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Journal of Electronic Networks, Devices and Fields

Aims and Scope

Journal of Electronic Networks, Devices and Fields is a journal that publishes original research papers in the fields of electronic networks, devices and fields. Journal of Electronic Networks, Devices and Fields is a new journal which publishes research papers in the areas of from electrical distribution networks to integrated circuits in VLSI design, and from static electric and magnetic fields through microwaves to optical design. Areas included (but not limited to) are information networks, analogue and digital circuits, power distribution, solid state devices, electronic tubes, electrical components, moving boundary problems, coupled problems, network modelling, energy and moment methods, element and ray methods, graphs, and pre- and post-processing of data.

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EMG Signal Based Muscle Fatigue Assessment – A Review

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Abstract

The Surface electromyography (sEMG) signal processing has become quite common to evaluate local muscle fatigue. A large number of research have been carried out to access muscle fatigue in primarily static but also in dynamic tasks. This paper gives an overview of the various non-invasive electromyography signal analysis techniques available for use in fatigue detection. This paper will be of interest to researchers who wish to select the most appropriate methodology for research on muscle fatigue detection or prediction, or for the development of devices that can be used to reduce various work related musculoskeletal disorders.

Keywords: *muscle fatigue; sEMG; power spectral density.*

Introduction

Musculoskeletal disorders are an important work related problem [Malińska et al 2010; Kamińska et al 2010]. The reason for the occurrence of musculoskeletal disorders may be muscle fatigue, associated with prolonged muscle load even at low load levels [De Looze et al 2009; Farina et al 2006; Visser et al 2006; Roman-Liu et al 2009]. This means that the reduction of the load and fatigue in the working conditions may be an important step in reducing the occurrence of musculoskeletal disorders. A valuable tool for assessment of muscle load and fatigue is non-invasive surface

electromyography (EMG) [Solnik et al 2010; Solnik et al 2008; Piscione et al 2006, Bartuzi et al 2010].
Normally, EMG signals are acquired by noninvasive surface electrodes that are placed on the skin superimposed on the targeted muscle for fatigue analysis. EMG signal feature is often extracted before performing analysis [Phinyomark et al 2012a] because a lot of information, both useful information and noise [Phinyomark et al 2012b], is contained in the raw EMG data. An EMG feature is a distinct characteristic of the signal that can be described or observed quantitatively. Generally, EMG features can be computed in numerical form from a finite length time interval and can change as a function of time, i.e. a voltage or a frequency. They can be computed in several domains, such as time domain, frequency domain, time frequency and time-scale representations [Boostani et al 2003]. However, frequency domain features show the better performance than other-domain features in case of the assessing muscle fatigue [Al-Mulla et al 2012]. Mean frequency (MNF) and median frequency (MDF) are the most useful and popular frequency-domain features [Phinyomark et al 2009] and frequently used for the assessment of muscle fatigue in surface EMG signals [Cifrek et al 2009].

Frequency Domain Features

Frequency domain analysis is mostly used to study muscle fatigue, and infer changes in motor unit (MU) recruitment. A signal spectrum is influenced by two factors: the firing rate of a recruited MU in the low-frequency range (below 40 Hz), and the morphology of the action potential travelling along a muscle fiber in a high-frequency range (above 40 Hz) [Karlsson et al 1999]. It is time variant, and directly depends on the contraction force, muscle fatigue, and inter-electrode distance. During a constant voluntary contraction, even when there is no voluntary change of muscle state, a myoelectric signal should be considered a non-stationary signal; due to the inherent physiology of an organ. However, it was shown in Refs. [Karlsson et al 2000; Merletti et al 1992], that during relatively low-level (20–30% MVC), and short-time contractions (20–40 s), it can be

assumed to be wide-sense stationary. Moreover, at higher levels, 50–80% of MVC, it can only be assumed locally stationary for a period of 500–1500 ms. Therefore, a myoelectric signal can be assumed stationary in real-time applications, even if it has variant spectral characteristics.

2.1 Power spectral density (PSD) plays a major role in spectral analysis. In wide-sense stationary stochastic signals, PSD is defined as a Furrier transform of the auto correlation function of a signal. PSD function shows the strength of the variations (energy) as a function of frequency and it is most suitable for pulse like signals having a finite total energy. The PSD of a signal x(t) is defined as:

$$S_{xx}(f) = |\hat{x}(f)|^2$$

Where

$$\hat{x}(f) = \int_{-\infty}^{\infty} e^{-2\pi i f t}\ x(t)\ dt \qquad (1)$$

Two characteristic variables of PSD are the mean and median frequency (MNF, MDF) which provide information about signal spectrum and its change over time.

1.2 Mean Frequency (MNF) is an average frequency which is calculated as the sum of product of the EMG power spectrum and the frequency divided by the total sum of the power spectrum [Oskoei et al 2008]. MNF is also called as mean power frequency and mean spectral frequency in several works. The definition of MNF is given by

$$MNF = \int_{f1}^{f2} f.P(f)\,df \Big/ \int_{f1}^{f2} P(f)df$$

(2)

Where P(f) is the EMG signal power spectrum calculated using Fourier Transform for the frequency f, f1 = 8 Hz and f2 = 500 Hz.

Median Frequency (MDF): is a frequency at which the EMG power spectrum is divided into two regions with equal amplitude [Oskoei et al 2008]. MDF is also defined as a half of the total power, or TTP (dividing the total power area into two equal parts). The median frequency is calculated numerically from the following equation:

$$\int_{f1}^{F_{MDF}} P(f).df = \int_{F_{MDF}}^{f2} P(f).df \qquad (3)$$

Where P(f) is the EMG signal power

spectrum calculated using Fouriere Transform, f1 = 8 Hz and f2 = 500 Hz .The behavior of MNF and MDF is always similar. However, the performance of MNF ineach of the applications is quite different compared to the performance of MDF, although both features are two kinds of averages in statistics.

It should be noted that MNF is always slightly higher than MDF because of the skewed shape of EMG power spectrum [Knaflitz et al 1990], whereas the variance of MNF is typically lower than that of MDF. In theory, the standard deviation of MDF is higher than that of MNF by a factor 1.253 [Balestra et al 1988]. However, the estimation of MDF is less affected by random noise, particularly in the case of noise located in the high frequency band of EMG power spectrum, and more affected by muscle fatigue [v et al 1981]in static contractions.

MNF and MDFfor assessment of muscle fatigue in static contractions have been hailed as good standard due to the fact that muscle fatigue results in a downward shift of frequency spectrum of the EMG signal. Moreover, during the fatigue of muscle, several changes have been found, i.e. a relative decrease in signal power at high-frequency, a small increase in signal power at low-frequency, an increase in spectrum slope at high-frequency, and a decrease in spectrum slope at low-frequency [Petrofsky et al 1982; Sato et al 1982; Viitasalo et al 1977].

Time Frequency Domain Features: In dynamic contractions, the EMG signal information has been changed as a function of time that cannot be analyzed by simply applying FFT and most recently EMG studies have been applied to the study of dynamic contraction. The instantaneous mean and median frequency (IMNF and IMDF) are introduced to fulfill the requirement [Roy et al 1998] by using time-frequency or time-scale approaches.

Bonato et al. [Bonato et al 2001] studied different Cohen class time–frequency distributions and concluded that the Choi–Williams distribution was themost suitable for the analysis of the surface EMG recorded from dynamic isokinetic tasks.

Choi–Williams distribution (CWD): Choi and Williams [Choi et al 1989] proposed a new time–frequency distribution that does not generate spurious values and preserves desirable properties such as marginal densities. The main characteristic of this Cohen class distribution is the exponential kernel, which determines the cross-term reduction and the elimination of undesirable terms.

From the Choi–Williams time–frequency distribution certain parameters were calculated, as follows: Instantaneous mean frequency (MF) calculated as:

$$MF\ (t) = \int_{f1}^{f2} f.P_{CW}(f,t)\ df \Big/ \int_{f1}^{f2} P_{CW}(f,t)\ df \quad (4)$$

where P_{CW} (f,t) is the time-dependent power spectrum obtained from the Choi–Williams distribution and again, f1 = 8 Hz andf2 = 500 Hz. Instantaneous frequency variance as indicator parameter of the total changes can be defined as:

$$F_{var}(t) = \int_{f1}^{f2} (f - MF)^2.P_{CW}(f,t)\ dt \Big/ \int_{f1}^{f2} P_{CW}(f,t)\ dt \quad (5)$$

where MF is the instantaneous mean frequency calculated as in (4), where P_{CW} (f,t) is the time-dependent power spectrum obtained from the Choi–Williams distribution and again, f1 = 8 Hz andf2 = 500 Hz.

