the individual scalar scales.

3.3 Objectives:

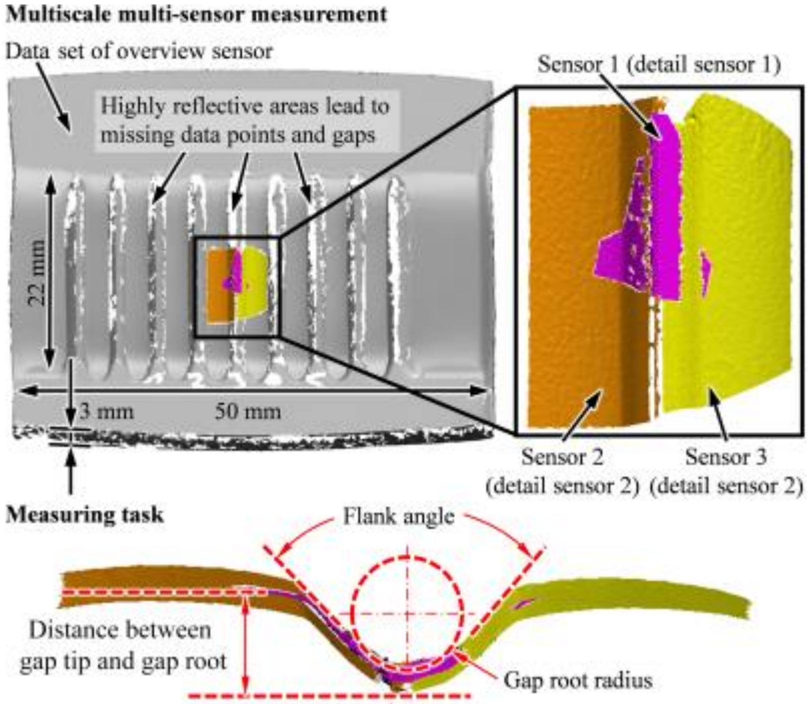
- To Study purpose of multi scale and multi sensor system
- Use of multi scale in RSI
- To study approach of multi scale in engineering applications
- To Overview multi-scale multi-sensor fringe projection system

3.4 Research Methodology:

Research Methodology refers the discussion regarding the specific methods chosen and used in a research paper. This discussion also encompasses the theoretical concepts that further provide information about the methods selection and application. The data used for preparing this paper are secondary in nature which are collected from the various published resources. The data derived for preparing this paper are from various relevant websites

3.5 Result and Discussion:

The automated measuring technique is used in an inspection of a sheet-bulk metal-formed object in order to demonstrate its advantages in a measuring task similar to that for which the multi-scale multi-sensor fringe projection system was created. DC04 sheet metal can be shaped into a multiple gap structure using the sheet-bulk metal forming process (see Figure. 3.2) [13]



A sheet-bulk metal produced multiple gap structure (upper side) was measured using a variety of scales and sensors, as shown in Figure 3.2 (lower side).

The concurrent multiscale technique remains a potent tool in linking the quantum, molecule, and continuum scales in engineering applications. The bridge domain coupling approach to model and simulate aluminum nanocomposites with embedded CNTs as illustrated in Figure. 3.3[14]

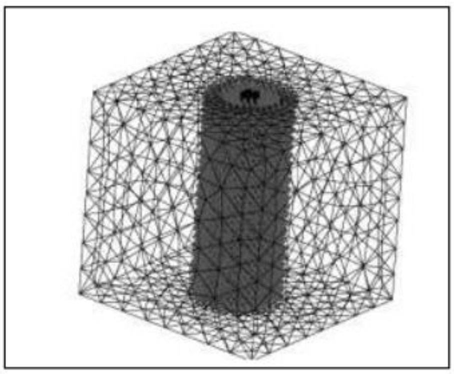


Figure 3.3: Multiscale model of a nanocomposite

Basic concepts and major processing steps for multi-scale classification will be discussed in the following sections. An example of a multi-scale training strategy is shown in Figure 3.4. [15]

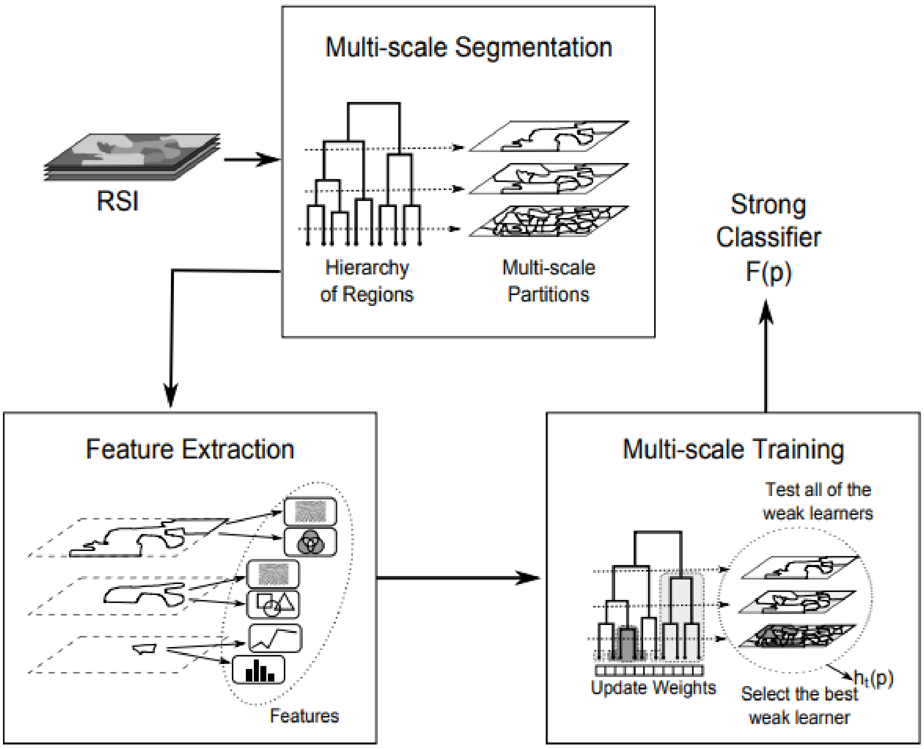


Figure 3.4: Steps of the multi-scale training approach

3.6 Conclusion:

To measure characteristics greater than the optical sensor's range, a sensor was introduced that was designed for optical multi-scale multi-sensor measurement systems. Using a multiscale technique, it is possible to simulate complete sensors at a cheap numerical cost while keeping incorporating relevant features of the microscopic structure of biomolecules. The simulation findings reveal that the conductance of the transducer is strongly affected by the orientation of the biomolecules with regard to the surface, i.e., different dipole moments. This suggests that biomolecule orientations at charged surfaces need to be studied.

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4. Recent Trends in Automotive Engineering and Technology

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Abstract:

The modern world has seen several transformations as a result of technological advancement. Adaptive and co-operative cruise control, self-driving cars, vehicles powered by artificial intelligence, and other new technology have improved road safety, observing traffic regulations, and thereby improving the life expectancy of people on the road. The big companies will gain a competitive edge if they have access to the latest and most efficient technologies and procedures. In India's automobile industry, it is critical to maximize the efficiency of production facilities while also being aware of the effects of government legislation. India's automobile industry has played a significant role in the country's GDP growth. One of India's fastest-growing industries is the automobile industry. The automobile industry in India's key growth driver is the increase in demand for cars and other vehicles as a result of rising incomes. The rise of the vehicle industry has also been aided by the advent of custom financing and flexible repayment plans. The automotive industry's current technology trends reflect a wide range of disciplines. With the use of computer-aided design and manufacturing (CADM), innovative engine transmission concepts, composite and ceramic materials, and electronic and microprocessor components, futuristic automobiles with remarkable quality, fuel economy, and performance will be possible.

Keyword:

Automotive, Car, AI, Recent Trends, Automobile.

4.1 Introduction:

Significant changes have taken place in the automobile sector in India over the past three to four decades. Since India was a closed market in the 1970s due to overregulation and high tariffs and sales taxes, the country's economic development was constrained. After liberalization, the automotive industry was given a pass, with automatic clearance for FDI up to 100% equity. [1]

In the field of automotive engineering, you design, develop, and manufacture automobiles on the ground. The development of automobiles is an interdisciplinary optimization challenge that is often at odds with each other. There are many factors to consider when designing a new car, but the most important ones are fuel economy, safety and durability in the event of a crash, as well as ergonomics and aerodynamics, as well as noise and vibration (NVH). [2] Original equipment manufacturers (OEMs) are forced by the competitive nature of the industry to make key judgments on these design factors.

Auto giants are consolidating, upgrading technology, expanding product lines, entering new markets, and reducing prices as a result of globalization. They've turned to shared platforms, modular assemblies, and systems integration of component suppliers and e-commerce in order to streamline their operations. It is becoming more common for system and assembly vendors to emerge rather than individual component suppliers in the component sector. [3] Larger manufacturers and MNCs are transforming into Tier 1 firms while component suppliers are integrating into Tier 2 and Tier 3 providers. As a result of growing environmental and public health concerns, the United States is enacting stricter safety and emission standards.

It is possible to describe automotive engineering as a word that encompasses all types of motor vehicles, however automobile engineering is mainly focused on automobiles. As a result, it is possible to tell the two apart solely on this small variation. Sub-discipline of vehicle engineering, automotive engineering deals with automobiles. As a sub-discipline of mechanical engineering, it can also be referred to as a sub-discipline. [4] The automobile is at the centre of automotive engineering. Designing automobiles, running a car factory, creating engines, and managing gasoline are all included in this course. Automotive engineering can therefore be broken down into sub-disciplines like automobile engineering. However, the terms "automotive branch" and "vehicular branch" are frequently used interchangeably. [5]

The special features of vehicle are:

- In that it does not require fuel or emit greenhouse gases, the fact that it is powered by the sun makes it environmentally beneficial.
- Adaptive Cruise Control: This function allows the car to modify its speed in response to the speed of the vehicles in front of it. This prevents the vehicles from colliding with each other in the event of an accident.
- Automatic Forward-Collision Braking: The forward-collision braking system warns the driver and applies the brakes immediately to avoid an accident.

Vibration and harshness are also major considerations in the design of automobiles (NVH). Both noise and vibration are caused by oscillatory motions, and this mechanism is the same for both. In automobiles, the sources and treatments for both interior and external noise are nearly same. There are laws in place to control exterior noise issues like pass-by-noise and traffic noise. [6]

4.2 Review Of Literature:

GPS and ultrasonic sensor skirt approach are used in the "Autonomous Electric Vehicle Using Ultrasonic Sensor Skirt Approach" to map the travel path and guide the vehicle in an autonomous manner. A UART connection is used to connect the three microcontrollers that make up the system. A straight course is maintained via the vehicle's detection of the side walls. It avoids all barriers, both static and dynamic, in its route. Solar panels with MPTT technology charge a battery that powers the system. The system is completely self-sufficient. For example, it can be used to transport people around an industrial site or a college campus in an automated fashion. [7]

For the paper "Self-Driving Cars: A Peep into the Future," this study presents a driverless car that is fuelled by green energy, collision protected, and steered by GSM. Camera, obstacle sensor, and GPS are used to automate the vehicle's operation. In order to provide power, the rooftop solar PV panel with a battery backup is used.

Use of a speaker along the route is utilized to relay significant details The NMEA messages generated by the proposed GPS system must be based on real-time data. This was accomplished by personally mapping the most essential locations in advance. [8]

Obstacle distance and location can be determined using the Raspberry-pi 3 Model B and a single-point scan. In this paper, we describe the challenge of measuring distance to obstacles for the purpose of generating a 2-D indoor map using an autonomous robot equipped with an ultrasonic sensor.

Ultrasonic sensors are used to measure the distance. There is a major drawback to using sensors to construct an indoor map of a 2-D structure. Using a sensor, a distance of between 2cm and 80cm has a good probability of matching the real distance, according to the data. It is possible to create the necessary indoor map by assembling three tiny wooden boxes around the robot. Ghost points can be removed with cluster analysis. [9]

Aerodynamic, electromagnetic, and mechanical noises make up electric motor noise (Dupont et al., 2013; Gurav et al., 2017). [10] At higher motor speeds, the fan or a similar device can generate a lot of aerodynamic noise.

Electromagnetic noise is generated in the electric drive system due to the switching activity of the power electronic converter supplying the motor. The stator is the primary source of mechanical noise, which is heard most clearly at immediate post engine speeds.

Automobiles, unlike in the past, are no longer merely mechanical gadgets. In the near future, they'll be the ultimate electronic devices on wheels. Autonomous driving, in-car entertainment, and software architecture for fully electric vehicles are just a few of the emerging developments in automotive electronics that necessitate a new way of thinking (Tummala et al., 2016). [11]

4.3 Objectives:

- To know about the emerging trends of Automobile Industry in India
- To know about the category wise details of Production, Sales and Export of Automobile Products in India.
- To study the trends shaping the global light vehicle industry in the present era.
- To know about the customer satisfaction in customer orientation model.

