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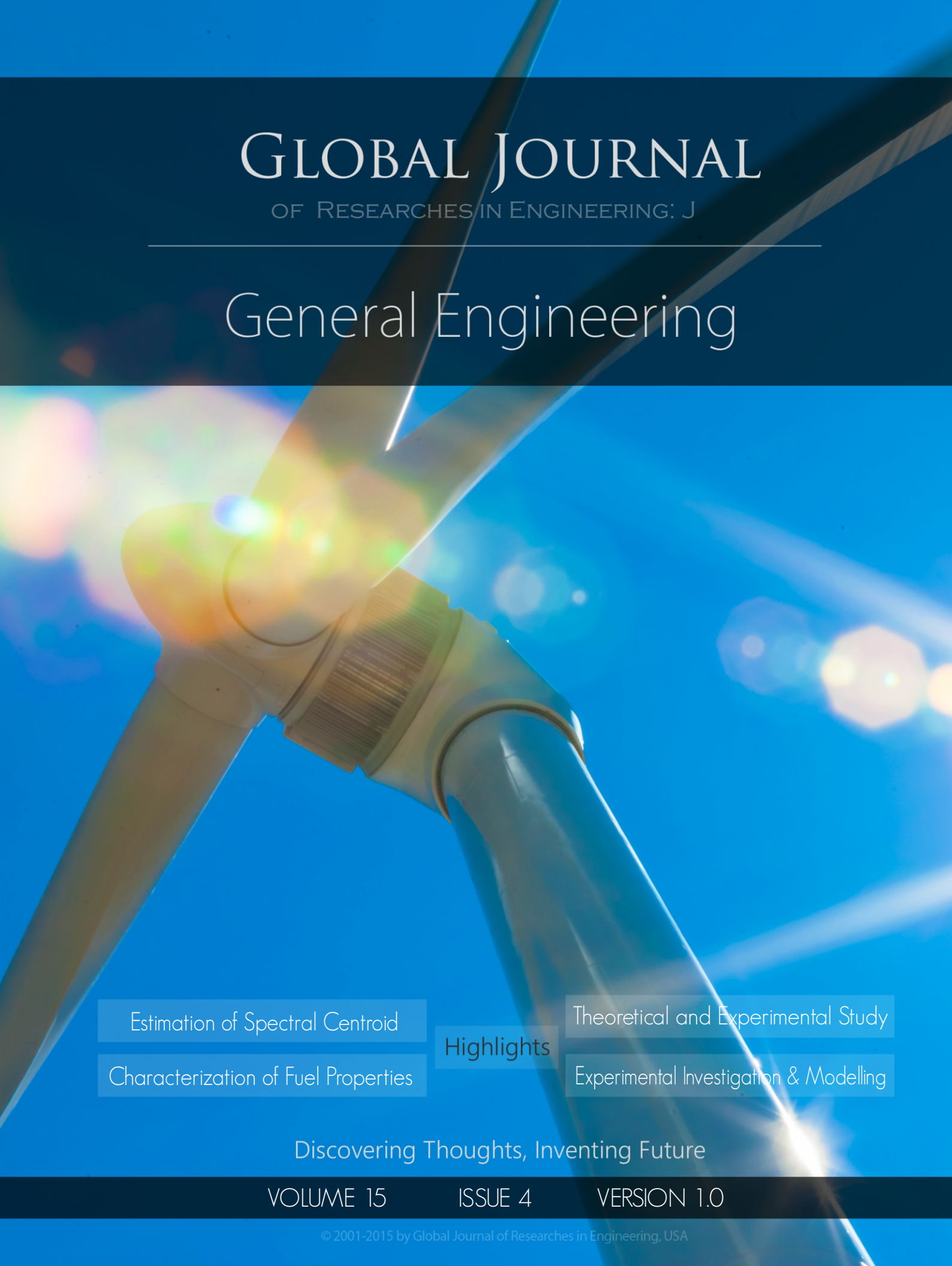

