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E-Learning Methods for Teachers to Play Dual Roles-As a Facilitator and a Leaner during Pandemic

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Chapter - 1

E-Learning Methods for Teachers to Play Dual Roles-As a Facilitator and a Leaner during Pandemic

Dr. Ganga G

Abstract

It is almost a year passed since the covid Pandemic started at the Wuhan City of China. The whole world had transformed into a new world of the day-to-day life. Education is one of the major areas where great transformation had occurred. Even from the Kinder garden to the higher education sector a drastic transformation had occurred, this chapter looks at the prospects and benefits of E-learning for the future education system even in the middle of such calamities and crises. The new normal had indeed opened a new window for the future education sector where there no boundary in the world between nations.

Keywords: e learning, covid 19, e-learning methods advantages

1.1 Introduction

Many countries around the world closed schools, colleges, and universities in response to the COVID-19 epidemic in order to stop the virus from spreading. The word "fresh normal" has been one of the most commonly used words in the aftermath of the pandemic. The expanded use of online learning resources has become the new standard of education. The COVID-19 pandemic has prompted new approaches to education. Educational institutions all over the world are turning to online learning sites to continue the process of educating students. The COVID-19 crisis has compelled educational institutions all over the world to seek out alternatives to face-to-face teaching. As a result, teachers and students have been using online teaching and learning on a massive scale.

The new standard now is a transformed educational concept, with online learning at its core. Students and schools all over the world now use digital learning as a required resource. This is an entirely new way of learning that many educational institutions have had to embrace. Online learning is now used not only for academic purposes, but also for a variety of other purposes.

Online learning, like most training methods, has its own collection of advantages and disadvantages. Decoding and comprehending these positives and negatives will assist institutes in developing methods for more effectively delivering lessons and ensuring that students have an uninterrupted learning journey. Transition of offline to online mode was hasty at the beginning but when it comes to practice the on-line mode made a drastic changes in the mode of teaching learning methods in an effective manner. Online learning is becoming increasingly popular, whether for convenience, to accommodate work hours, or simply to have the ability to study from anywhere. And now, more than ever, with the coronavirus pandemic forcing people to stay at home, it's more critical than ever. Government and institutions have taken steps to encourage staff and students to complete their daily tasks from home, proving that it is possible. As the new system introduced in education E- teaching learning methods are new to many teachers who were trained for conventional mode of teaching methods. E-learning techniques are new and many advanced technologies are involved in it; teachers played dual role as learners and facilitators for the smooth, effective implementation and impart of education during Covid pandemic situation.

This chapter discuss on how the new transformation in education effected the education system during the pandemic to continue the system of education throughout the world.

Current education system demand that the role of a teacher is not merely imparting knowledge the but to act a role in multiple manner. Teachers are considered as an architect of future generation. Teaching needs patience, passion towards profession, expertise not only in her or his own subject of teaching the styles of teaching, teaching methodologies and strategies, correct usage of evaluation techniques and the psychology of the students as well as the ability to motivate the students. To excel in teaching a teacher needs willingness to learn change herself in accordance with the need of learners and design and impart curriculum and teaching methodologies accordingly.

The current Covid crisis led our whole education system in to world of knowledge sharing. Online teaching and education become the need of the hour and it get a wide acceptance throughout the world. Opportunity of learning and imparting such gained knowledge through technology-based education is increasing. Getting familiarised with online platforms and adaptation to new learning world environment is challenging but beneficial for both teachers as well as students. Adapting to address the current demand need hard work and perseverance. Sticking on to old fashioned methods and traditional mode of education needs to refurbished. This change needs to instil effectives measures to fulfil the need of young talents.

Beginning of any new system needs adaptation period, especially when it come in education sector which is considered as an important back bone of social development. A well-suited education system needs to be rooted in a such manner that it will help in moulding up of students as per their need, keeping that in mind educational institutions should motivate and prepare teachers to make them adaptive with new system of E- learning. Online based education needs understanding various possibilities of E.teaching and E.learning resources. Learning is a process where new knowledge, skills and attitudes are achieved through an immersive and concrete learning experience. For that a teacher should that every teacher should act a dual role as a student and as a teacher and he or she should be well aware of "What are the avenues available for a blended learning to Implement teaching?" How to conceive those technologies or methodologies to improve one's pedagogy?" How to manage an on-line course in effective manner "What would be the outcome based to such education system?

This chapter tells about various ways how to conduct an online teaching in an effective manner. This chapter discuss about various methods in how E-learning can be performed effectively.

1. "How conduct online course and how it can used as an active learning model?

The conduct of an online course we need to understand various- e learning strategies. To implement an e. Learning programme, we need to classify the e learning programmes in to different categories. such as, Active learning, motivation. Feedback and assessment. By gathering the information obtained from afore said programmes teachers can create various courses and design their E-learning courses in an effective manner.

Active learning

Active learning is a student centric process in which certain strategies suggest how to put students into the centre of their learning process. Active learning also helps students to engage students into their learning progress. E-learning processes is not just mere classroom learning, teacher cantered classroom lecturers, tutorials and presentations. Students get a chance to get involved in self-learning activities and other active learning strategies. In active learning many activities are put together to improve the active learning of students through various platform.

Bonwell, & Eison, 1991 suggest idea about active learning approach. According to them active involvement of students is very important in student centred learning. Engage student in activities that impart knowledge and

support knowledge gain through internet and media-based technologies. This sort of learning should design in a such way that it should impart a forceful mode of learning but it should help themselves to investigate and create critical level of thinking

Some of the strategies promoting active learning in the classroom are

- Engage students in active learning methods like reading, discussing, and writing.
- Make them involved in activities of more than mere listening in class.
- Give emphasis on skill development than transforming mere information.
- Impart the learning activities reflect real life tasks.
- Give emphasis is placed on students' exploration of their own attitudes and values.

Active learning is based on key principles suggested by Barnes 1989 the principle of active learning are as follows

- **Reflective:** The learner reflects on the meaning of what is being learnt.
- **Purposive:** The task is seen by the learner as relevant to his/her concerns.
- **Situation-driven:** The learning tasks arise out of the needs of the situation.
- **Critical:** The learner appreciates different ways of interpreting learning.
- **Complex:** The learning tasks reflect real life complexity.
- **Negotiated:** The teacher and learner negotiate the goals and methods of learning.
- **Complex:** The learning tasks reflect real life complexity.

1.2 Motivation

Motivation is needed to create a positive attitude in learners and strategies need to employed which enables them to take part in learning activities in effective manner. Create a platforms or methods to engage students in motivational learning process is also required.

Motivation if found to be the key in Success of E-learning for students. Motivation directly or indirectly affect the E-learning process in many ways.

Keller & Burkman, 1993 provides an ARCS model systematic approach in the design of the motivation-based learning system approach. There are four major components that need to be satisfied in order to construct a learning system and applications, which can motivate learners.

These four components are as follows:

1. A-Attention
2. R-Relevance
3. C-Confidence
4. S-Satisfaction

Attention

To make students attentive in class is a prerequisite for any learning process. Due to the absence in face-to-face interaction direct method to measure the attentiveness of students are not possible. On line classes and lectures should conduct in such a way that it should ensure the attention of students in an optimal level. The material presented before leaners should be keep them engaged and self-explanatory.

Keller & Burkman, 1993, Picar, 2004 developed certain methods to catch attention are as follows

- Cartoon based /humour based
- Life example based
- Active student's participation needs to be involved (using interactive multimedia learning methods)
- Inquiry based
- Methods involve to Stimulate Perception
- provide incongruity and conflict-based concepts

Relevance

Teaching system should provide relevant study materials and classes to achieve their set goals. Relevant contents, general guidelines and structure given in syllabus need to be explained and made the students to understand how important every topic is. Teachers should design e-learning content to fulfil the syllabus-based content. A prior orientation for learners is needed in this regard. Keller & Burkman, 1993 developed strategy for relevance-based topic learning

- Orient the goals of the students according to lesson.
- Show them examples of successful candidates.

- Explain the worth and benefit of the course.
- Show the learning outcome of the course.
- Match their needs with the course.
- Give lecture-contents that present familiarity.

Confidence

Develop confidence and self-esteem in students is basic idea about any learning. To enhance confidence level in an e-leaning program learner performance needs to focused. Learners develop a confidence by themselves after accomplishing a given task in better manner. There should be various level of learning task with respect to their learning process. According to Keller & Burkman, 1993; Picar, 2004 Various confident building strategies of learners are there

- Constant Monitoring the learning requirements.
- Adaptive learning strategies.
- Knowing the expectation of students and try to satisfy those.
- Presenting tools for goal setting-scheduling.
- Feedback analysis and prompt actions.

1.3 Feedback

Feedback is one of the most important factors to ascertain if the learning is properly executed or if serve the purpose. Improvement and quality assurance of any learning process need a good feedback. In distance learning (also e-learning) the feedback system is effective and information collecting through feedback system valuable due the absence of face-to-face interaction Teachers need to understand the importance of feedback and how to use it for further refinement of teaching learning practices. To implement feedback-based curriculum improvement is effective in any learning.

1.4 Evaluation and Assessment

Evaluation and Assessment is very important to measure the extent of learning has achieved. The evaluation process helps teachers to asses how learning process goes? It helps learners to make sure if they are confident enough to comprehend and execute what they have learned in real life. There are different ways in which evaluation can be made based on understanding Bloom's taxonomy level outcome-based education model. To impart effective evaluation, methods needs to be developed to asses' various levels of understanding Summative and Formative assessment are the two major types of assessment in which are used in E-learning system.

Satisfaction

In E-learning system learning activities need to be design to make the learners comfortable and get satisfied in their learning process. Student satisfaction survey needs to be conducted based on survey effective measures needs to be implemented. According to Keller&Burkman,1993 the teachers can enhance the student satisfaction with following strategies

- Provide compliments or achieving targets.
- Encourage with positive outcomes.
- Never discourage a learner with punishments.
- Keep transparency in evaluation and fair in their result.
- Design the course according to the student's expectations.
- Transfer knowledge into real world settings.

Design a Web Based System to achieve ARCS goals in E-learning system with web-based software's with various ARCS components need to be used. A E-learning system with a course module must have following specifications (Shellnut, Savage, & Knowlton, 1998; Ardito *et al*., 2004: Perrin, 2005: Chen & Chen, 2006).

- To implement motivational strategies
- To filter and choose best motivational strategies for different users
- To support creation-storage and delivery of motivational work flows and objectives.
- To report-evaluate motivational results after each learning sessions
- To support the online communication
- To HELP options to enhance more user satisfaction
- To provide visuals to understand concept easily
- To include interactive tools of learning
- To support self-regulated learning tools
- To support the guided sequence of steps in each lesson

The online learning system can help educators to implement more educational teaching strategies however, the instructors also need to be conscious about the need of monitoring their students' performance-motivation levels also. Within the help of ARCS model strategies, the e-learning tools can be more beneficial to students to keep them interested-attended to the class.

Available e-learning technologies and tools for e-learning and e-teaching

To conduct an on-line course free open-source software and tools are prerequisite. There are several commercial tools readily available and free tools are available to perform the purpose. The quality, ownership value, validity and reliability of open-source software are sometimes needing to be validated and a comprehensive understanding in this respect needs to be taken account.

E-learning tools and methods

The digitization of education is captured its momentum at its paramount which help us shift in to new transformed education environment. Many avenues are available with teacher friendly and student friendly platforms. Designing of such eLearning platform is a challenging and is the most demanding methodology in higher education sector. In design of e-learning course, there are several factors needs to be taken care of

1. Learning content

Based on need and types of learners, content of E-learning can be categorised. The most common learning contents are

Learner-centred content

Designing of E-learning curriculum based on specific need of learners is taken account. Relevant topics will be selected in such a way that it will help them to take up various roles and responsibilities in professional life**.** Learners centred content such as skills, knowledge and all kind of learning media provided to keep the focus on learner's end.

Engaging content

Engaging learners with various methods that will help them to actively participate in learning process**.** Instructional methods and techniques should be used creatively to develop an engaging and motivating learning experience. Create and design student-oriented hands-on working activities is a way to engage learner through e-. learning platforms.

Interactive content

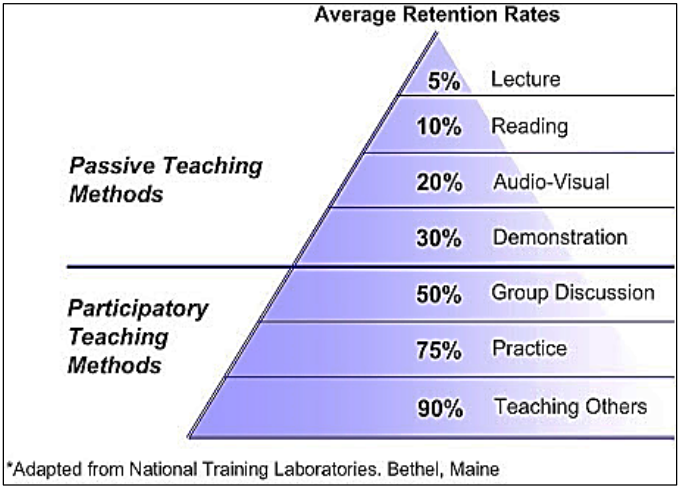
Teacher learner's interaction is needed to sustain attention and promote learning. Setting up of situation-based learning is a good example for this kind of learning media.

Personnel attention and progress evaluation

Content of the courses should be customed with respect to learner's interests and needs; in instructor-led courses, tutors and facilitators should be able to follow the learners' progress and performance individually.

Design the e-learning content

Design a learning content is the most important part of eLearning process. content designing should be made by conserving the learning pyramid.



Learning pyramid created by National Training Laboratories in Betel, Maine comprises of various levels of learning. The first four levels lecture, reading, audio-visual and demonstration are the passive learning methods. The bottom three levels are active learning methods comprised of discussion group, practice by doing and teach others and are also called as participatory learning methods. Letrud, Kåre (2012).

To choose a right E learning method, the learning pyramid method can be adopted. E-learning content of various types can be created with the help of E.-learning resources and advanced tools. E-learning resources management raining should be employed to train teachers. Create passion and interest in teachers to learn new technologies to abate with change in new technology is very important, though there are various types of E-Learning solutions that can be employed to train the learners, institution and Universities should take effort to make to ensure that if they are provided with right platform with respect to their subject or content they teach. E-Learning methods are of two types depends upon the learner's need and the learning objectives the first one is Synchronous in nature and second one Asynchronous in nature.

Synchronous methods and asynchronous method of e-learning

Synchronous learning

In synchronous type of learning the learning process events take place in real time. An effective communication is prerequisite for such sort of learning.

Learning are chat and IM, video and audio conference, live webcasting, application sharing, whiteboard, polling, and virtual classrooms. Are synchronous learning.

Asynchronous learning

In asynchronous learning the learning takes place at Learners will. It is a learning process that take place at time -independent manner. Learning on line courses or self -paced course are example of Asynchronous learning. E-mail or discussion forums are the major communication tools. Used in asynchronous learning. Learners can study the course at their own pace, by using various Learning Platform like an LMS. Self-paced (SCORM), Audio/Video, E-mail, Discussion forum, Wiki/Blog, Webcasting/ Conferencing, CBT and WBT, Simulations and Game-based learning. Multimedia, Graphics, Assignments, Note's collection with special digital tools- note, journal; On- line discussions; Simulation or application software are some of the learning methods that comes under asynchronous learning. Learning Methods adopted from the Asynchronous mode of learning are the most widely acceptable mode of E-. learning practices worldwide. Any learners can choose E-Learning methods based on your requirement and Learning Pyramid Analysis.

Computer based learning and web-based learning

This is asynchronous mode eLearning plat form and courses can conduct in a self-paced manner. In Computer-based learning courses are made available to the learners in the form of a CD or a Computer-based training (CBT), which can be run on the learner's system. In web-based learning (WBT) internet can be used as learner platform. Various learning management system are freely available for to teach as well to learn. This sort of learning method is well suited for learner to learn new skills, update knowledge in their respective field, update their resumes and attain professional excellence

Self-study

Self-study is very important and one of the major modes of study utilised by many students and as well as teachers. To improve the learning skills in teaching this is one the most effective method of teaching which is successfully achieved by many teachers and student leaners. The most common method which uses wiki, blog and any reading material like ppt, pdf files etc. Subject are available in internet platform for group of learners to resolve their queries and doubts.

Video/audio tape

Another mode of synchronous learning which learners can listen on watch the case at their own pace. This is one of the common methods to create demo video to train the learners. This method also will help to create learning asset which help the learner know about the basics by watching.

Blended e-learning

This is an instructor led training method which has a combination of synchronous and asynchronous learning**.** A part of the study will have a face-to-face component and other part will be using LMS or other asynchronous mode of learning. A blended approach works best here -where the classroom is utilized to conduct exercises and interactions. Meaningful peer interaction is possible in this approach. Teacher and student interaction are possible which help to build a teacher student relation too. There are few exercises or training which involved peer interaction or group activities. Blended learning approach is widely accepted approach and have many advantages than all other E-learning approaches throughout the world. In this method Learners can be allowed to prepare a background study prior to the class. Short E-courses can be created by teachers to help learners to prepare well in advance.

Mobile learning

Mobile learning is most easily and cheaply affordable learning method available for learners. as mobile devices are easily available for all learners. However, designing of course content for mobile compatible mode is taken in to consideration while using mobile based learning. The capabilities of the mobile device, including disk space, internet connectivity, and the screen size has to be taken into consideration. Authoring tools are needed to designs and developing a mobile based E-course.

Social media learning

Using social media as learning platform is becoming very popular now a days and is strongly utilised by many learners across the world. Face book and WhatsApp are the widely accepted media of learning which is widely used in synchronous and asynchronous mode of learning. The social interaction between peer leaners and teachers can be enhanced by this method of learning. The network of social platforms can use to discuss problems, queries, and can share experiences. Learning management system can be utilised by social collaboration platforms so that the learners do not have to discuss on public platforms and the learning which emerges from mutual collaboration resides and grows within the LMS.

Simulation and software-based learning

E-learning by Simulation or software based is highly interactive and relies heavily upon graphics, video, audio. Ecorse content can be developed using custom simulations videos or games, which could very well include 3D components. Graphics and virtual E-training contents are proved to be suitable methods in this context.

Choosing the right eLearning methods, totally depends upon the proper need analysis and upon the nature of the learners and their requirements. Understanding the benefits of choosing the right eLearning methods will help to design a new E-learning course of your choice, To cater the need of learners flexibility and choice of E-learning methods can be provided this will enhance the E-learning experience in a satisfied motivational finally they can achieve their set goals effectively.

Tools for e-learning

There are many tools available for designing e-learning materials. These tools can effectively utilised to perform E -learning courses effectively. Some of the tools can effectively use in higher education system are

Audio recording

Audio recording helps E-learning process simple and effective. Teachers can record their classes using record facilities available in their computers and mobiles and later can convert it in to digital mode. edit MP3 files, mix sounds together and change the sounds dynamics in the recordings with the help of audio editing tool Audacity is an example of such tool (http://audacity.sourceforge.net/) is a free audio editor and recorder. This tool also can be used to record an MP3 file to be used in the podcasting.