4.4 Research Methodology:

Research methodology is a systematic approach to tackling a research challenge. It can be viewed as a branch of science that focuses on the mechanics of scientific investigation. The logic behind the numerous procedures taken by a researcher to study his research problem is examined in this article. The researcher must be well-versed in both research methodologies and methodology. Data for this research was gathered from a variety of published sources and is considered secondary in nature. This paper's information was gathered from a variety of reliable online sources.

4.5 Result And Discussion:

Focus on multi-material understanding (corrosion, thermal expansion), shorter cycle times, and lower material prices are all important aspects of lightweight construction. Predictive modelling, as well as handling, joining, and automation, are among the most important technologies. [12]

Figure 4.1: Hybrid lightweight construction and its manufacturing

Figure 4.2 depicts the sensors and other components found in self-driving cars. Autonomous vehicles must know exactly where they are at all times. These automobiles have GPS antennas that offer centimeter-level position information. Decisions about how to get there should be made by the vehicle. The Lidar (light detection and ranging) is used to do this. The reflected pulses from a pulsed laser light are used to produce a 3D map of the environment. [13]

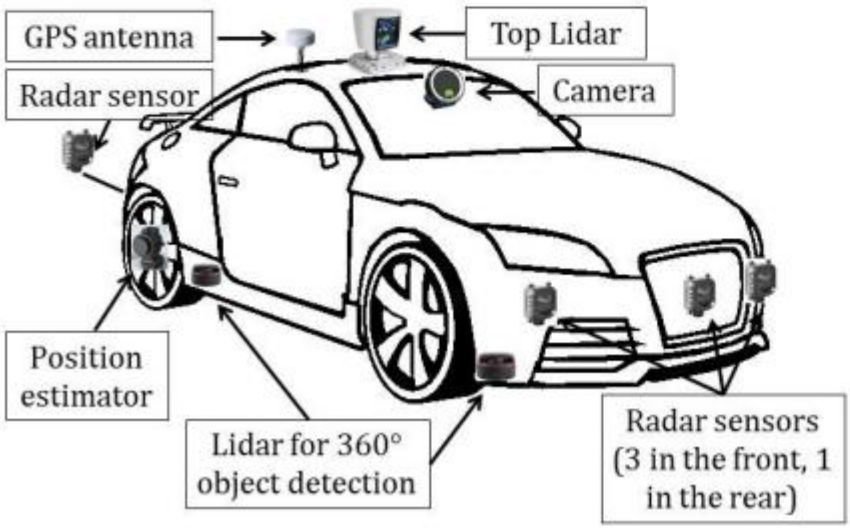

Figure 4.2: Sensors and technologies used in an autonomous vehicle

At low speeds, DC electric motors provide a lot of torque. Because of the high friction caused by the commutators and brushes, these motors can only run at a limited maximum speed. In addition, DC electric motors suffer from low efficiency and expensive maintenance costs.

They feature a wide torque-speed range, a long service life and low torque ripple. Multi-phase AC induction motors have many advantages. [14] Switched reluctance (SR) electric motors are another promising technique. SR electric motors provide a number of remarkable advantages, including excellent efficiency over a wide speed-torque range, simple temperature control, and great overload and fault tolerance.

Electric motors in vehicles are graded on a scale of "A" to "F," with "A" denoting the best performance. Nevertheless, various original equipment manufacturers (OEMs) use a variety of electric motors in their latest models. [15]

Criteria	DC motor	AC induction motor	PM motor	SR motor
Power density	E	C	A	D
Efficiency	E	C	A	B
Speed	F	B	A	A
Torque density	E	D	A	C
Torque ripple	D	B	C	E
Overload capability	E	C	B	C
Controllability	A	A	C	E
Reliability	E	A	C	B

Criteria	DC motor	AC induction motor	PM motor	SR motor
Service time	D	A	C	B
Maturity	A	B	C	D
Size and weight	E	C	B	C
Manufacturability	E	A	E	C
Cost	D	A	E	C

Table 4.1: Evaluation of electric motors used in the vehicle industry

DC: direct current, AC: alternative current, PM: permanent magnet, SR: switched reluctance

One of the most crucial issues in automobile history is looming. New markets in emerging countries are flourishing, and customers' behaviour is changing quickly and in a non-uniform manner as a result. Internal combustion engines will continue to be the dominant technology for the foreseeable future, despite the existence of new technologies. [16] The creation of these products must include the development of production processes, from efficient casting of novel alloys to micro-structured surfaces. Here are a few of the most promising manufacturing-focused technologies. [17]

Topic	2014	2017	2020	2025	Goal
Battery Technology	Li-Ion pouch cells	Electrochemical models, quality characteristics	Li-Sulphur and Li-Polymer		Li-Air
Fuel-Cell Technology	Novel catalysts, batch production of metallic bipolar plates	Batch production of MEA and plates, partially automated assembly of stack	Mass production of fuel cell stacks	Highly integration and automation of fuel cell system	Competitive costs and hydrogen infrastructure
Hybrid Lightweight Construction	Al, HSS, CFRP (RTM, low automation)	AHSS 3^{rd} Gen., Al, Mg, High Performance-RTM for CFRP, automated placement of hybrid structures, organic sheets, advanced joining		Metallic body structure planked with sheets of diverse materials (incl. composites)	System oriented, function-integrated Multi-Material-Mix
Additive Manufacturing	Rapid Tooling	Increase of build-up-rate in SLM and 3D printers, new materials models, quality assurance and reproducibility		One-shot production of whole modules	New design paradigma "Manufacturing for Functionality"

Topic	2014	2017	2020	2025	Goal
Flexible manufacturing of Body-in-White	Collaborating robots	Body-in-White after order penetration-point	Flexible joining technologies (e.g. remote laser)	Environment sensible handling devices	One piece flow for all types of a platform
Autonomous final Assembly	Strict sequences in flow	Human-machine collaboration	Flexibility in routes	Continuous re-scheduling of work-load	Labor-and technology-flexibility
Re-manufacturing	Recover end-of-life product to “as-good-as new” condition	Advancement in inspection and non-destructive disassembly	Re-man activities adaptive to machine state	Universal re-man standard for multiple product models	Cradle-to-cradle product design for remanufacturing

Table 4.2: Summary of current trends and possible roads to achieve future goals.

4.6 Conclusion:

It's important to remember that the global automobile sector has been one of the most important drivers of economic growth around the world, even though it's a traditional business. Due to environmental and energy concerns, fossil fuel car sales share is declining at a quicker rate than anticipated.

To adapt to the electric revolution, the global automotive industry has had to change for more than a century of selling fossil fuel vehicles. The global automobile sector has increased by 30 %. In order to reduce our dependence on finite resources, renewable energy sources like solar and wind can be used. In spite of the initial cost, these renewable resources will have a positive impact on the car sector in the long term.

The goal of creating a semi-autonomous vehicle is to secure a person's safety by directing him to follow the proper traffic laws. Growing a business relies heavily on retaining and gaining new customers, yet companies often neglect this aspect of their business in favour of other priorities. These advances necessitate that the automobile industry maintain pace. Only OEMs that are developing electric and autonomous car technology will be the automobile industry's worldwide leaders in the coming decade.

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5. Impact of Nanotechnologies in Modern Engineering

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Abstract:

Nanotechnology, in fact, is a very wide-ranging field of study and research. Numerous scholars have contributed to its development, which encompasses numerous disciplines, including as physics and biology as well as material science and engineering. With so many possible uses, it is critical that we have a fundamental grasp of nanotechnology. Global nanotechnology research is booming, and nanotechnology is already found in a wide range of products, including sunscreens and cosmetics. A wide range of biomedical devices and medication delivery systems are being created with nanotechnology. In addition, nanotechnology is being developed for environmental applications, such as the removal of contaminants from the environment. This article provides an overview of nanotechnology and explores its potential impact on human life in the near future.

Keyword:

Nanotechnology, nanomolecule, nanosystem.

5.1 Introduction:

Nanotechnology research is intimately linked to industry and daily life because of engineering's use of nanosciences and nanotechnolgies. As a result, a wide range of nanomaterials, nanodevices, and nanosystems have been produced and put to use in various engineering applications. In recent years, the application of nanotechnology in medicine has grown tremendously. The use of nanomaterials in the diagnosis and treatment of disease is being researched at a cost of billions of dollars. [1] For example, we have spent a lot of time developing nanomaterials loaded with a fluorescent dye that can identify disease-causing chemicals in the bloodstream. It is the study of phenomena and materials at the nanometer scale that constitutes nanotechnology, which includes research and development at the molecular, atomic, and macromolecular levels.

At the nanoscale scale, everything is one billionth of a metre in size or smaller. A human hair, by comparison, has a diameter of roughly 10,000 nanometers. [2]

The versatility of nanomaterials makes them extremely valuable in a wide range of technological fields. With this consistent development in federal funding for nanotechnology, the US government has invested about $1 billion in 2004 alone, according to Kenneth Olden, National Institute of Environmental Health Sciences. Investment in this area is also on the rise. Commercial applications for several nanomaterials have already begun. Because TiO2 nanoparticles are less hazardous than organic molecules currently utilised as UV absorbers in many sunscreen formulations, some businesses are employing TiO2 nanoparticles in sunscreen creams.[3] Sporting goods, apparel, and telecommunications infrastructure all contain nanomaterials. According to some speakers, nanotechnology's potential is limitless. According to Douglas Mulhall, author of Our Molecular Future, some of the things we have now were science fiction topics a decade ago and have the potential to transform our society quickly.[4]

5.2 Applications of Nanotechnology:

- Medicine (Diagnostic, Drug delivery, tissue engineering)
- Cryonics
- Environment (Filtration)
- Reducing energy consumption, increasing energy production efficiency, and cleaning up nuclear accidents and storing nuclear waste are all examples of energy conservation.
- The exchange of information and ideas (memory storage, novel semiconductor devices, novel optoelectronic devices, quantum computers)
- There is a lot of heavy industry here (aerospace, catalysis, construction)
- Consumer products (Food, nanofoods, household, optics, textiles, cosmetics, agriculture and sports)

5.3 Nanotechnology Contribute To Tackling The Grand Challenges:

The abolition of extreme poverty and hunger would be made possible in large part by productive nanosystems, abundance economics, and a drastically reduced global population. In addition, a better knowledge of essential agricultural processes like biological nitrogen fixation and the ways in which it might be improved through nanotechnology may lead to further advancements. The availability of strong information processors will aid integrative approaches to extremely complicated problems, such as desertification. [5] Meanwhile, a disequilibrium coming from the presence of nanotechnology in the middle of ignorance could lead to universal primary education. Poverty, health, and access to clean water can all be alleviated if more people are educated about these issues. We should focus on population and living standards (as measured by per-capita consumption of goods and services). There appears to be no organic way to overcome these difficulties; we do not have a superior power that could force us to use nanotechnology (even if that were sufficient to meet the challenges). [6] With the spread of nanotechnology, the aim is that everyone will take an active role in preserving our species' long-term survival by feeling a personal connection to the planet's future and taking action to help make a difference.

The "invisible hand" of Adam Smith's "common good" is embodied in this system, which allows everyone to do what is in their own best interest. [7]

Although it is theoretically possible to make nanoparticles from almost any chemical, the vast majority of nanoparticles now in use have been synthesised from transition metals (such as copper and nickel), silicon, carbon (carbon black, carbon nanotubes, and fullerenes), and metal oxides. Nanoparticles including carbon nanotubes, fullerenes, and quantum dots have only been discovered in the past two decades. [8] The development of nanomaterials is fast progressing, and the number of "makes" is expanding at a remarkable rate. The following is a short list of commercially viable man-made nanoparticles:

Type	Examples for use
Metal oxides	
• Silica (Si_{O2})	• Additives for polymer composites
• Titania (TiO_2)	• UV-A protection
• Aluminia (AL_2O_3)	• Solar cells
• Iron oxide (Fe_3O_4, FE_3O_3)	• Pharmacy/medicine
• Zirconia (ZrO_2)	• Additives for scratch resistance coatings
• Zinc dioxide (ZNO_2)	
Fullerenes	
• C_{60}	• Mechanical and trbological applications / additives to grease
Carbon Nanotubes	
• Single-wall carbon nanotubes	• Additives for polymer composites (mechanical performance, conductivity)
• Multiwall carbon nanotubes	• Electronic field emittes • Batteries • Fuel cells
Compound Semiconductors	
• CdTe	• Electronic an optical devise
• GaAs	
Organic Nanoparticles	• Micronised drugs and chemicals (Vitamins, pigments, pharmaceuticals) • Polymer dispersions
Metals	
• Au • Ag • Ni	• Catalytic applications • Optoelectronics • Wound dressings

Table 5.1: Manufactured Nanoparticles That Are of Commercial Interest

5.4 Review of Literature:

Nanotechnology advancements have resulted in the development or upgrading of smart materials that have a wide range of societal benefits. The last few years have seen the development of numerous engineered nanomaterials (ENMs) that may be found in a variety of connected fields such as health and food products, household goods, automobiles, electronics, and computers (Hansen et al., 2016)[9].