The interpretation of the sEMG during dynamic tasks is complicated and requires caution. Thus, during dynamic contraction, several factors like change in the number of active motor units, changes in force/power though the range of motion, changes in fiber and muscle length, together with the change in muscle fiber conduction velocity due to muscle fatigue [Farina et al 2006; Karlsson et al 2000], may increase the non-stationarityof the myolectrical signal. Hence, to extract valid physiologically relevant information future types of EMG-signal based analyses should thus require analysis of the possible confounding movement factors. In this context, the use of high-density, multichannel EMG, as well as direct estimation of conduction velocity could improve the interpretation of fatigue during dynamic tasks.

Conclusion

This paper has described various methods in the study of localized muscle fatigue for both isometric and non-isometric contractions. It is quite evident that the presented bioengineering approaches are quite successful in providing quantitative sEMG based information about the muscle fatigue state. Frequency domain features are found to be reliable for isometric or static contractions and time frequency domain features are found useful for non – isometric or dynamic contractions. Future work may be directed towards the development of automated muscle fatigue detection system to reduce work place injury and musculoskeletal disorders.

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Analysis of IC Engine Connecting Rod by Using Fem

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Abstract

IC engine connecting rod is the intermediate link between the piston and the crank rod, What's more, is capable to transmit the push and pull from the piston which is a reciprocating motion, hence changing over the responding movement of the piston to turning movement of the crank., by and large connecting rods are produced utilizing carbon steel and as a part of late day's aluminum combinations are discovering its application in connecting rod. In this work we are contrasting the von missesand distortion of two distinctive aluminum alloys with the forged C70S6. FEA investigation was done by considering three materials. The parameters like von misses and distortion were acquired from FEM programming. At that point compared the aluminum alloys with the produced steel and that point aluminum found to have less weight. It brought about diminishment of 59.18% of weight.

Key words- *Engine Connecting Rod, Analysis, Strength Evaluation.*

Introduction

The interfacing bar unites the piston to the crankshaft and they frame a basic instrument that changes over straight movement into rotating movement. The most extreme thrust happens in the interfacing of connecting rod close to the piston end because of push of the piston,thus tensile and compressive burdens are delivered because of gas pressure, and bending stresses are created because of radial impact and eccentricity. So the connecting rods are outlined by and large of I section to bear most extreme bending forces with least weight.

The connecting rod is the association between the piston and the crankshaft. It joins the connecting rod with the crankshaft, small end of the connecting rod is associated with the piston and big end to the crankshaft.

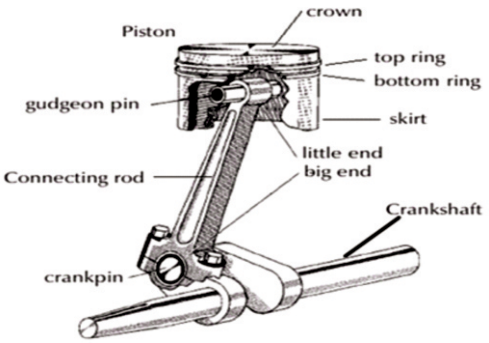

fig.1 piston, con-rod, crankshaft assembly.

The capacity of the interfacing bar is to change over direct movement of the piston into rotating movement of the crankshaft. The lighter associating bar and the piston greater is resulting power and less the vibration because of the reciprocating weight is less. The connecting rod carries the power thrust from piston to the crank pin and hence it must be very strong, rigid and also as light as possible. There are two types of end, small end and big end. Connecting rods are subjected to fatigue due to alternating loads. In the case of four stroke engines, during compression and power strokes the connecting rod is subjected to compressive loads and during the last part of the exhaust and the beginning of the suction strokes, to tensile loads. In double acting steam engines, during the forward stroke the connecting rod is subjected to compressive load and during the return stroke, to tensile load. Connecting rod materials must have good fatigue and shock resistances. Connecting rods for automotive applications are typically manufactured by forging from either wrought steel or powdered metal. They could also be cast. However, castings could have blow-holes which are detrimental from durability and fatigue points of view. The fact that forgings produce blow-hole-free and better rods gives them an advantage over cast rods. Between the forging processes, powder forged or drop forged, each process has its own pros and cons. Powder metal manufactured blanks have the advantage of being near net shape, reducing material waste. However, the cost of the blank is high due to the high material cost and sophisticated manufacturing techniques. With steel forging, the material is inexpensive and the rough part manufacturing

process is cost effective. Bringing the part to final dimensions under the tight tolerance results in high expenditure for machining.

Literature Review

For the present study, it is important to examine failure modes of connecting rod, its enhancement procedures, innovation, new materialsetc. This literature survey reviews some of these aspects. Failure of a connecting-rod is one of the most common causes of catastrophic engine failure causing irreparable engine damage.

Chang Ping Zouet et al (2012) found that the connecting rod of a certain type of continuous mill produced crackle & could not work, thus hindering the production. The authors entrusted with the 3D Finite Element Analysis (FEA) of the connecting rod utilizing the large scale Integrated-Design Engineering Analysis Software, I-DEAS. The authors found the solution of several kinds of law of stress distribution and deformation, and reached valuable conclusions.

Mohammad Reza Asadi et al (2009) Performed detailed load analysis for a connecting rod followed by finite element method.in order to calculate stress in connecting rod, the total forces exerted connecting rod were calculated and then it was modeled, meshed and loaded in ANSYS, software. The maximum stresses in different parts of MF-285 connecting rod were determined. The maximum pressure stress was between pin end and rod linkages and between bearing cup and connecting rod linkage. The maximum tensile stress was obtained in lower half of pin end and between pin end and rod linkages.

Ramanpreet (2013) conducted simulation on a model of connecting-rod of a single cylinder four stroke engine. The main objective of his paper was to develop a new insight for the use of composite material in connecting rods. Finite element analysis was done to compare the conventional isotropic material and the orthotropic composite material. Modeling of connecting rod was done using software CATIA V5 and for stress analysis it was imported to MSC PATRAN. Linear static analysis was carried out for both isotropic material and orthotropic composite material with mesh to obtain the stress results. Comparison of both the material was

done, keeping the boundary conditions same for both materials.

Suraj and Sunil (2012) evaluated the design parameters of connecting rod using FEM to achieve suitable design for connecting-rod. Finite element analysis of single cylinder four stroke petrol engines was taken for the study. A proper finite element model was developed using cad software Pro/E Wildfire 4.0. Then static analysis is done to determine the von misses stress, shear stress, elastic strain, total deformation in the present design of connecting rod for the given loading conditions using ANSYS v 12. Based on the observations of the static FEA and the load analysis results, the load for the optimization study was selected. The results were also used to determine of various stress and the fatigue model to be used for analyzing the fatigue strength. Outputs of the fatigue analysis of include fatigue life, damage, factor of safety, stress biaxiality indication.

Based on the combination of modal analysis technology and finite element method (FEM), the 3D model of a diesel engine's connecting rod was established with UG software, and then a free modal analysis of it was carried out with ANSYS. Through the analysis, the inherent frequencies and mode shapes of first 5 order modes were obtained respectively. The free modes of the connecting rod were verified by testing using hammer beat method (Shao Zhong Jiang and Wen Bing Yan, 2011).

VatroslavGrubisic (2004) found that component failure due to fatigue arises due to improper material selection, fabrication defects, improper heat treatments, design errors and unexpected operating conditions. Failure of automotive component due to fatigue contributes to 24 %.

Wenzhe Chen et al (2012) Investigated the connecting rod design and optimization of the engineering clamp hanger based on metamodel. The structure of the clamp hanger and the working load status of the connecting rod were firstly analyzed. Then the metamodel theory was applied to the connecting rod design and optimization: The metamodel of the connecting rod was set up in Solid Edge, and the design factors were signed as function-based parameters, with their geometrical relation changeless. Finally, keeping the fine

strength security and stability, the structure of the connecting rod was optimized. The presented research in this paper offered a new reference and thought for the hanger design and improvement.

Structural Analysis

The principle focus is to determine the connecting rod structural design to achieve the maximum resistance to bending stress and its structural behavior during its operational period, to avoid its failure under the mass and gas forces acting on it while keeping the rotating and oscillating mass to a minimum. A higher oscillating mass leads to a higher tensile stress on the stem of the connecting rod during the gas exchange phase and can lead to failure. Also, a higher tensile force can lead to a relatively higher ovalization of the big end, because of a combination of all these factors, the choice of the load cases for the structural analysis needs careful attention. Experimental procedure involves modeling of connecting rod using CAD software. Static analysis of connecting rod is done using cad analysis software in order to understand the stress and deformation locations in connecting rod.

fig.2 3D solid model of a connecting rod.

