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Performance Analysis of Diesel Engine Fueled with Lemon Grass Oil/Diesel Fuel Blends

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Abstract--- *Due to the concern on the availability of recoverable fossil fuel reserves and the environmental problems caused by the use of those fossil fuels, considerable attention has been given to biodiesel production as an alternative to petrodiesel. The two most common types of biofuels are ethanol and biodiesel. However, as the biodiesel is produced from vegetable oils and animal fats, there are concerns that biodiesel feedstock may compete with food supply in the long-term. Hence, the recent focus is to find oil bearing plants that produce non-edible oils as the feedstock for biodiesel production. In this project, plant species, Lemon grass (Cymbopogan flexuosus) is discussed as newer sources of oil for biodiesel production. Lemongrass is native to India and tropical Asia. In India, it is cultivated along Western Ghats (Maharashtra, Kerala), Karnataka and Tamil Nadu states besides foot-hills of Arunachal Pradesh and Sikkim i.e., it can be cultivated on wide range throughout India and may favor easy availability. This study investigates the performance of Lemongrass oil and its blends as fuel for a CI engine. The data thus generated were compared with the data obtained using diesel. The engine exhibited a very good performance without any problem of combustion. It is suggested that, Lemongrass oil and its blends can be used as an alternate fuel for diesel engine. However, as the biodiesel is produced from vegetable oils and animal fats, there are concerns that biodiesel feedstock may compete with food supply in the long-term. Hence, the recent focus is to find oil bearing plants that produce non-edible oils as the feedstock for biodiesel production. Hence, the contribution of non-edible oils will be significant as a non-edible plant oil source for biodiesel production.*

Keywords--- *Biodiesel Production, Oil/Diesel Fuel Blends, Diesel Engine, Performance Analysis.*

I. INTRODUCTION

With petroleum prices soaring, people are looking for cheaper, renewable sources of fuel for their vehicles. India imported about 2/3rd of its petroleum requirements which involved a cost of approximately Rs. 80,000 crores in foreign exchange. Even 5% replacement of petroleum fuel by bio-fuel can help India save Rs.4000 crore per year in foreign exchange. The country has been hit hard by the increased cost and uncertainty and so is exploring other energy sources occurring bio-diesel extracted from trees is one such alternative under consideration. Bio-diesel burns cleaner than traditional petroleum diesel fuel and is biodegradable, making it an interesting alternative fuel option in terms of both environmental protection and energy independence. Bio-diesel would be cheap to produce as it can be extracted from certain species of tree that are common in many parts of India.

However, as the biodiesel is produced from vegetable oils and animal fats, there are concerns that biodiesel feedstock may compete with food supply in the long-term. Hence, the recent focus is to find oil bearing plants that

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produce non-edible oils as the feedstock for biodiesel production. Hence, the contribution of non-edible oils will be significant as a non-edible plant oil source for biodiesel production.

Bio-diesel fuels commonly available are really blends of bio-diesel and petroleum diesel. An important distinction needs to be made between bio-diesel and bio-diesel blends. Pure bio-diesel, also known as neat bio-diesel, is commonly noted as B100, indicating that the fuel has 100 percent biodiesel and 0 percent diesel. The most common bio-diesel blend is B20, which contains 20 percent biodiesel and 80 percent diesel.

In this project we produce bio-diesel from lemon grass oil and to compare the performance and characteristics of diesel engine using diesel and bio-diesel blends. Lemongrass (Cymbopogan flexuosus) is a native aromatic tall sedge (family: Poaceae) which grows in many parts of tropical and sub-tropical South East Asia and Africa. In India, it is cultivated along Western Ghats (Maharashtra, Kerala), Karnataka and Tamil Nadu states besides foot-hills of Arunachal Pradesh and Sikkim. Lemongrass is native to India and tropical Asia. Citronella grass (Cymbopogon nardus and Cymbopogon winterianus) grows to about 2 meters (about 6.5 feet) and has red base stems. These species are used for the production of citronella oil, which is used in soaps, as an insect repellent in insect sprays and candles.

The lemongrass essential oil is extracted from Cymbopogon citrates. The main chemical components of lemongrass oil are myrcene, citronellal, geranyl acetate, nerol, geraniol, neral and traces of limonene and citral.