Estimation of Spectral Centroid

Characterization of Fuel Properties

Highlights

Theoretical and Experimental Study

Experimental Investigation & Modelling

Discovering Thoughts, Inventing Future

VOLUME 15 ISSUE 4 VERSION 1.0

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Characterization of Fuel Properties for the Biodiesel-Petro-Diesel Blends Dosed with the FPC

By Mosesane M. J., Mbaya R. K. K., Tshabalala L. C. & Kalombo L.
Tshwane University of Technology, South Africa

Abstract- The effect of the Fuel Performance Catalyst (FPC) on the different diesel properties namely density, viscosity and flashpoint of biofuel has been investigated. The biodiesel-petro-diesel blends concentrations (Vol %) of B10, B20 and B30 have been analyzed with the pure biodiesel (B100) and petro-diesels (B0) as upper and lower boundaries respectively. The results indicated that the FPC: Diesel fuel ratio of 1: 10 100 did not have a significant effect on density and viscosity of the biofuel at a temperatures of 20 °C to 80 °C. The observed increase in flash point as blend concentration increased may be considered as good results with respect to safety and fuel handling requirements. The FPC lowered the flash point marginally; this can be good for ignition of fuel in combustion ignition engines and can be attributed to the observed reduction in fuel viscosity and density as studied in this work.

Keywords: FPC, biodiesel, petro-diesel, biodiesel-petro-diesel blend, viscosity, density, flash point.

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Mosesane M. J. [α], Mbaya R. K. K. [σ], Tshabalala L. C. [ρ] & Kalombo L. [ω]

Abstract- The effect of the Fuel Performance Catalyst (FPC) on the different diesel properties namely density, viscosity and flashpoint of biofuel has been investigated. The biodiesel-petro-diesel blends concentrations (Vol %) of B10, B20 and B30 have been analyzed with the pure biodiesel (B100) and petro-diesels (B0) as upper and lower boundaries respectively. The results indicated that the FPC: Diesel fuel ratio of 1: 10 100 did not have a significant effect on density and viscosity of the biofuel at a temperatures of 20 °C to 80 °C. The observed increase in flash point as blend concentration increased may be considered as good results with respect to safety and fuel handling requirements. The FPC lowered the flash point marginally; this can be good for ignition of fuel in combustion ignition engines and can be attributed to the observed reduction in fuel viscosity and density as studied in this work.

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I. Introduction

Due to the fluctuating cost of common petroleum products (petro-diesels) and the need to reduce fuel consumption worldwide, there has been a renewed investment in the development of the alternative energy sector in South Africa (White Paper, 2006). According to Pradhan and Mbohwa (2014), South Africa is the largest energy consumer amongst the African countries as it contributes to about 31% of Africa's primary energy consumption. The highest energy demands have been predominantly attributed to the transport sector. In light of this, the Department of Minerals and Energy (DME) initiated the development of a Bio-fuels Industrial Strategy in the year of 2005, to systematically quench these growing energy demands (White Paper, 2006). Later, the Position Paper was published in terms of National Energy Act 34 of 2008. However, challenges such as biodiversity, impacts on food security, lack of understanding of the new technology and slow agricultural development due to land use changes have stalled the targeted biofuel commercialization potential over the years (Avinash A. et al, 2014; Mobida E. et al, 2014).

Nevertheless, studies have been conducted in recent years to investigate the economic viability of biodiesels derived from vegetable or animal fats as well as synthetic diesels from biomass, biogas, natural gas, and coal (Avinash A. et al, 2014; Mobida E. et al, 2014). A detailed account on the production of biodiesel can be found elsewhere (Mittelbach M. and Gangl S., 2001; Kivevele T. and Huan. Z.,2015).The effects of different formulations of biodiesel and petro-diesel blends on fuel flow properties such as density and viscosity have been investigated by numerous scholars (Mittelbach M. and Gangl S. 2001; Kivevele T. and Huan. Z., 2015, Enmeremadu C.C., 2011). All these studies aided in developing a knowledge base on the potential alternative fuel sources and the effects of blending different fuels in order to create a better fuel economy.