Mesh Generation

The finite element method (FEM) is by far the most widely used method for performing the structural analysis For an accelerated design exploration, approximation techniques such as surrogate models, reduced order models, and reanalysis methods, which are reviewed in, should be used to reduce the computational effort while keeping a certain level of accuracy.

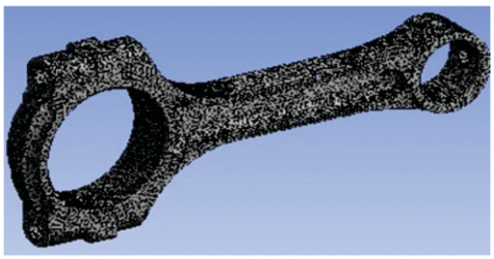

fig.3 meshing is performed with global element length with tetrahedral mesh type.

A typical connecting rod is plane or point symmetric. Usually a half or sometimes even a quarter models can be sufficient, but if connecting rod is not symmetric then full assembly has to be considered. From experience, the critical areas of the connecting rod are known to be the areas where there is a sudden change in the profile of the geometry. Additionally, the radius around the stem close to the big end and the transition radius of the bearing cap must be kept in mind. Hence these areas are meshed with a fine mesh and a high mesh quality is maintained and their mass is connected to the connecting rod body at its local COG by using a mass element in order to simulate the exact inertia forces.

FEA design. Keep in mind, you'll need nodes and elements for the finite element solution, not just the actual solid model. The solid design does not take part in that specific element solution with this connecting rod, prior to finalization associated with element size pertaining to meshing, a meshing convergence is performed by tetrahedral element with various feature lengths.

Results

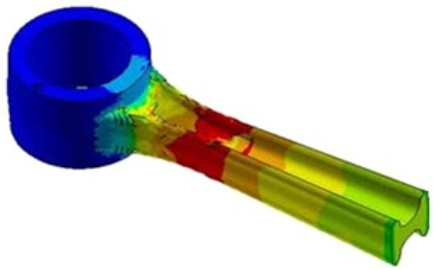

fig.4 Static results I-Section.

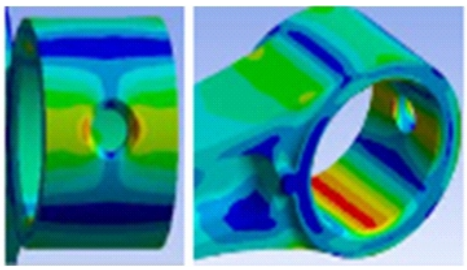

fig.5 statics results at small end.

In this section results will be obtained pertaining to static stress evaluation in the form of Von-Misses stresses. While performing this static stress analysis in FEM program, connecting rod is to be divided in to different specific zones for understanding stresses at various locations of connecting rod.

Conclusion

From the above analysis we can determine that stresses of all the elements are comparable and also

within safe limit. Weight of the connecting rod can be reduced by replacing currently using forged steel in by C70S6 alloy. The section modulus of the connecting rod should be high enough to prevent high bending stresses due to inertia forces, eccentricities, as well as crankshaft and case wall deformations. In order to achieve results that are reliable when using the finite element method one has to use an acceptable element mesh with respect to the shape and size of the elements. As a help to produce an acceptable mesh there are quality criteria that must be fulfilled.

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T-spline: A Novel Tool to Model and Modify the Objects in Virtual Reality Environment- A Review

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Abstract

In today's world the geometric design of any product should not be restricted to the orthodox formulaic approach which is followed by most of the commercial CAD packages available in the market. The designers have to follow more or less artistic and sculptured approach for the concept in their mind for any geometric design. The effectiveness of the design directly depends upon the various properties (like computation speed and design modification tools) of the CAD package provided to the designer. Virtual reality is one of the sciences which can help designers to explore various designs without the need to deal with highly complex CAD software or building prototypes. It also gives freedom to the designers to give shape to their conceptual ideas, manipulate them according to their need and demand. However, there are many bottlenecks which need to be addressed before virtual reality can be used to enhance the experience of designers and industrial engineers. The major issues that need to be dealt with are modeling of the virtual objects, collision detection, and merging of these objects to generate complex and interesting designs. In this research paper the pro and cons of different surfaces has been discussed for their application in different aspects of virtual reality viz. modeling and merging of virtual environment, haptic modeling and collision detection between model and tool. In this regard, T-spline curves and surfaces can be explored to represent these virtual objects. In this study a general review of T-spline

surfaces and their properties like local refinement, partition of unity, isogeometric analysis etc. is discussed.

Keywords: *Virtual Reality, Collision Detection, Haptic modeling, Local refinement, Isogeometric analysis*

1. Introduction

In today's world the designing of the objects has moved to a level where formulaic approach provides less freedom to the designer due to its various constraints. So it is necessary to provide the designer the geometric tool s which leads to more freedom and also explores the sculptured thoughts. In this regard virtual reality provides that freedom to the designer. The geometry of the object can be stored in algorithms in Computer Aided Geometric Design (CAGD). The costly prototypes that were built physically in the past proved to be costly in comparison to designs made in CAGD [1]. In most of the geometrical design applications the free-form curve used is NURBS (Non-Uniform Rational B-Splines). These are the parametric curves which mean a curve is traced out as the value of the related parameter is changed within an interval. The reason behind the usefulness of the NURBS lies in their properties like local control, partition of unity, variation diminishing property and constraints on the continuity of the curve [2, 3, 4]. NURBS also poses some major limitations before they are used for geometric designs. The major limitations that are to be addressed before they are used in CAD are firstly that during merging of the surfaces if a designer wants to insert a control point on the surface than in NURBS an entire row of control points is inserted instead of an individual control point. This leads to the manifold increase in the computational cost and complexity of the geometric models [5, 6]. Secondly the gaps and overlaps at the interactions of the merging surfaces are unavoidable. Further the mesh generation is complicated due the use of the tensor product structure. It cannot be used for the complex shapes due to strict parameterization [6]. Due to these mentioned drawbacks researches had started exploring about the new curves that can provide more freedom in handling of these curves. So in the recent studies a new curve T-spline has been

introduced in the research of [7]. T-splines possess the same properties of NURBS such as local refinement, non-negativity and partition of unity as stated in the researches of [5, 7]. In addition to these existing properties of the NURBS, T-splines posses the property of insertion of control points at the location where the local refinement has to be done and there is no need to pass the line of control points to pass through whole control grid. Thus the problem of tons of superfluous associated with the NURBS due to insertion of control point line through the whole control grid has been eliminated in the case of T-splines [5, 8]. As T-splines are more advantageous than the NURBS for knot insertion, so they provide freedom for control point embedding and the applications such are merging and intersection of surfaces which were formally infeasible now well permitted by the T-splines [9]. So the attempts should be made to fit them in the geometric applications of CAD like merging, Virtual Reality, Haptic Interaction and Collision Detection.

Components of A Virtual Modeling Module

The diagrammatic view of this interface as depicted in the literature of [10] is shown in figure 1. The virtual modeling module generally consists of three major components viz. Haptic Interface which is used to interact with the virtual world i.e. solid and tool interacting with it to do all the communication with the model i.e. modifications and deformation. The second one is Collision Detection System that will detect the co-ordinates of interference of tool and model in virtual world. Generally this system tells about of the contact of the tool and solid and more about tool penetration.

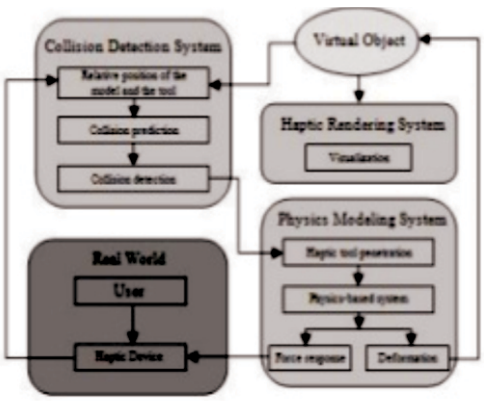

Fig. 1 Schematic of Haptic based modeling in virtual reality

The third vital component is the virtual reality module is Physics Modeling System with the help of which by using collision detection system we come to know about the extent of deformation

caused on the model which is under the various internal and external forces. This is achieved with the help of physics based mass-spring-damper system and also by assigning the material properties to the solid virtual model. It also gives the fed back force to the user considering various reactive forces.