II. HISTORY

Transesterification of a vegetable oil was conducted as early as 1853 by scientists E. Duffy and J. Patrick, many years before the first diesel engine became functional. Rudolf Diesel's prime model, a single 10 ft (3 m) iron cylinder with a flywheel at its base, ran on its own power for the first time in Augsburg, Germany, on August 10, 1893. In remembrance of this event, August 10 has been declared "International Biodiesel Day". Diesel later demonstrated his engine and received the *Grand Prix* (highest prize) at the World Fair in Paris, France in 1900.

This engine stood as an example of Diesel's vision because it was powered by peanut oil a biofuel, though not *biodiesel*, since it was not transesterified. He believed that the utilization of biomass fuel was the real future of his engine. In a 1912 speech Diesel said, "the use of vegetable oils for engine fuels may seem insignificant today but such oils may become, in the course of time, as important as petroleum and the coal-tar products of the present time."

During the 1920s, diesel engine manufacturers altered their engines to utilize the lower viscosity of petrodiesel, rather than vegetable oil. The result, for many years, was a near elimination of the biomass fuel production infrastructure. Only recently, have environmental impact concerns and a decreasing price differential made biomass fuels such as biodiesel a growing alternative.

Despite the widespread use of fossil petroleum-derived diesel fuels, interest in vegetable oils as fuels in internal combustion engines is reported in several countries during the 1920's and 1930's and later during World War II. Belgium, France, Italy, the United Kingdom, Portugal, Germany, Brazil, Argentina, Japan and China have been reported to have tested and used vegetable oils as diesel fuels during this time.

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On August 31, 1937, G. Chavanne of the University of Brussels (Belgium) was granted a patent for a "Procedure for the transformation of vegetable oils for their uses as fuels" (fr. 'Procédé de Transformation Huiles Végétales en Vue de Leur Utilisation comme Carburants') Belgian Patent 422,877. This patent described the alcoholysis (often referred to as transesterification) of vegetable oils using methanol and ethanol in order to separate the fatty acids from the glycerol by replacing the glycerol by short linear alcohols. This appears to be the first account of the production of what is known as "biodiesel" today.

More recently, in 1977, Brazilian scientist Expedito Parente produced biodiesel using transesterification with ethanol, and again filed a patent for the same process. This process is classified as biodiesel by international norms, conferring a "standardized identity and quality. No other proposed biofuel has been validated by the motor industry." Currently, Parente's company Tecbio is working with Boeing and NASA to certify bioquerosene (bio-kerosene), another product produced and patented by the Brazilian scientist. Research into the use of transesterified sunflower oil, and refining it to diesel fuel standards, was initiated in South Africa in 1979. By 1983, the process for producing fuel-quality, engine-tested biodiesel was completed and published internationally. An Austrian company, Gaskoks, obtained the technology from the South African Agricultural Engineers; the company erected the first biodiesel pilot plant in November 1987 and the first industrial-scale plant in April 1989.

Throughout the 1990s, plants were opened in many European countries, including the Czech Republic, Germany and Sweden. France launched local production of biodiesel fuel from rapeseed oil, which is mixed into regular diesel fuel at a level of 5%, and into the diesel fuel used by some captive fleets at a level of 30%. Renault, Peugeot and other manufacturers have certified truck engines for use with up to that level of partial biodiesel; experiments with 50% biodiesel are underway. During the same period, nations in other parts of the world also saw local production of biodiesel starting up: by 1998, the Austrian Biofuels Institute had identified 21 countries with commercial biodiesel projects. 100% Biodiesel is now available at many normal service stations across Europe.

Production of Bio-Diesel

In general, vegetable oil contains 97% of triglycerides and 3% di- and monoglycerides and fatty acids. The process of removal of all glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called transesterification. The vegetable oil reacts with methanol and forms esterified vegetable oil in the presence of sodium/potassium hydroxide as catalyst.

Transestrification is crucial for producing biodiesel from oils. The transesterification process is the reaction of a triglyceride (fat/oil) with a bioalcohol to form esters and glycerol. However; consecutive and reversible reactions are believed to occur.

Lemon grass

Lemongrass (Cymbopogan flexuosus) is a native aromatic tall sedge (family: Poaceae) which grows in many parts of tropical and sub-tropical South East Asia and Africa. In India, it is cultivated along Western Ghats (Maharashtra, Kerala), Karnataka and Tamil Nadu states besides foot-hills of Arunachal Pradesh and Sikkim. It was introduced in India about a century back and is now commercially cultivated in these States.