Program image editing

This provides educators and students with an intuitive, easy-to-learn photo editing methods. Teachers can utilise this tool to create – edit graphics and photo file for their lessons. This tool helps to create and modify many of the known digital photo file. The GNU Image Manipulation Program (http://www.gimp.org/) is an example for a photo editing tool.

Screen recording

Recording a screen helps teachers to show slides and explain information's that they have in their computers or mobiles. This will also enable screen recording for teachers can have tutorial and presentation on how to use software applications. Zoom plat form Flashback Screen cast-O-matic

and Wink (http://www.debugmode.com/wink/) are certain plant form and tools to serve this purpose very good tool to achieve this purpose. Using these tools teachers can capture screen shots, add some labels to the video and have a step by step.

Web content design-development

The web content design will help teachers to publish the online content or course material developed and they need to embedded in web-based system. There are various application and software available in this regard. eXe (http://exelearning.org/) is an application that help teachers to create, edit, format web content, package and export resources in IMS Content Package, SCORM1.2, or IMS Common Cartridge formats. There is another tool called my Udutu (http://www.myudutu.com/myudutu/login.aspx) that help teachers and give the opportunity to have collaboration online, and stencil-based editing.

Learning management system tools

A learning management system (LMS) is a software application for the administration, documentation, tracking, reporting, automation and delivery of educational courses, training programs or learning and development programs. The learning management system concept emerged directly from e-Learning.

LMSs are focused on online learning delivery but support a range of uses, acting as a platform for online content, including courses, both asynchronous based and synchronous based. An LMS may offer classroom management for instructor-led training or a flipped classroom, used in higher education, (Davis *et al*. 2009). There are various freely tools available for LMS google class room is most widely accepted and extensively using platform by teachers and learners.

Moodle

According to Moore (Moore, 2005) one of the main advantages of Moodle over other systems is a strong grounding in social constructionist pedagogy. Moodle can run any kind of servers hosting the PHP engine (Unix, Linux, Windows, and Mac OS X). The Moodle also uses database support (which is costly to get a license also) freely on MySQL and PostgreSQL. Moodle (http://moodle.org/) is designed to help teachers to create almost any kind of online courses. Moodle can use commercial databases such as Oracle, Access, Interbase, ODBC and others. It can support over 40 languages (most of them are also developing countries languages). The available tools and

modules of Moodle are design tools, site management, user management, course management, assignment module, chat module, choice module, forum module, journal module, quiz module, resource module and survey module.

LAMS

According to LAMS Foundation, 2008LAMS (http://www.lamsinternational.com/) is a new tool for designing, managing and delivering online collaborative learning activities. LAMS gives the opportunity to the teachers to create a visual learning environment with such activities as individual tasks, small group work and whole class activities. LAMS can be used as a standalone system or in combination with other learning management systems (LMS) such as Moodle, Sakai, LRN, Web CT and Black Board. The available LAMS tools are assessment, branching, chat and forum, image gallery, journal, mindmap, scribe, shared resources, spreadsheet, survey, task list, voting and wiki.

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Chapter - 2
Sanitary Napkin: A Solution in Menstrual Hygiene

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Chapter - 2

Sanitary Napkin: A Solution in Menstrual Hygiene

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Abstract

Menstrual hygiene and sanitation are the most challenging development issues today. But in rural areas, only a small percentage of women have awareness on menstrual hygiene. Poor hygiene during menstruation can cause fungal infections, RTI, cervical cancer and vulnerable to infertility. So proper hygienic practices such as the use of sanitary napkins are very essential during menstruation. It is nessessary to every women to use of clean and comfortable absorbent sanitary products which apart from ensuring proper hygiene would also protect their health.

Keyword: menstrual, hygiene, sanitation, napkins, infertility

Introduction

Menstruation is a natural process that is key to maintain the reproductive health of a woman. So, proper menstrual hygiene management is an essential aspect of feminine health but unfortunately, that is neglected due to illiteracy, socio-cultural beliefs, poverty, lack of sufficient menstrual awareness, etc. (Israr & Nasir 2012). Women of reproductive age require clean and comfortable absorbent sanitary products that will provide proper hygiene to protect their health. Sanitary napkins are one of the hygienic practices that useful during menstruation (Misra *et al*., 2013).

The Sanitary napkin is a product of nonwoven textiles that comes under the category of health & hygiene Products (Nyoni *et al*., 2014). It is a kind of protection used by women during menstruation for the absorption of menstrual blood for hygiene purposes (Mishra, 2017). Sanitary napkin comes in various sizes, absorbency, and materials and comprises a layered structure design made of blends of plastics, rayon, and cotton. Pads should include wings to prevent leakage and keep the pad more securely in place (Unicef, 2019). Women wear sanitary napkins to protect menstrual fluid. In developing countries like India, only a small percentage of women use

sanitary napkins. The primary reason for using this is affordability to buy sanitary products (Petchimuthu *et al*., 2019). Today Menstrual hygiene is the most challenging development issue. In developing countries like India, out of 355 million menstruating women, only 12% of women use sanitary napkins (Nielsen, 2010). Over 88% of women use un-sanitized cloth, ashes, and husk sand to manage their menstrual flow (Goyal, 2016). In India, around 70% of women say they can't use a sanitary napkin as affordability is the biggest barrier to them and it increases the percent of Indian women who suffer from "Reproductive Tract Infections"(Sinha, 2011). In the market, there are non-biodegradable sanitary napkins are available now which affecting the health of women. Recently, to overcome this challenge, biodegradable sanitary napkins are made from natural materials that are eco-friendly and cost-effective. (Petchimuthu *et al*., 2019).

Nowadays, people are concern about their good health and sanitation, and it increases the demand for antimicrobial textiles among consumers (Nadeem, 2019). The products of antimicrobial textiles have been widely using in the hospital, hygiene, and healthcare sectors. Also, the products are used in hotels, homes, and other environments where hygiene is required. Both in developed and developing countries the demand for products of medical textile is immeasurable (Rajendran & Anand, 2006).

Materials used in a sanitary napkin

Absorbent filler: The fillet material which is used as an absorbent filler in sanitary napkin should be such as cellulose pulp, cellulose wadding, tissue, cotton, etc, and it must be free from lumps, oil spots, dart, or foreign material (IS: 5405 • 1980).

Covering: Good quality cotton or rayon knitted sleeving, gauze or non-woven fabric with sufficient porosity should be used for covering the absorbent filler to permit the assembled pad to meet the absorbency requirements (IS: 5405 • 1980).

Barrier sheet: Non-biodegradable plastic like polyethylene and polyurethane is widely used in the protective film in sanitary products. But these plastic materials can be replaced by bio-based plastic prepared from starch (Barman *et al*., 2017).

Design and construction of a sanitary napkin

The primary function of sanitary napkins is to absorb and hold off menstrual blood (Kaur, 2014). The sanitary napkins contain a three-layered structure design with a top fluid transferable layer, an absorbent core, and a

barrier sheet and each layer have a clear cut own function to perform (Pohlmann, 2016).

The top sheet is the external layer of a sanitary pad that is designed for transferring the menstrual fluid quickly from the top layer to absorbent layers and feces to the layer underneath. On the top sheet material, emollient or lotion is applied to skin softness and also to gain protection from irritation (Woeller & Hochwalt 2015). The top sheet layer is made of perforated polypropylene and/or polyethylene nonwoven which is in direct contact with skin (Ajmeri & Ajmeri 2010).

In modern napkin design, an optional acquisition layer (also called the distribution layer) may exist for the pads between the top sheet and the absorbent core (Kosemund *et al*., 2009). A cellulose patch and a polyester nonwoven are used to compose this layer, and the function of this layer is to facilitate the spread of fluid evenly across the entire area. Besides, this layer helps to prevent fluid reflux by retaining the fluid and transfer the fluid to the next absorbent layer (Bae *et al*., 2018).

The primary function of the absorbent layer is to absorb and retain the menstrual blood (Barman *et al*., 2017). The absorbent layer is developed by a blend of superabsorbent polymer particles and cellulose pulp that are encapsulated by cellulose or polypropylene nonwoven (Barman *et al*., 2017). The sodium polyacrylate granules are used for making the superabsorbent polymer (SAP) and it is modified into a gel-like substance so that it would not pull back. (Bae *et al*., 2018). When it is wet, it absorbs up to 50 times its weight liquid (Rajendran & Anand, 2006). The absorbent core absorbs liquid quickly and transfers to SAP due to cellulose pulp present in the absorbent core. After that, the blood fluid is locked and stored in this layer even the pressure is applied on the pad. (Bae *et al*., 2018).

The barrier sheet layer is designed to protect the fluid from staining or leakages (Shishoo, (1992). The polyethylene or polypropylene film laminated with polypropylene nonwoven is widely used for making the barrier sheet of the sanitary napkin (Wang & Jin, 2010). A panty-fastening adhesive substance is adding to the napkin for the backing (Woeller & Hochwalt 2015).

Antimicrobial finishing

The microorganisms such as bacteria and fungi are found almost everywhere in the environment and can increase quickly when basic requirements such as moisture, nutrients, and temperature are met (Maleknia *et al*., 2010). Subdivisions in the bacteria family are Gram-positive

(Staphylococcus aureus), Gram-negative (E-Coli), spore-bearing, or non-spore bearing type. Pathogenic and cross-infection are some specific types of bacteria. (Gopalakrishnan & Aswini., 2007).

The direct contact of material with the skin easily develops the microorganisms. Sanitary napkins are such materials that are highly vulnerable to bacterial infestation, contributing to diseases of the body (Boryo, 2013).

The sanitary napkin should be treated well otherwise it may bring considerable problems. The sanitary napkin-associated infections may occur from some bacterial and fungal organisms **(**Mishra, 2016). When the drops of blood are excreted from the body the bacteria may grow on menstrual blood. The sanitary napkin surface may have bacteria numbering up to 107 per square centimeter when the napkin is used continuously for two hours and this impurity may seriously affect the health of the women(Davies, 2011). Therefore the sanitary pads should be designed under the control to prevent infections. To inhibit infections in the sanitary napkin, the fabrics should have antimicrobial activity. The antimicrobial finishing process can prevent the growth or reproduction of at least some types of microorganisms (Blackburn, 2004).

A variety of antimicrobial finishing agents are available that may impart a significant effect in textile fibers to inhibit the growth of microorganisms (Patel & Tandel, 2005).

The organic antimicrobial agents for the antimicrobial treatment are quaternary ammonium compounds (QACs), N-Halamines, Polyhexamethylene Biguanide; triclosan, silicon-based quaternary agent, have been used (Allent, 2006). Besides, iodophors, phenols and thiophenols, heterocyclics, inorganic salts, nitro compounds, urea, amines, and formaldehyde derivatives, have been used for antimicrobial effect on textiles (Ristic, 2011).

Inorganic finishing agents such as metal oxides, copper and zinc, titanium, magnesium, silver, and gold were used for antimicrobial treatment on textiles. These finishing agents showed good durability for cellulose, protein, regenerated and synthetic materials with MIC value 0.05-0.1mg/versus gram-negative bacteria, E.coli. One of the wide acceptable inorganic antimicrobial agents is silver that kills microorganisms by blocking and disengages the intracellular proteins. (Afraz *et al*., 2019).

The natural plants that possess the efficient antimicrobial property and applied for antimicrobial treatment on textiles such as Neem extracts, Prickly

chaff flower, Azuki beans, Aloe vera, Turmeric, Clove oil, Tulsi leaf, etc. (Yasotha *et al*., 2019).

Silk sericin is a natural macromolecular protein that constitutes about 25-30% of silk protein. It has antibacterial, UV resistant, oxidative resistant, and moisturizing properties that suitable for antimicrobial finishing agents on textiles. (Joshi *et al*., 2009).

Important properties of the sanitary napkin

The primary property of a sanitary napkins is to protect against leakage. (Pancholi Naik, 2008) It should be comfortable as the napkin is used throughout the day during menstruation and should have the absorptive capacity to retain menstrual fluid (Teli *et al*., 2015). Other important and desired properties are odorless, stay in place, infection and irritation-free, hygienic, high-quality bio biodegradable, and no unaesthetic appearance (Ajmeri & Ajmeri 2010).

Sanitary napkins selection

The selection of sanitary napkin is a personal decision that depends on user preferences and cultural acceptability. There are also many options like funds, water supply, affordability, etc. that are influenced by a user. (Sarah *et al*., 2012). Cultural acceptability, availability, affordability, comfortable absorbency are also considered as the primary factor while selecting a sanitary napkin (Mburu & Kinyanjui, 2013). The choice of the sanitary napkin is varying among rural and urban women and girls. In rural areas, reusable cloth napkins are preferred most by girls and women and in urban areas, women and girls prefer to use commercial sanitary pads (Kaur *et al*., 2018).

Reusable and washable sanitary napkin: The napkin contains several layers of absorbing fabric as well as an underlining plastic-coated fabric that serves as a leak-proof barrier. Fleece or cotton is used as an absorbing fabric (Larsson and Olsson, 2014). The napkins are usually accomplished with a napkin holder that secures the placement in the underwear (House, *et al*., 2012). These cloth pads are cost-effective, easily available, and environment friendly. The brand names Saafkins and Safepads are very popular in the market as reusable and washable sanitary napkins (Nayak, 2017).

Disposable commercial sanitary napkin: These are worn to absorb the menstrual flow. After a maximum use of 8 hours, they are disposed of. Commercial Sanitary napkin comes in various sizes, absorbencies, and materials. The girls and women are most often preferred as they are reliable,

hygienic, comfortable, easy to use, and no access to water requirements for cleaning(Unicef, 2019). They are nonreusable, and not very environment-friendly. The used cotton in making is not 100% and may have pesticides (Kaur *et al*., 2018).

Disposable biodegradable sanitary napkin

Bamboo fibre napkin: In this napkin, Bamboo pulp is used instead of wood pulp as an absorbing material. The napkin has a more absorbing capacity that wicks water 3-4 times better than cotton and reduces body odor (Mburu and Kinyanjui, 2013). They are highly Comfortable, easily decomposed, infection and irritation-free, and a biodegradable napkin that also has antibacterial properties (Dixit and Tambi, 2018).

Banana fiber napkin: For this napkin, naturally occurring banana fiber is used. They are biodegradable and poses no side effects on humans and the environment. After using the napkin they decompose within six months (Shanmugasundaram & Gowda, 2010). Nowadays, rural women made low-cost sanitary napkins from banana fiber that were sold under the trade name "Saathi" in India. They are unbleached and nontoxic (Nayak, 2017).

The parameters for a sanitary napkin (IS: 5405 • 1980)

1. **Size of sanitary napkin**

- **Length:** The requirement for regular, large, and extra-large sizes is 200 mm to 220 mm, 240 mm to 260 mm, and 280 mm to 300 mm, respectively, to be able to provide adequate coverage.
- **Width:** The width of the napkins has to be in the range of 60 mm-75 mm depending upon the size as declared.
- **Thickness:** The thickness of the napkins has to be in the range of 15 mm-17 mm depending upon the size as declared.

2. **Absorbency and absorbability to withstand pressure after absorption**

When coloured waters or oxalate sheep or goat blood or test fluid flowed in the center of the napkin at the rate of 15 ml per minute, the absorbency capacity of the sanitary napkin is 30 ml.

3. **Covering**

A good quality cotton or rayon knitted sleeving, gauze is used to cover the absorbent filler. Also, a piece of non-woven fabric with sufficient porosity used to permit the assembled pad to meet the absorbency requirements.

4. Disposability

All the absorbing material that is packed with covering in the sanitary napkin is to be removed, then immersed in 15 liters of water and stirred. To disintegrate the immersed material of the pad should not more than five minutes.

5. pH

The range of pH of the absorbent material should be 6 to 8.5 when tested, and the material of the napkin should be free from acid and alkali.

6. Packaging

For packing the sanitary napkins a polyethylene-lined carton or a polyethylene bag is used.

Conclusion

Hygienic menstrual management is the most important as it plays a fundamental role in reproductive health. The maintenance of hygienic practices during menstruation is the basic right of every woman. Poor hygiene during periods causes a great impact in increased susceptibility to reproductive tract infections which may lead to infertility (Dasgupta & Sarkar, 2008). So women should use a sanitary napkin during menstruation to grant protection from reproductive tract infections. The sanitary napkins are more natural that allow the skin to breathe (Jayakrishnan, 2019). Sanitary napkins not only provide protection and comfort but also enhances a woman's health and lifestyle (Arugula *et al*., 2017). Besides this, the sanitary napkin ensures dignity and mobility for a woman during her menstruation (Chanana, 2016).

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Chapter - 3
Modern Trends in HVDC Transmission Systems

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Chapter - 3

Modern Trends in HVDC Transmission Systems

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Abstract

HVDC allows power transmission between unsynchronized AC transmission systems. Since the power flow through an HVDC link can be controlled independently of the phase angle between source and load, it can stabilize a network against disturbances due to rapid changes in power. HVDC also allows transfer of power between grid systems running at different frequencies, such as 50 Hz and 60 Hz. This improves the stability and economy of each grid, by allowing exchange of power between incompatible networks.

Keywords: HVDC, HVAC, converters, reliability, technical performance, economy

I. Introduction

The industrial growth of a nation requires increased consumption of electrical energy. This has leads to increase in generation and transmission facilities to meet the increasing load demand.

	Country	Demand Doubles
1970's	U.S.A.	Every 10 Years
	India	Every 7 Years

This requires a considerable investment in electric power sector.

A high-voltage, direct current (HVDC) electric power transmission system (also called a power super highway or an electrical super highway) uses direct current for the bulk transmission of electrical power, in contrast with the more common alternating current (AC) systems. For long-distance transmission, HVDC systems may be less expensive and suffer lower electrical losses. For underwater power cables, HVDC avoids the heavy currents required to charge and discharge the cable capacitance each cycle. For shorter distances, the higher cost of DC conversion equipment compared

to an AC system may still be justified, due to other benefits of direct current links.

Power Transmission was initially carried out in the early 1880s using Direct Current (DC). With the availability of transformers (for stepping up the voltage for transmission over long distances and for stepping down the voltage for safe use), the development of robust induction motor (to serve the users of rotary power), the availability of the superior synchronous generator, and the facilities of converting AC to DC when required, AC gradually replaced DC. However in 1928, arising out of the introduction of grid control to the mercury vapour rectifier around 1903, electronic devices began to show real prospects for high voltage direct current (HVDC) transmission, because of the ability of these devices for rectification and inversion.

The most significant contribution to HVDC came when the Gotland Scheme in Sweden was commissioned in 1954 to be the World's first commercial HVDC transmission system. This was capable of transmitting 20 MW of power at a voltage of -100 kV and consisted of a single 96 km cable with sea return.

II. Economics & terminal equipment

Comparison of AC and DC transmission

The relative merits of the two modes of transmission which need to be considered by a system planner are based on the following factors.

1) Economic of Transmission
2) Technical Merits of HVDC
3) Reliability

A major feature of power system is the continuous expansion imposed by increasing power demand.

1) Economic of power transmission

The cost of a transmission line includes the a) Investment cost and

a) Operational costs
b) The investment costs includes

i) Cost of Right of Way (RoW)
ii) Transmission towers
iii) Conductors

iv) Insulators

v) Terminal equipment

c) The operational costs include mainly the cost of losses.