By enhancing catalysis and decreasing friction, nanotechnology is reducing fuel consumption in automobiles and power plants while simultaneously increasing the efficiency of fuel production from ordinary and low-grade crude petroleum materials (Low et al., 2015)[10]. Cellulose can be converted into fuel from wood chips, corn stalks (not just the kernels), and unfertilized perennial grasses using nano-bioengineering of enzymes (Chaturvedi and Dave, 2014). [11]

Nanotechnology is being used to stimulate the formation of nerve cells, for example, in the spinal cord or the brain. Filling the space between cells with a nanostructured gel can help stimulate the growth of new cells. There is preliminary research on this in hamster optical nerves. The use of Nano fibres to restore injured spinal nerves in mice is another way now being investigated (Qazi et al., 2015[12], Ahmadi and Ahmadi, 2013[13]; Parpura and Verkhratsky, 2013[14]; Zhan et al., 2013[15]; Ehrhardt and Frommer, 2012[16]; Jain, 2012[17]; Nunes et al., 2012[18])

A wide range of typical environmental toxins, such as chlorinated organic solvents, organochlorine insecticides, and PCBs, can be effectively transformed and detoxified using nanoscale iron particles according to Zhang's findings (Rickerby and Morrison, 2007)[19]. Fast in situ responses with TCE decrease up to 99 % have been seen following the injection of nanoparticles into the soil and water, which are highly reactive towards pollutants. Nanoparticles such as TiO_2 and ZnO, carbon nanotubes, magnetic nanoparticles, and amphiphilic polyurethane nanoparticles have all been proved by numerous researchers to be effective in the remediation and treatment of contaminated water, soil, or air.

5.5 Objectives:

- To study nanotecnology development
- To study nanotecnology impact in society
- To study various uses of nanotechnology in nanomedicine
- To study some manufactured nanoparticles

5.6 Research Methodology:

Research design is the design selected for this research study was qualitative in nature using interviews, observations, and documents. Qualitative research provides an understanding of a situation or phenomenon that tells the story rather than determining cause and effect. Literature review constitutes a significant portion of research work. In order to identify and fill out the research gaps, it is important that the preceding studies and research in the associated areas of the issue be briefly referred to. The literature pertinent to the research topic and the environment have been thoroughly examined. The secondary data are based on the study.The required data were collected from various sources

5.7 Result and Discussion:

When it comes to detecting, treating and preventing disease as well as severe injury and pain, "Nanomedicine" is the topic of study. It uses nanoscale structured materials and biotechnology and genetic engineering as well as complex machine systems and nonorobots to achieve these goals. [20] It was thought to encompass five key subdisciplines, several of which overlap due to similar technical challenges (see Figure. 5.1 below).

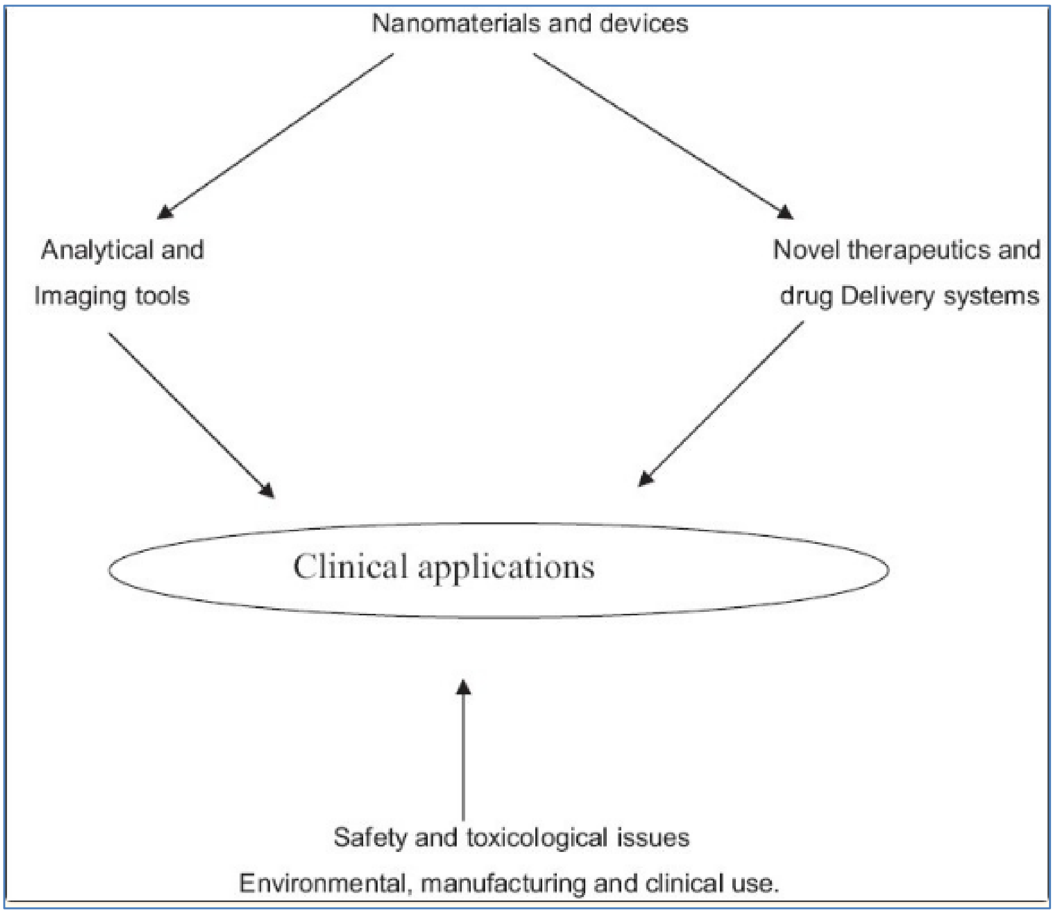

Figure 5.1: Dimensions in Nanomedicine

A subset of the nanosciences known as nanomedicine focuses on the diagnosis of disease using a narrow set of diagnostic criteria. As agents or biomarkers, nanoparticles are used in the therapy [21]. Figure 5.2 depicts the different medicinal applications of nanotechnology [22]. To simplify the many health variables and diseases while minimizing damage to normal tissues, highly effective pharmacological carriers are necessary.

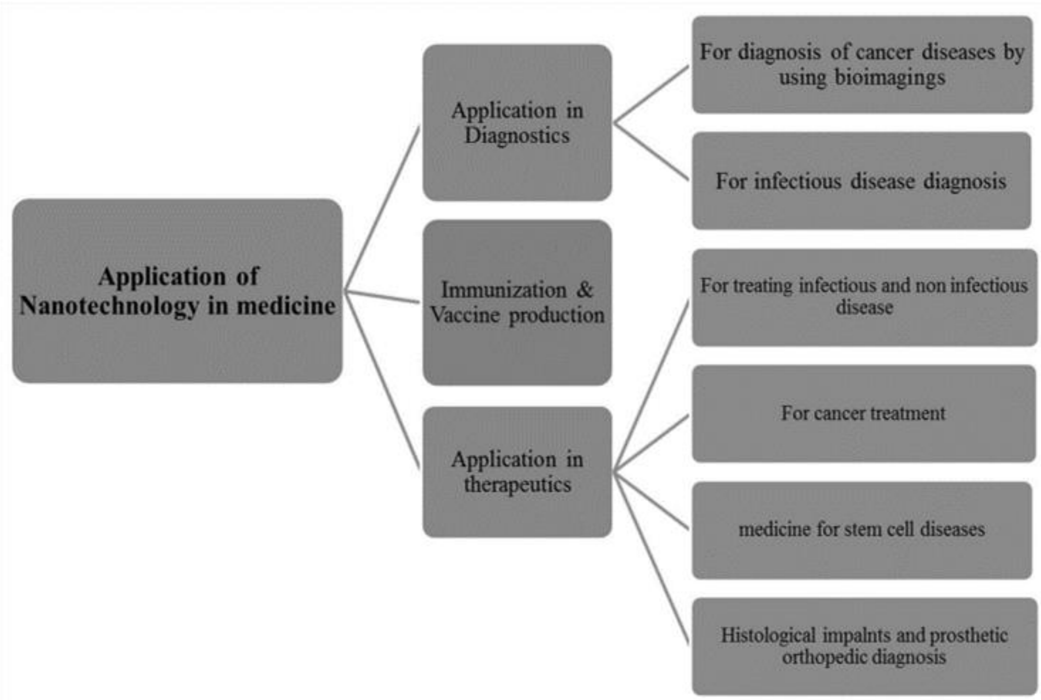

Figure 5.2: Application of nanotechnology in medical science

Table 5.2: lists a summary of present and future impacts of nanotechnology

Nanotechnology area	Present Impact	Future Impact
Dispersions and Coatings	- Thermal barriers - Optical barriers - Image enhancement - Ink-jet materials - Coated abrasive slurries - Information-recording layers	- Target drug delivery/gene therapy multifunctional nanocoatings
High Surface Area Materials	- Molecular sieves - Drug delivery - Tailored catalysts - Absorption/desorption materials	- Molecule specific sensors - Large hydrocarbon or bacterial filters - Energy storage - Gratzel-type solar cells
Consolidated Materials	-Low-loss soft magnetic materials - High hardness, tough WC/Co cutting tools -Nanocomposite cements	- Superplastic forming of ceramics - Ultrahigh-strength, tough structural materials - Magnetic refringements -Nanofilled polymer composites - Ductile cements

Nanodevices	- GMR read heads	- Terabit memory and microprocessing -Single molecule DNA sizing and sequencing -Biomedical sensors - Low noise, low threshold lasers Nanotubes for high brightness displays
Biological	- Biocatalysis	- Bioelectronics - Bioinspired prostheses - Single-molecule-sensitive biosensors -Designer molecules

Table 5.2 Present and Future Impact of Nanotechnology Area Nanotubes, nanomaterials, nanoelectronics, nanomanipulation, nanomedicine, and nanorobots will have a significant impact on society, according to a large majority of respondents (91%-96%) Disagreement between the participants was minimal (4%-10%) [22]

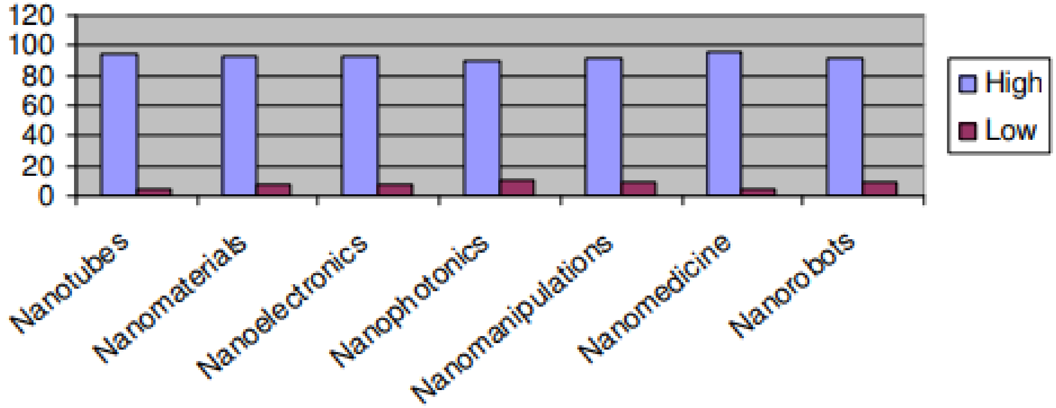

Figure 5.3: Impact of nanotechnologies on society

5.8 Conclusion:

Humans must be ready to embrace the possibilities of nanotechnology. We need to be ready to put what we've learned to good use. With so many complicated interactions occurring at such a microscopic level, we need to be prepared to govern nanotechnology. The impact of nanotechnology on dentistry, health care, and everyday life will be greater than that of previous technological advances. Nanotechnology, like other technologies, has the potential to be misused and abused on a size and scope that has never before been possible. It is also possible that they can lead to important benefits such as greater health, better use of resources and less environmental damage. These are definitely the days of awe and miraculous.

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6. A Grid Connected Inverter Topology for Solar PV System Based Renewable Energy Systems with Maximum Power Point Tracking

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Abstract:

There has been a generous increase of photovoltaic (PV) power generators installations in recent years, due to the brilliant efficiency of solar cells as well as the continuous improvements of manufacturing technology of solar panels. These generators are used in both grid-connected and stand-alone types of applications.