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Cymbopogon (lemongrass) is a genus of about 55 species of grasses, (of which the type species is Cymbopogon citratus [a natural and soft teaAnxiolytic]) native to warm temperate and tropical regions of the Old World and Oceania. It is a tall perennial grass. Common names include lemon grass, lemongrass, barbed wire grass, silky heads, citronella grass, cha de Dartigalongue, fever grass, tanglad, hierba Luisa or gavati chaha amongst many others.

The lemongrass essential oil is extracted from Cymbopogon citratus (also known as Andropogon citratus, A. schoenathus - West Indian, Madagascar or Guatemala lemongrass; Andropogon flexuosus, Cymbopogon flexuosus - East Indian, Cochin, British India or native lemongrass), of the Poaceae family. It is fresh smelling oil that can be used with success for fighting jet lag, cellulite, as well as keeping the family pet free of fleas and ticks.

Lemongrass is native to India and tropical Asia. It is widely used as a herb in Asian cuisine. It has a subtle citrus flavor and can be dried and powdered, or used fresh. Citronella grass (Cymbopogon nardus and Cymbopogon winterianus) grows to about 2 meters (about 6.5 feet) and has red base stems. These species are used for the production of citronella oil, which is used in soaps, as an insect repellent in insect sprays and candles, and also in aromatherapy, which is famous in Bintan Island, Indonesia. Therefore it's assumed that its origin is from Indonesia. The principal chemical constituents of citronella, geraniol and citronellol, are antiseptics, hence their use in household disinfectants and soaps. Besides oil production, citronella grass is also used for culinary purposes, in tea and as a flavoring.

Lemon Grass Oil, used as a pesticide and preservative, is put on the ancient palm-leaf manuscripts found in India as a preservative. It is used at the Oriental Research Institute Mysore, the French Institute of Pondicherry, the Association for the Preservation of the Saint Thomas Christian Heritage in Kerala and many other manuscript collections in India. The lemon grass oil also injects natural fluidity into the brittle palm leaves and the hydrophobic nature of the oil keeps the manuscripts dry so that the text is not lost to decay due to humidity.

East-Indian Lemon Grass (Cymbopogon flexuosus), also called Cochin Grass or Malabar Grass (Malayalam: (inchippullu), is native to Cambodia, India, Sri Lanka, Burma,and Thailand while the West-Indian lemon grass (Cymbopogon citratus) is native to maritime Southeast Asia.

It is known as serai in Malaysia, serai or sereh in Indonesia, and tanglad in the Philippines. While both can be used interchangeably, C. citratus is more suited for cooking. In India C. citratus is used both as a medical herb and in perfumes. Cymbopogon citratus is consumed as a tea for anxiety in Brazilian folk medicine, but a study in humans found no effect. The tea caused a recurrence of contact dermatitis in one case.

Lemon grass is also known as Gavati Chaha in the Marathi language (Gavat=grass; Chaha=tea), and is used as an addition to tea, and in preparations like 'kadha,' which is a traditional herbal 'soup' used against coughs, colds, etc. In Kerala, lemon grass is steeped as an herbal tea called "Chukku Kaapi", literally "dried ginger coffee.

Origin of lemongrass oil

It is a perennial fast-growing aromatic grass, growing to about 1 meter (3 feet) high with long, thin leaves and originally was growing wild in India. It produces a network of roots and rootlets that rapidly exhaust the soil. Most

of the species of lemon grass are native to South Asia, Southeast Asia and Australia. The so called East Indian lemon grass (Cymbopogon flexuosus) , also known as Malabar or Cochin grass is native to India , Sri Lanka, Burma and Thailand ; for the related West Indian lemon grass (C. citratus), a Malesian origin is generally assumed. Both the species are today cultivated throughout tropical Asia.

Lemon grass is a tall, perennialsedge throwing up dense fasciclles of leaves from a short rhizome. The culm is stout, erect, upto 1.8 meter high. Leaves are long, glaucous, green, linear tapering upwards and along the margins; ligule very short; sheaths terete, those of the barren shoots widened and tightly clasping at the base, others narrow and separating. It is a short day plant and produce profuse flowering in South India. The inflorescence is a long spike about one metre in length. Flowers borne on decompound spatheate; panicles 30 to over 60 cm long.