The characteristics of insulators vary with type of voltage applied. For simplicity, if it is assumed that the insulator characteristics are similar for AC and DC and depend on the peak level of voltage applied with respect to ground, there it can be shown that for lines designed with the same insulation level, a DC line can carry as much power with two conductors (with positive and negative terminals W.R.T. ground) as an Ac line with 3 conductors of the same size. This implies that for a given power level, DC line requires less RoW, Simpler and cheaper towers and reduced conductor and insulator costs.

The power losses are also reduced with DC as there are only two conductors (about 2/3=67% of AC with same current carrying capacity of conductors). The absence of skin effect (skin effect α f) with DC also beneficial in reducing power losses marginally. The dielectric losses in case of power cables is also very less for DC transmission.

The variation of transmission costs with distance for AC and DC as shown in Fig. 1.1. From Fig. 1.1, AC transmission is economical before break even distance (d*) and costlier for longer distances when compared to DC. The break-even distance can vary from 500-800 km.

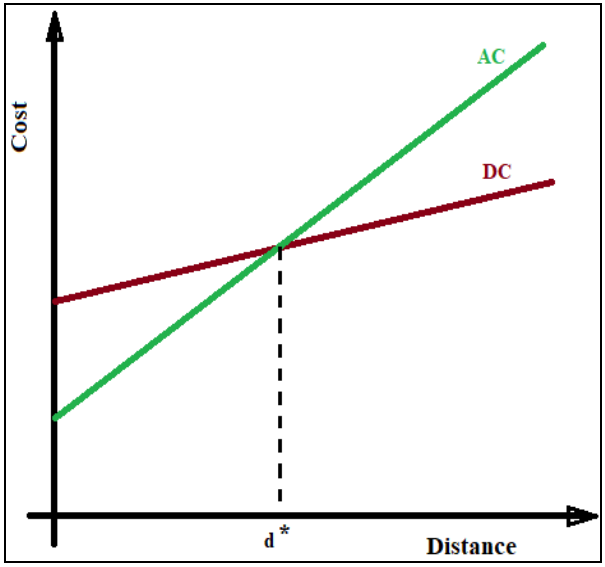

Fig 1.1: Variation of Cost with Line Length

The corona effects (corona effect α f+25) tend to be less significant on DC conductors than for AC. This leads to the choice of economic size of conductors with DC transmission. The other factors that influence the line costs are the costs of compensation and terminal equipment. DC lines do not require any compensation but the terminal equipment costs are increased due to the presence of converters and filters.

2) Technical performance

The DC transmission has some positive features which are linking in AC transmission. These are mainly due to the fast controllability of power in DC lines through converter control. The advantages are

- Full control over power transmitted
- The ability to enhance transient and small signal stability in associated AC networks.
- Fast control to limit fault currents in DC lines. This makes it feasible to avoid DC breakers in two terminal DC links.

In addition to the above, the DC transmission overcomes some of the problems of AC transmission. These are described as follows.

Stability limits

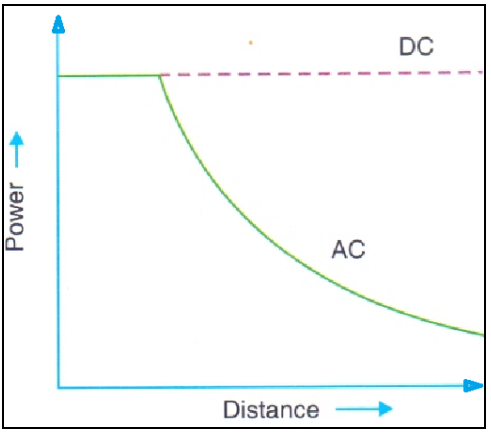

Fig 1.2: Power Transfer Capability vs Distance

The power transfer in AC lines is dependent on the angle difference $(\delta = \delta_1 - \delta_2)$ between the voltage phasors at the two ends

$$P = \frac{E.V}{X} \sin(\delta_1 - \delta_2)$$

The maximum power transfer is limited by the considerations of steady state and transient stability. The power carrying capability of an AC line as a function of distance as shown in Fig. 1.2.

Voltage control

The voltage control in AC lines is complicated by the line charging and inductive voltage drops. The voltage profile in an AC line is relatively flat for a fixed level of power transfer corresponding to surge impedance loading (SIL). The voltage profile varies with the line loading. For constant voltage at the line terminals, the midpoint voltage is reduced for line loading higher than SIL and increased for loadings less than SIL. This is shown in Fig. 1.3.

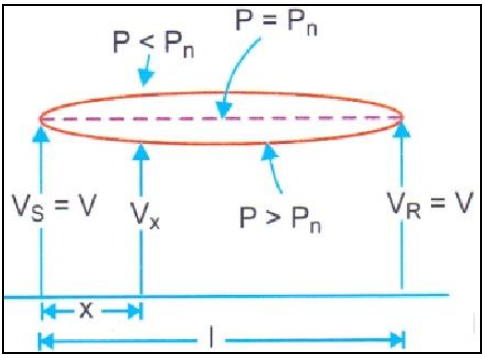

Fig 1.3: Variation of voltage along the line

Here, x is distance from the sending end

l is length of the line

The maintenance of constant voltages at the two ends requires reactive power control from inductive to capacitive as the line loading is increased. The reactive power requirements increase with the increase in the line lengths. Although DC converter stations with line commutated converters require reactive power related to the line loadings, the line itself does not require reactive power.

Line compensation

The AC lines require series and shunt compensation in long distance transmission to overcome the problems of line charging and stability conditions. Series capacitors and shunt inductors are used for this purpose. The increase in power transfer and voltage control is also possible through the use of shunt connected Static Var Compensator (SVC).

In AC cable transmission, it is necessary to provide shunt compensation at regular intervals. This is a serious problem in underwater cables.

Reliability

The reliability of DC transmission is quite good and comparable to that of AC systems. There are two measures of overall system reliability.

Energy availability: This is defined as

$$\% \text{ Energy availability} = \left(1 - \frac{\text{equivalent outage time}}{\text{total time}}\right) * 100$$

Transient reliability: This is a factor specifying the performance of HVDC system during recordable faults on the associated AC system's.

$$\% \text{ Transient Reliability} = \frac{\text{No.of times HVDC system performed as designed}}{\text{No.of recordable AC faults}} * 100$$

III. Types of HVDC links

The DC links are classified into three types. They are

A. Monopolar DC Link

B. Bipolar DC Link

C. Homopolar DC Link

A) Monopolar

The monopolar link has one conductor usually of negative polarity and use ground return as shown in Fig. 1.4 (a). Sometimes sea return or metallic return is also used.

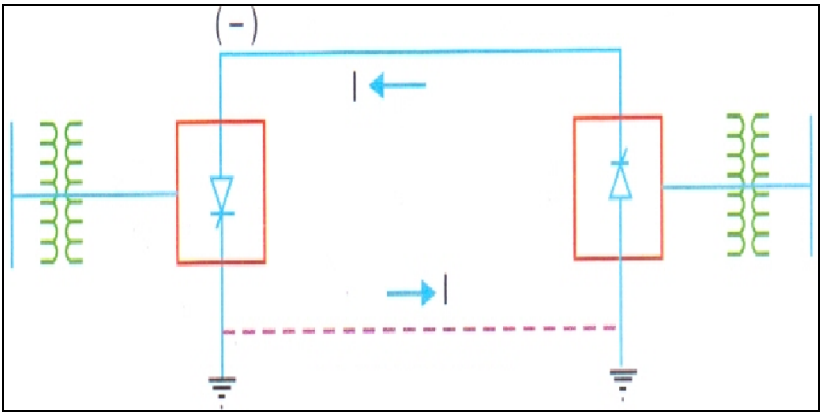

Fig 1.4: a) Monopolar DC Link

B) Bipolar

Bipolar link has two conductors, one positive and the other is negative as shown in Fig. 1.4 (b). Each may be bundled conductors in EHV lines. Each terminal has two sets of converters of identical ratings, connected in series on the DC side. The junction between the two sets of converters is grounded at one or both ends. Normally, both poles operate at equal currents and hence there is zero ground current flowing under these conditions.

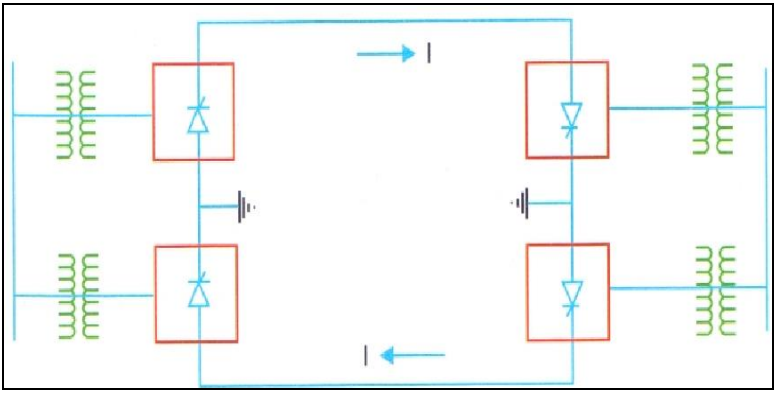

Fig 1.4: b) Bipolar DC Link

C) Homopolar

Homopolar link has two are more conductors, all having the same polarity (usually negative) and always operated with ground or metallic return.

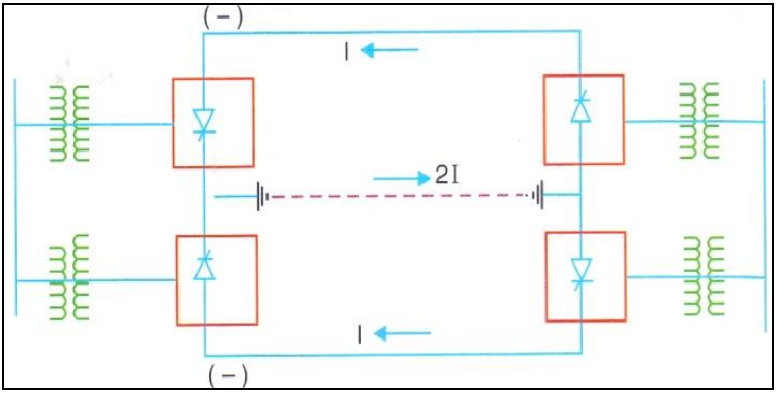

Fig 1.4: c) Homopolar DC Link

Because of the desirability of operating of a DC link without ground return, Bipolar links are most commonly used. Homopolar link has the

advantage of reduced insulation costs, but disadvantages of earth return compensate the advantages. Incidentally, the corona effect in a DC line is substantially less with negative polarity of the conductor when compared to the positive polarity.

The monopolar operation is used in the first stage of the development of a bipolar line, as the investments on converters can be postponed until the growth of load which requires bipolar operation at double the capacity of a monopolar link.

IV. Structure of a converter station

The major components of a HVDC transmission system are converter stations where conversions from AC to DC (Rectifier station) and from DC to AC (Inverter station) are performed. A point-to-point transmission requires two converter stations. The role of rectifier and inverter stations can be reversed by suitable power control.

A typical converter station with one 12-pulse converter unit per pole as shown in Fig. 1.5.

The various components of a converter station are

- 12-pulse converter
- Transformer
- Smooth Reactors
- DC switchgear
- Reactive power source
- DC Filters
- Tuned AC Filters
- HP AC Filters

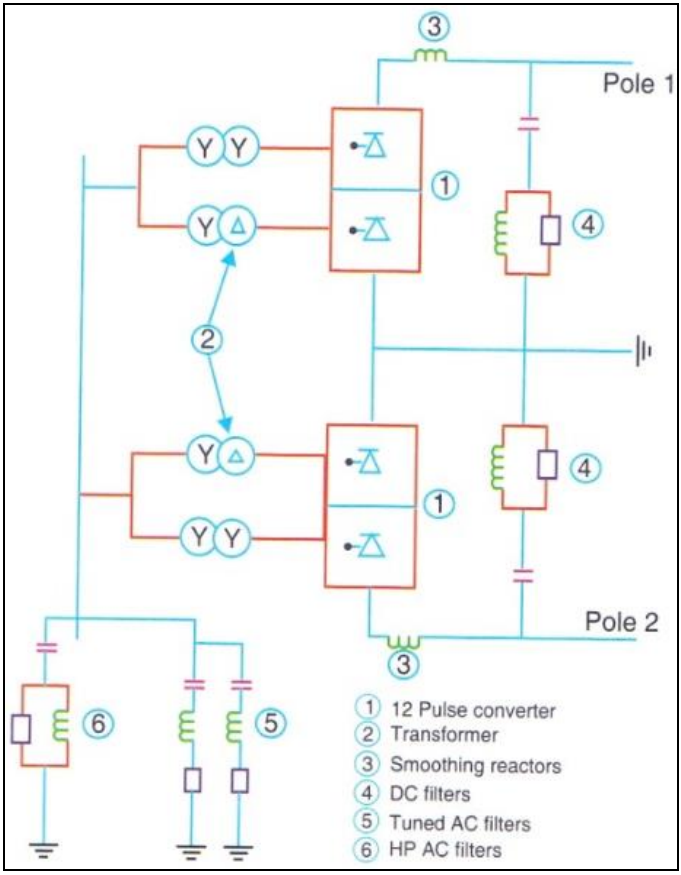

Fig 1.5: Schematic Diagram of a Typical HVDC Converter Station

Converter unit

This is usually consists of two 3-ø converter bridges connected in series to form a 12-pulse converter unit as shown in Fig. 1.6. The total numbers of valves in such a unit are twelve. The valves can be packaged as a single valve, double valve or quadric valve arrangements. Each valve is used to switch in a segment of an AC voltage waveform. The converter is fed by converter transformer connected in star/star arrangements.

The valves can be cooled by air, oil and water. Liquid cooling using deionized water is more efficient and results in the reduction of station losses. The ratings of a valve are limited more by the permissible short circuit currents than steady state load requirements. The design of valves based on the modular concept, where each module contains a limited number of series connected thyristor valves.

Valve firing signals are generated in the converter control at ground potential and are transmitted to each of the thyristor in the valve through a fiber optic light guide system. The light signal received at the thyristor level is converted to an electrical signal using gate drive amplifiers with pulse transformers. The valves are protected by snubber circuits, protective firing and gapless surge arresters.

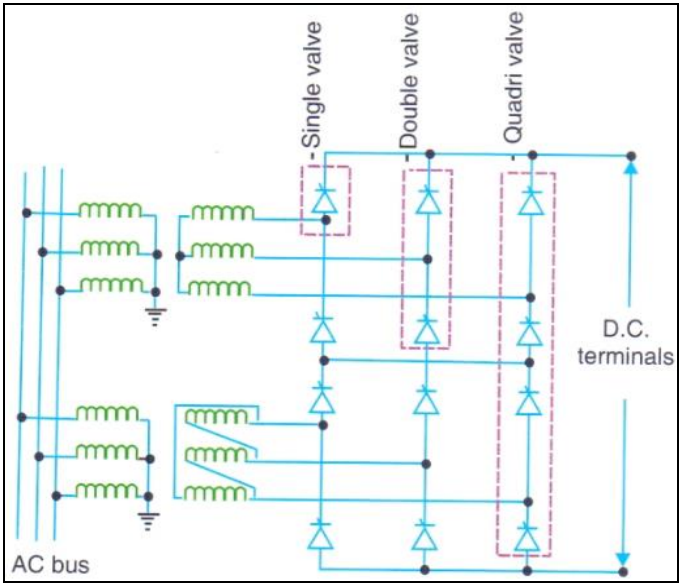

Fig 1.6: A 12-pulse converter unit

Converter transformer

The converter transformer can have different configurations as

i) 3-ø, 2-winding

ii) 1-ø, 3-winding

iii) 1-ø, 2-winding

The valve side windings are connected in star and delta with neutral grounded. On the AC side, the transformers are connected in parallel with neutral grounded. The leakage reactance of the transformer is chosen to limit the short circuit currents through any valve.

The converter transformers are designed to withstand DC voltage stress and increased eddy current losses due to harmonic currents. One problem that can arise is caused by the DC magnetization of the core due to un-symmetric firing of valves.

In back-to-back links, which are designed for low DC voltage levels, an extended delta configuration can result in identical transformers being used in 12-pulse converter units. This result in the reduction of the spare capacity required. However, the application is extended to delta transformers is limited.

Filters

There are 3 types of filters used.

- AC Filters
- DC Filters
- High Frequency Filters

AC Filters

These are passive circuits used to provide low impedance, shunt paths for AC harmonic currents. Both tuned and damped filter arrangements are used.

DC Filters

These are similar to AC filters and are used for the filtering of DC harmonics.

High frequency filters

These are connected between the converter transformer and the station AC bus to suppress any high frequency currents. Sometimes, such filters are provided on high voltage DC bus connected between the DC filter and DC line and also on the neutral side.

Reactive power source

Converter stations require reactive power supply that is dependent on the active power loading (about 50-60% of the active power). This is due to the fact that current drawn by a line commutated (current source) converter (LCC) can only lag the supply voltage. Fortunately, part of this reactive power requirement is provided by AC filters. In addition, shunt capacitors, synchronous condensers and static var systems (SVC or STATCOM) are used depending on the speed of control desired.

Smooth reactor

A sufficiently large series reactor is used on DC side to smooth DC current and also for protection. The reactor is designed as a linear reactor and is connected on the line side, neutral side or at intermediate location.

DC switchgear

This is a usually a modified equipment used to interrupt small DC currents. DC breakers or metallic return transfer breakers (MRTB) are used, if required for interruption of rated load currents.

In addition to the above equipment, AC switchgear and associated equipment for protection and measurement are also part of the converter station. This includes DC current and voltage transducers.

V. Application of DC transmission system planning

The system planner must consider DC alternatives in transmission expansion.

The factors to be considered are

i) Cost

ii) Technical performance

iii) Reliability

Generally, the last two factors are considered as constraints to be met and the minimum cost option is selected among various alternatives that meet the specifications on technical performance and reliability.

For submarine, cable transmission and interconnecting two systems of differential nominal frequencies, the choice of DC is obvious. In other cases, the choice is to be based on detailed techno economic comparison.

The considerations in the planning for DC depend on the application. Two applications can be considered as representative. These are

1. Long Distance bulk power transmission
2. Interconnection between two adjacent systems

In the first application, the DC and AC alternatives for the same level of system security and reliability are likely to have the same power carrying capability. Thus, the cost comparisons would form the basis for the selection of the DC or AC alternative, if the requirements regarding technical performance are not critical.

In the second application, AC interconnection causes several problems in certain cases. For the same level of system security (and reliability), the capability of AC interconnection will be much more than that for DC. Thus, the choice for interconnection will be based on the following considerations.

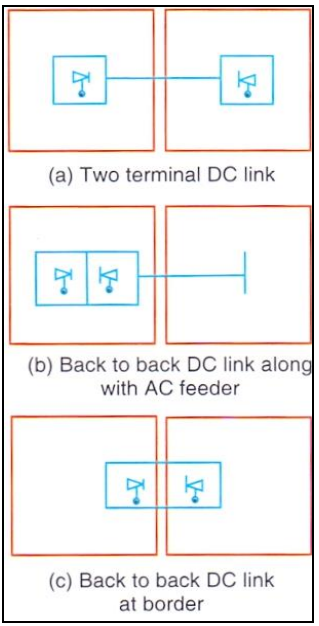

Fig 1.7: Different configurations for asynchronous interconnection

1. Small fluctuations in the voltage and frequency do not affect the power flow which can be set at any desired value.
2. The system security can be enhanced by fast control of DC power.