In addition, successful reports on studies aiming on the reduction of fuel consumption in South African UD60 diesel trucks using a homogenous catalyst called the Fuel Performance Catalyst (FPC) have been reported by Mosesane et al (2015). Elsewhere, scholars such as Zhang (2009) also reported positive results on the performance of this catalyst. The FPC is a homogenous diesel additive made from ferrous picrate with a complex concoction of short-chain alkyl benzenes (±87%), n-butanol (±12%), dioctyladipate (±1%) and a common plasticizer (Zhang, 2009). Although the fuel consumption studies have been documented, there is still a knowledge gap on the effects of the FPC on the stability of the density and viscosity of pure petro-diesels, biodiesels and their blends. Characterization of these properties is crucial as they determine the ease of flow and atomization in diesel engines (Schwab A.W. et al., 1987).

Numerous researchers have investigated different biodiesel-petro-diesel blends on various diesel engines to examine fuel performance characteristics such as exhaust emission parameters (Durbin, T. D. et al, 1999), energy output, thermal efficiency and other fuel performance associated properties (Nwafor, O.M.I. and Rice, G., 1996; Misra, R.D. and Murthy, M.S., 2011). Their formulations showed comparable performance in relation to the pure diesel. Their results also showed a reduction in harmful exhaust gas emissions by the biodiesel-petro-diesel blends as compared to the pure diesel feeds. Common blends may range from a ratio(s) of 2:98% (B2) up to 100% (B100) by volume. Although biodiesels are miscible with petro-diesel in a variety of proportions, not all formulations may be used in diesel engines as an increase in biodiesel concentration

Author α σ ρ ω: e-mails: mosesanejm@tut.ac.za, mbayar@tut.ac.za, kgomarilc@tut.ac.za, kalombol@csir.co.za

increases both fuel density and viscosity (Enmeremadu C.C., 2011). According to the Engine Manufacturers Association (EMA), blends of up to 20% biodiesel and 80% petro-diesel (B20) can be used in nearly all diesel equipment and are compatible with most storage and distribution equipment. Blending ratios higher than B20 may clog up the engine piping systems and also necessitate engine modifications (Schwab A.W. et al., 1987). Hence, the warranty on most new engines only allows a maximum of B 20 to be used as reported by Enmeremadu (2011). Biodiesel blends of up to 20% have been reported to reduce emissions of hydrocarbon (HC), carbon monoxide (CO), sulphur dioxide (SO_2), and particulates as well improve the engine performance (Balat and Balat, 2008; Zhang et al, 2003).

In this regard, this work aims at studying the effect of the FPC on the flow properties namely; density and viscosity of biodiesel-petro-diesel mixtures of different ratios. Flash point tests have also been incorporated to the test matrix to account for the minimum temperature at which the fuel burns when subjected to an external heat source. This work forms part of the biodiesel-petro-diesel blending investigations in terms of Act 120 of 1997 in line with the position taken by the South African petroleum regulators (White paper, 2006 and Green Cape, 2013).

II. Materials and Methods

The biodiesel used was produced by Matayo Bio-fuels Pty Ltd, South Africa using the Fuel Meister 2 which requires vegetable oil with about 0% to 10% Free Fatty Acid (FFA) content. Samples of biodiesel and petro-diesel (50ppm Sulphur) were collected from the Matayo storage tank and the local Garankuwa filling station respectively. The experiments were carried out in two stages namely: (i) FPC and Biodiesel-Petro-diesel blending and (ii) Fuel blend property characterization involving density, viscosity and flash point investigations. All measurements were carried out in at least three repetitions. For each set of conditions, the mean was used for analysis.

a) Fuel blending

The fuel blends formulated in this work are made up of a volume by volume (Vol %) mixture of biodiesel and petro-diesel at ratios of 10:90, 20:80 and 30:70 to expand the test range. These were given acronyms of B10, B20 and B30 respectively. The FPC dosed batch of the B10, B20 and B30 blends was added to the experiment matrix at an FPC: Biodiesel-petro-diesel ratio of 1:10 000 by volume. FPC dosages were made using a Gilson micropipette. All blending was performed at room temperature. All doses of biodiesel or FPC were added to the petro-diesel under continuous mixing by a magnetic stirrer in a 500mL beaker.