This inverter topology is focussed on the grid connected solar PV power generators based renewable energy system. The proposed model of grid connected solar PV system employing P& O MPPT technique with battery back -up system is implemented. The proposed topology is analysed and obtained results in simulation has been verified. In this topology the simulation of renewable energy systems is carried out under different solar radiations and load conditions.

Keywords:

Maximum power point tracking (MPPT), Solar photovoltaic, Perturb and observe (P&O), Converter.

6.1 Introduction:

Solar Photovoltaic is a technology that changes solar radiation into direct current electricity with the help of semiconductors. When the sun radiations falls on the semiconductor within the PV cell, electrons are excited as they leave their bond , light generated holes will move towards and light generated electrons will rush towards and a potential difference will create which ultimately form an electric current which is meant to the quench the needs of load (Grid in our case) .

Solar PV expertise is by and large employed on a panel. PV cells are typically found to be connected to each other and attached on a frame called a module. Then the multiple modules can be wired together to form an array, which can be increased or decreased in number to produce the amount of power required.

PV cells are generally found to be connected to every different and connected on a frame known as a module. Then the multiple modules is wired along to create Associate in Nursing array, which may be increased or attenuated in range to provide the number of power needed.

PV cells is made up of numerous semi-conductor materials. The best typically used material nowadays is silicon however except that different elements are being brought in to use to extend the capability of changing daylight to electricity.

- Crystalline element
- Mono-crystalline element
- Metallic element compound (Cd Te)
- Amorphous element
- Copper atomic number 49 metallic element Selenide (CIGS)

More or less ninety fifth of the world's PV know how, today, are based on some similarity of element. In 2011, more or less ninety-seven of all consignments by U.S. makers to the residential sector were crystalline element solar panels. Each form of material has completely different attributes, leading to completely different applications and efficiencies. At large, the potency of Solar PV technologies varies, move between 6-18% at the instant.

6.2 Types of Solar PV (Photovoltaic) Systems:

6.2.1 PV (Photovoltaic) Direct System:

These unit referred to as the foremost modest of Solar PV systems, with the fewest components: the load and therefore the Solar Panels. As a result of they are not connected to the grid and that they don't have batteries, conjointly they solely provide power to the masses once the sun is all radiating. They are appropriate for a few applications e.g. attic ventilation fan or water pumping.

6.2.2 Stand Alone System:

Stand Alone system is additionally named as Off-Grid System; it's aimed in such the way that it's independent of the ability grid. Batteries are bring into use to store energy when the sun rays do not seem to be available during cloudy days or in the dark. This sort of system would require consistent care to terminal corrosion and battery electrolyte levels. The characteristics of this technique are:

- It does not depend on the utility grid
- It helps in avoiding blackouts.

- It largely boosts energy efficiency
- Batteries have limited life and require maintenance
- More complexity because of more components
- System efficiency decreases due to batteries
- Compared to a grid-direct system, it is more expensive
- Potential power from the PV array is not utilized when the batteries are fully charged
- Back-up electricity is required to run load when the PV system fails
- For non-sunny days most off-grid systems use a backup generator.
- They are expensive, dirty and noisy.
- They also require regular maintenance and fuel.

6.2.3 Grid-Tied System:

Grid-Tied System is the extensively used PV systems. They are also known as on-grid, grid-intertie, grid-tied or grid-direct systems. They generate solar electricity and route it to the grid and to the loads, offsetting some of the electricity usages.

The system components are comprised of the PV inverter and array. The grid-connected system is quite similar to the regular electric powered system with the exception that some or all of the electricity comes from the sun.

This is the major drawback here that they do not have battery for outage protection. So, these systems fails to operate when there is some issues in the utility. The characteristics of Grid-Tied System are:

- As the system does not have to power all of the home's loads design flexibility Increases
- It is less expensive when we talk about standalone system.
- Smallest amount of maintenance is required
- It has a higher efficiency because batteries are not part of the Grid-direct systems
- Higher voltage leads to smaller wire size
- When the grid goes down, there is no power to the home
- There is a provision of sending the excess electricity generated by Solar PV modules to the grid also, thus helping you to save your money on electricity bills also.

6.2.4 Grid-Tied with Battery-Backup System:

In terms of components and style, this sort of system is extremely kind of like an off-grid system but adds the utility grid, which successively reduces the requirement for the system to produce all the energy in any respect times. The characteristics of grid-tied- with-battery-backup are: The characteristics of grid-tied-with-battery-backup are:

- When the grid goes down, designated loads have power.
- If the system produces more than the home requires, then the extra energy produced is sold back to the utility- it is not lost after the batteries get full on a sunny day as in the case of a stand-alone systems
- Maintenance is required for the batteries

- Rewiring circuits from main service panel to a separate subpanel is required
- Because of the efficiency losses of the batteries system performance decreases
- Compared to a grid-direct system, it is more expensive
- It typically only provides modest backup – generally, not all of the loads are backed up

Photovoltaic systems are designed to deliver AC and/or DC power service. They can be operated as interconnected with or independent of the utility grid, and can be connected with other energy sources and energy storage systems.

6.3 Proposed Scheme for Grid Connected Solar PV System Employing P&O MPPT Technique With Battery Backup System:

- A Simulink model is formed based on the Grid connected PV system.
- Following steps were taken to ensure a fully simulated model is formed

6.3.1 Solar Panel:

- A PV Panel comprised of comprised of 30 solar cells connected in series and rated power 40W is formed .
- 6 PV Panels are connected in parallel configuration , so as to get increased current value in the system .

6.3.2 MPPT Charge Controller:

An MPPT which goes as Maximum Power Point Tracking is a charge controller which helps in improving the connection between solar panels and battery or the utility grid (13 bus system in our case). The maximum power point is the ideal point on an I-V curve where current and voltage multiply to provide the maximum power that the given PV system can produce at a given moment with great efficiency MPPT charge controllers are DC to DC converters that take the voltage output from solar panels and convert them to a more suitable voltage to charge a battery bank.

To implement charge controllers, in this paper designed an algorithm in Simulink based on the working .

6.3.3 Perturb & Observe Algorithm:

Perturb & Observe is that the simplest of all method MPPT method. During this it is taken into the account only 1 sensor which is that the voltage sensor which aids in sensing the PV array voltage therefore the implementation cost is a smaller amount and hence easy to implement. The time difficulty of this algorithm is extremely less but on reaching very near the MPP, it does not stop at the MPP and keeps on going on both the directions.

When this happens, the algorithm reaches very near the MPP and that we can set an appropriate error limit or can use a wait function which winds up increasing the time complexity of the algorithm.

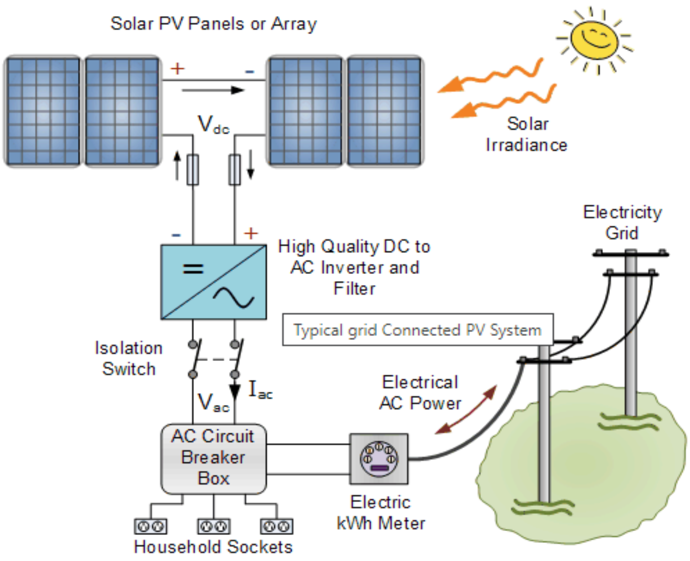


Figure 6.1: model of a grid connected solar PV system

However, the strategy does not realise of the rapid change of irradiation level (due to which MPPT changes) and considers it as a change in MPP because of perturbation and winds up calculating the incorrect Perturbing the duty ratio of dc-dc boost converter which is also known as step up converter perturbs the PV array current and consequently perturbs the PV array voltage so that we can bring into the account maximum efficiency of PV array. To configure the power at various duty cycles and to compare it with the power of the current operating point, the MPPT subsystem is used. The duty cycle either increases or decreases or remains the sam

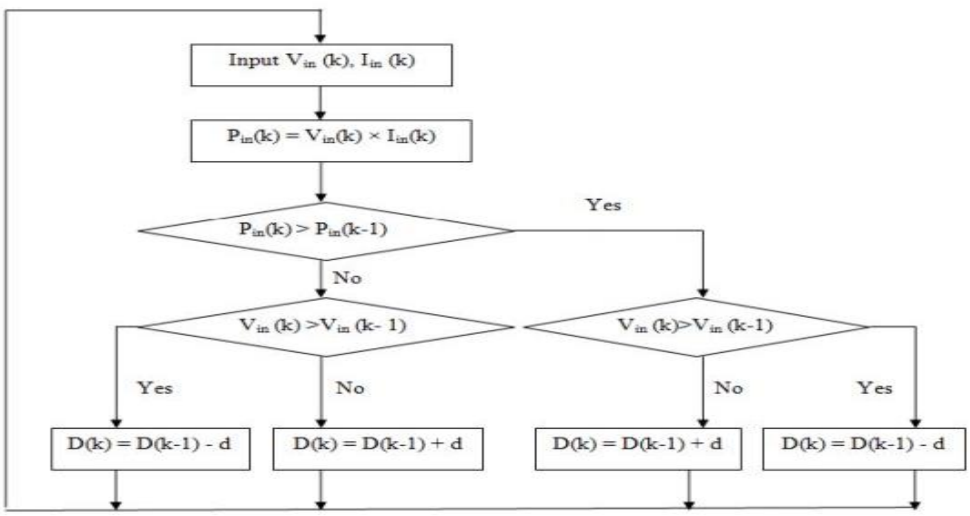


Figure 6.2: Algorithm for perturb and observe method of MPPT for grid tied PV system Converters

DC-DC converters are used to step up the voltage coming from PV array

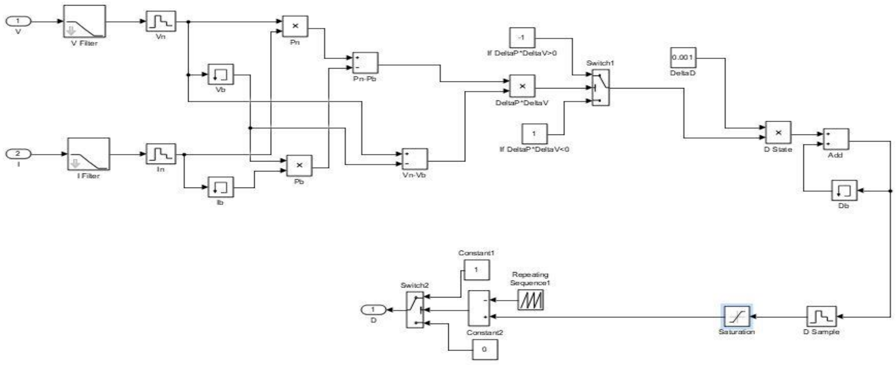


Figure 6.3: Simulink model of a grid tied PV system

6.3.4 Mode 1 Operation of the Boost Converter:

When the switch is closed, the inductor charges and stores the energy.

In this mode inductor current rises on an upward trend but for easiness we assume that the charging and the discharging of the inductor are linear.

The diode blocks the current that is flowing in the circuit and so the load current remains constant which is due to the discharging of the capacitor.

6.3.5 Mode 2 Operation of the Boost Converter:

It is the mode 2 which is of prime significance to us.

In mode 2 the switch is open which short circuits the diode. The energy stored in the inductor from mode 1 operations gets discharged through opposite polarities which charges the capacitor.

The load current remains constant throughout the operation but the voltage increases in this case.

6.4 Proposed Model of Grid Connected Inverter Topology for Solar PV System Based Renewable Energy Systems with Maximum Power Point Tracking:

The output of MPPT algorithm is fed to gate of MOSFET which accordingly adjusts the duty ratio of the converter.