Having settled on the DC link for interconnection, there are three possible configurations for interconnection. These are

1. A two terminal transmission where each terminal is located at a suitable place somewhere within the network and connected by a DC overhead line or cable.
2. A back-to-back HVDC station (also called HVDC coupling station) located somewhere within one of the network and an AC line from the other network to the common station.
3. A back-to-back station located close to the border between the two systems. This is a special case of the above.

In the choice between the first and second configuration, it is to be noted that converter costs are less for the common coupling station and the AC line costs are greater than the DC line costs. If the distances involved are less than 200 km, the second configuration is to be preferred. If the short circuit ratio (SCR) is acceptable then the third alternative will be the most economic.

The specifications and design of DC system require an understanding of the various interactions between the DC and AC systems.

The interruption of power in a DC link can occur due to

a) DC line faults

b) AC system faults

The speed of recovery from transient DC line faults is of concern in maintaining the integrity of the overall system. The power flow and stability studies are used in this context. The recovery of DC link from AC system faults is more complex. The depression of AC voltage at the inverter bus can lead to commutation failure and loss of DC power. The DC power is ramped up on the clearing of the fault. Too fast an increase in DC power output can lead to reduction of AC voltage and failure of commutation. An optimum rate of increase in DC power can be determined by control strategy and system characteristics.

The following aspects also require a detailed study of the system interactions.

1. VAr requirements of converter stations and voltage stability.
2. Dynamic over voltages.
3. Harmonic generation and design of filters.
4. Damping of low frequency and sub-synchronous torsional oscillations.
5. Carrier frequency interference caused by spiky currents in valves due to the discharge of stray capacitances and snubber circuits.

The converter control plays a major role in these interactions and control strategy should be such as to improve the overall system performance. Digital simulation and HVDC simulators are used for planning and design studies.

Choice of voltage level

For long distances bulk power transmission, the voltage level is chosen to minimize the total costs for a given power level P. the total costs include investment (C_1) and cost of losses (C_2).

The investment costs per unit is given by

$$C_1 = A_0 + A_1 n\,V + A_2 nq \qquad \ldots (1.1)$$

Where V is the voltage level w. r. t. ground

n is the number of conductors

q is the total cross section of each conductor

A_0 A_1 and A_2 are constants

The cost of losses per unit length is given by

$$C_2 = \frac{\left[n\left(\frac{P}{nV}\right)^2 \rho T L_p\right]}{q} \quad \ldots (1.2)$$

Where, ρ is the conductivity

T is the time operation in a year

L is Loss Load Factor

p is cost per unit energy

C_2 can be simplified as

$$C_2 = \frac{\left[A_3\left(\frac{P}{V}\right)^2 \rho\right]}{nq} \quad \ldots (1.3)$$

Where,

$A_3 = TL_p$

By minimizing the sum of C_2 and the third term in C_1, we have,

$$nq = \sqrt{A_3\rho/A_2}\,.\,(P/V) \quad \ldots (1.4)$$

$$J = \frac{P}{(nqV)} = \sqrt{A_2/(A_3\rho)} \quad \ldots (1.5)$$

Where,

J is the current density.

The total cost can be written as

$$C = C_1 + C_2 = A_0 + A_1 n V + 2\sqrt{A_2 A_3 \rho}.\,(P/V) \quad \ldots (1.6)$$

The voltage level *V* is chosen to minimize *C*. The eq. (1.6) ignores the variation of terminal costs with the voltage. Fig. 1.8 shows the selection of optimum system voltage to minimize the sum of converter and line costs.

In case of back-to-back DC ties, the line costs are absent. Hence, the voltage level is chosen to minimize converter costs. This level is generally much lower than that in the presence of an overhead line.

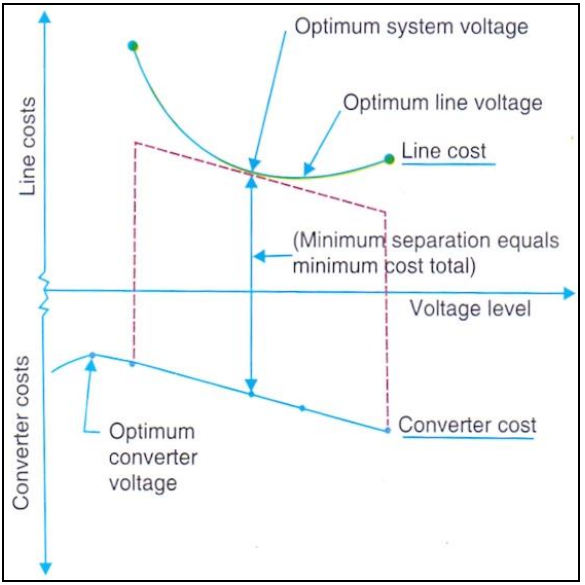

Fig 1.8: Selection of optimum voltage for a fixed power transfer

VI. Modern trends in HVDC technology

The continuing technological developments in the areas of power semiconductor devices, digital electronics, adaptive control, DC transmission. The major contribution of these developments is to reduce the cost of converter stations while improving the reliability and performance.

1. Power semiconductors and Valves

The cost of the converters can come down, if the number of devices to be connected in series and parallel can be brought down. The size of the devices has gone up to 125 mm (in diameter) and there is no need for parallel connection. The increase in the current rating of the devices has made it possible to provide higher overload capability at reasonable costs and reduce the lower limits on transformer leakage impedance thereby improving the power factor. The voltage ratings are also on the increase. The development of direct light triggered thyristors (LTT) should also improve the reliability of converter station. The cost of the valves is also reduced by the application of zinc oxide gapless arresters and protective firing methods.

The power rating of thyristors is increased by better cooling methods. Deionized water cooling has now become a standard and results in reduced losses in cooling. The power rating of a 12-pulse converter unit has increased upto 3000 MW at 500 kV. Two phase flow using forced

vaporization is also being investigated as a means of reducing thermal resistance between the heat sink and the ambient.

As forced commutated converters operating at high voltages are uneconomic, the development of devices that can be turned off by application of a gate signal would be desirable. Gate Turn Off (GTO) thyristors are already available at 6 kV and 4000A. However, the main disadvantage of GTO's is the large gate current needed to turn them off. MOS (metal oxide semiconductor) controlled thyristor or MCT appears to be a promising technology. An MCT would consists of an MOS integrated circuit created can be switched off by a small gate current. The turn - off time of MCT is also less than one third that of GTOs. However, MCTs are still in the early stages of development.

The cost of silicon used in the manufacture of power semiconductor devices can be brought down (by 15 to 20 percent) from the use of magnetic CZ (Czochralski) method, instead of the conventional FZ (float zone) method. Research is also underway in reducing this packaging cost of a device.

2. Converter control

The development of micro-computer-based converter control equipment has now made it possible to design systems with completely redundant converter control with automatic transfer between systems in the case of a malfunction. Not only is the forced outage rate of control equipment reduced but it is also possible to perform scheduled preventive maintenance on the stand -by systems when the converter is in operation. The use of a mini-simulator will make it feasible to check vital control and protection functions.

The micro-computer-based control also has the flexibility to try adaptive control algorithms or even the use of expert systems for fault diagnosis and protection.

3. DC Breakers

With the development and testing of prototype DC breakers, it will be possible to go in for tapping an existing DC link or the development of new MTDC systems. Parallel, rather than series operation of converters is likely as it allows certain flexibility in the planned growth of system. The DC breaker rating as the control intervention is expected to limit the fault current.

The control and protection of MTDC systems is not a straightforward extension of that used in the two terminal DC systems. The possibility of decentralized control necessitated by communication failure, the coordination of control and protection are some of the issues currently being studied.

4. Conversion of existing AC lines

The constraints on RoW are forcing some utilities to look into the operation of converting existing AC circuits to DC in order to increase the power transfer limit. There could be some operational problems due to electromagnetic induction from AC circuits operating in the same RoW.

An experimental project of converting a single circuit of a double circuit 220kV line is currently under commissioning stage in 1989-90 in India.

5. Operation with weak AC systems

The strength of AC systems connected to the terminals of a DC link is measured in terms of short circuit ratio (SCR) which is defined as

$$SCR = \frac{short\ circuit\ level\ at\ the\ converter\ bus}{Rated\ DC\ Power}$$

If SCR is less than 3, the AC System is said to be weak. The conventional constant extinction angle control may not be satisfactory with weak AC system. The recovery of inverters following the clearing of fault in the connected AC system can also be problematic.

Constant reactive current control or AC voltage control has been suggested to overcome some of the problems of weak AC systems. The use of fast reactive power control at the converter bus by applying static var systems is another alternative. Limiting dynamic over voltages through converter control during load rejection is becoming a standard practice.

The power modulation techniques used to improve dynamic stability of power systems will have to be modified in the presence of weak AC systems. Coordinated reactive and active power modulation has been suggested to overcome the problems of voltage variations that can limit the effective of power modulation.

6. Active DC filter

In the nineties, a hybrid filter made up of an active filter in series with the passive filter has been developed to improve the filtering of harmonic currents flowing in the HVDC lines. The active filter can eliminate both characteristic and low frequency non-characteristic harmonics. Both Siemens

and ABB have supplied active filters. In India, Chandrapur-Padghe HVDC project uses an active filter in each pole.

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Chapter - 4
Bacteriological Quality of Ready-To-Eat Roasted Cashew Kernels on Retail Sale in Tropical Environment

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Chapter - 4

Bacteriological Quality of Ready-To-Eat Roasted Cashew Kernels on Retail Sale in Tropical Environment

Douglas Mushi

Abstract

Despite the increased consumption worldwide, information regarding bacteriological safety and dominating risk factors contributing to the contamination of ready-to-eat roasted cashew kernels (RCK) on retail sale in a tropical environment is incomplete. This investigation uses 324 samples of RCK in small (n=109), medium (n=87) and large-sized (128) packages randomly collected from vendors and investigated for their bacteriological safety, the presence of carbapenem-resistant *Enterobacteriaceae* and the dominant source of RCK contamination using standard procedures. There was a significant (p<0.05) difference in *Enterobacteriaceae* concentration of RCK before (median: 0 cfu/g) and after packaging (median: 63 cfu/g), suggesting that packaging process was the basis of contamination. Although small-sized packages had elevated concentrations of *Enterobacteriaceae* in comparison to the rest of the package types, the concentrations of *Enterobacteriaceae* on the investigated RCK was within the range acceptable by food quality guidelines. Further, there was a strong correlation (r=0.67, p<0.05) of *Enterobacteriaceae* concentrations between RCK and the hands of RCK packers, suggesting that contamination during packaging process was due to poor hygienic condition of RCK packers. Interestingly, pathogenic species (*Salmonella typhi*, *Enterobacter aerogenes*) and carbapenem-resistant isolates (*Klebsiella pneumonia*, *Escherichia coli*, *E. aerogenes* and *S. typhi*) were detected from the investigated RCK. These findings suggested that RCK may serve as a vehicle for transmitting enteric pathogens and carbapenem-resistant bacteria in the food supply.

Keywords: ready-to-eat roasted cashew kernel, *Enterobacteriaceae* species, carbapenem resistance, bacteriological contamination

1. Introduction

Cashew kernels substantially contribute to global economy [1] and dietary intake [2]. Due to their luxuriant nutrient contents and health benefits [3], the

consumption rate of cashew kernels has shown the increasing trend at the national and global level. Because RCK are ready-to-eat food [2] and manufacture confectionery products [4], their microbiological safety must conform to the food guidelines. As a result, stringent look-overs of RCK safety from harvesting to post packaging stages are performed to comply with international food safety regulations before being consumed locally or exported. Despite the increasing trend of RCK sale at the national and international level [1], little information is available on the extent of application of these stringent food regulations during RCK processing by small scale industries (SSI). Lack of this information not only complicates the management of foodborne illnesses but also makes it difficult to predict foodborne infections and food associated with carbapenem-resistant pathogens [13].

RCK need careful packaging to avoid contamination by pathogenic microbes that are harmful to human health. Previous studies highlighted that poor personal hygiene and contaminated food handlers are the contributing factors to foodborne illnesses [2, 5, 6]. However, these studies neither quantified the bacteriological link between the microbiological condition of RCK and hand hygiene of RCK packers in small scale industries (SSI) nor compared the bacteriological safety of distinct volumes of RCK packages. This information is crucial, especially in understanding the critical sources of contamination in small scale industries dealing with ready-to-eat foods such as RCK. Food industries have been associated with news related to contamination of ready-to-eat foods as proven by the detection of aerobic plate count bacteria [7], E. coli [8], Salmonella spp. [8] and fungi species [9] from RCK. This evidence is a result of the ability of microbes to attach and survive longer on the surface of nuts like RCK despite being very hostile habitat [10, 11]. As such, RCK act as a vehicle that transmits microbes, including those capable of causing human illnesses. Although previous studies reported the survival of microbes on the surface of RCK [10], none of these microorganisms was tested for their resistance to carbapenem antibiotics, which are essential in treating infections caused by multi-drug-resistant gram-negative bacteria [12, 13]. Resistance to carbapenems is mostly due to the production of carbapenemases, which are β-lactamase enzymes with a capacity to hydrolyze not only the carbapenems but also all the other beta-lactam agents. Infections caused by bacteria resistant to carbapenems often fail to respond to conventional treatment and are said to kill up to 50% of patients with bloodstream infection [12]. Although carbapenem resistance has been detected in sea foods [14], water [15] and agricultural animals including pigs, poultry and dairy cow [13, 16], no data are available regarding the detection of carbapenemase-producing

organisms from RCK despite being highly consumed worldwide. Hence, the objective of this study was to evaluate the bacteriological safety of RCK produced by SSI in Tanzania and examine the source of their contamination and possible occurrence of carbylamine resistant *Enterobacteriaceae* on RCK. Data from this study will allow understanding of the movement of antimicrobial-resistant organisms into people from the food chain and help to explain the vehicle of *Enterobacteriaceae* clinical isolates resistant to carbylamine antibiotic that has been recently reported in Tanzania [24].

2. Materials and Methods

Between October 2016 and July 2017, packaged RCK in small (n=109), medium (n=87 and large (n=128) transparent plastic bags (Fig. 1) were randomly collected from retailing in three different bus stops located along the highway (192 km) connecting Dar es Salaam City and Morogoro region in Tanzania. Kibaha (6.7831°S, 38.9910°E) and Chalinze (6.6386°S, 38.3521°E) bus stops are located in the coastal region while Msamvu (6.8040°S, 37.6647°E), which is the largest bust stop, is located in Morogoro region. In each of these bus stops, >20 vendors were selling packaged RCK to travellers in retail format. RCK samples (Table 1) randomly collected from vendors were transported to the laboratory where they were separately subjected to sterile Whirl-Pak® bags each containing 100 ml of distilled water. RCK were left for 3 minutes in distilled water before being massaged to release surface-attached bacteria to the distilled water. After shaking vigorously, 10 ml of RCK extract from each sample were separately filtered on the membrane filtration unit before transferring the filter paper on the standard reference medium consisted of Endo agar (Becton Dickinson GmbH) and prepared according to the manufacturer's guidelines. Incubation of culture medium plates was performed at the 37 ^{o}C for 18-24 hours, after which colonies congruent to the Endo agar manufacturer's identification criteria were counted and expressed as colony-forming units per 100 ml (cfu/100 ml). Based on the concentration of *Enterobacteriaceae* colonies, a ruling was made regarding the bacteriological quality of the RCK by guidelines for ready-to-eat foods[17]. To confirm the identity of these colonies, each counted colony was separately sub-cultured on nutrient agar and incubated at 37 ^{o}C for 18 hours to obtain pure colonies. The identity of pure colonies to species level was performed by using an API 20E system (bioMe´rieux SA, Marcy l'Etoile, France) following the manufacturer's instructions. Since labels of RCK packages indicated that RCK on retail sale were from the same SSI, RCK samples were obtained from this SSI immediately after roasting and treated in the same way as for the samples collected from the bus stops in order to understand the source of contamination.

Fig 1: A plate showing small (A), medium (B) and large (C) sized packages of RCK as sampled from vendors in the respective bus stops (Kibaha, Chalinze, Msamvu) in Tanzania

In the same vein, the hygienic condition of the RCK packers was investigated by washing their hands in a Whirl-Pak® bag with 500 ml sterile distilled water without soap as described by Pickering *et al.* [18] and afterwards, 10 ml of the hand extract was analyzed using a similar procedure as for the RCK samples described above. Also, plastic bags intended for packaging of RCK were tested for their sterility by swabbing the surfaces of the bags and transferring the swabs to the 10 ml sterile distilled water before being vigorously shaken to extract bacterial cells from the swab and analyzed by using the procedures applied to the RCK samples.

Susceptibility testing was done for the following antibiotics: meropenem, imipenem, ertapenem and doripenem using the Kirby Bauer disk diffusion as described by Markelz *et al*. [19] and interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines [20].

3. Results and discussion

The characteristics of RCK samples analyzed in this survey are presented in Table 1. RCK samples had a mixture of whole and halved kernels in which out of 324 samples analyzed, 34% were small (35 ± 3.9g), 27% medium (63 ± 4.0g) and 39% were large-sized packages with an average weight of 153 ±14g. These RCK samples were from the same SSI located in the southern part of Tanzania (0.3112° S, 40.1760° E). Being one of the ready-to-eat foods with the rising trend of consumption[8], RCK contained *Enterobacteriaceae* organisms (Table 1) despite having low water activity [7, 8]. The *Enterobacteriaceae* levels in 324 investigated samples ranged from 1 to 192

cfu/g with a median of 63 cfu/g. *Enterobacteriaceae* organisms were detected in all samples regardless of the package size and points of sampling. These *Enterobacteriaceae* levels were a result of the poor hygienic condition during packaging of RCK as *Enterobacteriaceae* organisms were detected on neither the packaging bags nor RCK surfaces immediately after being roasted. Microbiological quality of investigated RCK samples ranged from good to acceptable based on the guidelines for ready-to-eat foods [17]. However, there was a significant correlation of *Enterobacteriaceae* concentrations ($r=6.7$, $p<0.05$; Fig. 2) between RCK and RCK packer's hands. This finding explains the source of *Enterobacteriaceae* detected from RCK and corroborates the previous findings reported by Faour-Klingbeil *et al.* [5] Consequently, the occurrence of *Enterobacteriaceae* on the contaminated hands of RCK handlers can substantially increase the likelihood of predicting their occurrence on the surface of the packaged RCK and serve as a base for improving hygiene in the SSI and microbiological safety of RCK. Nonetheless, the observed contamination, call for the use of post-packaging decontamination approaches [21] to further improve the microbiological quality of RCK. Further, there was a significant difference in *Enterobacteriaceae* concentration (Kruskal Wallis test: $P<0.05$) between package sizes in which small RCK packages were the most contaminated with *Enterobacteriaceae* (median: 70 cfu/g) compared to the medium (median: 7 cfu/g) and large (median: 8 cfu/g) packages.