Lemongrass oil has a lemony, sweet smell and is dark yellow to amber and reddish in color, with a watery viscosity.

Appearance	: dark yellow to amber and reddish
Net calorific value	: 36960 KJ/Kg
Auto-ignition temperature	: 343˚C
Viscosity @ 40˚C in cst	: 4.16
Flash point	: 82˚C
Fire point	: 88˚C
Specific gravity @ 30˚C	: 0.9253 g/cm^3

Chemical Properties

- Stable, Combustible, Incompatible with strong oxidizing agent.
- Non-toxic, heat and light sensitive.

Chemical composition

The main chemical components of lemongrass oil are myrcene, citronellal, geranyl acetate, nerol, geraniol, neral and traces of limonene and citral.

- Fresh C. citratus grass contains approximately 0.4% volatile oil.
- The oil contains 65% to 85% citral, a mixture of 2 geometric isomers, geraniol and neral.
- Related compounds geraniol, geranic acid, and nerolic acid have also been identified.
- Other compounds found in the oil include myrcene (12% to 25%), diterpenes, methylheptenone, citronellol, linalol, farnesol, other alcohols, aldehydes, linalool, terpineol, and more than a dozen other minor fragrant components.
- Nonvolatile components of C. citratus consist of luteolins, homo-orientin, chlorogenic acid, caffeic acid, p - coumaric acid, fructose, sucrose, octacosanol, and others.
- Flavonoids luteolin and 6-Cglucoside have also been isolated.
- C. flexuosus volatile oil typically contains up to 85% citral.

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- Many strains have a higher concentration of geraniol (50%), with citral (10% to 20%) and methyl eugenol as minor components.
- Another type of East Indian lemongrass is reported to contain no citral but up to 30% borneol.

Method of Extraction

Lemongrass oil is extracted from the fresh or partly dried leaves by **steam distillation**.

Steam Distillation

When a mixture of two practically immiscible liquids are heated while being agitated to expose the surfaces of both the liquids to the vapor phase, each constituent independently exerts its own vapor pressure as a function of temperature as if the other constituent were not present. Consequently, the vapor pressure of the whole system increases. Boiling begins when the sum of the partial pressures of the two immiscible liquids just exceeds the atmospheric pressure. In this way, many organic compounds insoluble in water can be purified at a temperature well below the point at which decomposition occurs.

Experimental Test Setup

The experimental setup consists of diesel engine, gas analyzer, brake drum, and Plenum chamber. The engine used in the investigation is a constant speed kirlosker engine, four stroke single cylinder, direct injection, vertical diesel engine. The specification of which are given below.

Engine Specification

1. Brake power : 3.7 KW
2. Speed : 1500 rpm
3. Bore : 80 mm
4. Stroke : 110 mm
5. Type of loading : brake drum dynamometer
6. Radius of brake drum : 152.4 mm

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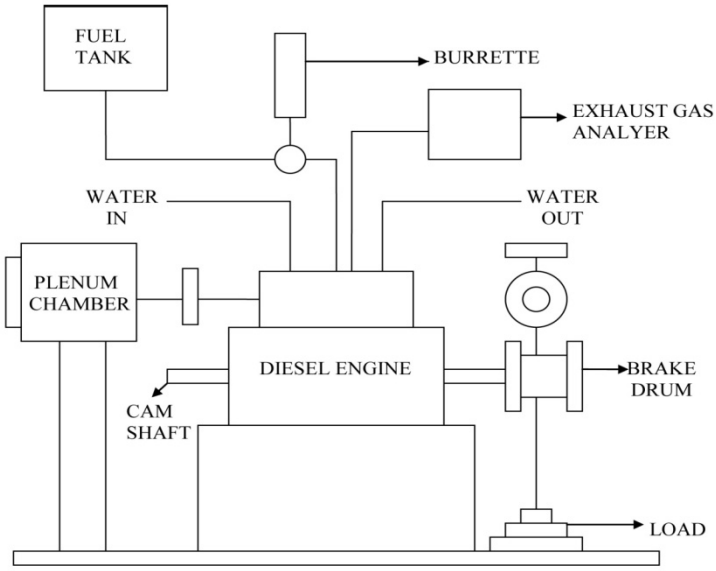
7. Type of cooling : water cooling

8. Orifice diameter : 0.02 m

9. C_d of orifice : 0.62

The engine is mounted on concrete bed with suitable connection for water-cooling and lubrication. The outlet temperature of water from engine is maintained at 50°C by adjusting the flow of the coolant. A photography view is shown in fig.8.1.1a and the schematic arrangement of experimental test setup is shown in fig.8.1.1.