2.1 T-splines for Virtual Reality (VR)

The modeling packages that are available in the market in today's world are more or less dependent upon the orthodox formulaic approach which does not provide that much freedom to the designer that is indeed needed. Virtual reality is a science which provides opportunity to the designer to physically interact with the geometric model in a very sculptured approach. This interaction with the geometric model is through the Haptic interface, which act as a link between the model and human, is a tool which provides the touch and sense of the modeled object. The designer can sense the strength, finish and resistance of the model in way that model originally in the hands. VR is finding its vast and novel application in the fields like medicine, training of miners and the nursing students, nuclear waste management and many more to quote. The application of VR in the surgical fields of laparoscopy and nursing was well studied in the researches of [11, 12, 13]. Further in [11] it is stated the training for laparoscopic surgery is with VR is pressure free in the sense that it is not directly on the patients. The trainee on the VR can be directly transferred to the operating room. In the study of [13] the training was given to the nursing students in the VR environment for the various critical processes like insertion of Foley catheter and the results were in accordance with the control environment results. VR also have its application in the processes where humans are subjected to danger like in the fields of mining and nuclear waste management [14, 15]. As mining is one of the most dangerous industry of the time, so the research made by [14] made and attempt to train the coal miners through the VR which proved to be very effective. It suggests high immersive VR used with wide FoV (Field of View) as the best for the training of the coal miners. The VR can be used for training of the people involved in dangerous activities related to the nuclear energy as in nuclear waste management [15]. VR can be used at any level in shipbuilding

industry [16]. It requires a 3D model of the ship, a viewer to roam around the ship and a compatible hardware system to integrate the first two. As VR holds its application in almost each and every field of the science, so it is need of the time to model each and every thing in the VR environment more effectively. T-splines can be used more effectively than NURBS in VR to merge the existing surfaces. Many research works had found T-splines to be more advantageous than NURBS for iso-geometric analysis and local refinement [6, 17, 18, 19]. The T-spline blending functions are linear independent as found in the research of [20]. The properties of the T-spline for iso-geometric analysis were studied by [21] and these properties were used for gluing two iso-geometric patches. An algorithm for local refinement using the concept of influence knot sets was introduced by [22]. The theoretical framework and algorithm for classification of T-spline was given by [22] and the results of this algorithm were in well accordance with the experimental results.

2.2 Collision Detection

Collision detection is a part of the VR environment which provides the information to the designer about the interaction with the VR model. It further informs about the correct collision between the tool and the geometric model which is an important feature of VR for proper manipulation of the model. Further there are two types of geometric models that a designer comes across viz. rigid and deformable bodies. The detailed survey of collision detection was studied by [23] which categorized the collision detection algorithms on the basis of the model representation techniques. In this study it is further stated that these techniques can broadly classified in four categories as space–time volume intersection, swept volume interference, multiple interference detection and trajectory parameterization. Many researches has contributed towards the effective algorithms for collision detection for deformable bodies as in [24, 25, 26, 27]. A time critical collision detection algorithm was suggested by [24] which are based on the construction of sphere tree using medial axis approximation of a dense mesh. An algorithm to detect the continuous collision between the general deformable models was given in the study of [25] which uses the chromatic decomposition computation of the models to easily detect the self

collision of the primitives. The algorithm was tested on 3.0 GHz Pentium IV PC with a NVIDIA 7800 GPU and results was tested on the complex simulation comprising of several thousand of triangles and the algorithm was able to detect the self collision in tens of milli-second. In the research of [26] an effective algorithm was proposed to detect the collision between the freeform deformable shapes in VR environment. This study used B-splines to represent the virtual model. A transformation matrix and its inverse was calculated and stored to discretize the B-spline surface. The intensity of the points was increased on the lower level of the detail depending upon the accuracy and the region that undergo collision are tessellated using these points. The proposed algorithm was able to calculate the tangents and normal to calculate the properties such as inside/outside of the surface and tangential forces. This algorithm is well suited for sculpting in VR environment. In the research of [27] a fast continuous collision detection (CCD) algorithm for deformable bodies was presented using multi-core processors. In this approach the computational work was distributed among the multi cores to enhance the speeds. The application of collision detection for the virtual manufacturing was studied by [28, 29]. In the study of [28] the importance of collision detection for operator-system in virtual manufacturing environment was emphasized upon. An efficient and precise collision detection algorithm for the objects which are modeled by Constructive Solid Geometry (CSG) was devised in this study. The performance of the approach was tested by virtual training on CNC milling and virtual assembly operations were found to be very effective. The collision detection algorithm for the non-convex objects used in virtual manufacturing domain was introduced by [29]. This approach finds its good application in the fields of interactive simulations and animations for examples in the fields of virtual assembly, manufacturing processes and mobile robot simulations. A CCD algorithm for the Composite Quadric Models commonly used in CAD/CAM of the type in which their boundary surface intersects only at straight line segments or conic curve segments, was proposed by [30]. In the research of [31] the authors used a new technique of polar diagrams to

detectthe collision between the objects in the scene. This technique involves the partition of the plane with similar features by computing minimal polar angle as it change by criteria of Euclidean distance of Voronoi Diagram, thus resulting in new type of tessellation called polar diagram.

2.3 Haptic Interaction

The interaction with the virtual model is done with the help of haptic device (touch feedback system) with which the geometric model in the VR environment can be manipulated easily. The haptic device should be such that it provides proper feedback to the user and manipulations to the interacting model. A VR environment is only effective with a good haptic feedback system. In the recent years many researches had contributed towards the advancement of the haptic interaction. In the research of [32] the authors introduced the concept of deformable tool for interaction with the soft objects like catheters in virtual surgery and rubber parts in assembly operations. The rigid tool is unable to provide the force feedback to the hand. An algorithm in this study was proposed which uses a tool which comprises of rigid and deformable components that enables interactive contact between deformable objects, including self-collisions and friction. The range of force feedback in human-excavator interface in virtual environment for best operator performance was studied by [33]. This study empirically formulated the range of force feedback which is necessary for efficient human-excavator interface. The use of haptic feedback in driving control system was studied by [34] which developed drive-by-wire technology with haptic feedback. The use of haptic device for the manipulation of objects in 3D virtual environment was faster than the 2D displays because in interactive 3D stereoscopic display manipulations and pointing tasks were performed more effectively as stated in the study of [35]. In the research of [36] it is stated that if the virtual is more accurately described then the force feedback system is as efficient. So due to this reason triangulated surfaces are more used to describe the object. During the haptic interaction the triangle which is nearest to haptic probe has to be identified. To achieve the above task a algorithm is designed to identify the triangle in collision with the haptic probe and in the direction of the haptic probe motion vector. The

proposed algorithm is fast enough to be used in haptic visualization with millions of triangles.

Conclusion

By going through the above survey it has become clear that virtual reality can be a vital tool in the hands of a designer in the earlier phase of design process. A designer can modify the design like a sculpture and give shape to its creative ideas by integrating virtual reality with tools like haptic interaction, collision detection and mass property calculations. Furthur the use of virtual reality can be extended to life saving applications like surgical training and by equipping it with finite element it can be used for surgical element like suturing. However, there are many bottlenecks in the use of virtual reality for these applications which need to be resolved. In virtual reality, when a model is designed during merging of the surfaces with the help of B-splines and NURBS, a lot of superflous data needs to be dealt with which increases the computational time. T-splines can be a good modeling tool for merging of the surfaces due to the properties of local refinement and data compression. The algorithms to represent the virtual objects using T-spline should be constructed. An efficient collision detection algorithm should be developed for interfacing the haptic environment with virtual reality using T-spline surfaces. Furthur the research can be extended for having the real feeling of the deformation of the virtual model by using physics based mass-spring system and the algorithms can be developed for calculating the deformation caused by internal and external force.

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Lean and Six Sigma an Integrated Approach for Waste Reduction in Indian SMES: A Review

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Abstract

In present manufacturing scenario Lean manufacturing is among the major businesses initiatives which has been taken around the globe in order to remain competitive in ever increasingly global market demands where as Six Sigma is a technique to measure the number of "defects" in the process, As "Zero Defect" can be systematically figured out in order to get close to accuracy as possible. The combined approach of Lean manufacturing and Six Sigma methodology may can lead to higher benefits including reduction in process variation and dramatic improvement in business. Ultimately combination of Lean manufacturing and Six Sigma can be used in order to get optimal results. In beginning the process of Six Sigma can be changed from slow to fast by Lean Manufacturing. Last, Lean manufacturing and Six Sigma can provide the structure easily for optimum flow. In simple language the ultimate goal is to create value to the customer for the company hence the customer settles the quality for the product. The quality of the product is its ability to satisfy and preferably exceed the needs and expectations of the customers. Lean Six Sigma's growing prevalence and importance in industry, presently companies have acknowledged that Lean and Six Sigma share a common objective: to create value based end customer requirement.