b) Fuel density and viscosity determination

The fuel density was analyzed as a function of temperature using a Rudolph Research Analyzer - Automatic Density Meter in accordance with ASTM D1250 standard. Viscosity was measured using a Brookfield DV II + Pro Viscometer as per ASTM D7467-13 standard. All samples were subjected to a temperature range of 20-80˚C with 5˚C increments.

c) Fuel flashpoint determination

The fuel flashpoint investigations were conducted using a Normalab Flashpoint Tester which was set at 60˚C as per NFEN 22719 standards. Samples of 75mL were poured into a flash point cup which was connected to the regulator bath to steadily increase the sample temperature from 20˚C to a maximum of 80˚C.

III. Results and Discussion

a) Fuel blending

In the Fig. 1 are shown the density data obtained for the pure biodiesel (B100), petro-diesel (B0) and the fuel blends (B10-30) studied as a function of temperature. The Fig. 1a represents the study where the FPC was not added to the fuel while the FPC dosed fuel tests at a 1: 10 000 FPC to Fuel ratio are depicted on Fig.1b. The collected data shows are linear decline in fuel density as the temperature increases irrespective of its blend formulation and catalyst dosage.

A fuel concentration packing order can be observed on both density plots where for blended fuel the reduction in biodiesel content translates results of reduced density. For instance, when referring to Fig. 1a, the density curve packing order is a follows: B100>>B30>B20>B10>B0. Referring to Fig.1a, the pure petro-diesel appeared to have lower density in comparison the pure biodiesel by 6.08% when taking the mean of the resulting density range. Blending proved to generate a median density with respect to both biodiesel (B100) and petro-diesel (B0) pure fuels as depicted on Fig 1 irrespective of the FPC dose investigated. To establish the line of fit, the fuel blend results were observed to be congruent with the work of Enweremadu et al (2011), whereby blend formulations data set followed the equation (1) that follows:

$$\rho = AT + B \quad (1)$$

Where ρ represents the density of the blend (g/cm^3), A and B denote the fitting curve coefficients for the temperature range, T (˚C) investigated. Taking a blend with common concentration of FPC undosed biodiesel blend of B20 in this study and the data was best modelled by equation (2) that follows:

$$\rho = -0.0007T + 0.8696 \quad (2)$$

When equation (2) is used, the fitting curves produced a regression coefficient of R^2=0.9999. For the

FPC dosed fuel, the data set followed the equation (3) that follows:

$$\rho = -0.0007T + 0.8704 \quad (3)$$

The regression coefficient obtained from the line of fit was R^2=0.9999. It can be observed that the fuels showed equivalent values of "A" and minor deviation in "B" which was translated to a standard deviation of 0.0005657. The summary of the fitting curve coefficients and R2 values are represented on Table 1. When comparing the complete data set of the FPC dosed and undosed fuel, a maximum standard deviation of $2.7305x10^{-4}$ was obtained as shown on Table 2. With regards to the values of the mean density for the FPC dosed fuel, one may deduce that the influence of the FPC on fuel density was insignificant for the studied samples as evidenced by the low standard deviation values.

b) Effect of FPC on fuel viscosity

Biofuel has been reported by numerous scholars to exhibit high viscosity as compared to petro-diesel (Franco Z. and Nguyen Q.D., 2011; Misra R.D. and Murthy M.S., 2011; Geacai S. et al, 2015). This often causes poor fuel atomization crucial for combustion in combustion chambers leading to injector chocking and the accumulation of carbon in the engines (Schwab A.W. et al., 1987). One solution often proposed is the efficient biodiesel-petro-diesel blend formulation which then leads to the attainment of acceptable flow properties as conducted in this work. On the Fig.2, the viscosity data for the blend formulations presented in the previous section is depicted. It can be observed that fuel viscosity decreases with an increase in operating temperature for the both FPC dosed and undosed fuel. The relationship between viscosity and temperature for the data collected was discovered to follow a power fitting curve as in equation (3) that follows:

$$\nu = cT^d \quad (4)$$

Where ν is the fuel viscosity (cP), c and d are the fitting curve coefficients. The summary of the fitting coefficients for the investigated fuels is displayed on Table 3. From the regression coefficient values (R^2), it can be deduced that the fitting curve represented by equation (3) can be used to predict the fuel viscosity as a function of temperature since R^2>0.96 for the majority of the blends. The expected packing order exhibited on the density curves in previous section where the highest values were obtained at high biodiesel concentration was also realized on the viscosity curves as seen on Fig. 2.