Schematic diagram of CI engine

III. PERFORMANCE CHARACTERISTICS

CI Engine Performance and Characteristics

One of the biggest concerns for any prospective biodiesel user is whether an engine using biodiesel will perform differently than an engine using normal gasoline-based diesel. This section of the report is about the performance characteristics of engine using bio-diesel blends.

Torque and Power

Performance of any fuel can be judged by the power and torque output that it can generate. Biodiesel has lower energy content per volume. Because of the lower energy content, using biodiesel without any change in the fuel injection system would result in a slight loss of engine power.

Engine Durability and Materials Compatibility

While engine durability testing of biodiesel blends have no appreciable difference between biodiesel and conventional diesel fuel. The lubricity benefits of biodiesel, specially compared to low-sulfur petroleum diesel, help to reduce engine wear. Various blends of biodiesel produced engine wear similar to, or less than, petroleum diesel and produced the same or better engine durability.

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Fuel Efficiency

Fuel consumption for both biodiesel and diesel on a mass basis was very similar for all blends tested.

The comparison of performance characteristics of CI engine using diesel and blends of Lemongrass oil is charted. The graphs are plotted.

IV. PHOTOGRAPHIC VIEW

Lemongrass

CI Engine Setup

Apparatus for Steam Distillation

S.No	*LOAD IN K.G*			*LOAD IN NEWTON (F)* (W-S)×10	CAM SHAFT (R.PM)	*CRANK SHAFT SPEED(N) (2×CRANKSHAFT)*	*POWER IN KW*
	W	S	(W-S)				
1	**3**	**1**	**2**	**20**	**712**	**1428**	**0.447**
2	**6**	**2**	**4**	**40**	**710**	**1420**	**0.89**
3	**9**	**3**	**7**	**70**	**708**	**1416**	**1.556**
4	**12**	**3**	**9**	**90**	**705**	**1410**	**2**

FUEL USED-: 5%Lemon grass +95% diesel

S.No	*LOAD IN K.G*			*LOAD IN NEWTON(F)* (W-S)×10	CAM SHAFT (R.PM)	*CRANK SHAFT SPEED(N) (2×CRANKSHAFT)*	*POWER IN KW*
	W	S	(W-S)				
1	**3**	**2**	**1**	**20**	**712**	**1424**	**0.447**
2	**6**	**4**	**2**	**40**	**710**	**1420**	**0.89**
3	**9**	**6**	**3**	**70**	**703**	**1406**	**1.545**
4	**12**	**9**	**3**	**90**	**698**	**1396**	**1.97**

Fuel used-: 10% lemon grass +90% diesel

S.No	*LOAD IN K.G*			*LOAD IN NEWTON(F)* (W-S)×10	CAM SHAFT (R.PM)	*CRANK SHAFT SPEED(N) (2×CRANKSHAFT)*	*POWER IN KW*
	W	S	(W-S)				
1	**3**	**1**	**2**	**20**	**705**	**1410**	**0.44**
2	**6**	**2**	**4**	**40**	**701**	**1402**	**0.88**
3	**9**	**3**	**7**	**70**	**682**	**1364**	**1.499**
4	**12**	**3**	**9**	**90**	**661**	**1322**	**1.867**

Calculations

Circumference of fly wheel = 92 cm = 0.92m

$\pi D = 0.92m$

$D = 0.92\pi = 0.292m$

$r = D/2 = 0.292/2 = 0.146$

$r \cong 0.15m$

Engine power = $2\pi NT / 60$ Watts

$= 2\pi NT / 60 \times 1000KW$

$= 2\pi N(F \times r)/60000$

Result

Use of 5% lemon grass with 95% of diesel in diesel engine gives almost simillar engine performance as that of conventional diesel engine.

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While uses 10 % lemon grass oil with 90% diesel fuel engine power output slightly decreases.