Keywords: *Lean manufacturing; Six Sigma; Lean Six Sigma; SMEs; Business Performance.*

Introduction

In present manufacturing scenario waste reduction is one of the prime objectives of all industrial organizations in order to maximize the profits. Industrial waste is the unwanted wastage of resources produced during industrial activities which may include any material that is rendered useless during a manufacturing process. Indian Small and medium enterprises (SME'S) are facing huge losses due to controlled and uncontrolled wastage of available resources. Even though many efforts are done by various researchers to optimize the whole manufacturing process by using various techniques in order to minimize the losses beard by Indian SME's due to wastage of resources. But still there is a huge scope of improvement in this field. Lean six sigma is one of the major tools that can be used by the manufacturing organizations to achieve this target. The goals in implementing the Lean Manufacturing are lower production costs; increased output and shorter production lead times. [Mekong‟s capital review (2004)]. Waste can be defined as unwanted and useless material and resources which increases the cost of final products. Broad classification of the waste is as follows.

Controlled waste: Controlled waste is that waste which can be prevented by small human efforts and proper process awareness. Example operator skill (highly skilled worker can perform significant role minimizing the waste of raw material.), maintaining adequate inventory, improper working environment etc.

·**Non Controlled Waste:** Those wastes which cannot be prevented by human efforts such as due to climatic damages, sudden accidents, electricity breakdowns etc.

Literature Review

Thorough literature survey has been carried out to capture the voice of concerned people and their relevant works as far as implementation of Lean manufacturing and Lean six sigma implementation in various (Large, Medium and MSME's) industrial organizations. Brief description of these has been represented below. Literature based upon waste management has been reviewed. P.UMA (2013) discussed that Industrialization is an effective means for solving the problems of economic and social progress in developing countries of the world. Gunwar Myrdal has rightly described

the relationship of industrialization to economic development when he observes “the manufacturing industry represents, in a sense, a higher stage of production in advanced countries. Vinesh V. Rakholiyaetal (2012) Modern environmental legislation is becoming much more internationally coherent and less prescriptive, and focused on prevention of pollution through control of hazardous materials and processes as well as on protection of eco-systems. Girish. C. Pude (2012) purposed Value Stream mapping technique involves flowcharting the steps, activities, material flows, communications, and other process elements that are involved with a process or transformation. E. M. Elsayed (2009) studied that This paper investigates a method to electro reduce toxic hexavelent chromium to trivalent state using rotating disc electrode (RDE) and rotating cylinder electrode (RCE) cell. Electrolysis of acidic hexavalent chromium solution using a rotating lead cathode reduces the hexavalent chromium Cr to trivalent chromium. G. Tamizharasietal (2014) Discussed in paper regarding benefits of implementing lean concept and focuses on Value Stream Mapping (VSM) and Single Minute Exchange of Dies (SMED) in Carriage Building Press shop. As VSM involves in all of the process steps, both value added and non-value added, are analysed and using VSM as a visual tool to help see the hidden waste and sources of waste. Rakesh Kumar etal (2014) focused on Lean Manufacturing system has been acknowledged by Indian industry as a capable system in enhancing organisational performance by focusing on elimination of waste from the manufacturing system and thus improving effectiveness of the organisation. M.C. Prieto-avalos (2014) studied that organizations are involved in a complex environment with continues changing, that should impels the innovations looking for increase production performance, quality improvement, customer satisfaction and create a competitive advantage. Mohamed K. Hassan (2013) this study was applied in a welding wire manufacturing plant to improve the quality of the manufactured welding wires, reduce the manufacturing waste and increase the yield of the manufacturing process, by applying the Lean Six Sigma (LSS) methodology and waste management. LLS is considered one of the successful approaches in the field of quality improvement and cost reduction. Man Mohan Siddhetal

(2013) put emphases on Lean manufacturing is one of the initiatives that major businesses all around the world have been trying to adopt in order to remain competitive in the increasingly global market and Six Sigma was an American “invention”. The Central idea behind Six Sigma is that if you can measure how many “defects” you have in process, you can systematically figure out how to eliminate them and get as close to “Zero Defect” as possible. Akhilkumaretal (2014) examined efforts have been made to identify the barriers to lean implementation and then to develop the relationships among these identified barriers. While literature survey suggested some important barriers in the lean implementation, additional few barriers were identified through discussions with the subject matter experts from the industry.

Sme's and their Significance In India

Small and medium enterprises are playing an important role in the economic growth of india. As per available data SME's are contributing 18% in the GDP growth of India (FY 2014-2015). SME's are also a source of employments for the 50% of Indian population. Today SME's are flourished in a well-organized clusters based manner.

The main barrier in the growth of SME's is the optimum utilization of available resources. Even National manufacturing competive ness Council (NMCC) has proposed the various schemes for developing the global competitiveness of Indian SME's but still they are facing huge losses due to wastage of available resources.

Lean Manufacturing

Lean", is a systematic method for the elimination of waste within a manufacturing process. Basically lean is a methodology which makes improvement in the processes in order to get an overall improved system.Lean also takes into account waste created through overburden and waste created through unevenness in workloads. Working from the perspective of the client who consumes a product or service, "value" is any action or process that a customer would be willing to pay for. Essentially, lean is centered on making obvious what adds value by reducing everything else. Lean manufacturing is a management philosophy derived mostly from the Toyota Production System (TPS).

Six Sigma

Six sigma is a well-established approach that seeks to identify and eliminate defects, mistakes or failures in business processes or systems by focusing on those process performance characteristics that are of critical importance to customers (Snee, 2004). Six sigma provides business leaders and executives with the strategy, methods, tools and techniques to change their organisations. Six sigma has been on an incredible run for the last five years producing significant savings to the bottom-line of many large manufacturing organisations. There are four aspects of the six sigma strategy that are not emphasised in other business improvement methodologies and total quality. management (TQM). First of all, six sigma places a clear focus on bottom-line impact in hard dollar savings. No six sigma project will be approved unless the team determines the savings generated from it. Second, six sigma has been very successful in integrating both human aspects (culture change, training, customer focus, etc.) and process aspects (process stability, variation reduction, capability, etc.) of continuous improvement. Third, six sigma methodology (define-measure-analyse-measure-control or DMAIC) links the tools and techniques in a sequential manner. Finally, six sigma creates a powerful infrastructure for training of champions, master black belts, black belts, green belts and yellow belts (Harry and Schroeder, 2000; Pande et al., 2000; Adams et al., 2003).

Lean & Six Sigma (lss): A Combined Approch

The "lean" concept has often successfully allowed companies to deliver bottom-line savings in production through improves process efficiency. Lean is aimed at reducing waste and adding value to production systems so that systems performance is significantly improved and a company "does more with less". A typical example is applying TPM techniques to poorly maintained machinery. This provides for value-added inputs by way of ensuring machinery remains in productive operation for longer periods of time (Jostes and Helms, 1994). Maintenance procedures and systems are designed so that they are easier to accomplish and this is achieved through machine redesign and modifications in order to facilitate this process. The basic lean philosophy relies on a five phase approach. This is:

· Identify value (from the point of

the customer).

- Measure the value stream.
- Pull on customer demand.
- Create flow.
- Achieve perfection.

Employing therefore a standard operational framework for implementing both lean and six sigma approaches is seen as an obvious and necessary step for companies to achieve simultaneous benefits from the both strategies (George, 2002). To this end the DMAIC process is used as the main functional system for the implementation of lean six sigma (LSS) approach. framework. The main phases of the integrated LSS approach are:

- Ÿ Define – what is the problem? Does it exist?
- Ÿ Measure – how is the process measured? How is it performig?
- Ÿ Analyse – what are the most important causes of defects?
- Ÿ Improve – how do we remove the causes of the defects?
- Ÿ Control – how can we maintain the improvements?

Conclusion

Lean and Six Sigma are evolved into business strategy in many large originations and also having a very important place in ever-growing SMEs of India. Lean and six sigma are emerging as a new wave for changing the financial culture of industrial organizations. The development of a LSS model developed a culture towards continuous improvement and the systematic implementation of the approach throughout the organisation. The application of the LSS approach allowed the company to develop advanced statistical techniques and to become generally more "technical" in their approach to problem solving.

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Performance Analysis of Climatic Conditions on Ideal and Single Diode PV Systems

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Abstract

In this paper, MATLAB/Simulink modeling of ideal and single diode photovoltaic (PV) system is presented based on their mathematical modeling. A comparative transient analysis of ideal and single diode PV system has been done with a resistive load. Furthermore, effect of climatic conditions such as varying solar irradiation, wind speed and temperature on the designed ideal and single diode PV system is examined. The acquired results show acceptable performance for real-time model of PV system.

Index Terms—Renewable Energy, Photovoltaic system, Ideal PV system, Single diode PV system, Climatic conditions.

I. Introduction

The consumption of electrical energy is increasing exponentially all over the world. Therefore, there is an urgent need for the utilization of alternative renewable energy sources such as solar energy, wind energy, biomass, geothermal, hydro energy etc., for electric power generation. These energy sources are also called non-conventional energy sources [1].