It is ON/OFF time of the converter which helps in delivering stepped up DC voltage to be fed to the inverter

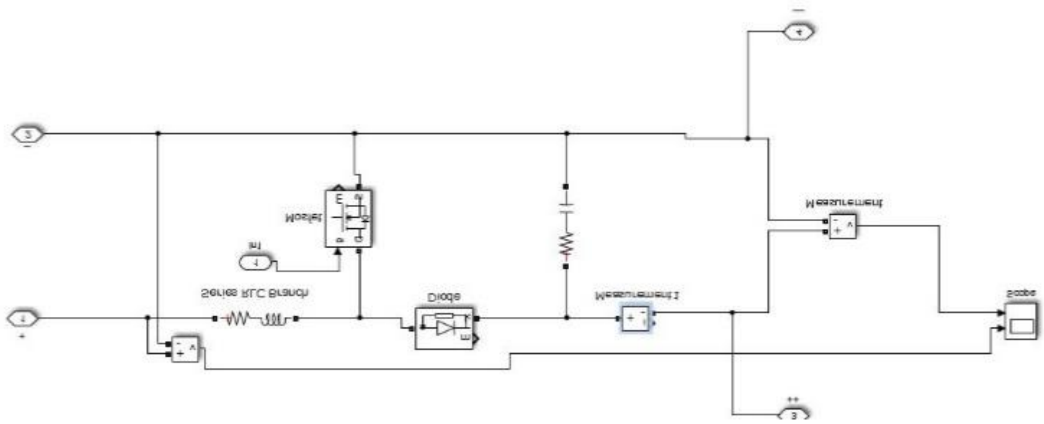


Figure 6.4: Model of grid connected inverter topology for solar PV system based renewable energy systems with maximum power point tracking

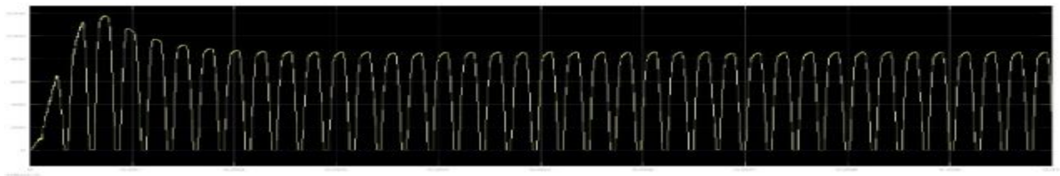


Figure 6.5: Simulation results of the proposed converter topology for solar PV system

6.4.1 Solar PV With Battery With PWM Charge Controller:

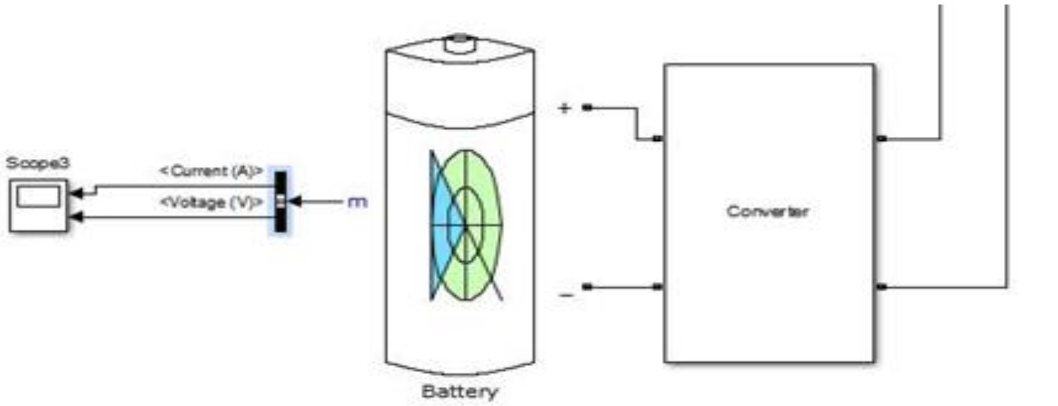
PWM charge controllers are the customary type of charge controller available to solar customers.

They are very much simple than MPPT controllers, and thus generally less expensive.

PWM controllers work by slowly decreasing the amount of power going into supply a small amount of power constantly to keep the battery charged up.

With a PWM controller, a solar panel system and a battery used must have a necessary condition of matching voltages.

A. Proposed Model of Battery Along With DC-DC Converter With PWM Controller:



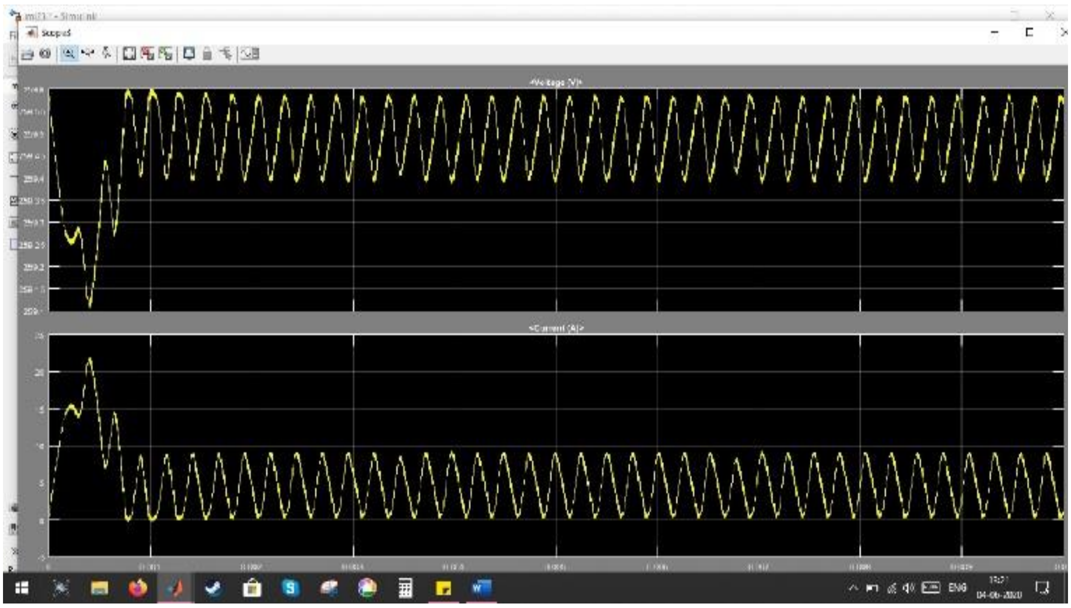


Figure 6.6: Output waveforms of Battery along with DC-DC converter with PWM controller

B. Proposed Model of Grid Connected Inverter Topology:

As Solar PV module generated DC power, Grid-tie inverters plays an important role in transforming DC electrical power into AC power suitable for adding into the electric utility company grid. The grid tie inverter must be equal to the phase of the grid and maintain the output voltage marginally upper than the grid voltage at any instant. A Best-quality modern grid-tie inverter has a fixed power factor which is 1, therefore it means that its output voltage and current are perfectly ordered, and its phase angle is contained by 1 degree of the AC power grid. Grid connected inverters are designed to quickly disengage from the grid if the utility grid goes down.

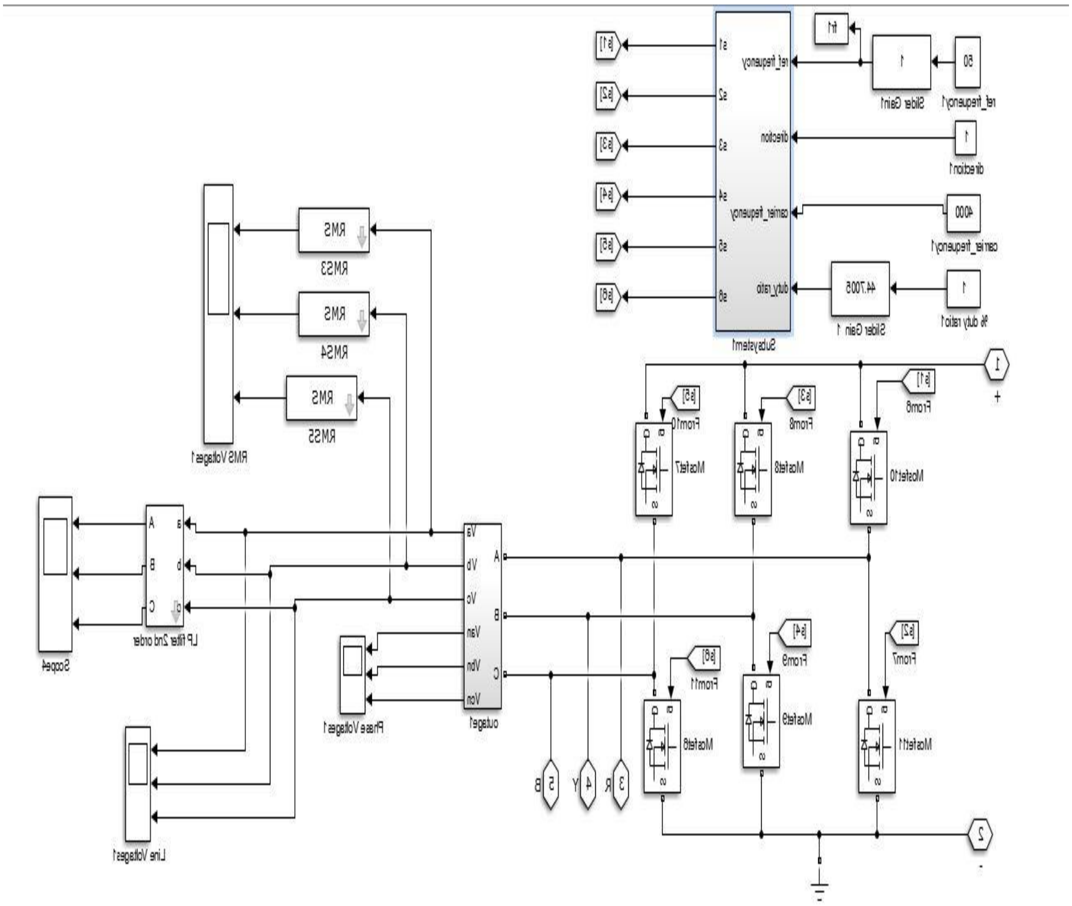
Here 120 degree PWM VSI inverter as

- We need to kept output voltage independent of load.
- It offers good dynamic performances due to lack of an inductor in dc link
- It has higher efficiency as semiconductor used has low switching time.

C. Bus System:

The Bus system is a type of distribution test grids which is very useful and commonly applied tools in power system research. It helps to ensures that the research results can be easily tested and compared with the results of other studies. They are built with the purpose of allowing testing of various algorithms like MPPT in our case on three-phase grids. Hence, they have all necessary constraints clearly given, as well as the schematics and instructions for modelling of each part of the grid, which helps them in much faster computation and more reliable simulation results.

The IEEE certified 13 bus system distribution test grids as our grid to complete our proposed topology grid connected PV system.



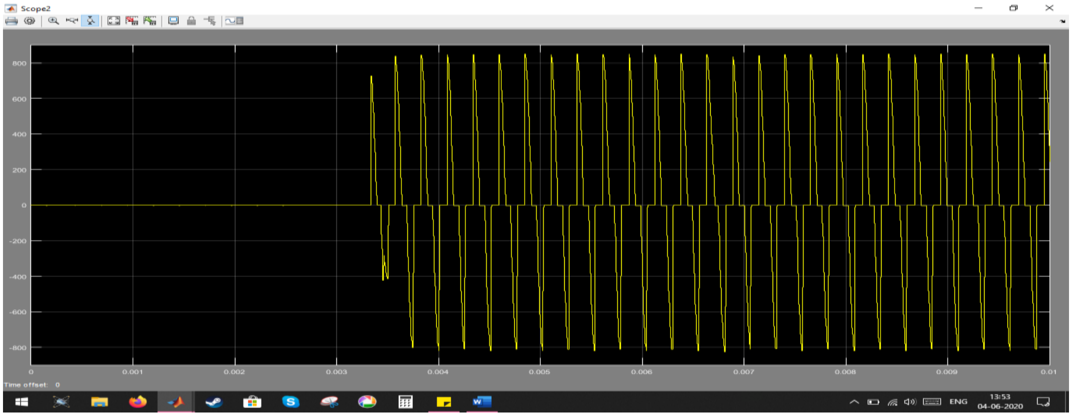


Figure 6.7: Voltage b/w R and B phase

Ours is a synthetic test grid. Although this grid is quite small but it has very interesting characteristics to garner results that are required.

This system was planned to evaluate and target algorithms in solving unbalanced three phase radial systems. System consists of 13 buses which are interconnected with 10 overhead lines, one generation unit, one voltage regulator unit, one transformer ΔY, one in-line transformer YY, two shunt capacitor banks, unbalanced spot, shunt capacitor bank and unbalanced spot in the bus system and distributed loads.

6.5 Application of Proposed Grid-Connected Systems with the Help of Metering and Rate Arrangements:

By means of a grid-connected system, when your renewable energy system generates more electricity than you can use at that moment, the electricity can be fed to the electric grid for your utility to use elsewhere.

There is a public Utility Regulatory Policy Act of 1978 requires power providers to purchase excess power generated by Solar PV modules at that rate at which they are producing at their power plant. Power providers generally implement this requirement through various metering arrangements. Here are the metering arrangements which is followed everywhere.

6.5.1 Net Purchase and Sale:

In this arrangement, two unidirectional meters are installed: one accounts electricity taken from the grid, and the other registers excess electricity generated and fed back into the grid. You pay retail rate for the electricity you employ, and therefore the power supplier purchases your excess generation at its avoided value (wholesale rate).