Table 1: Characteristics of the studied RCK regarding *Enterobacteriaceae* concentrations

Package size	Sample (n)	Weight (g)	Price (USD)	*Enterobacteriaceae* (cfu/g)		
				Median	Min.	Max.
Small	38	35 ± 3.9	0.43	70	3	192
Medium	29	63 ± 4.0	0.87	7	2	84
Large	17	153 ±14	2.17	8	1	80

Unlike medium and large RCK packages, cashew nuts in small packages were highly exposed to the contamination by hands of workers involving in the filling of the plastic bags with RCK as a result of their small volume. Despite such risk, small RCK packages are highly marketable as they are being sold at the lowest price compared to other packages. Therefore, the hygienic condition of small size packages requires close attention to prevent foodborne illnesses in the public domain.

In the previous studies, *Enterobacteriaceae* organisms were used to examine the microbiological quality of ready-to-eat nuts [8, 11, 22]. In these

studies, the application of *Enterobacteriaceae* was because these organisms are not normal flora of unshelled nuts [17], comprise >210 species [22] and the majority of *Enterobacteriaceae* are responsible for a broad range of infections. Despite such usefulness of *Enterobacteriaceae*, this report is the first to gauge the quality of packaged RCK from SSI by using *Enterobacteriaceae* organisms despite the increasing trend of gastrointestinal illnesses at the local and global level. According to manufacturer's directions, determination of *Enterobacteriaceae* with Endo agar captures a significant number of *Enterobacteriaceae* species, including pathogenic *S. typhi*, a key causative agent of food quality deterioration. In this study, identified *S. typhi* was <1 cfu/g which is in a range similar to that found elsewhere [8, 22]. Although this concentration seems very low, it has been shown to cause salmonellosis [23]. So, the cheapest method applied here for the analysis of *Enterobacteriaceae* on surfaces of RCK can be used for determining the risk associated with ready-to-eat foods in developing countries.

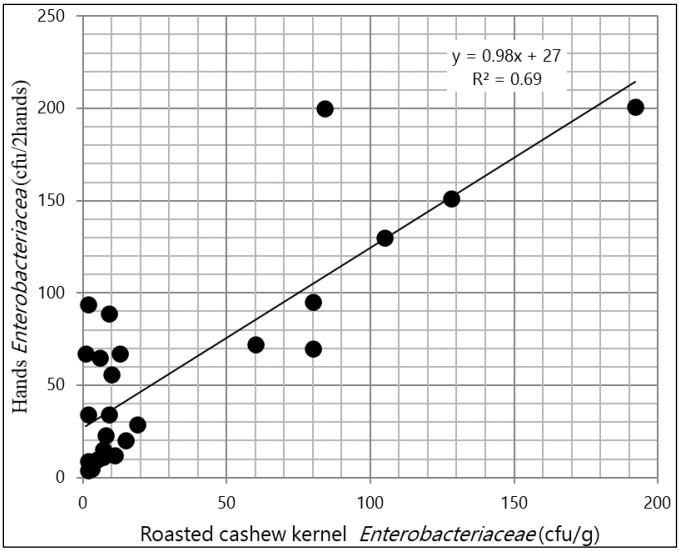

Fig 2: Regression analysis of *Enterobacteriaceae* concentrations between ready-to-eat cashew kernels and hands of RCK packers

Identity of 236 colonies from 324 samples based on EPI 20E system suggests that RCK were contaminated with *Enterobacteriaceae* organisms belonging to six (6) species (Table 2), which managed to survive the harshness of RCK surfaces. *E. coli* (29 isolates), *K. pneumonia* (89 isolates), and *Proteus vulgaris* (65 isolates) were frequently isolated from RCK samples regardless of the package size and sampling location. In contrast, *E. aerogenes* (15

isolates identified in small and large size packages), *Enterobacter cloacae* (12 colonies from large packages) and *S. typhi* (6 colonies from all package sizes) were present in samples collected from Morogoro. It should be noted that *Enterobacter cloacae* and *S. typhi* were from the repackaged bags by the vendors following the damage of the original package while supplying to the customers. This repackaging may have contributed to the observed pathogens on the surfaces of the RCK as pathogens like *S. typhi* are endemic in Morogoro region. Presence of pathogenic bacteria in the samples whose *Enterobacteriaceae* concentrations were within the acceptable concentration suggests that the microbiological safety of ready-to-eat food should rely on not only the concentration of *Enterobacteriaceae* for protection and control of pathogens on RCK but also the *Enterobacteriaceae* species identification to achieve complete risk assessment which will lead to the improved management of microbiological quality and safety of ready-to-eat RCK.

Table 2: *Enterobacteriaceae* species detected on the surface of RCK regarding the package type and number of samples

***Enterobacteriaceae* species**	**Number of samples with *Enterobacteriaceae* species**					
	Small size (n=38)		**Medium size (n=29)**		**Large size (n=17)**	
	Positive samples	**%**	**Positive samples**	**%**	**Positive samples**	**%**
Enterobacter aerogenes	3	7.8	nd		1	5.9
Escherichia coli	3	7.8	4	14	1	5.9
Klebsiella pneumoniae	7	18	5	17	7	41
Proteus vulgaris	3	7.8	6	21	4	23
Salmonella typhi	3	7.8	6	21	4	23
Enterobacter cloacae	nd		nd		2	11.8

Of the six *Enterobacteriaceae* species identified in this study, four species were carbapenem-resistant (Table 3) including *E. coli* (15% of isolates susceptible to meropenem, 5.6% to imipenem, 50% to ertapenem and 0% to doripenem), *K. pneumonia* (25% to meropenem, 15.6% to imipenem, 18% to ertapenem and 0% to doripenem), *S. typhi* (100% to meropenem, 100% to imipenem, 2% to ertapenem and 0% to doripenem) and *Enterobacter cloaca* (0% to meropenem, 100% to imipenem, 100% to ertapenem and 100% to doripenem). Although carbapenem-resistant bacteria have been isolated from clinical samples in Tanzania [24], Uganda [12] and Kenya [25], this is the first report in East African countries regarding the occurrence of carbapenem-resistant *Enterobacteriaceae* bacteria (CRE) in RCK samples. While RCK might be a new vehicle for spreading antibiotic-resistant genes, it may also pose a serious threat to the communities with infections caused by multidrug resistance gram-negative bacteria [26, 27] as carbapenem antibiotics are used as

the last resort salvage treatment for infections caused by multidrug resistance gram-negative bacteria [24]. Therefore, appropriate processing and packaging of RCK that follow strict hygienic conditions and post packaging treatment are needed to prevent RCK from being a vehicle for spreading CRE.

Table 3: *Enterobacteriaceae* isolates resistant to carbanamen antibiotics with concerning the package size and sampling location. S, small size; M, medium size; L, Large size; Ms, Msamvu; Ch, Chalinze and Ki, Kibaha

***Enterobacteriaceae* species**	**Total isolates**	**Carbylamine resistant isolates**	**Package type found**	**Sampling location found**
Enterobacter aerogenes	23	0	S, L	Ms
Escherichia coli	35	5	S, L, M	Ms, Ki, Ch
Klebsiella pneumoniae	49	45	S, L, M	Ms, Ki, Ch
Proteus vulgaris	30	0	L, M	Ms, Ki, Ch
Salmonella typhi	6	1	L	Ms
Enterobacter cloacae	4	1	L, M	Ms

Despite the investigation on the small sample size of RCK (n=84), this study used RCK samples originating from a single SSI and biochemical analysis for Enterobacteriaceae species identification and CRE determination without confirmation by currently available molecular procedures. Data presented herein can be used as background information for designing a comprehensive research regarding microbiological safety of RCK from small scale industries in developing countries. Such study will be needed to use more specific molecular tools guided by the results of this work to identify sources of the observed *Enterobacteriaceae* and quantify microbial risks associated with RCK as recommended by the Centers for Disease Control and Prevention [28]. Further, these tools can later be extended to detect carbapenem resistance in non-*Enterobacteriaceae* gram-negative pathogens such as *Acinetobacter baumannii* and *Pseudomonas aeruginosa* on RCK samples.

4. Conclusion

This study investigated the bacteriological safety of ready to eat RCK processed and packed by SSI in Tanzania. Although the bacteriological safety of RCK was within the acceptable range according to guidelines for ready-to-eat foods, RCK were contaminated with potential enteropathogenic bacteria (*S. typhi and E. aerogenes*) and carbapenem-resistant *Enterobacteriaceae* which question the reliability of using *Enterobacteriaceae* level in monitoring the hygienic condition of ready to eat food like RCK. Data from this study further showed that roasting unshelled cashew inactivated *Enterobacteriaceae*, but packaging processes contaminated RCK via the

hands of RCK packers. To minimize foodborne illnesses and risk of acquiring CRE by RCK consumers, hygienic processing and handling of RCK coupled with post packaging decontamination are necessary for small scale industries.

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Chapter - 5
Digital Twin Technologies in Business Reorganization

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Chapter - 5

Digital Twin Technologies in Business Reorganization

Dr. Baldev Singh

Abstract

Digital twin is amongst of the 10 emerging strategic technology trends. The notion of digital twin is basically the convergence of physical and virtual product. Digital twin technologies provide the digital footprint of the whole process of an industrial product life cycle. The connection of physical and digital product life line generates data which helps to analyse the product or process in advance and realize the problems before the development of physical products and avoid risks. The driving forces of Digital twins include the growing adoption of IoT, Machine learning, big data and cloud that are predominantly used in various industries such as manufacturing, healthcare, aerospace and defence, supply chain, real state, automotive and transportation and is having major role in the fourth industrial revolution (Industry 4.0) which is digital transformation of manufacturing and production process. With the advent of digital twin technologies there is huge potential of their adoption in various sectors due to high reasons of their implementation which are deliberated in this chapter.

Keywords: digital twin, IoT, virtual product, digital technologies, machine learning

1. Introduction

Digital twin is defined as a software design pattern that represents a physical object with the objective of understanding the asset's state, responding to changes, improving business operations and adding value [https://www.gartner.com/en/documents/3647717/top-10-strategic-technology-trends-for-2017-digital-twin]. It is a virtual representation of various physical assets of a product that acts as tools to test new products before its actual implementation and launching so as to optimize operations and minimizing costs [https://www.rockwellautomation.com/en-gb/company/news/magazines/digital-twins-deliver-greater-manufacturing-efficiency.html]. Digital twins provides the prospects to have the virtual view

of the physical product before it's going to live [https://www.rockwellautomation.com/en-in/company/news/blogs/digital-twins--creating-smarter-products-on-time-and-on-budget.html]. In this stage various opportunities are uncovered that can be applied to the actual environment. Digital twin [[https://www.plm.automation.siemens.com/global/en/our-story/glossary/digital-twin/24465] is also defined as "an end-to-end virtual model of a physical thing, process, or service to enable data-driven decision-making and to put an end to business-process inefficiencies" [https://www.pratititech.com/digital-twin-software-platforms]. It is estimated that digital twin technology be act as tool to save millions of dollars related to maintenance costs by way of its deployment in oil fields and refineries only by 2024. [https://www.forbes.com/sites/bernardmarr/2019/04/23/7-amazing-examples-of-digital-twin-technology-in-practice/?sh=7dcf43db6443]. Digital twin technologies comprises its core technologies [https://www.plm.automation.siemens.com/global/en/our-story/glossary/digital-twin/24465] including Internet of Things (IoT), simulation tools and big data analytics. Digital twin technologies impacted the various sectors of industries mainly includes automotive & transportation sector, energy & power sector, and aerospace & defence sector. [https://www.marketsandmarkets.com/Market-Reports/digital-twin-market-225269522.html].

Digital twin is basically termed as a pairing of two worlds that are virtual and physical by way of analysing data and the monitoring of the paired system so that problems can be resolved before their actual occurrences. The enablers of digital twin technologies comprises sensors, connectivity and predictive analysis [F. Biesinger, D. Meike, B. Kraß, M. Weyrich (2019)] that adds the value of its implementation so that its vehicle of implementation can run smoothly and steadily without distraction, mental effort, flawlessly and error freely. This technology adds the value in the product life cycle by way of analysing the problems in better way, situation predictions in addition to minimizing the cost of products, processes and systems verification. Digital twin technologies helps to provide in-time support and services in the product development life cycle [S. Hagemann, A. Sünnetcioglu, and R. Stark (2019)] in addition to monitoring the health of the products.

2. Levels of digital twins

The concept of digital twins uses data which consists of past, present and future data. Past data is concerned with the historical performance of individual machines, particular systems, as well as overall process. Present

data consists of data which is derived from equipment sensors, outcomes of systems and its distribution chains, customer feedback etc. The future data consists of data that is to be taken from concerned engineers and high-tech technicians as well as collected by way of machine learning. The main critical assets of the digital twin comprises:

- Virtual products which are implemented in virtual space.
- Physical products which are implemented in in real space.
- Mirroring of the connected data of products and process which is tied together in the two domain which are virtual and physical.

Factors driving the unprecedented growth of Digital Twins include the growing adoption of IoT and cloud for the implementation of Digital Twins and the promising prospects of their use in industries such as manufacturing [F. Biesinger, D. Meike, B. Krab, M. Weyrich (2019)], healthcare, aerospace and defence, supply chain, real state, automotive and transportation. There is much faster growth in the use of digital twins in recent years. It is because of data science and analytics possibilities, fast digitalization, lower down in costs of digital technologies, boost in IoTs and sensors. The improvement in effectiveness of products and process of various large industrial organization is expected by 10% by 2021 [https://www.gartner.com/en/newsroom/press-releases/2019-02-20-gartner-survey-reveals-digital-twins-are-entering-mai].

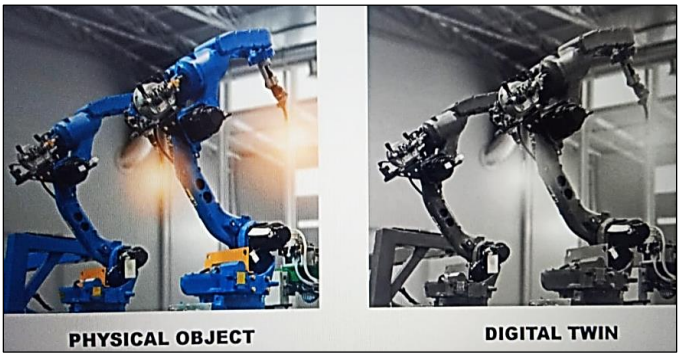

Fig 1: Working of Digital twin technology

3. Prominence of digital twins

Prominence of digital twins is rising in this technological era day by day after the prominence of IoT. With the advent and growing adoption of deep learning, IoT, cloud computing, machine learning and artificial intelligence, digital twins is expected to act as drivers of modern business for the business value and their sustainability [F. Biesinger, D. Meike, B. Krab and M.

Weyrich (2018)]. Applications of digital twins is witnessed in the days to come in various industrial sectors including production & manufacturing, supply-chain, defence, automobile, aerospace, transportation, healthcare, retail and construction etc. Adoption of digital twins benefits various organization in various ways. Some of these are appended below:

- **Innovative product design:** Virtual replica provide through digital twins acts as enabler of testing and then it is made as an actual fine-tuned product. [F. Biesinger, D. Meike, B. Kraß, and M. Weyrich (2019)]
- **Granular view details:** Digital twins act as a provider of granular view which is received as feedback which helps in continuous betterment and upgrading of the product or process [E. Negri, L. Fumagalli and M. Macchi (2017)].
- **Predictive maintenance:** Digital twins uses various sensors as well that are the enables of large amount of data which is emitted out of digital twin sensors. The predictive use of the emitted sensors' data is advantageous in the implementation of predictive maintenance the product or process [T. Bauernhansl, S. Hartleif, and T. Felix (2018)]. Otherwise, the organizations may depend on guesswork or rough ideas about the products-requirement related to service or maintenance.
- **Complex and technology:** Intensive physical assets model- Digital twin is an enabler of best model of complex and technology-intensive physical assets which is using Industrial Internet of Things in context of design, engineering and manufacturing [Florian Biesinger, Michael Weyrich (2019)].
- **Lowering service costs:** Digital twins act as enabler to reduce the service costs otherwise corrupted and least-optimized services without the use of digital twin's causes to huge service costs.
- **Enhance customer satisfaction:** Digital twins act as enhancer of customer satisfaction. As it helps to identify the customer requirements and the products and processes are made physically or in actual as per customer needs because virtual replicas are converted into actuals.
- **Continuous product-process improvement:** Digital twin will be proved as a key player in the improvement, betterment of products and processes [Florian Biesinger, Michael Weyrich (2019), 1 D.T. Heber, F. Michelbach, F.S. Morelli, M. W. Groll, Ed (2018)] by way

of eliminating errors in advance of actual manufacturing and development, predictive maintenance support, better product rollouts.

- **Faster production times:** Digital twin technologies helps in better production times as it not only provides virtual model but also timing of operations, customer feedback and its implementation before actual production. Today's world expects the improved productivity and enhanced operational efficiencies of the generated products.
- **Better efficient delivery and supply chains:** The business world is expecting better efficient delivery and supply chains with the usage of Digital Twin technologies. These technologies are expected to accelerate the delivery process and quality decision making of supply chain activities.
- **Improved customer service:** Expected better delivery and supply chain by way of using digital twins will improve customer service and retention of the customers.
- **Prediction of maintenance issues:** Digital twin technologies helps to predict the maintenance issues that are expected to occur due to breakdowns. [https://www.marketsandmarkets.com/Market-Reports/digital-twin-market-225269522.html]
- **Time savings and lowering costs:** The digital twin technology is considered as a time saving lowering cost mechanism through which product development cycle is determined and deployed. It helps in various levels of product process like asset level, process level or system level.
- **Optimizing process times:** Digital twins are expected to speed up the production process and its delivery cycle which leads to better quality decision making of supply chain related activities.
- Betterment in cyber security, improving plant efficiency, Minimization of risks, increase in efficiency, Complexity minimization, increase in production and productivity are some other attractions and efficiencies of digital twins of the modern business world.
- **Better product line:** The modern world is demanding the better and efficient product and its supply chains which is fulfilled with the use of Digital Twin technologies.
- Reducing asset downtime, minimizing time to market, increase in enterprise value are some other prominences of digital technologies

that are expected in business improvements and better product and process life cycle.

- **Better data-driven decisions:** Digital twins help in better data-driven decisions as data is fuel in the modern business process whether it is at production or manufacturing process level or its tuning process.
- **Deeper insights of monitored products or processes:** Digital twins support a production line at various levels like at Asset level, component level, process level and system level to improve and betterment of the product through its product life cycle process.
- **Ecosystem-based innovation:** Ecosystem is the major concern of the day. Digital twins enhance better architecture, better equipment line etc. that are main concerns of the ecosystem-based innovations in production process.
- **Reduced maintenance costs:** The business world is expecting least maintenance costs of the physical products and process, better equipment lines, enhanced reliability, improved profits and sustainability in the business by way of implementing digital twin technologies.

4. Digital twin predictions in the present scenario

The digital twin technologies used for realization their impact in various sectors are termed as digital models. Some of the main technologies used for realization of digital twins now-a-days are namely 3D Point Cloud, 360° images, Real-time coupling, QR codes, RFID chips and Controller backups. These digital twin technologies can be used by way of combining to form the digital image of physical system. Digital twin-based market is predicted to expand in the time to come. It is expected that it will grow to US$48.2 billion by 2026 from the existing (2020) US$ 3.2 billion. [https://www.marketsandmarkets.com/PressReleases/digital-twin.asp#:~:text=The%20report%20%22Digital%20Twin%20Market,2020%20and%20is%20expected%20to,]. Figure-2 depicts the scenario of digital market from the year 2016 to 2026.