A PV system is used to directly convert solar energy into electrical energy. A PV array comprises of various PV modules connected by series and parallel connections. For the simulation of PV modules under varying climatic conditions, their electrical equivalent circuits and basic circuit equations are most commonly used [2].

The authors in [3], have performed modeling and simulation of double diode PV system in Pspice environment. For the analysis purpose partially shadowed conditions are

used. In [4], modeling of two PV systems has been done and the experimental data of a commercially available panel is validated with the simulation models.
In [5], modeling and comparative study of single and double diode PV system has been performed. Furthermore, the accuracy of the model is validated using the data-sheet of a commercially available PV module. In [6], all the major problems governing modeling of PV system are discussed. The authors have concluded that a real-time model of PV system is essential for proper study of the working of PV system.
From the above literature review, the research addition of this paper is to present a detailed transient analysis of ideal and single diode PV system. Furthermore, the effects of variable solar irradiation, temperature and wind speed are also studied.
The complete system proposed in this paper is shown in Fig. 1 as,

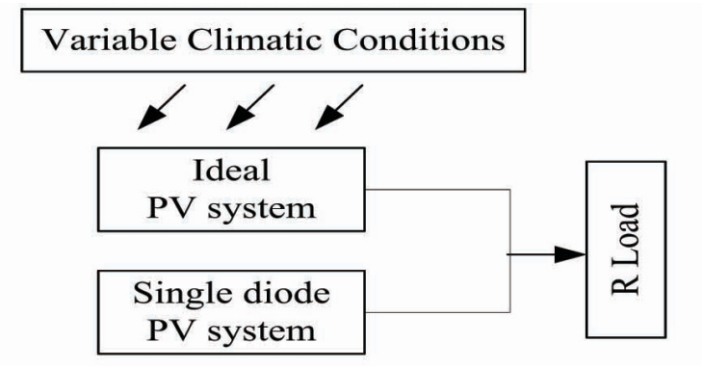


Fig. 1 Block diagram of the complete system

The system comprises of two non-conventional energy based power generating sources i.e. ideal PV system and single diode PV system. Both the sources are connected with resistive load for transient analysis and are subjected to variable climatic conditions.

II. Solar Pv System

A. Ideal PV system

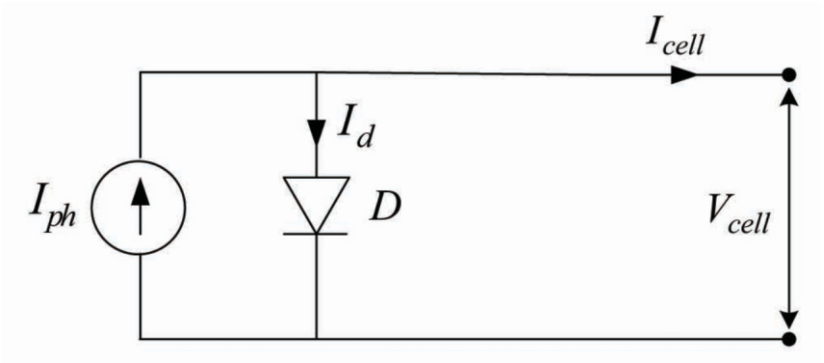


Fig.2 Equivalent circuit diagram of ideal PV system

B. Single diode PV system

The single diode PV system has two resistances *Rs* and *Rp* connected in series and parallel respectively. The

$$V_{Cell} = \frac{AkT_C}{e} \ln\left(\frac{I_{ph} + I_d - I_{cell}}{I_d}\right) \quad (1)$$

h range current 's is kept very small so that the cell current is maximum [9]. The electrical equivalent circuit diagram of single diode PV system is shown in Fig. 3 as, The cell voltage of single diode PV system is expressed using Eq. (2) [10] as,

Where,

R_s: Series resistance of cell (10^{-3} Ω). s R

R_p: Shunt resistance of cell (10^{5} Ω). p R

C. Climatic conditions

The climatic conditions such as solar irradiation (*Ir*), temperature and wind speed (*W*), affect the PV cell voltage (*Vcell*) and PV cell current (*Icell*). These effects are incorporated in the modeling of the PV systems using the correction coefficients *CIrI*, *CIrV*, *CTI*,

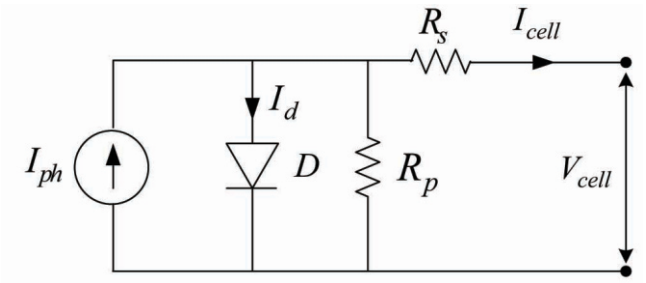


Fig . 3 Equivalent circuit diagram of single PV system

CTV.

The effect of temperature on PV cell current and voltage is expressed using Eq. (3) & (4) as [10],

$$V_{cell} = \frac{AkT_C}{e} \ln\left(\frac{I_{ph} + I_d - I_{cell}}{I_d}\right) - \left(\frac{R_s \times R_p}{R_s + R_p}\right) I_{cell} \quad (2)$$

Where, *T* is the reference temperature and *Tx* is the actual temperature. *Irc* is the reference solar irradiation level and γT is the short circuit current coefficient and *β* is the open circuit voltage coefficient [11].

The effect of change in solar irradiation level on PV cell current and voltage is expressed using the Eq. (5) & (6) as,

$$C_{TI} = 1 + \frac{\gamma_T}{Ir} T_x - T \quad (3)$$

$$C_{TV} = 1 + \beta_T T_x \quad (4)$$

Where, *Ir* is the reference solar irradiation level, *Irx* is the actual solar irradiation level and *αs* is a constant value of 0.2. Hence, by using the correction coefficients *CIrI*, *CIrV*, *CTI* and *CTV*, new magnitudes of PV cell voltage and current can be expressed as,

$$C_{IrI} = 1 + \frac{1}{Ir} Ir_x - I_x \quad (5)$$

$$C_{IrI} = 1 + \alpha_S \, Ir_x - I \quad (6)$$

In the above PV models, the temperature was only dependent on solar irradiation level and the model is static [12]. Therefore, in order to overcome this limitation a new relation is used in which the cell temperature depends on the solar irradiation level and wind speed [13]. The relation of wind speed and temperature is expressed in Eq. (9) as,

Where, *Tmod* is the modified PV system temperature, *W* is the wind speed, *Ir* is the solar irradiation level and *a1*, *a2* & *a3* are the constant values.

$$V_{cell_x} = V_{cell} \times C_{TV} \times C_{IrV} \quad (7)$$

$$I_{ph_x} = I_{cell} \times C_{TI} \times C_{IrV} \quad (8)$$

III. Matlab/simulink Models

A. Ideal PV system

The MATLAB/Simulink model of ideal PV system is shown in Fig. 4 as,

IV. Results and Discussion

The I-V and P-V characteristics obtained from the simulation of above designed PV models are shown in Fig. 6 (a) & (b) respectively. The I-V and P-V