There could also be a big distinction between the retail rate you pay and therefore the power provider's avoided value.

6.5.2 Net Metering:

Net metering provides the best profit to the operator.

In this arrangement, a single, bi-directional meter is employed to record each electricity unit you draw from the grid and therefore the excess electricity your system feeds back to the grid.

The meter spins forward as you draw electricity, and it spins backward because the excess is fed into the grid.

If, at the top of the month, you've used a lot of electricity than your system has created, you pay retail worth for that further electricity.

If you have got created quite you have got used, the facility supplier typically pays you for the additional electricity at its avoided price.

The most important good thing about net metering is that the electricity supplier primarily pays you retail worth for the electricity you feed back to the grid.

Some power providers will now let you carry over the balance of any net extra electricity your system generates from month to month, which can be an advantage if the resource you are using to generate your electricity is seasonal. If, at the end of the year, you have produced more than you've used, you forfeit the excess generation to the power provider.

6.6 Conclusion:

In this paper, a new design of Grid connected power generation systems with MPPT charge controllers employed for maximum utilisation of PV arrays is discussed. This was followed by a modelling a Grid connected system along with developing Perturb and oscillation based MPPT Charge controller for comprehensive reporting of results. This design is implemented to analyse Grid connected renewable energy systems that include PV array–inverter assemblies. Solar PV system based renewable energy system is implemented to observe applications and cost-effective performance of renewable energy systems, analyse both static and dynamic performance, develop control strategies, and simulate autonomous renewable energy systems under different generation and load conditions (such as different solar radiations, and load profiles like use of IEEE certified 13 bus system).

The MPPT algorithm formed is of prime significance as it holds the great role in enhanced power generation by controlling duty ratio of step up chopper (buck boost converter). It is apparent that the PV array assembly along with MPPT charge controller has the ability to balance the energy, and supply good power quality to the grid. The proposed topology allowed to operate solar PV system based renewable energy systems with maximum power point tracking and also the topology hold good for grid-tied mode of operation. The proposed topology has been implemented in Matlab / Simulink. The simulation results proves the feasibility of proposed topology in grid connected mode operation of solar PV generation.

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7. Modelling, Implementation and Performance Analysis of a Grid-Connected PV/Wind Hybrid Power System

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Abstract:

This paper investigates dynamic modelling, design and control strategy of a grid-connected photovoltaic (PV)/wind hybrid power system with the help of the artificial neural network (ANN) controller. The hybrid power system consists of PV system and wind farm that are connected through main AC-bus to enhance the system performance and the combination of PV and wind system with the grid makes the system hybrid. The Maximum Power Point Tracking (MPPT) technique is applied to both PV system and wind farm to extract the maximum power from hybrid power system during variations in the environment conditions. The hybrid power system operates at unity power factor (P.F.) since the injected current to the electrical grid is in phase with the grid voltage. In addition, the control strategy successfully maintains the grid voltage and DC link voltage constant throughout the simulation irrespective of the variations. The main objective of this paper is to propose a new algorithm that is based on artificial neural network (ANN) and maximum power point tracking (MPPT), which was simulated in a MATLAB. The development of an advanced ANN controller that improves the power quality and reduces THD values.

Keywords:

Photovoltaic, Artificial neural network, Maximum power point tracking, Power factor, Total harmonic distortion.

7.1 Introduction:

Nowadays, the critical issue within the entire world is to satisfy the permanent growth of the energy demand. Moreover, the rapid depletion and therefore the exhaustible nature of the traditional power sources, has necessitated imperative researches for the renewable energy sources as alternative sources of energy.

Among the renewable sources of energy, photovoltaic energy and wind energy have attracted great attention and may be considered because the most promising power technologies to supply electricity. Renewable energy sources are found to be promising energy sources toward building a sustainable and environment friendly energy economy within the next decade [1]. Among these renewable energy sources, solar and wind energy which are two of the foremost promising renewable power generation technologies. The expansion of PV and wind generation systems has exceeded the foremost optimistic estimation.

However, geographic and seasonal climate affect the solar-wind energy output. Therefore, the combination of both i.e., hybrid system is more reliable and efficient as compared to other systems.

The proposed system is designed using the controller which is ANN i.e., artificial neural networks. With the assistance of this controller the system's effectiveness is increased as compared to other controllers like PI and fuzzy logic controllers because it works automatically, there's no need to tune this controller manually.

Distributed generation (DG) technology also referred to as dispersed generation technology is electricity generating plant connected to a distribution grid instead of the transmission network. There are many sorts and sizes of DG facilities. These include wind farms, solar photovoltaic (PV) systems, hydroelectric power, or one among the new smaller generation technologies.

The DG concept emerged as how to integrate different power plants, increasing the DG owner's reliability and security, providing additional power quality benefits of the facility grid [2], [3], and in addition, the value of the distribution power generation system using the renewable energies is on a falling trend and is predicted to fall further as demand and production increase [4].

Different implementation techniques like *dq*, stationary, and natural frame control structures were presented, and their major characteristics were pointed out [5].

The proposed system is based on Double fed Induction Generator (DFIG). In the present scenario DFIG is commonly used in the hybrid system because it is simple in construction, flow of active & reactive power is controlled and also the important ability to extract the maximum power from wind turbines [6].

This hybrid system consists of PV system of 1MW rating and a wind farm of 9MW rating that are integrated through main AC – bus to inject the generated power and to improve the system performance.

7.2 PV/ Wind Hybrid System:

The developed system of the PV/ wind is shown in the Figure 1.1 The hybrid system consists of PV system of rating 1MW and the wind farm having 9MW rating are connected through main PCC- bus i.e., point of common coupling in order to inject the generated power and to enhance the system's performance.

The PV system consists of modules which are connected in parallel and series combinations so that desired power capacity can be achieved.

In addition, with this, DC/DC boost converter is used to step up the array output voltage and then with the help of three level inverter this DC power is converted to AC power. The PV station is interconnected with the PCC – bus through 260V/ 25 KV Δ/Y transformer.

Similarly, the wind farm is considered to contain one equivalent aggregated DFIG that is driven by a largeaggregated wind turbine. In the wind farm grid side converter (GSC) and rotor side converter (RSC) are very important as they maintain DC- bus voltage constant and extracting the maximum power from the wind turbines.

Here also MPPT technique is used to capture the maximum power from the wind farm during variations in the wind speed. In addition,the wind farm is interconnected with the PCC-bus through 575V/25 KV Δ/Y transformer.

The hybrid power system is controlled in such a way that it operates at a unity power factor and the system is connected to the electrical grid through 30 km transmission 110 KV/20 KV Y/Δ transformer.

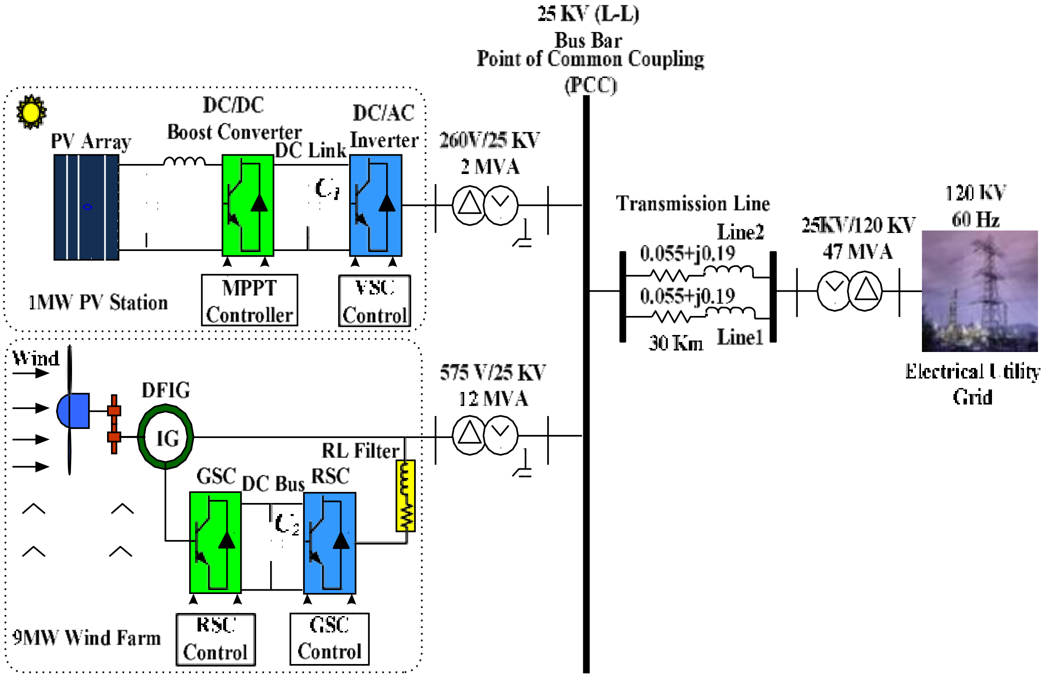

Figure 7.1: Hybrid system of PV/ wind farm (1MW PV system & 9MW Wind system)

7.3 Control Strategy:

The control algorithm used here is based on the MPPT control, voltage and current control and rotor side control, grid side control in the case of wind farm is used respectively.

7.3.1 Maximum Power Point Technique:

The maximum power point tracking techniques are very essential in the photovoltaic systems and also in hybrid systems. Since the intensity of solar irradiation varies with time, the MPPT technique is employed to extract the maximum output power from PV array.

The main objective of the MPPT technique is to regulate the boost converter so that PV array operates at the maximum power point. Due to its simplicity and having the advantage of offering good performance under variations of the solar irradiance.

The incremental conductance strategy depends on the fact that the slope of the P-V curve is equal to 0 at the MPP [8].

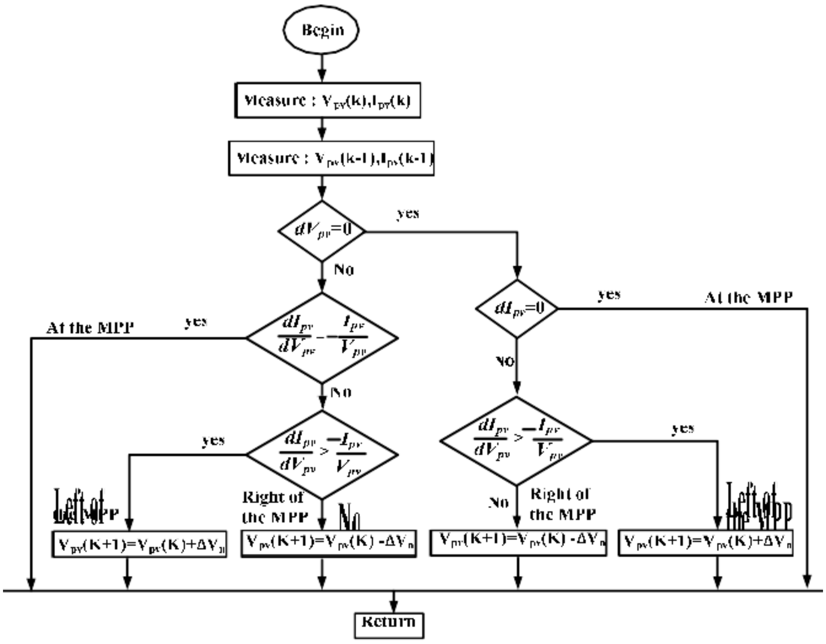

Figure 7.2: Flow chart of Incremental conductance.

7.3.2 Photovoltaic System:

The photovoltaic system contains many PV modules which are connected in series and parallel combinations. To attain the desired voltage levels the PV modules are connected in series.

Similarly for the power capacity these modules are connected in parallel combinations. Each PV array is connected to the DC/DC boost converter to extract the maximum power under variationof the solar irradiation.

Then, the PV arrays are connected in parallel to the main DC/AC inverter to control the injected active power to the electrical grid and achieve the demanded reactive power. This configuration has many advantages such as constant DC-link voltage, low losses, higher efficiency, andcost-effective [7].

The electrical modelling of PV array has been introduced based on the Shockey diode as shown in **Figure** 7.3.

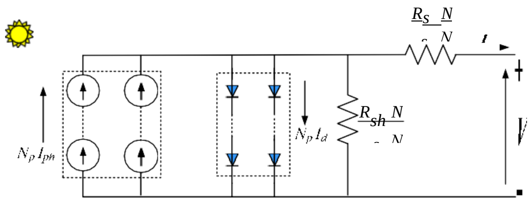

Figure 7.3: Electrical circuit of PV array

7.3.3 DC Voltage Controller:

The DC link voltage controller is responsible for regulation voltage at constant specified value. The reference DC-link voltage (VdC1-ref) is compared with an actual value (VdC1) and the error is applied to PI-controller to regulate the DC-link voltage at 500 V.

The output of this controller is used as direct- axis of reference current (Id ref) for the inner current controller.