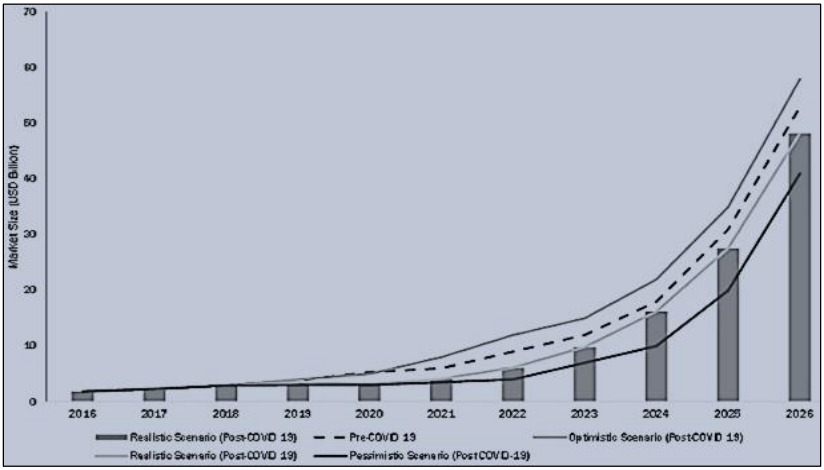

Fig 2: Digital twin market scenario [https://www.marketsandmarkets.com/Market-Reports/digital-twin-market-225269522.html]

As per statistics [Digital Twin Market Statistics | Global Size Forecasts 2026], the size of digital twin market in 2019 was more than US$4 billion. It is predicted that this will increase over 30% (CAGR) in between 2020 and 2026. The reasons behind progression in the digital twin market are the penetration of Internet, advent of various technologies [https://www.gartner.com/en/newsroom/press-releases/2019-02-20-gartner-survey-reveals-digital-twins-are-entering-mai] like artificial intelligence, augmented reality, virtual reality, deep learning, machine learning, blockchain, adoption of industry 4.0 [https://www.i-scoop.eu/internet-of-things-guide/industrial-internet-things-iiot-saving-costs-innovation/digital-twins/], abolition of unplanned downtimes, etc. as well as proliferation of smartphones. Like other sectors, ecommerce sector is having great potential of adoption of digital twins [https://www.pratititech.com/digital-twin-software-platforms]. Amazon is one of the best example who is having the largest market share of ecommerce business and is adopting the digital twin technologies. When users visit the amazon site for purchase of products, they view the products, buy the products or sometimes add them to their virtual baskets. Amazon adopted digital twin algorithm [https://www.forbes.com/sites/bernardmarr/2019/04/23/7-amazing-examples-of-digital-twin-technology-in-practice/?sh=7dcf43db6443] that create the virtual image or to say as digital replica of the whole users' buying process and that is further used for business strategies.

5. Driving factors and potential for growth of digital twin

There is great potential to create and implement digital transformation [F. Biesinger, D. Meike, B. Kraß, M. Weyrich, (2019), T. Bauernhansl, S. Hartleif, and T. Felix (2018)] in manufacturing enterprises. With the progression in the adoption of IoT, urbanization, competitive global market, great evolution in software & IT industry [https://www.netobjex.com/h accessed on 24/10/2020.ow-can-digital-twin-technology-benefit-your-organization], increase in per capita income as well as large-scale industrialization are some of the main driving forces for the growth of digital twin that increase the potential in progression of digital twin. Following are some other common factors that leads towards digital twin:

- Business optimization
- Move towards smart manufacturing
- Progression in manufacturing facilities
- increase in predictive maintenance application division
- Progression in the development of numerous software
- Deployment of automation solutions
- Growth and improvement in production lines
- More focus in the use of digital twin in designing
- More focus in the use of digital twin in production and after service
- More focus in the use of digital twin by way of simulation
- Potential for more use of digital twin to avoid huge losses
- More adoption of digital twin in Automotive & transportation sector
- Growing demand for more efficient and cost-effective technologies for production and manufacturing
- Progression in R&D the field of IoT and IIoT
- Monitor and analyse the product and process in real time
- Manage business processes in efficient way using digital twin that helps to provide actionable insights to the concerns
- Optimization in product service life cycle management

6. Conclusion

There is huge potential and significant opportunities in the adoption and implementation of digital twins in various segments of the industry especially the manufacturing ones due to adoption and deployment of smart

manufacturing and Industrial IOT (IIoT). The other main end-user industries have the great opportunities for digital twin namely Energy, Healthcare, Aerospace, Automotive, Retail, Agriculture, Defence, Transportation, Chemical, Water, Semiconductor etc. due to increasing growth in the domain of cloud computing and IoTs. Various organizations are already adopted digital twins, some of the names of these industries are LOCOMACH, Tesla Motors, Bosch Building Technologies. The major companies playing a vital role in the digital twin market are IBM, Microsoft Corporation, Oracle, SAP, General Electric, Robert Bosch and PTC (US), Rockwell Automation, Honeywell, Hirotec Corporation (JPN), Siemens (AG), Cenit AG (GER), Daimler AG (GER). The base of digital twin technologies are IoT & IIoT, Virtual Reality, Augmented Reality, Artificial Intelligence, Mixed Reality, Big Data Analytics, Blockchain, Machine Learning, Deep Learning, 5G.

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Chapter - 6
Act East Policy and Its Role in Bridging the Gap of Trade between India and other South-East and East Asian Countries

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Chapter - 6

Act East Policy and Its Role in Bridging the Gap of Trade between India and other South-East and East Asian Countries

Sameer Baruah

Abstract

Until 2014 India limited its international trade system with few countries of the world. With the emergence of "Look East Policy" in 1991 and "Act East Policy" in 2014, India has been able to extend its volume of trade to South-East as well as East Asian nations. The Act East policy was launched at the East Asia Summit in Myanmar in November 2014. The main difference between the Look East and Act East Policy lies in the fact that Look East Policy aims to increase economic integration with the South-East Asian nations, while the Act east Policy focus on economic and security integration with South-East Asia as well as East Asian nations. Act East policy emphasized on India-ASEAN cooperation on infrastructure, manufacturing, trade etc. The major objective of the policy is to promote economic cooperation in the Asia-Pacific region through bilateral, regional and multilateral levels. Thus the policy provides connectivity to the N.E. States of India. N.E. India has been a priority in the Act East policy, which provides an interface between N.E. India and the ASEAN region through various bilateral and regional levels. It is in this way, Act East policy plays a crucial role in connecting India with other Asia-Pacific countries in respect of trade and other bilateral economic activities.

Keywords: act east policy, bilateral & regional trade, North-East India etc.

1. Introduction

Act East Policy is a modified version of the Look East Policy which was started by then Prime Minister P.V. Narsimha Rao in 1993. The main objective of Look east Policy was to strengthen the economic ties with the eastern countries and was limited to South-east Asia. But in 2014, PM Narendra Modi changed Look east policy to Act East Policy which focuses on economic and security integration with South-East Asia as well as East

Asian nations. China's string of pearls project and One Belt One Road initiative can prove negative to India and thus India needs to maintain the good relationship with its neighbor as well as ASEAN countries. Act east Policy was brought by Narendra Modi Government to counter the China's increasing ties with the ASEAN countries and countries in Indian Ocean.

Act East policy emphasized on India-ASEAN cooperation on infrastructure, manufacturing, trade etc. The major objective of the policy is to promote economic cooperation in the Asia-Pacific region through bilateral, regional and multilateral levels. Thus the policy provides connectivity to the N.E. States of India. N.E. India has been a priority in the Act East policy, which provides an interface between N.E. India and the ASEAN region through various bilateral and regional levels. It is in this way, Act East policy plays a crucial role in connecting India with other Asia-Pacific countries in respect of trade and other bilateral economic activities.

1.1 Objectives of the study

The followings are the major objectives of the study:

1. To understand the major aims and objectives of the Act East Policy.
2. To know the role of the Act east Policy in promoting the international trade between India and other ASEAN and East Asian Countries.

1.2 India's act east policy and ASEAN and other east asian countries

India's Act east Policy focuses on the extended neighborhood in the Asia-Pacific region. The policy has gained political, strategic and cultural dimensions. India has upgraded its relations with Indonesia, Vietnam, Malaysia, Japan, Republic of Korea, Australia, Singapore and ASEANs and forged close ties with all countries in the Asia-pacific region. Act east Policy has placed emphasis on India-ASEAN co-operation in our domestic agenda on infrastructure, manufacturing, trade, skills, smart cities, make in India and other initiatives.

1.2.1 Objectives of the act east policy

The major objectives of the Act East Policy include:

a) To promote economic co-operation, cultural ties and develop strategic relationship with countries in the Asia-Pacific region through continuous engagement at regional, bilateral and multilateral levels.

b) To increase the interaction of the North-Eastern Indian states with other neighboring countries.

c) To find out the alternatives of the traditional business partners; more focus on the pacific countries in addition to the South-east Asian countries.

d) To curb the increasing impact of China in the ASEAN region.

e) To provide enhance connectivity to the states of North-Eastern region including Arunachal Pradesh with other neighboring countries.

The north-eastern part of India has been a priority in the Act east Policy, which provides an interface between north-east India including the state of Arunachal Pradesh and the ASEAN region. North-east India is not just a gateway to South-east Asia but is an extended corridor for growth, progress and prosperity of India. Various plans at bilateral and regional levels include some efforts to develop and strengthen the connectivity of North-East India with ASEAN region through trade, culture, people-to-people contacts and physical infrastructure such as road, airport, telecommunication, power etc. Some of the notable projects include Kaladan Multi-Model Transit Transport Project, the India-Myanmar-Thailand Trilateral Highway Project etc.

North-East India has been significantly emerged as a land bridge to reach out to the rest of ASEAN countries. The Act east Policy passing through Northeast region has now become the centre of geo-economics and geopolitics. Building infrastructure in the North-Eastern region is an important element in India's engagement with South-East Asian countries. This policy would definitely help growth, progress and development of people of the region. The Act east policy is also an important factor in ending the geographical isolation of the region.

1.3 India-Japan relation and act east policy

Act East Policy not only helps to maintain trade relations with South-East Asian nations but with the East Asian nations also. The trade relation between India and Japan is an example of the same. India-Japan relations are passing through a good phase from last few years. During the last couple of years Japan is helping India in many infrastructure projects. These projects are like Delhi Metro Corporation and the recent Ahmedabad-Mumbai bullet train project. On the other hand, Indian export to Japan was around Rs. 21.36 billion per month in 2017.

Table 1: India's Merchandise Export & Import (2012-13 & 2016-17) (All Figures are in $ billion)

Years	Export	Import	Trade Deficit
2012-13	6.1	12.4	6.3
2013-14	6.8	9.5	2.7
2014-15	5.4	10.1	4.7
2015-16	4.7	9.8	5.1
2016-17	3.8	9.7	5.9

Source: Indian Commerce Ministry

India's trade deficit with Japan widened to $5.9 billion during 2016-17 against $2.7 billion in 2013-14. During 2016-17, India's exports to Japan contracted 17.5% and its imports fell by 1%. India's export to Japan have almost halved to $3.85 billion in 2016-17 from $6.81 billion in 2013-14.

The ASEAN-Indian Plan of action for the period 2016-20 has been adopted in August 2015 which identifies concrete initiatives and areas of cooperation along the three pillars of political-security, economic and socio-cultural. The ASEAN-India Agreement on trade in Service and Investments has entered into force from 1 July 2015. India has also invited ASEAN member states to participate in the International Solar Alliance which has co-launched with France on 30 November 2015.

1.4 India-ASEAN relations through act east policy

Act East Policy has helped India to maintain its trade balance with ASEAN countries. In order to harness the benefits of Act East Policy, India has upgraded its relations with Japan, Australia, Vietnam, Indonesia, Malaysia, Republic of Korea etc. The policy made it possible for India to export its surplus products to the ASEAN nations, and also to import necessary items from the same (Table-2).

Table 2: India's Export and Import Value with ASEAN Countries

Countries	Total Export		Total Import	
	2016-17	2017-18	2016-17	2017-18
Brunei	42.88	29.88	627.85	286.56
Cambodia	105.06	64.15	36.1	29.68
Indonesia	3488.12	1982.48	13427.99	9402.25
Laos	25.72	11.24	207.38	125.27
Malaysia	5244.86	2788.34	8933.59	5211.17
Myanmar	1107.89	511.19	1067.25	540.28
Philippines	1482.52	900.85	494.62	465.15

Singapore	9564.48	5623.9	7086.57	4038.78
Thailand	3133.44	1978.47	5415.4	3916.55

Source: Indian Commerce Ministry.
*All Figures are in $ million

Apart from ASEAN, ASEAN Regional Forum (ARF), and East Asia Summit (EAS) etc. India has also been actively engaged in regional forum such as Indian Ocean Rim Association (IORA), Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), Asia Cooperation Dialogue (ACD) etc.

1.5 Major findings

Major findings of the study include:

a) Act East Policy plays an important role in promoting, strengthening and improving economic activities among the ASEAN and other East Asian nations.

b) Trade relationship among the ASEAN countries is possible with the emergence of Act east Policy.

c) North-East India is significantly emerged as an important centre point for trade among the ASEAN and East Asian countries.

d) Many developmental activities have been taken place in North-East India with the emergence of Act east Policy.

To conclude it can be said that the Act east Policy is a step ahead of Look East Policy of India. If everything goes as per the policy, then the objectives of the Act east Policy will give more fruitful results very soon.

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Chapter - 7
Choice of Support for New and Renewable Energy System Operations

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Chapter - 7

Choice of Support for New and Renewable Energy System Operations

Bhairi Saritha, M.V. Vara Lakshmi and Immaneni Sri Deepthi

Abstract

The global requirement for sustainable energy provision will become increasingly important over the next fifty years as the environmental effects of fossil fuel use become apparent. Therefore, the issues surrounding integration of renewable energy supplies need to be considered carefully. The focus of this work was the development of a decision support framework that will aid the design of sustainable energy systems for the supply of electricity, heat, hot water and fuel for transportation. This work has succeeded in developing a more complete tool for analysing the feasibility of integrated renewable energy systems. This will allow informed decisions to be made about the technical feasibility of supply mix and control strategies, plant type and sizing, suitable fuel production, and fuel and energy storage sizing, for any given area and range of supply options.

Keywords: RES, fuel combustion, diesel engine modelling

1. Introduction

Sustainable design can be described as that which enhances ecological, social and economic well being, both now and in the future [1]. The global requirement for sustainable energy provision will become increasingly important over the next fifty years as the environmental effects of fossil fuel use become apparent. As new and renewable energy supply technologies become more cost-effective and attractive, a greater level of both small-scale and largescale deployment of these technologies will become evident. This chapter discusses the problem of increasing global energy use, potential sustainable energy supply system options, and the various complex integration issues that are inherent in the design of sustainable energy supply systems that are both reliable and efficient. The creation of a decision support framework is proposed that will aid the technical design of sustainable energy systems, in order to encourage and support planning for future development.

Since the discovery of fire, and the harnessing of animal power, mankind has captured and used energy in various forms for different purposes. This has included the use of fire, fuelled by wood, biomass and other waste for cooking, heating and the melting of metals, the use of windmills, waterwheels and animals to produce mechanical work, and the use of animals for transportation. However, it was not until the industrial revolution that humans began to rely heavily on energy utilisation for everyday life. With the development and exploitation of electricity, the discovery of abundant reserves of fossil fuels with higher energy densities than biomass fuels, and the rapid expansion of energy intensive industrial processes and vehicles, the use of energy in industrialised countries increased at an incredible rate, with no concern for energy conservation as fuels were inexpensive and plentiful. In fact, machines that were originally designed to run on biomass derived fuels (e.g., Rudolf Diesel's first engine ran on peanut oil [2] and the Model T Ford was designed to run on alcohol [3]), were redesigned to run on fossil fuel derived fuels as these were abundant and cheap.

2. Options for new and renewable energy systems

This work discusses the options for, and the issues involved in, the design of integrated sustainable energy supply systems that are reliable and efficient, and allow consideration of transport, heat, hot water and electricity demands. Technologies currently available to meet these demands, and their potential role in the overall supply system, are described. There are various technologies currently available that will supply the energy needs for transport, heat, hot water and electricity, in a sustainable manner. Electricity may be generated by harnessing weather-related sources of energy (e.g., wind, sunlight, waves, rainfall), however, this gives an intermittent and unpredictable output. In order to provide a reliable electricity supply, reduce energy wastage and enable the energy requirements for heat and transport to be met, the outputs of these intermittent sources may be supplemented by various means. These may include the use of storage devices and/or the use of biomass and waste materials (in their original form, or converted into other fuels) in engines, turbines and fuel cells for the production of electricity and heat, in vehicles for transportation, or in heating supply or storage systems.

3. Vehicle performance algorithm

The input to this part of the procedure, at the demand and supply matching stage, is a transport demand profile (km/h versus time) and the

appropriate fuel availability profile. From these, the ability to meet the transport demand, and half hourly fuel use, must be derived. To do this, the specific fuel consumption of the chosen vehicle, the amount of fuel that can be stored on board, and the refuelling requirements are defined when choosing the load following supplies, and examples of the vehicle definition windows for the different fuel types can be used.

Fuel consumption

A number of factors affect the fuel consumption of a vehicle, including personal driving style, driving speeds, and the number of stops and starts. To allow comparison, international standard test conditions have been set to determine fuel consumption figures for different vehicles for three typical types of driving condition-urban, extra-urban and combined driving [1] and these typical figures are used in this program in order to calculate vehicle fuel use. The fuel consumption units used by the program depend on the fuel type, as discussed below, but all are quoted as an amount of fuel per 100km. As the transport demand is in km/h, all consumption figures are converted to the amount of fuel required per km by dividing by 100, to allow the actual fuel requirement to be calculated in the correct units (kWh for gases and electricity, and litres for liquid fuels). This calculated specific fuel consumption (kWh/km or litres/km) is then input into the algorithm defined later.

Fuel consumption figures for electric vehicles are quoted in kWh/100km, which is divided by 100 to give the fuel consumption in kWh/km. The overall amount of energy available from a battery depends on its rate of discharge [3], however, when considering vehicles, no information is given about the effects of rate of discharge on the delivered energy. As the vehicle 'fuel consumption', or more correctly for a battery, discharge rate, is quoted for typical use, and there are a limited range of discharge rates at which the vehicle would require to draw energy, the quoted discharge rate (kWh/100km) is used, and not varied with the energy drawn. This is the same simplification as using average fuel consumption rates for the other types of vehicle, as the fuel consumption of these vehicles would vary with the speed and type of driving. Also, as general transport demands are being modelled over half hourly time periods, and the use of onboard storage is being taken into consideration, these are reasonable assumptions.