$$T_{\mathrm{mod}} = a_1 . T + a_2 . Ir - a_3 . W \quad (9)$$

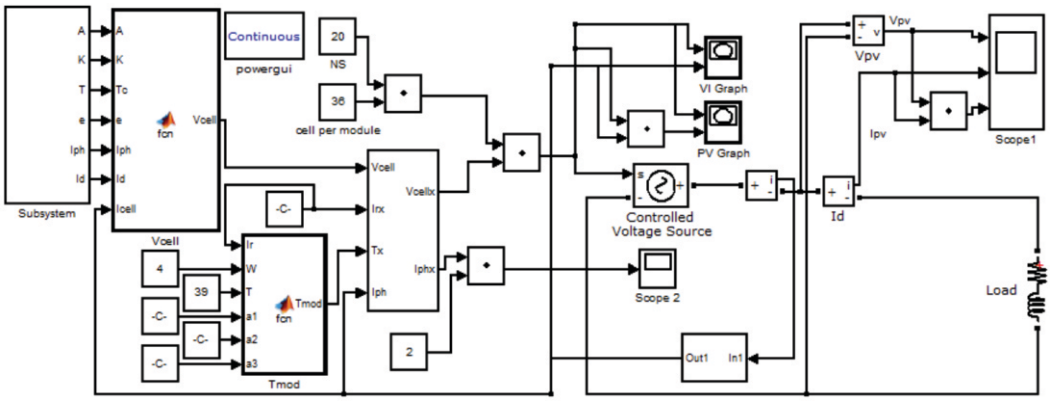


Fig. 4 MATLAB/Simulink model of ideal PV system

B. Single diode PV system

The MATLAB/Simulink model of single diode PV system is shown in Fig. 5 as

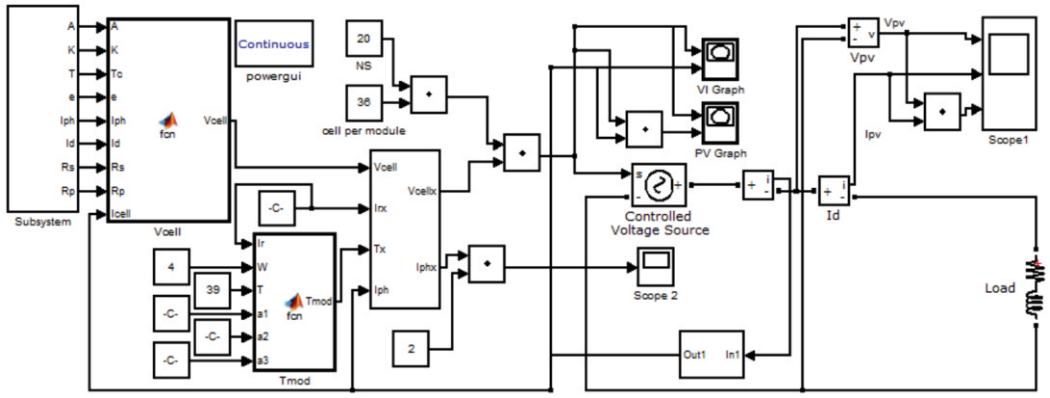


Fig. 5 MATLAB/Simulink model of single PV system

characteristics of ideal and single diode PV system are similar.

From Fig. 6 (a)-(b) it cab be observed that the open circuit voltage and short circuit current of the designed PV

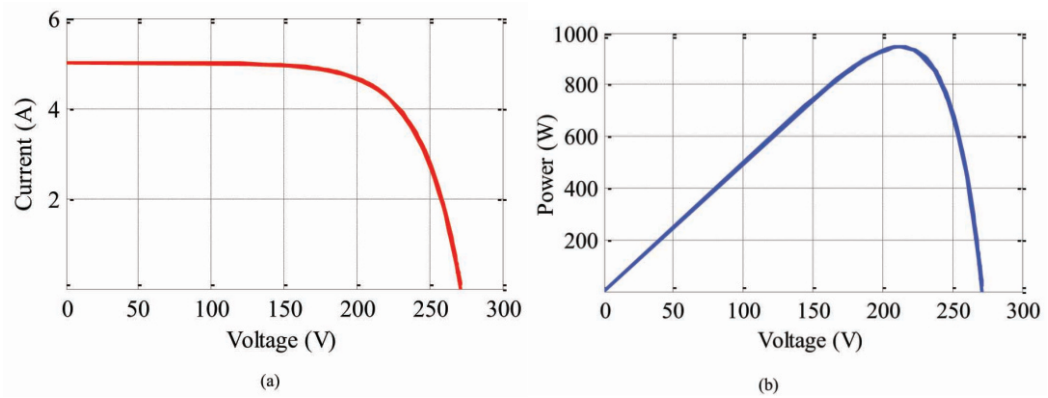


Fig. 6 (a)-(b) I-V and P-V characteristics of modeled PV system

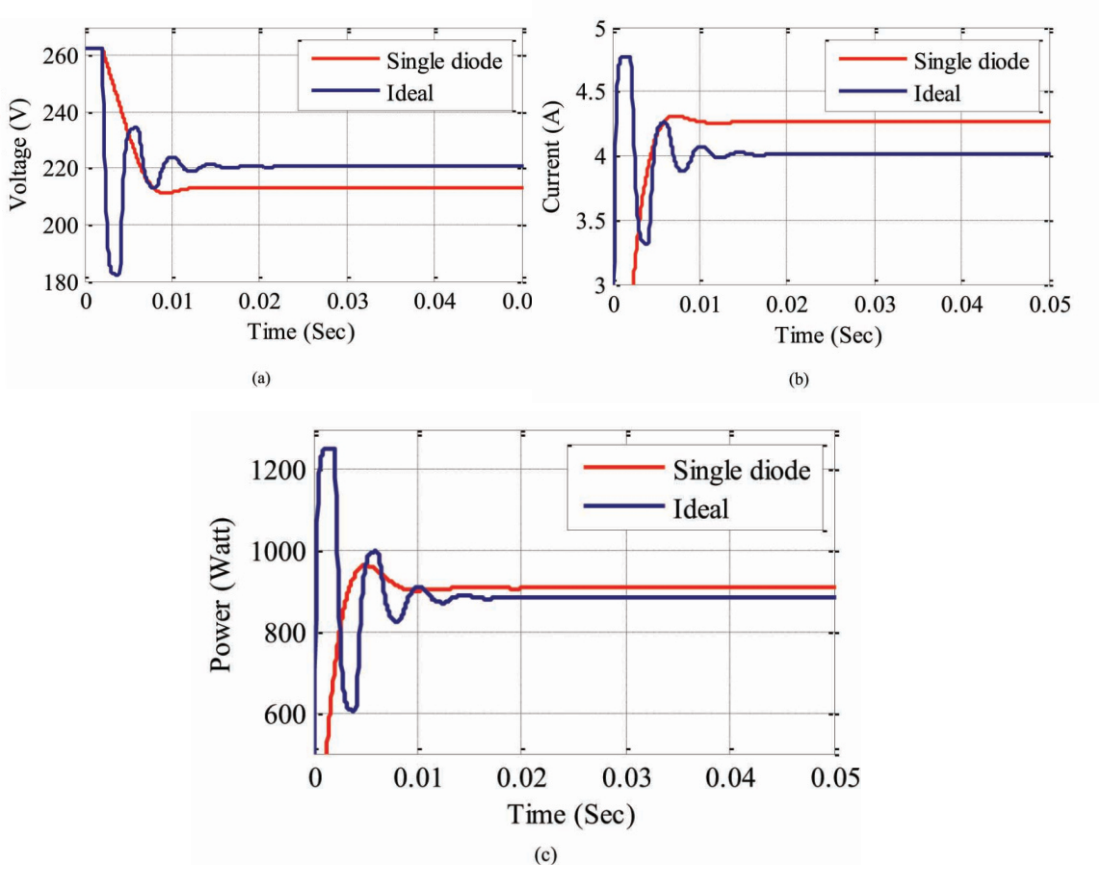


Fig. 7 (a)-(c) Transient analysis of ideal and single diode PV system

system are 269.3 V and 5.1 A respectively.

The comparison of transient analysis of ideal and single diode PV system in terms of output voltage, current and power is shown in Fig. 7 (a)-©.

From Fig. 7 (a)-(c) it is observed that the output voltage of single diode PV system is less that the ideal PV system mainly due to the voltage drop due to the series and shunt resistance connected to it. Furthermore the value of output current is greater in case of single diode as the value of series resistance is very small.

The effect of climatic conditions i.e. solar irradiation, temperature, winds peed is investigated and shown in Fig. 8(a)- (c), Fig. 9 (a)-(c) & Fig. 10 (a)-© respectively.