7.3.4 Current Controller:

The main objective of current controller is to control d- axis of inverter current (I_d) to regulate the DC- link voltage and also the q- axis of inverter current (I_q) to control the injected power independently.

The current controller employs independently the d- axis of reference current generated from DC –link voltage controller to regulate the DC – link voltage and the q-axis reference current is imposed to zero for maintaining the unity power factor [9].

Since, the grid voltage of the d-axis is aligned with the grid- voltage vector, thus the q-axis of grid voltage is set to zero (V_q=0). Therefore, the active power (P) and reactive power (Q) can be controlled independently by I_d and I_q respectively.

7.3.5 Wind Turbine Model:

The wind turbines can be modelled as aerodynamic input torque which drives the DFIG. Figure 1.4 demonstrates power characteristic curve for wind turbine at different wind velocities [10]. The extracted mechanical power (Pm) from wind turbine can be expressed as follows-

$$P_m = ½ A_t C_p(\lambda, \beta)V_w^3 \qquad (1)$$

The performance coefficient of the wind turbine (Cp) depends upon the blade aerodynamics and represents the efficiency of the wind turbine.

The performance coefficient (Cp) can be described as follows:

$C_p(\lambda, \beta) = 0.5176(^{116/}\lambda_i - 0.4\beta - 5)\, e^{(-21/}\lambda_i) + 0.0068\,\lambda$ (2)

$1/\lambda_i = 1/\lambda + 0.008\,\beta - 0.0035/\beta^3 + 1$ (3)

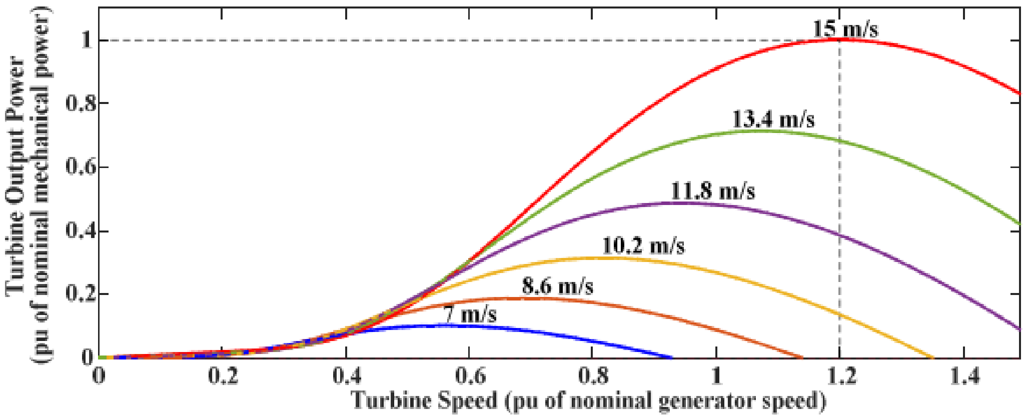

Figure 7.4: Power characteristic curve of Wind Turbine.

7.3.6 Rotor Side Converter Control:

The main objective of RSC is to capture the maximum power from a wind turbine and control the injected reactive power by the DFIG to keep the stator at unity power factor [11].

The stator flux-oriented control (SFOC) strategy has been utilized to achieve the controller system, with stator flux (λ_S) oriented along synchronously rotating d-axis (λ_S=λ_{ds}) thus, λ_{qs}=0.

Therefore, the d-q axis components of stator currents and voltages can be expressed as follows-

$I_{qs} = -(L_m/L_s)\, i_{qr}$ (4)

$I_{ds} = (1/L_s)\,\lambda\, d_s - (L_m/L_s)\, i_{dr}$ (5)

$V_{ds} \approx 0$ and $V_{qs} \approx \omega_e \lambda\, d_s$ (6)

The d-q axis components of reference rotor voltage in the synchronous reference frame can be expressed as follows:

$V_{dr}^{*} = (V_{dr})' - (\omega_{slip})\, \sigma L_r i_{qr}$ (7)

$V_{qr}^{*} = (V_{qr})' + (\omega_{slip})\, ((L^2_m/L_s) i_{ms} + \sigma L_r i_{dr})$ (8)

The q-axis component is used to extract the maximum power from wind turbine under variation of the wind speed. Thus, the q-axis of reference rotor current (iqr*) is created from the MPPT controller.

This signal is compared with the q-axis of measured rotor current (iqr) and the difference is applied to the current regulator to generate the q-axis of reference rotor voltage (Vqr*). The d-axis of reference rotor current (idr*) is generated from reactive power control loop.

The reference reactive power (Qs *) is set to zero to keep the stator of DFIG at unity power factor [12]. Then, the d-axis of reference rotor current (idr*) is compared with the d-axis of measured rotor current (idr) and the error is passed through the current regulator to generate the d-axis of reference rotor voltage (V_{dr}^{*}).

7.3.7 Grid Side Converter Control:

The main objective of GSC is to maintain the DC-bus voltage constant and control the exchanged reactive power with the electrical grid. The d-q axis components for GSC voltage in synchronous reference frame can be expressed as follows:

$$V_d = V_d1 + Ri_d - \omega_e L i_q + L di_d/dt \quad (9)$$

$$V_q = Ri_q + L di_q/dt + \omega_e L i_q + V_q1 \quad (10)$$

The d-axis current component (id) is used to keep the DC-bus voltage constant, while the q-axis current component (iq) is used to regulate exchanged reactive power with the electrical grid.

Now, the difference d- axis of reference grid current and d- axis of measured grid current is passed through the current regulator to create the d-axis reference grid side voltage. And, on the other hand the q-axis of reference grid current is set to zero so that the DFIG can operate unity power factor [13].

7.3.8 MPPT Technique for Wind:

In this designed system, an improved MPPT technique is used for the maximum power from a wind turbine is extracted at the optimum rotational speed of the rotor (ωref). Hence, when the wind speed varies the MPPT strategy calculates this optimum rotational speed to extract maximum power from a wind turbine. In this paper, modified MPPT control strategy has been proposed based on measurement of mechanical power (Pm-pu) to determine the optimum rotational speed (ωref) [14]. The flow chart of the proposed MPPT strategy is depicted in **Figure 7.5**. The MPPT control technique can be discussed as follows:

- Firstly, the MPPT technique put initial values for mechanical power (Pm-pu) and optimum rotational speed (cref).
- Then, the MPPT technique calculates the actual mechanical power to calculate optimum rotational speed (cref).

- When the mechanical power (Pm-pu) is greater than 0.75 p.u., the optimum rotational speed is normally 1.2 p.u. that corresponding to maximum power from wind farm (9 MW).

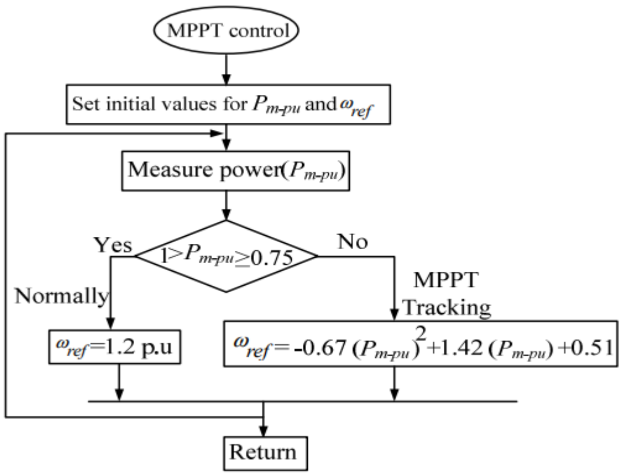

Figure 7.5: Flow chart of improved MPPT technique.

7.3.9 Artificial Neural Network Controller:

The ANN controller has been developed for current regulator of VSC. The proposed ANN controller is applied for VSC of hybrid PV/Wind based Micro grid system.

Artificial Neural Networks (ANNs) is an information processing technique that consist of networks of many simple processors (units) operating in parallel, each possibly having a small amount of local memory [15].

A multilayer perceptron neural network, with feed forward architecture with three layers of units is used due to its status and capacity to solve large number of problems. The algorithm used for the training is the well-known back-propagation method. Back propagation is a common method for training a neural network. The main objective of this technique is to optimize the calculations.

This neural network shows the first layer (layer A) and the second layer (layer B), which are called hidden layers. This network has one unit in the third layer (layer C), which is called the output layer.

Each network-input-to-unit and unit-to-unit connection (the lines in Figure 7.6) is modified by a weight. In addition, each unit has an extra input that is assumed to have a constant value of one. All data propagate along the connections in the direction from the network inputs to the network outputs, hence the term feed-forward is used.

7.4 Simulink Model:

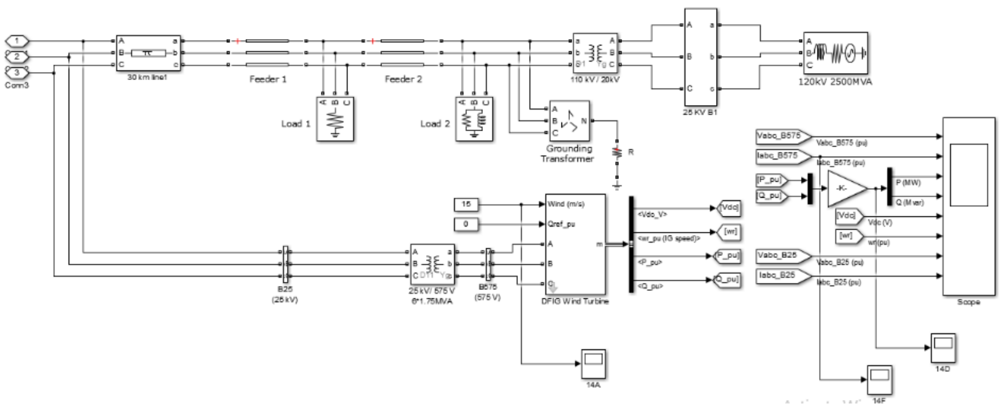

Figure 7.6: Simulink model of Wind Farm (9 MW wind farm DFIG)

The complete Simulink hybrid model can be shown as-

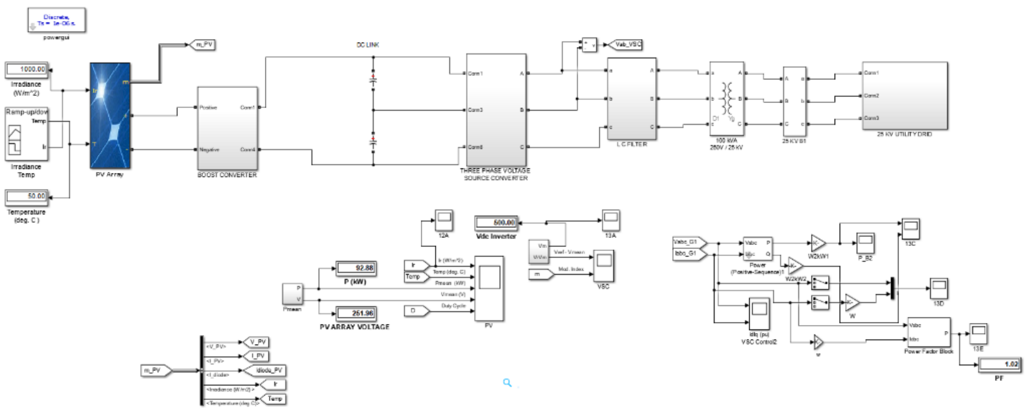

Figure 7.7: PV/ WIND system Simulink model (100 KW Solar System)

7.5 Results & Discussions:

7.5.1 Performance of PV System:

In this section the dynamic performance of the PV station during variation of the solar irradiance is investigated.

The temperature of the PV array surface is considered to be in the range of 25 to 50 degree C during the simulation.

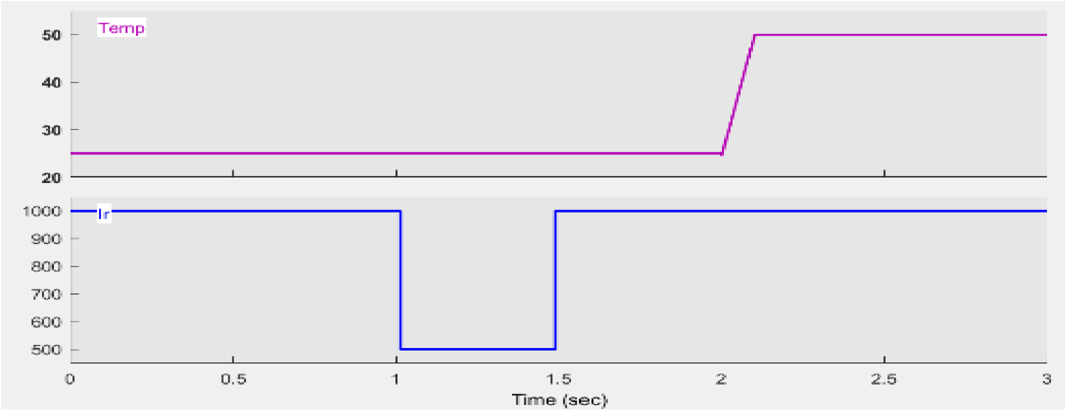

Figure 7.8: Temp. & Irradiance

CASE 1 When current is injected from PV station:

Now, the **Figure -** shows that the injected current from PV station is in phase with the grid voltage and therefore with the proposed control strategy, the PV station successfully operates at unity power factor as shown in the **Figure**. (7.9).