While uses 20% lemon grass oil with 80% diesel fuel the engine tends Go off particularly at fuel load operation

REFERENCES

[1] Thooyamani, K.P., Khanaa, V., & Udayakumar, R. (2014). Virtual instrumentation based process of agriculture by automation. *Middle-East Journal of Scientific Research*, *20*(12): 2604-2612.

[2] Udayakumar, R., Kaliyamurthie, K.P., & Khanaa, T.K. (2014). Data mining a boon: Predictive system for university topper women in academia. *World Applied Sciences Journal*, *29*(14): 86-90.

[3] Anbuselvi, S., Rebecca, L.J., Kumar, M.S., & Senthilvelan, T. (2012). GC-MS study of phytochemicals in black gram using two different organic manures. *J Chem Pharm Res*., *4*, 1246-1250.

[4] Subramanian, A.P., Jaganathan, S.K., Manikandan, A., Pandiaraj, K.N., Gomathi, N., & Supriyanto, E. (2016). Recent trends in nano-based drug delivery systems for efficient delivery of phytochemicals in chemotherapy. *RSC Advances*, *6*(54), 48294-48314.

[5] Thooyamani, K.P., Khanaa, V., & Udayakumar, R. (2014). Partial encryption and partial inference control based disclosure in effective cost cloud. *Middle-East Journal of Scientific Research*, 20(12), 2456-2459.

[6] Lingeswaran, K., Prasad Karamcheti, S.S., Gopikrishnan, M., & Ramu, G. (2014). Preparation and characterization of chemical bath deposited cds thin film for solar cell. *Middle-East Journal of Scientific Research*, *20*(7), 812-814.

[7] Maruthamani, D., Vadivel, S., Kumaravel, M., Saravanakumar, B., Paul, B., Dhar, S.S., Manikandan, A., & Ramadoss, G. (2017). Fine cutting edge shaped Bi2O3rods/reduced graphene oxide (RGO) composite for supercapacitor and visible-light photocatalytic applications. *Journal of colloid and interface science*, *498*, 449-459.

[8] Gopalakrishnan, K., Sundeep Aanand, J., & Udayakumar, R. (2014). Electrical properties of doped azopolyester. *Middle-East Journal of Scientific Research*, *20*(11). 1402-1412.

[9] Subhashree, A.R., Parameaswari, P.J., Shanthi, B., Revathy, C., & Parijatham, B.O. (2012). The reference intervals for the haematological parameters in healthy adult population of chennai, southern India. *Journal of Clinical and Diagnostic Research: JCDR*, *6*(10), 1675-1680.

[10] Niranjan, U., Subramanyam, R.B.V., & Khanaa, V. (2010, September). Developing a web recommendation system based on closed sequential patterns. In *International Conference on Advances in Information and Communication Technologies*, *101*, 171-179. Springer, Berlin, Heidelberg.

[11] Slimani, Y., Baykal, A., & Manikandan, A. (2018). Effect of Cr3+ substitution on AC susceptibility of Ba hexaferrite nanoparticles. *Journal of Magnetism and Magnetic Materials*, *458*, 204-212.

[12] Premkumar, S., Ramu, G., Gunasekaran, S., & Baskar, D. (2014). Solar industrial process heating associated with thermal energy storage for feed water heating. *Middle East Journal of Scientific Research*, *20*(11), 1686-1688.

[13] Kumar, S.S., Karrunakaran, C.M., Rao, M.R.K., & Balasubramanian, M.P. (2011). Inhibitory effects of Indigofera aspalathoides on 20-methylcholanthrene-induced chemical carcinogenesis in rats. *Journal of carcinogenesis*, *10*.

[14] Beula Devamalar, P.M., Thulasi Bai, V., & Srivatsa, S.K. (2009). Design and architecture of real time web-centric tele health diabetes diagnosis expert system. *International Journal of Medical Engineering and Informatics*, *1*(3), 307-317.

[15] Ravichandran, A.T., Srinivas, J., Karthick, R., Manikandan, A., & Baykal, A. (2018). Facile combustion synthesis, structural, morphological, optical and antibacterial studies of Bi1− xAlxFeO3 ($0.0 \leq x \leq 0.15$) nanoparticles. *Ceramics International*, *44*(11), 13247-13252.

[16] Thovhogi, N., Park, E., Manikandan, E., Maaza, M., & Gurib-Fakim, A. (2016). Physical properties of CdO nanoparticles synthesized by green chemistry via Hibiscus Sabdariffa flower extract. *Journal of Alloys and Compounds*, *655*, 314-320.