4. Storage and refuelling options

As vehicles have onboard storage, it is unrealistic to model them as continuous users of fuel. Instead they require refuelling when their tank is

running low or at certain times each day, depending on the users requirements. Therefore, the initial fuel level as a percentage of the tank capacity must be known, and a refuelling method must be defined. Options for refuelling given in the program are, refilling to maximum when the level falls below a given minimum percentage, or choosing to refuel at the same time or times each day. If continuous use is to be analysed, the options to always keep at maximum or an input minimum, where possible, are also available. These options are available for all types of vehicle, except electric vehicles, whose recharging is a separate case with specific considerations, which is described later. The amount of storage available on the vehicle is also an important factor when considering fuel use and refuelling profiles. This is not often quoted as a storage amount, and where these figures are available, they are again subject to confusion due to the different storage methods for gases. However, a parameter that is widely available, which is directly related to the storage capacity of the vehicle, is the driving range between refuelling. If the range and fuel consumption of a vehicle, and the number of vehicles, are known, the total available onboard storage capacity can easily be calculated. This parameter is required for the vehicle use algorithm described later. Where more than one vehicle is being used, an even distribution of use across these vehicles is assumed.

This is a more useful method of calculating the storage capacity of an electric vehicle as it eliminates the problems of minimum discharge level, which can be misleading, and calculates the total capacity actually available. In this case, the output graph at the matching stage shows the percentage of available battery capacity.

The recharging of a battery generally takes place in three stages, two of which can be seen in Figure below [3]:

- **Bulk charge:** The battery is charged using a constant current until it reaches around 70 or 80% charge. This is the maximum safe charging current that does not cause overheating in the cables.
- **Absorption charge:** As the battery gets close to full charge, the internal resistance increases. To avoid damage and overheating, the charging voltage remains constant, while the current decreases exponentially.
- **Float charge:** Once the battery reaches full charge, the charging voltage is reduced to prevent damage to the battery from overcharging when the recharger has not been switched off.

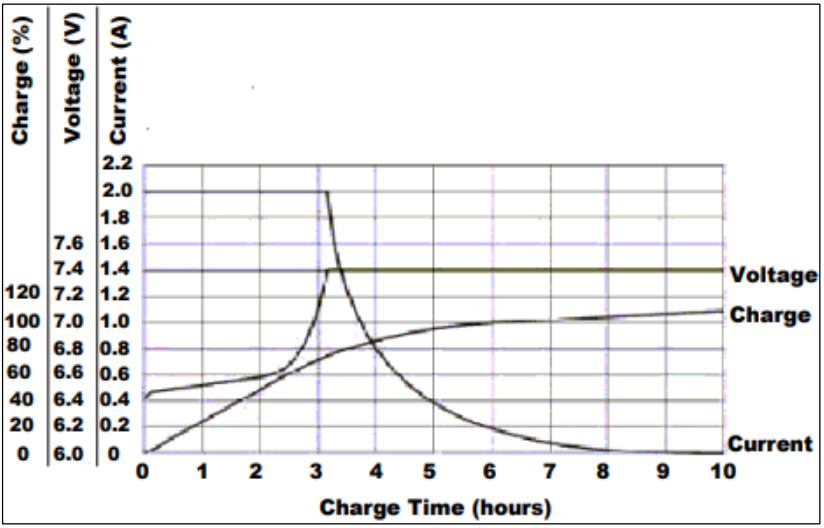

Fig 1: Battery Charging Characteristics

In general, the bulk charge phase for an electric vehicle takes half of the recharging time, recharging the battery to around 70% and the absorption charge phase uses the second half of the recharge time [5]. The float charge phase is not considered here as this is designed mainly to limit battery damage due to overcharging, which this model will not allow. The initial state of charge of the vehicle battery is defined with the vehicle characteristics, along with the time to start the slow recharge, and whether or not to allow fast recharges (although the number of fast recharges a vehicle undergoes should be limited as this affects the battery life). The time taken for a full slow recharge, the maximum bulk charge percentage and the percentage of the charge time this takes, also need to be input in order to define the recharge curve. This allows the algorithm shown in Figure. 2, for charging and discharging the electric vehicles, to be used at the matching stage. Discharging is similar to the other vehicles, except that no recharging takes place if the level falls below 0, unless fast recharging has been allowed. The efficiency of the battery must also be taken into consideration, as more energy is required to recharge the battery than will be available from the battery after recharging. This efficiency is generally around 85% and is taken into account when recharging the battery, by increasing the amount necessary for recharging. This procedure is slightly different than for the other vehicles as, although the demand is still in storage units (kWh), the supply profile is a supply rate (kW) rather than an available amount. This must, therefore, be taken into consideration throughout the procedure.

Firstly, the maximum storage capacity (maxkWh) must be calculated. Time steps per day, start time1, and start time2, should be calculated as before. Then, for each time step, the residual electricity supply should be read in as the fuel supply, and i is equal to the current time step value. The i value is checked to see if it corresponds with either of the recharge start times. If not, the vehicle battery is discharged in a similar manner to the other vehicles. If the battery charge goes below zero, and fast recharging is not allowed, the transport demand that can be met with the available charge is calculated and the available battery charge is set to zero. This gives the electricity supply rate required to fully recharge the battery over the available times tep interval in kW, which can be directly compared to the available supply.

Required (kW) = (max kWh-tank) x time steps per hour

Likewise, when this electricity supply is used to add charge to the battery, the electricity supply in kW must be divided by the timesteps per hour to find the storage value (kWh) that can be added to the tank in that timestep interval.

Tank (kWh) = tank + (fuel supply/time steps per hour)

In reality, the recharge would probably take less time than the full timestep interval, but in dealing with, mainly, half-hourly timesteps, there is a necessary averaging out of all supply data [4]. To avoid this, a greater number of timesteps per hour may be chosen, but this only makes sense if other electricity supply profiles and climate data are also available at that frequency.

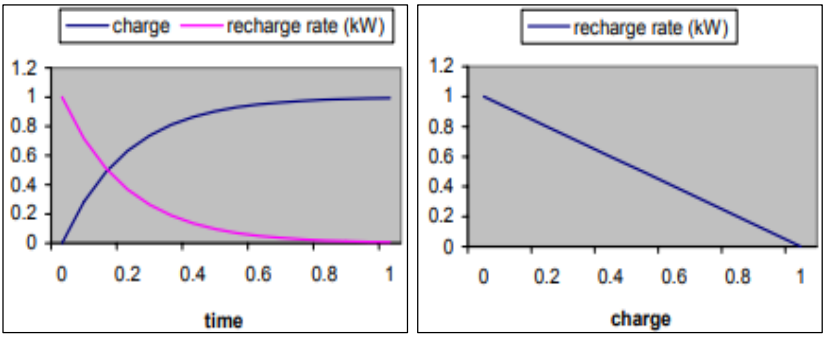

Fig 2: Relationship between Percentage Charge and Recharge Rate

5. Internal combustion and diesel engine modelling

There are two possible ways to approach the performance modelling of internal combustion or diesel engines. Firstly, the combustion process and

thermodynamic cycle could be explicitly modelled, in order to predict the performance of different engine designs. This approach, however, would require a large volume of data that would not be easily available (much of which might be proprietary), or may require tests to be carried out on the specific engine being considered. Also, the complexity and variety of designs available would make it difficult to create a generic model for a wide variety of engines. Alternatively, the performance of an engine can be predicted from actual performance data quoted by manufacturers, which is already widely used to predict engine performance under different load and ambient conditions. A model of this type would be more generally useful and applicable, as it would use readily available manufacturers' data, and it could also be easily applied to other engine types and new technologies as they arise. An example of this would be the Proe Afterburning Ericsson Engine [8], which is a multi-fuelled engine that uses the Ericsson thermodynamic cycle rather than the Diesel or Otto cycles, and may also be modelled using the generic approach outlined in this section. The existing diesel generator model in MERIT has been enhanced to allow consideration of different engine and turbine types, part load performance (of efficiency and heat to electricity ratio), minimum load, the possible use of multiple engine sets to allow more efficient performance (i.e., only one operating at low load times), derating for altitude and ambient temperature, and the possibility of using different types of fuel. The ability to follow heat and/or electricity demand, run at a constant load, or run at specified varying loads at different times of the day and year, has also been added. To allow derating, the altitude of the site is input with the climate data selection.

Conclusion

This work described the algorithms used to estimate the performance of various load following supplies, based on residual demand, supply and fuel availability information sent by the matching process and the algorithms used to create fuel supply and related energy use profiles for specified derived fuels.

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Chapter - 8
Hybrid Solar-Wind Generation Based Renewable Energy Resources

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Chapter - 8

Hybrid Solar-Wind Generation Based Renewable Energy Resources

Dr. M. Kondalu and Swarupa Rani Naidu

Abstract

The main objective of this work is Fuzzy controller design for solar wind-based hybrid system. Renewable Energy Resources (RES) plays an active responsibility in standing against comprehensive warming and reduce the use of conventional energy sources. Hybrid systems formed by combining the renewable energy sources are efficient relatively. The intent of this paper is to furnish endurable power for frontier and far-off places with hybrid-system of architecture. The intended system embodying DFIG and solar PV based wind turbine. In solar systems, control mechanism is essential for improving the performance. This paper proposes a method of incremental conductance approach based MPPT Adaptive Fuzzy Logic Controller for grid connected PV system which is composed of a boost converter and a three-phase inverter. Adaptive Fuzzy Logic Controller provides fast response and better % THD compared to Fuzzy and PI controllers. The modelling of the circuit is done is MATLAB /Simulink environment with graphical representations respect to time.

Keywords: solar, wind, MPPT

1. Introduction

Photovoltaic (PV) is a technique for producing electrical force by changing over solar based radiation into direct flow power utilizing semiconductors that display the photovoltaic impact. Photovoltaic force age utilizes solar based boards including various cells containing a photovoltaic material. Materials by and by utilized for photovoltaic incorporate mono crystalline silicon, polycrystalline silicon, nebulous silicon, cadmium telluride, and copper indium selenide/sulfide [1]. Due to the developing interest for sustainable power sources, the assembling of solar oriented cells and photovoltaic arrays has progressed significantly lately.

Starting at 2010, solar oriented photovoltaic creates power in excess of 100 nations and while yet involving a little part of the 4800 GW all out worldwide force producing limit from all sources, is the quickest developing force age innovation on the planet. Somewhere in the range of 2004 and 2009, Grid-associated PV limit expanded at a yearly normal pace of 60 percent, to around 21 GW. Such establishments might be ground-mounted (and now and again coordinated with cultivating and brushing) or incorporated with the rooftop or dividers of a structure, known as Building Integrated Photo voltaics or BIPV for short. Off-lattice PV represents an extra 3-4 GW. Driven by progresses in innovation and increments in assembling scale and refinement, the expense of photovoltaic has declined consistently since the primary solar oriented cells were fabricated. Net metering and budgetary motivating forces, for example, special feed-in taxes for solar based produced power; have bolstered solar powered PV establishments in numerous nations.

The photovoltaic impact is the age of a voltage (or a comparing electric flow) in a material upon introduction to light. Despite the fact that the photovoltaic impact is legitimately identified with the photoelectric impact, the two procedures are extraordinary and ought to be recognized. In the photoelectric impact, electrons are catapulted from a material's surface upon presentation to radiation of adequate energy. The photovoltaic impact is diverse in that the created electrons are moved between various groups (for example from the valence to conduction groups) inside the material, bringing about the development of a voltage between two terminals. In most photovoltaic applications the radiation is daylight and therefore the gadgets are known as solar powered cells. On account of a p-n intersection solar based cell, light of the material outcomes in the age of an electric flow as energized electrons and the rest of the gaps are cleared in various ways by the implicit electric field of the consumption area. The photovoltaic impact was first seen by Alexandre-Edmond Becquerel in 1839.

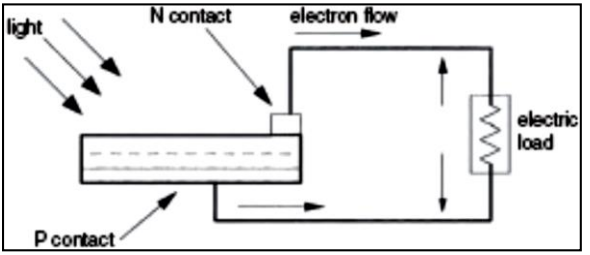

Fig 1: PV effect converts the photon energy into voltage across the pn junction

2. Maximum power point tracker

Principle of MPPT

MPPT (Maximum power point tracker) is an algorithm used to get the maximum power from any PV array using charge controllers. The point at which we can draw a maximum power from a PV module is called as maximum power point. There are few factors like temperature, solar radiation, etc which affect this MPP. MPPT is a DC-to-DC convertor which produces the voltage suitable for the load and provides optimum electricity to the solar panel.

A PV cell gives maximum output power only at single point. The value of the resulted maximum power can be obtained by equation V/I as specified by Ohm's Law. Here I is the current and V is the voltage. As we know that the PV cell has exponential relationship between voltage and current, the maximum power point is observed at the knee of the curve. Here the resistance will be equal to the negative of the differential resistance (V/I = -dV/dI). So MPPT uses these formulas and using control logic it searches the maximum point at which a solar cell can covert maximum amount of light energy into electricity and then the convertor circuit extracts the electricity at that point.

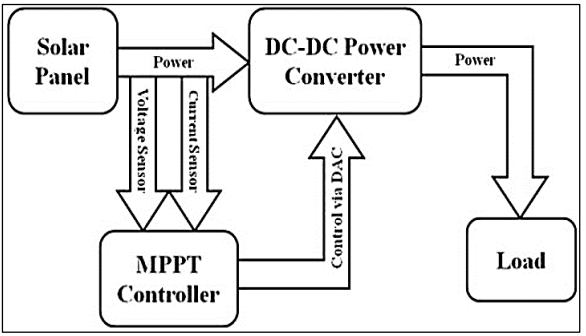

Fig 1: Block diagram of MPPT algorithm

3.2 Algorithm of perturb observe method

Using above flow chart, we can derive the maximum power point for any solar cell. When we know power and voltage values of the previous output then we can derive the current that need to be adjusted for getting MPP.

MPPTs can also be designed without stored energy by just giving an initial current. This can drive an electric motor. This has significant

advantages, when we start a motor with load. When we provide initial current to start the motor and drop the current requirements, then we will be able to increase the voltage and reach the MPPT automatically. So, by this we can say that MPPT can act as electrical analogue to the transmission.

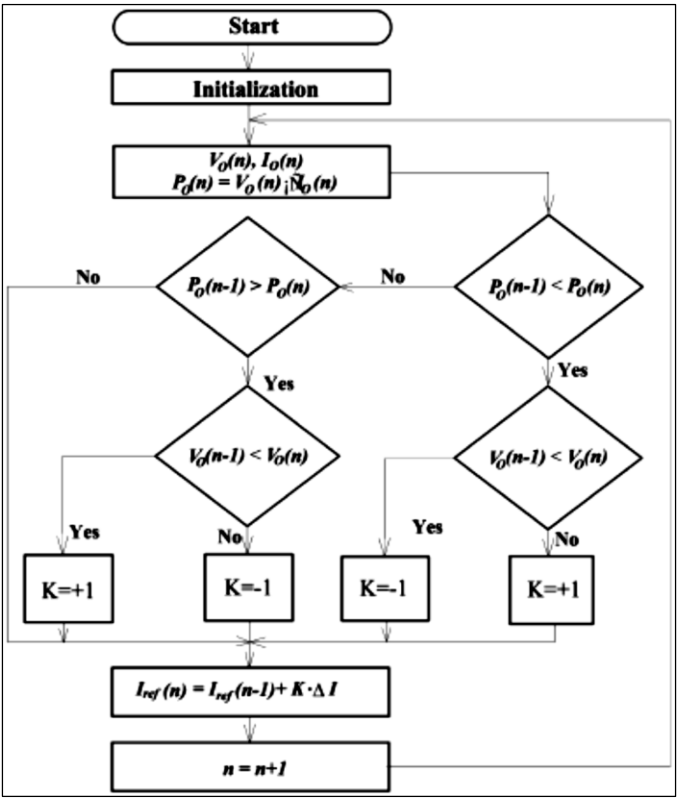

Fig 2: MPPT algorithm using P&O method

3. Hill climb search strategy

If we observe clearly, the curves of the wind and PV power array look similar. So, we call this curve as the hill climb search (HCS). This strategy is usually applied to this type of energy sources to extract maximum power which in turn makes the operating point unstable and makes it excited to observe the output. If the increase in voltage increases the performance, then it continues increasing the voltage or if the performance is increased by decreasing the voltage, then it decreases the voltage. If there is no change in the output by increasing or decreasing the voltage, then it stabilizes the voltage and runs at that voltage point. In this way it adjusts the voltage and make sure that max output is received.

4. MPPT Scheme of β method

Fast MPPT schema is called as Beta(β) method. In This method, the MPP condition is observed in a certain range using intermediated defined variable β. We observe the variance of MPP i.e., $PMPP_{(max)}$ to $PMMP_{(min)}$ between the narrow band ($\beta_{max} - \beta_{min}$). Here we maintain full insolation and temperature ranges varies between (λ_{max}, T_{max} to λ_{min}, T_{min}).

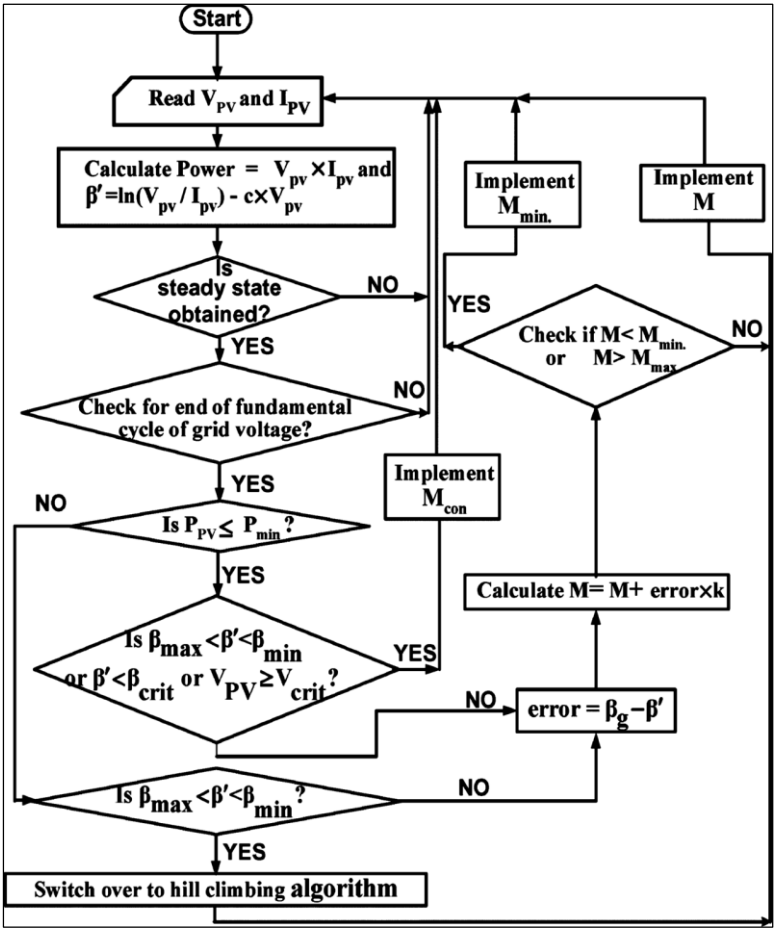

Fig 4: MPPT algorithm for β-method

Here we get β value by using MPP condition, $\partial P/dV = 0$ and it is derived as below,

$$\beta = \ln(-I_o \times c) = \ln\frac{I_{pv}}{V_{pv}} - c \times V_{pv}$$

Where I_0 is the reverse saturation current of the diode. By performing repetitive steps varying the current, we can track β and can bring MPP into the narrow band. This means that by changing β we can change operation voltage of the PV array and balance the power across the capacitor (C_{pv}).