From the **Figure**. (7.10) It is clear that the DC voltage of the inverter is constant i.e. 500V (approx.).

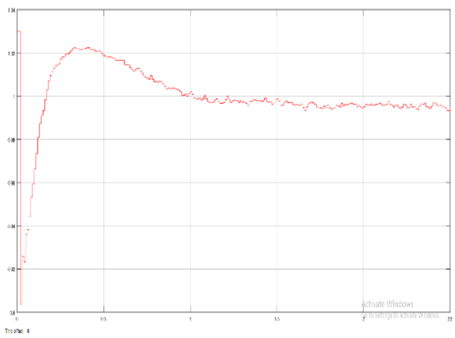

Figure 7.9: Power factor is almost unity.

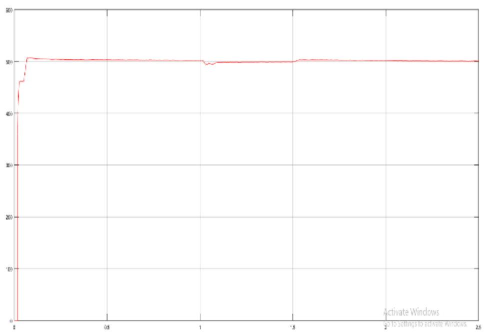

Figure 7.10: DC link voltage is constant (500Volts)

In the **Figure** (7.11) the waveforms of the PV system includes the irradiance , temperature, Pmean, Vmean and the duty cycle.

These waveforms vary according to the quantities mentioned above. The PV system is maintaining 100KW(approx.) and the temperature is in the range of 25 to 50 degree C as we change the irradiance.

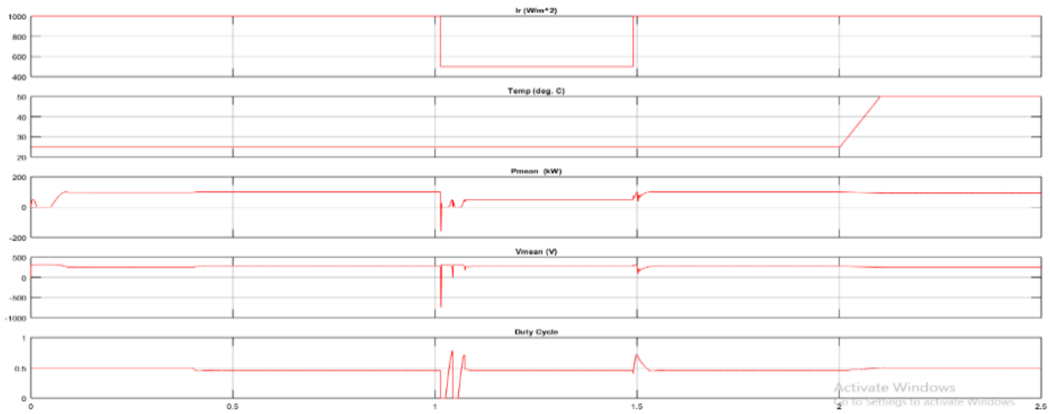

Figure 7.11: PV System waveforms(PV 100 KW & temp. 25deg. To 50 deg.)

Waveforms of the grid side voltage and current are shown in the **Figure**. and the waveforms are sinusoidal in nature. These waveforms are for the single phase , the waveform with high amplitude shows the voltage and the lower one shows the current.

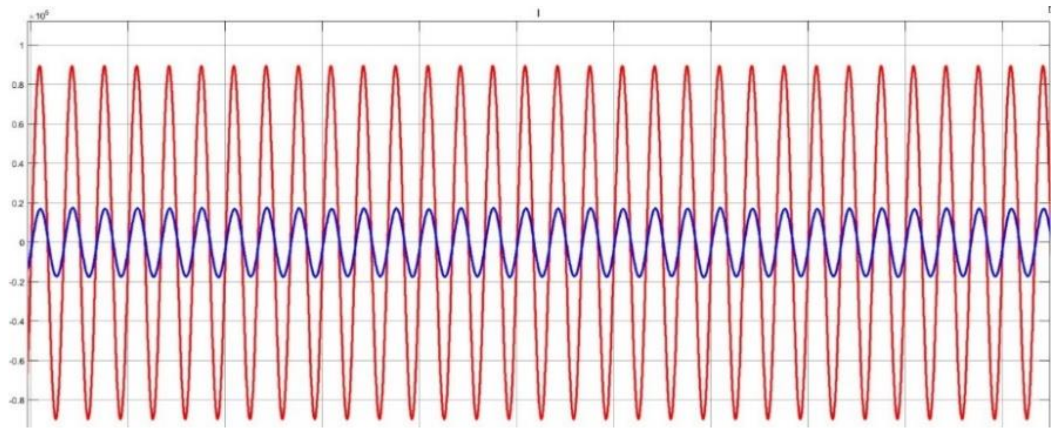

Figure 7.12: Grid voltage & current(Lower amplitude shows current & higher one shows voltage)

CASE 2 Performance analysis of the Hybrid system:

In this section we will analyse the results of the active and reactive power injected and absorbed by the system and also the grid voltage and grid currents in the combination with wind farm.

As non- inductive elements are used in the system so there will be some reactive power. Also at the point of common coupling the voltage and currents are getting sinusoidal in nature. In the **Figure** (7.13) the first waveform is of the DC voltage at the wind side which is around 1145 TO 1155 V.

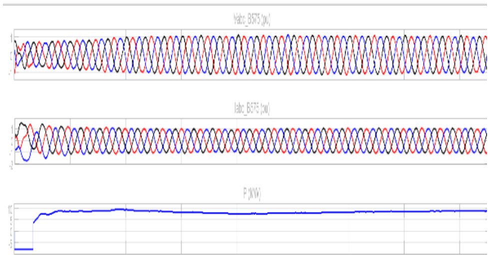

Figure 7.13: WIND WAVEFORMS (voltage, current& Power)

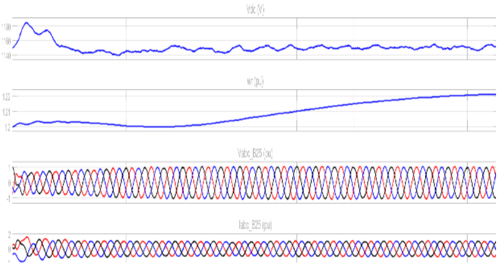

Figure 7.14: PCC voltage & current

Now the active and reactive power of the grid is also important so for that, the waveforms are shown in the **Figure 7.**14.

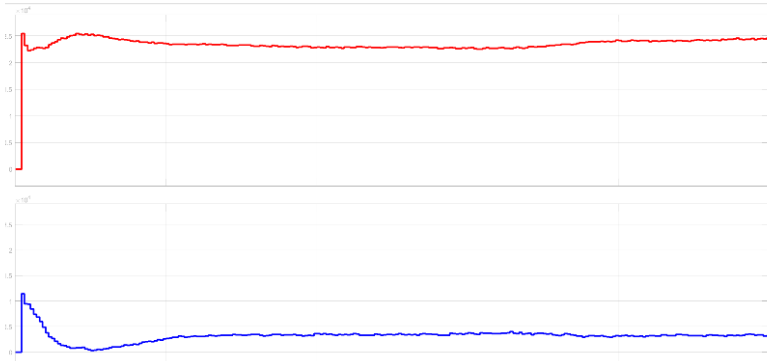

Figure 7.15: Active & Reactive power (Grid.- Red showing active power and blue showing reactive power)

7.5.2 Total Harmonic Distortions:

The THDs are also very important while implementing a simulink model, because with the help of the THD analysis the system performance can be easily identified. Now , for the proposed model the THDs are coming less than 5 % , which fullfill the IEEE standards. **Figure** 7.16 & 7.17 are showing the THD of Point of common coupling. **Figure** 7.17 & 7.18 are showing the THDs for the grid voltage and current.

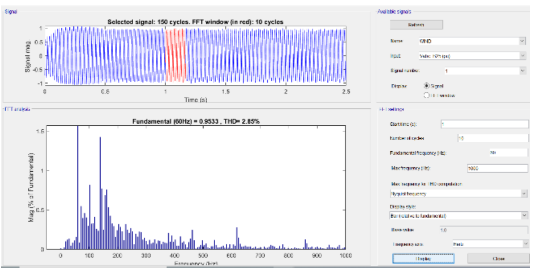

Figure 7.16: Voltage THD (PCC)(2.85%)

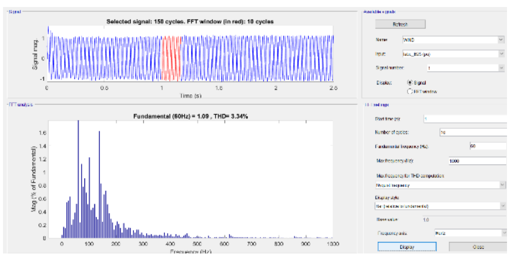

Figure 7.17: Current THD (PCC)(3.34%)

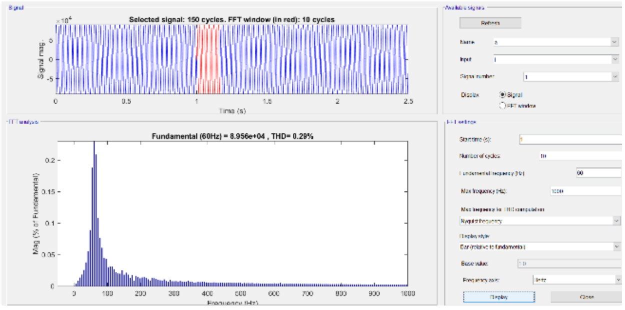

Figure 7.18: Grid voltage THD(0.29%)

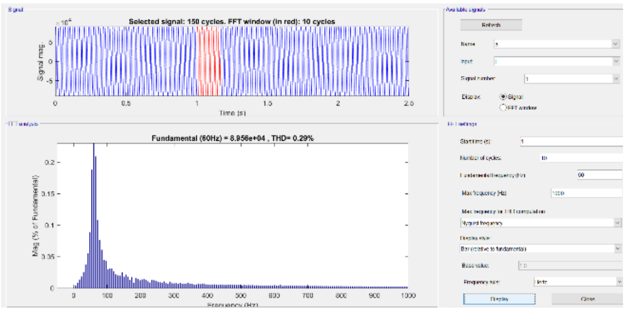

Figure 7.19: Grid current THD(0.28%)

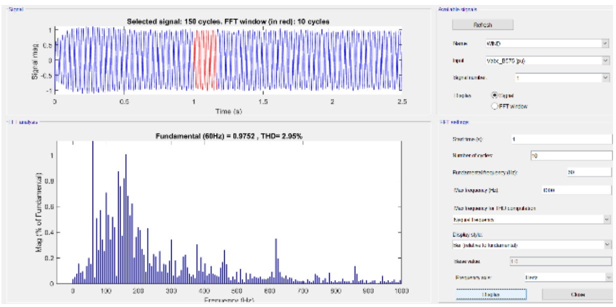

Figure 7.20: Wind Voltage THD(2.95%)

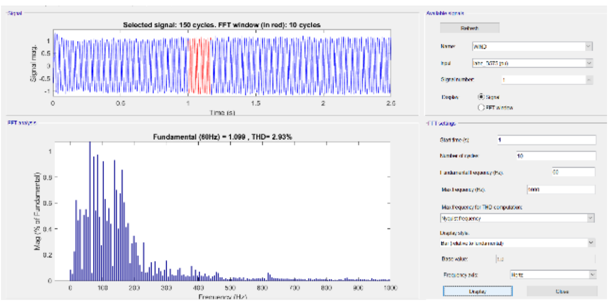

Figure 7.21: Wind Current THD(2.9%)

7.6 Conclusion:

The proposed paper is designed in the simulink model, is working accurately and is operating at a unity power factor while maintaining the DC-link voltage constant. Also the output of the voltage source converter is sinusoidal in nature. The PV array is working effectively and the environmental conditions does not effect the PV system irrespective of the changes in the temperature and irradiance. The wind farm is also maintaining the sinusoidal voltage and current waveforms and it is also observed that the what amount of active power is injected or absorbed by the grid and the system also. The voltage and current at PCC are also sinusoidal in nature and the integration of PV and WIND system can be seen with the help of waveforms . The THD is also within the IEEE standards i.e. less than 5%.

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