[17] Arya, G.P., Nautiyal, A., Pant, A., Singh, S., & Handa, T. (2013). A Cipher Design with Automatic Key Generation using the Combination of Substitution and Transposition Techniques and Basic Arithmetic and Logic Operations. *The SIJ Transactions on Advances in Space Research & Earth Exploration*, *1*(1), 25-28.

[18] Arya, G.P., Singh, A., Painuly, R., Bhadri, S., & Maurya, S. (2013). LZ Squeezera Compression Technique based on LZ77 and LZ78. *The SIJ Transactions on Advances in Space Research & Earth Exploration*, 1(2), 1-4.

[19] Kavitha, S., & Dr.Sutha, S. (2019). Pollution Monitoring and Controlling System Using Global System for Mobile Communication Network. *Bonfring International Journal of Software Engineering and Soft Computing, 9*(2), 40-42.

[20] Viraktamath, S.V., Katti, M., Khatawkar, A., & Kulkarni, P.(2016).Face Detection and Tracking using Open CV. *The SIJ Transactions on Computer Networks & Communication Engineering (CNCE), 4*(3), 1-6.

[21] Vignesh, M. & Jayaseelan, J.(2016).Test Pattern Generation for Transition Faults with Low Power using BS-LFSR and LOC. *The SIJ Transactions on Computer Networks & Communication Engineering (CNCE), 4*(5), 1-5.

[22] Kandavel, B., Uvaraj, G., & Dr.Manikandan, M. (2018). Harmonic Study on DFIG Fed Voltage Source Inverter.*Journal of Computational Information Systems, 14*(4), 150 - 158.

[23] Sivasankari, M., Dr.Velmani, P., & Dr.ArokiaJansi Rani, P. (2018). Multilingual Off-Line Handwriting Recognition in Real-World Images Using Adaptive Neuro Fuzzy Inference System (ANFIS).*Journal of Computational Information Systems, 14*(5), 21 - 33.

[24] Saranya, K. (2014). Reliable Energy Efficient Multi-Path Routing and Enhancement of Network Lifetime Using Network Coding and Duty Cycle in WSN. *International Journal of Advances in Engineering and Emerging Technology, 6*(1), 28-44.

[25] Krishnaveni, C. (2014). Blue Brain- Artificial Intelligence in the Future Generation. *International Journal of Advances in Engineering and Emerging Technology, 6*(1), 19-27.

[26] Dr.AntoBennet, M., Sankarbabu, G., Kaushik Krishna, R., Jelcinrenis, S., Jayavignesh, B.S., & Aswin, B. (2016). Error Performance and Peak to Average Power Ratio (PAPR) Analysis for LTE-A System. *Excel International Journal of Technology, Engineering and Management, 3*(1), 5-9.

[27] Thooyamani, K.P., Khanaa, V., & Udayakumar, R. (2014). Wide area wireless networks-IETF. *Middle-East Journal of Scientific Research*, *20*(12), 2042-2046.

[28] Sundar Raj, M., Saravanan, T., & Srinivasan, V. (2014). Design of silicon-carbide based cascaded multilevel inverter. *Middle-East Journal of Scientific Research*, *20*(12), 1785- 1791.

[29] Achudhan, M., Jayakumar M.P. (2014). Mathematical modeling and control of an electrically-heated catalyst. *International Journal of Applied Engineering Research*, *9*(23), 23013.

[30] Thooyamani, K.P., Khanaa, V., & Udayakumar, R. (2013). Application of pattern recognition for farsi license plate recognition. *Middle-East Journal of Scientific Research, 18*(12), 1768-1774.

[31] Jebaraj, S., Iniyan S. (2006). Renewable energy programmes in India. *International Journal of Global Energy Issues, 26*(43528), 232-257.

[32] Sharmila, S., & Jeyanthi Rebecca, L. (2013). Md Saduzzaman., Biodegradation of domestic effluent using different solvent extracts of Murraya koenigii. *J Chem and Pharm Res, 5*(2), 279-282.

[33] Asiri, S., Sertkol, M., Guner, S., Gungunes, H., Batoo, K.M., Saleh, T.A., Manikandan A., & Baykal, A. (2018). Hydrothermal synthesis of CoyZnyMn1-2yFe2O4 nanoferrites: magneto-optical investigation. *Ceramics International*, *44*(5), 5751-5759.