When there is low isolation there might be chance of shifting of OV of the PV array towards the OCC as the voltage increases across C_{pv} due to imbalance in input and output power. When there is high or normal isolation then the system draws required amount of power from FC. To overcome those problems, we need to modify the logic accordingly to ensure that the PV array voltage is always less than the Critical voltage.

This logic ensures that Array voltage is always less than or qual to critical voltage by setting the modulation index to fixed point.

5. Incremental conductance method

This method uses the slope of the IV diagram of PV array and ensures to reach the Maximum power point. Variance of MPPT also depends on the climatic conditions as discussed in previous sections. In summer/hot climatic conditions, if the batteries are low in charge then we might see maximum performance but where in in cold climatic conditions, the V_{pp} can raise to 18V. Also, in such conditions as the need is more, we get boost in the energy and see high performance.

For example, consider a windy day having Outside temperature: 20°F (-7 °C). assuming that the wind flow is low, and which is helps the PV cell temperature to rise around 32°F (0 °C). Vpp = 18V.Also consider that the batteries are a bit low, and loads are on, so battery voltage = 12.0 and ratio of Vpp to battery voltage is 18:12 = 1.5:1. Under these conditions, a theoretically perfect MPPT having no voltage drop would deliver a 50% increase in charge current. But in real life, we will see some losses and the output may result in 20 to 30% only.

MPPT technique used in this work

We have seen many MPPT techniques in previous sections but among all those, Perturbation observation method and incremental conductance method are used widely as it has high efficiency. So, we are using Perturbation observation method due to its simplicity and accuracy. We use same MPPT technique in both wind turbine and PV array. So, to achieve maximum power we need to adjust both wind turbine and PV array to achieve maximum power point.

As we know this algorithm starts with the initial values, here we consider the initial reference rotor speed for the wind turbine and voltage for the photovoltaic array. Along with the input values of wind, PV we do take the output powers of these systems. When all the required inputs are captured, the algorithm checks if it matches with the maximum power or not and it keeps on increasing or decreasing the voltage until it doesn't see any difference in the voltage.

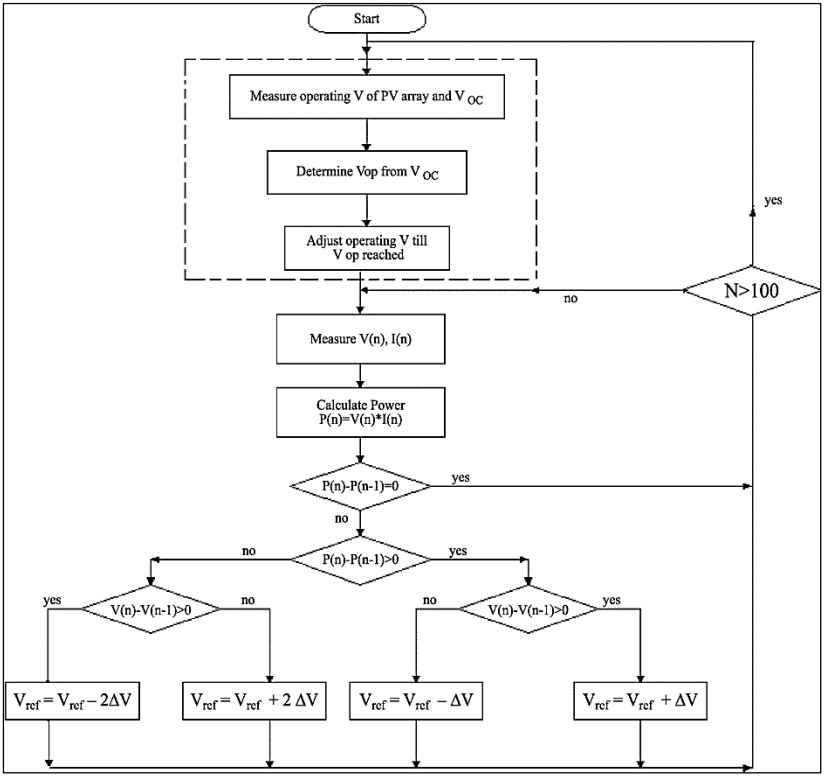

Fig 5: Incremental Conductance Method Algorithm

6. Power control

Power circuit topology

As wind turbine and Photovoltaic array are the primary energies sources for our system, we arrange these both in parallel by using DC-Dc converters and we will connect this to a common PWM voltage source inverter. This topology considers the energy sources as diodes having current of $I_{D1}+I_D$. If we consider our sources s diodes D1 and D2, then D1 and D2 will allow unidirectional flow of the power. So, if there is any malfunction occurred then only diode will be disconnected from this system.

Control circuit topology

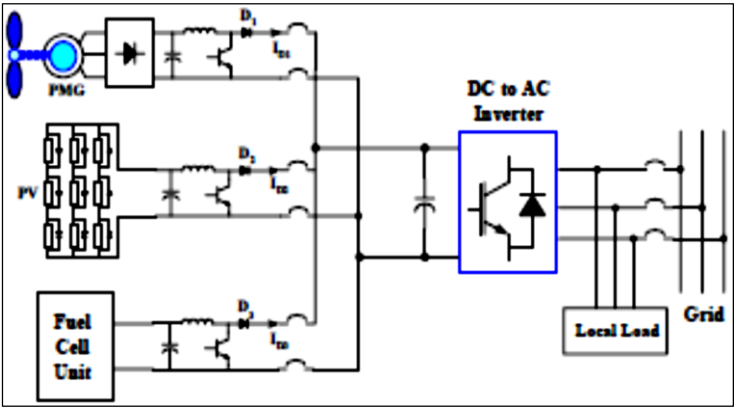

Fig 6: Configuration of Hybrid System

Below are the basic structure and control topology details of the dc-dc boost converter. This system uses a converter to divide the input dc-link voltage into two stages: one is obtained at the output terminals as the variable dc-link voltage of the energy source and other is obtained at the input terminals as the fixed dc-link voltage of source inverter. Now we are going to analyse the boost chopper theoretically. The energy sources are first replaced with a variable DC voltage source. To get a resistive load we are simulating the inverter circuit connected to a DC-link. Assuming the inductance and capacitance are large enough for switching the device current and the DC output. The energy is stored in L when S_{dc} is 1, the energy is transferred to C and when S_{dc} is 0.

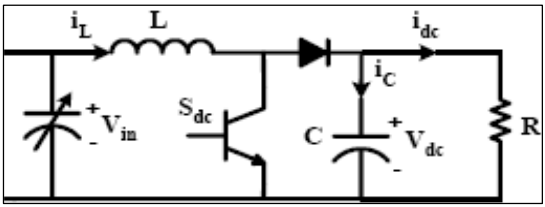

Fig 7: Circuit of Step-up DC-DC boost converter

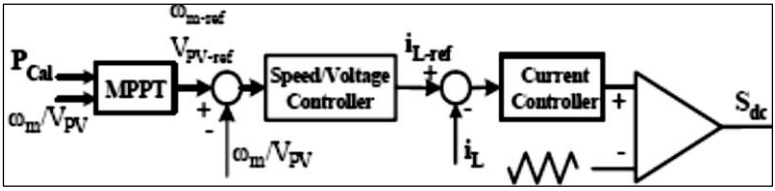

Fig 8: MPPT tracking for Wind and Photovoltaic Sources

The wind turbine and photovoltaic array are controlled using an error signal which is generated through inductor current. The difference between the speed of reference turbine using MPPT and actual speed is determined as error signal for wind turbine. Whereas the difference between the reference voltage set by the MPPT and actual voltage is determined as error signal for photovoltaic array. The proportional integrator (PI) controller uses this obtained error to controls the duty cycle of the DC-DC converters.

Simulation results

Existing results

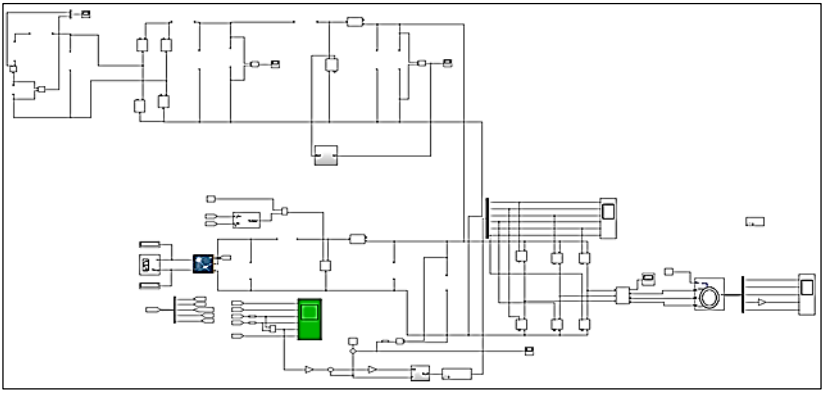

Fig 10: MATLAB/SIMULINK diagram of solar water pumping system interfaced with intelligent grid

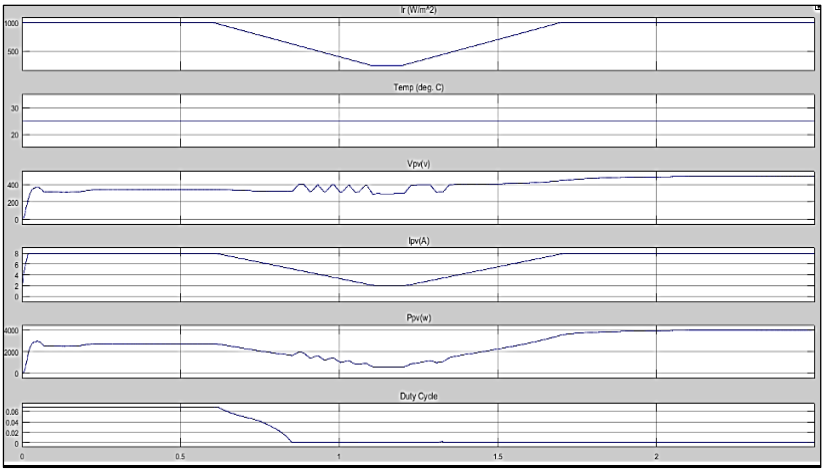

Fig 11: Steady state performance of the system in different modest below parameters(A)G (W/m^2) (B) Temperature (C) Vpv (volts)(D) Ipv (amps)(E)Ppv (watts)(F) Duty cycle

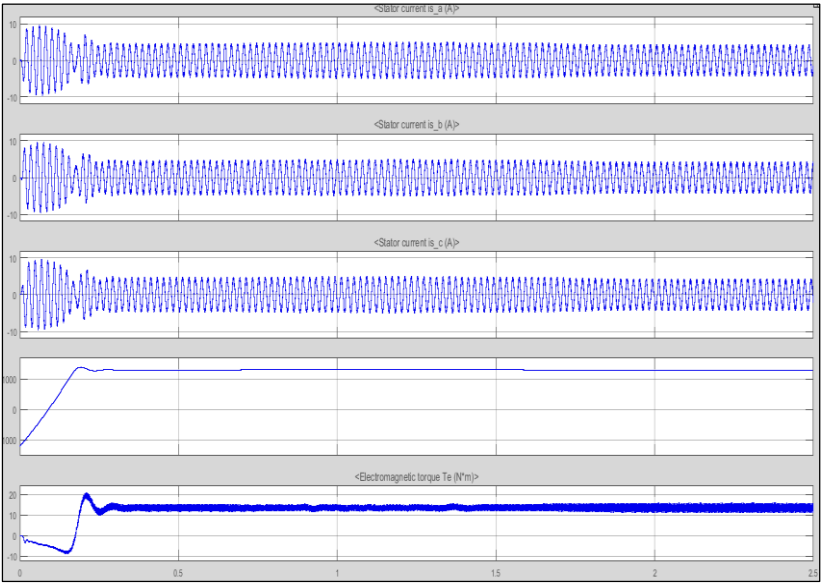

Fig 12: (A)Isa(amp) (B)Isb(amp) (C)Isc(amp) (D) Speed(rpm)(E) Torque ($N*m^2$)

Proposed results

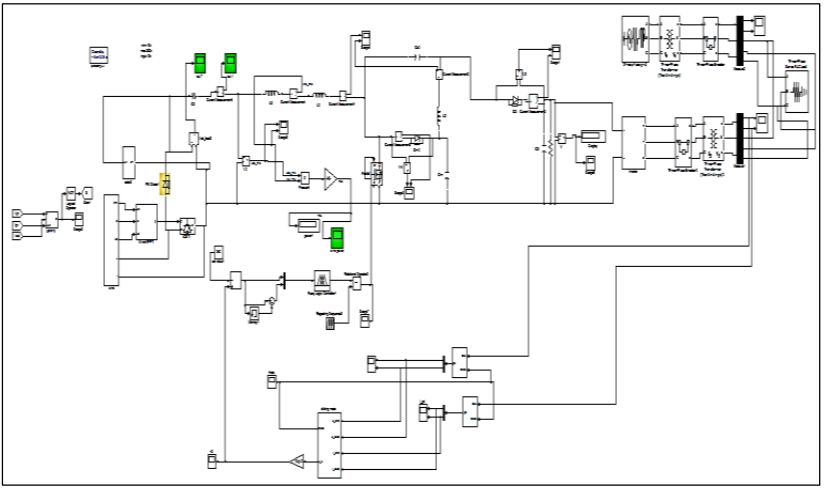

Fig 13: MATLAB/SIMULINK diagram of proposed hybrid system

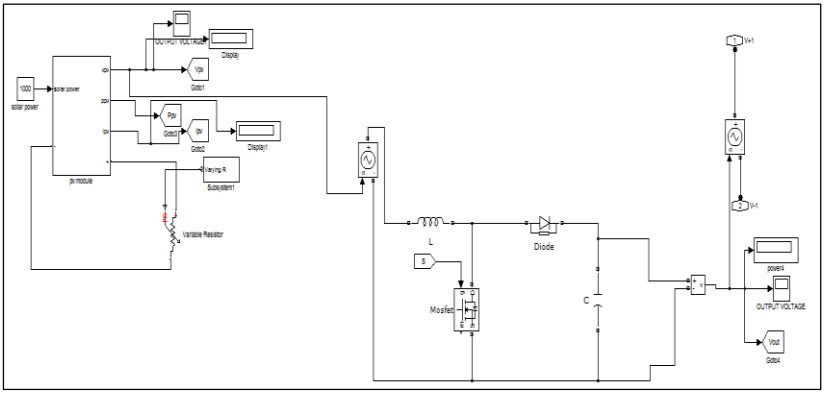

Fig 14: PV subsystem

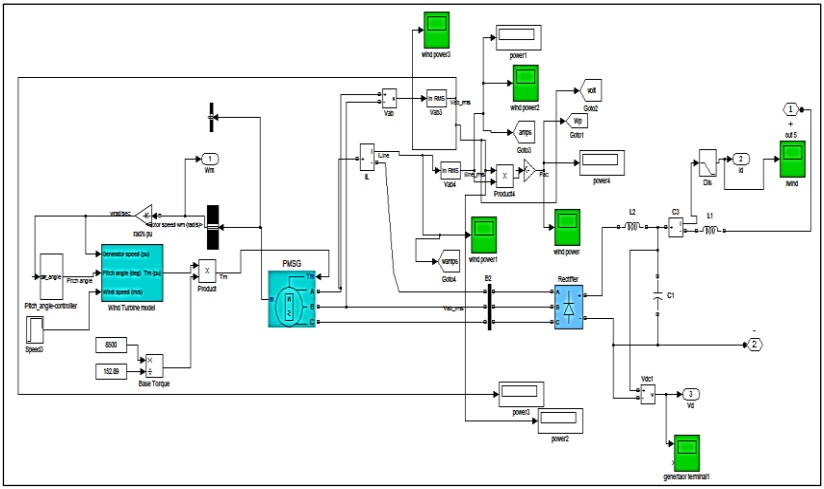

Fig 15: Wind subsystem

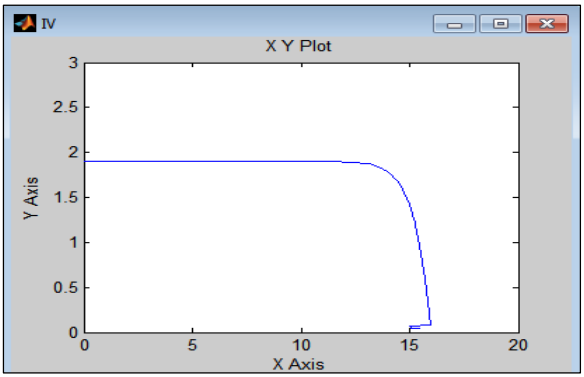

Fig 16: PV VI Characteristics

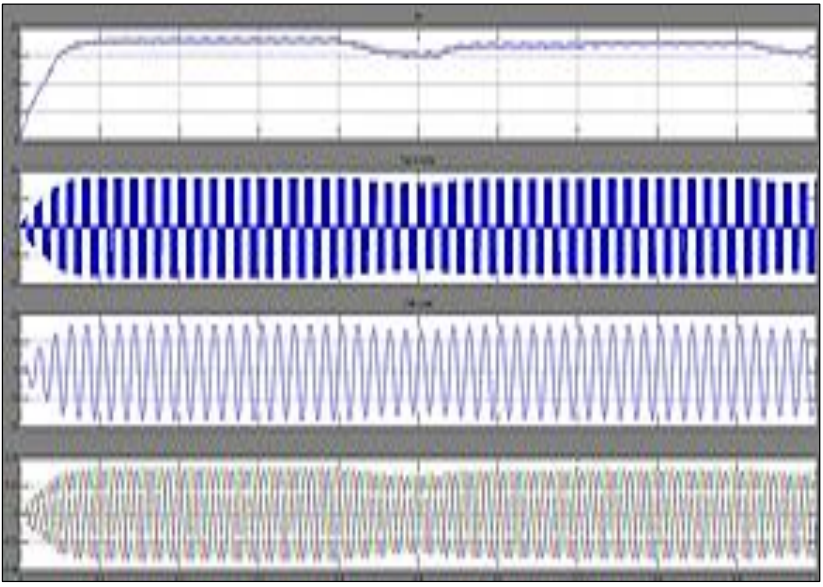

Fig 17: Output Characteristics

a) Dc converter output

b) Inverter output

c) Vab load

d) Vabc load

Conclusion

This work presented with system integration of power management of a grid connected Hybrid renewable energy source (HRES). The hybrid system is the combination of photovoltaic (PV) array, wind turbine, and battery storage via a common current source interface multiple-input dc-dc converter. This converter is used to integrate the renewable energy sources to the utility grid.

Future scope

1) Every corner of the world will be able to easily harvest water pup using this technique.
2) The efficiency of the solar power usage increases and in return the cost of the solar panels manufacturing decreases.
3) The power generation through solar energy can be increased to 80% of the total power generation.

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