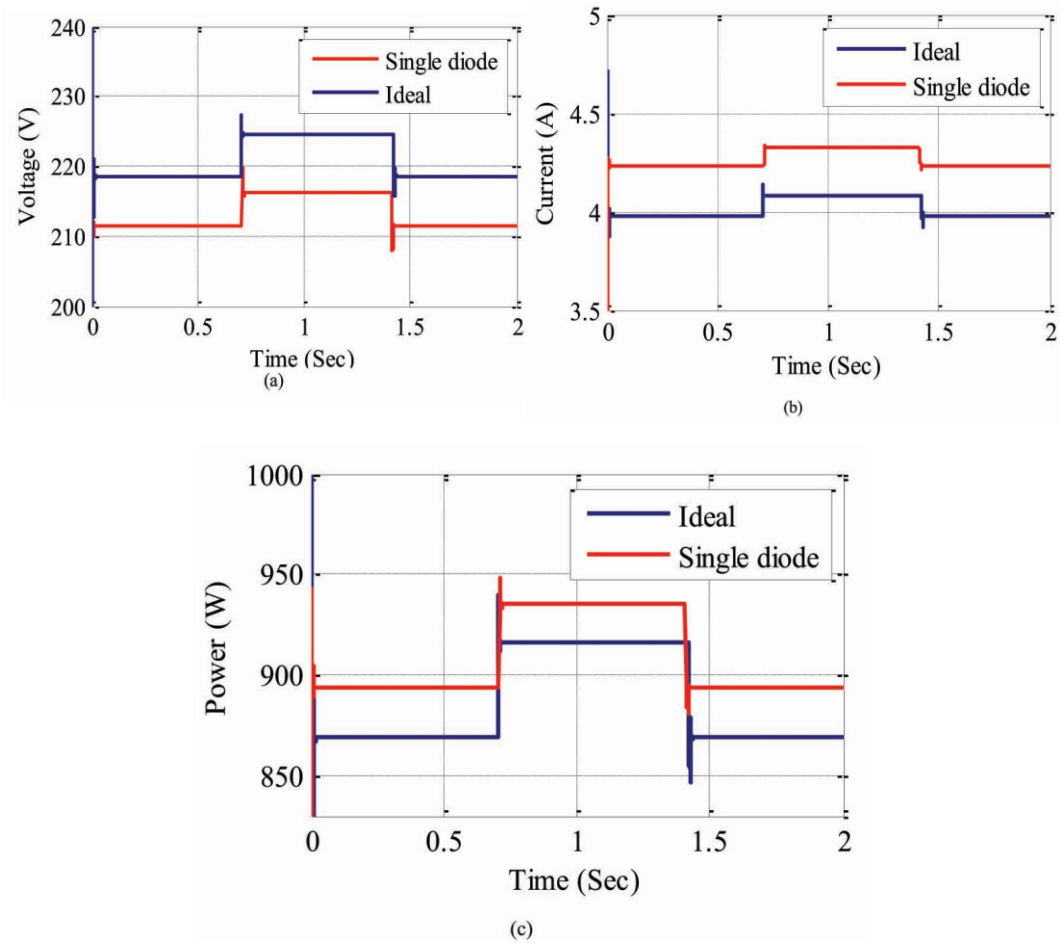


Fig. 8 (a)-(c) Effect of variable solar irradiation.

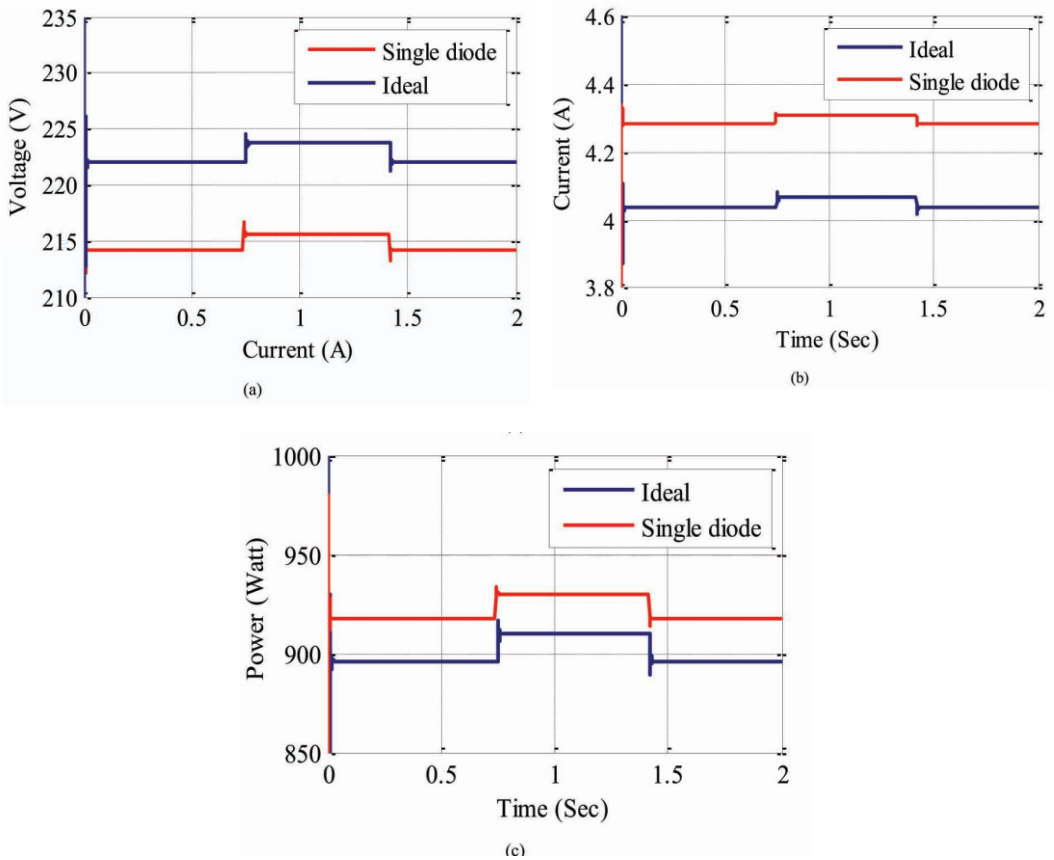
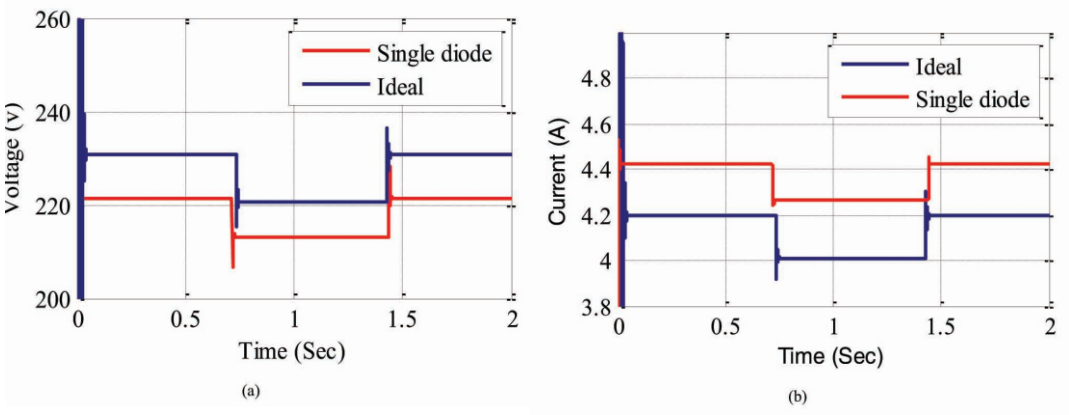


Fig. 9 (a)-(c) Effect of variable wind speed



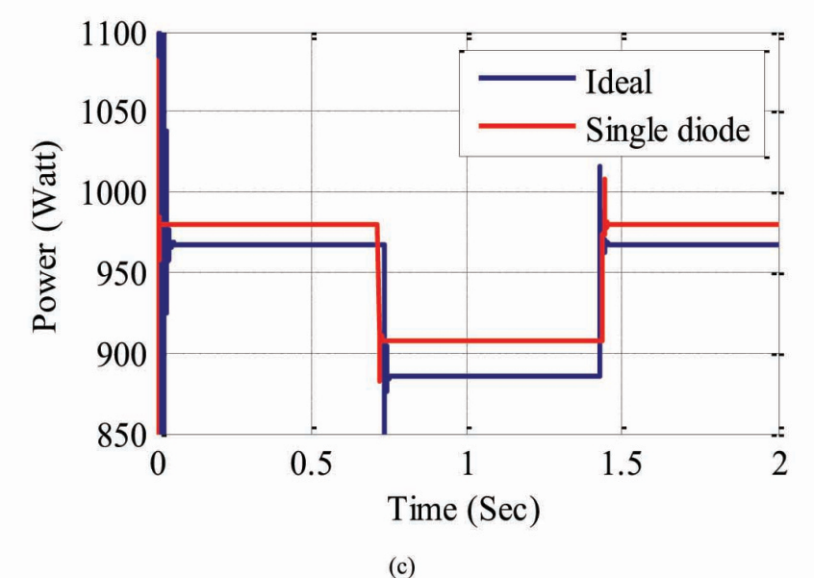


Fig. 10 (a)-(c) Effect of variable temperature

From Fig. 8 (a)-(c), Fig. 9 (a)-(c) and Fig. 10 (a)-(c) it is observed that the change in solar irradiation level has most impact on the output voltage current and power than the change in wind speed and temperature. Furthermore, it is observed that the change in solar irradiation and wind speed are directly proportional to the PV output voltage, current and power whereas the change temperature has inverse effects on PV outputs mainly due to increase in resistance as the temperature increases.

Conclusion

In this paper, modeling of ideal and single diode PV system has been done and a comparative transient analysis is made in terms of PV output voltage, current and power. Furthermore, both the models are analyzed under varying climatic conditions such as solar irradiation, wind speed and temperature. It can be concluded that change in solar irradiation level have the greatest impact on the PV output voltage, current and power among the three considered climatic conditions. Furthermore, it is concluded that the modeling of the ideal and single diode PV system is successfully done and the acquired results shown satisfactory performance.

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