[34] Rani, A.J., & Mythili, S.V. (2014). Study on total antioxidant status in relation to oxidative stress in type 2 diabetes mellitus. *Journal of clinical and diagnostic research: JCDR*, *8*(3), 108-110.

[35] Karthik, B. (2014). Arulselvi, Noise removal using mixtures of projected gaussian scale mixtures. *Middle-East Journal of Scientific Research*, *20*(12), 2335-2340.

[36] Karthik, B., Arulselvi, & Selvaraj, A. (2014). Test data compression architecture for low power VLSI testing. *Middle - East Journal of Scientific Research, 20*(12), 2331-2334.

[37] Vijayaragavan, S.P., Karthik, B., & Kiran Kumar, T.V.U. (2014). Privacy conscious screening framework for frequently moving objects. *Middle-East Journal of Scientific Research*, *20*(8), 1000-1005.

[38] Kaliyamurthie, K.P., Parameswari, D., & Udayakumar, R. (2013). QOS aware privacy preserving location monitoring in wireless sensor network. *Indian Journal of Science and Technology*, *6*(5), 4648-4652.

[39] Silambarasu, A., Manikandan, A., & Balakrishnan, K. (2017). Room-temperature superparamagnetism and enhanced photocatalytic activity of magnetically reusable spinel ZnFe 2 O 4 nanocatalysts. *Journal of Superconductivity and Novel Magnetism*, *30*(9), 2631-2640.

[40] Jasmin, M., Vigneshwaran, T., & Beulah Hemalatha, S. (2015). Design of power aware on chip embedded memory based FSM encoding in FPGA. *International Journal of Applied Engineering Research*, *10*(2), 4487-4496.

[41] Philomina, S., & Karthik, B. (2014). Wi-Fi energy meter implementation using embedded linux in ARM 9. *Middle-East Journal of Scientific Research*, *20*, 2434-2438.

[42] Vijayaragavan, S.P., Karthik, B., & Kiran Kumar, T.V.U. (2014). A DFIG based wind generation system with unbalanced stator and grid condition. *Middle-East Journal of Scientific Research, 20*(8), 913-917.

[43] Rajakumari, S.B., & Nalini, C. (2014). An efficient data mining dataset preparation using aggregation in relational database. *Indian Journal of Science and Technology*, *7*, 44-46.

[44] Karthik, B., Kiran Kumar, T.V.U., Vijayaragavan, P., & Bharath Kumaran, E. (2013). Design of a digital PLL using 0.35 Î¼m CMOS technology. *Middle-East Journal of Scientific Research, 18*(12), 1803-1806.

[45] Sudhakara, P., Jagadeesh, D., Wang, Y., Prasad, C.V., Devi, A.K., Balakrishnan, G., Kim B.S., & Song, J.I. (2013). Fabrication of Borassus fruit lignocellulose fiber/PP composites and comparison with jute, sisal and coir fibers. *Carbohydrate polymers*, *98*(1), 1002-1010.

[46] Kanniga, E., & Sundararajan, M. (2011). Modelling and characterization of DCO using pass transistors. In *Future Intelligent Information Systems*, 86(1), 451-457. Springer, Berlin, Heidelberg.

[47] Sachithanandam, P., Meikandaan, T.P., & Srividya, T. Steel framed multi storey residential building analysis and design. *International Journal of Applied Engineering Research*, *9*(22), 5527-5529.

[48] Kaliyamurthie, K.P., Udayakumar, R., Parameswari, D., & Mugunthan, S.N. (2013). Highly secured online voting system over network. *Indian Journal of Science and Technology*, *6*(S6), 4831-4836.

[49] Sathyaseelan, B., Manikandan, E., Lakshmanan, V., Baskaran, I., Sivakumar, K., Ladchumananandasivam, R., Kennedy, J., & Maaza, M. (2016). Structural, optical and morphological properties of post-growth calcined TiO2 nanopowder for opto-electronic device application: Ex-situ studies. *Journal of Alloys and Compounds*, *671*, 486-492.

[50] Saravanan, T., Sundar Raj M., & Gopalakrishnan K. (2014). SMES technology, SMES and facts system, applications, advantages and technical limitations. *Middle - East Journal of Scientific Research, 20*(11), 1353-1358.

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