The FPC dosed fuel blends followed a similar trend, with the curves approaching a similar value of 95.8 cP at 80 °C. Having B30 approaching B20, more statistical analysis was needed to validate the presence of variance in the mean data sets of the FPC dosed and undosed fuels. A comparative study of the FPC dosed and undosed fuels depicted on Table 4 shows that there is variance in the means of viscosity since ANOVA(n=13, P=0.05) F test value of 494.140 is greater than F_{crit} of 2.604, requiring further t-Test analysis assuming unequal variance between the two data sets of n=13 each. From the Table 4, the difference between the B30 sample means of 134.6297 and 132.759 cP for the FPC undosed and dosed fuels respectively can be observed. The significance of the standard deviation (Std. Dev) of 1.3228 was investigated using the t-Test. The statistical analysis showed a t_{stat} value of 0.1466 which is greater than the $t_{critical}$ value of 2.064 and this justify that there was no need to reject the null hypothesis as the observed difference between the mentioned sample means is not convincing enough to conclude that the average viscosity values differ significantly. The comparative study on Table 4 still shows insignificant variance between FPC dosed and FPC undosed blends as the t_{stat} values are lesser than those of the $t_{critical}$ values.

c) Effect of FPC on fuel flash point

The flash point temperature of biodiesel is the minimum temperature at which the fuel will ignite (flash) in the presence of an ignition source. Flash point varies inversely with the fuel's volatility (Sivaramakrishnan and Ravukumar, 2012). Biodiesels have been reported to have higher flash and fire points than the petro-diesel by Odeigah Edith et al (2012). From the Table 5, it can be observed the flash point values generally increase with an increase in biodiesel concentration. When comparing the FPC undosed and dosed blends, the results showed a slight increase in flash point of B10 samples while at higher blend concentrations, the FPC dosage marginally lowered the flash point of all investigated blends. Nevertheless, the observed increase in flash point as blend concentration increases may be considered as good results with respect to safety and fuel handling requirements. At the same time having FPC lower the flash point marginally can be good for ignition of fuel in combustion ignition engines. This can be attributed to the observed reduction in fuel viscosity and density as discussed in the previous section, although the deviation is insignificant.

IV. Conclusion

The results have revealed that at an FPC: Diesel fuel dosage ratio of 1: 10 000, the FPC did not have significant effects on both density and viscosity of the fuel when temperature was steadily increased from 20°C to 80°C. An increase in blend concentration resulted to an increase in flash point. This was considered as good safety feature for fuel handling purposes.

Finally, the results presented in this paper should not be presumed to be the final answer to properties studied in this work on the specific biodiesel-

petro diesel blends used but rather be used as an aid in the dosing, testing and blending of other biodiesel blends from other sources.

V. Abbreviations

FPC – Fuel Performance Catalyst

DME – Department of Minerals and Energy

EMA – Engine Manufactures Association

HC – Hydrocarbon

CO – Carbon monoxides

SO_2 – Sulphur dioxide

NFEN – French regulations and standards

FFA – Free Fatty Acids

Vol % – Volume by volume percentage

ASTM – American Society for Testing and Materials

ANOVA – Analysis of Variance

Std. Dev – Standard deviation

R^2 – Regression coefficient or Correlation factor

F_{crit} – F-test critical value

t_{crit} – t-test critical value

t_{stat} – t-test statistical analysis value

B0, B10, B20, B30, B100 – Biodiesel 0% (Pure diesel), Biodiesel 10%, Biodiesel 20%, Biodiesel 30%, Biodiesel 100% (Pure biodiesel).

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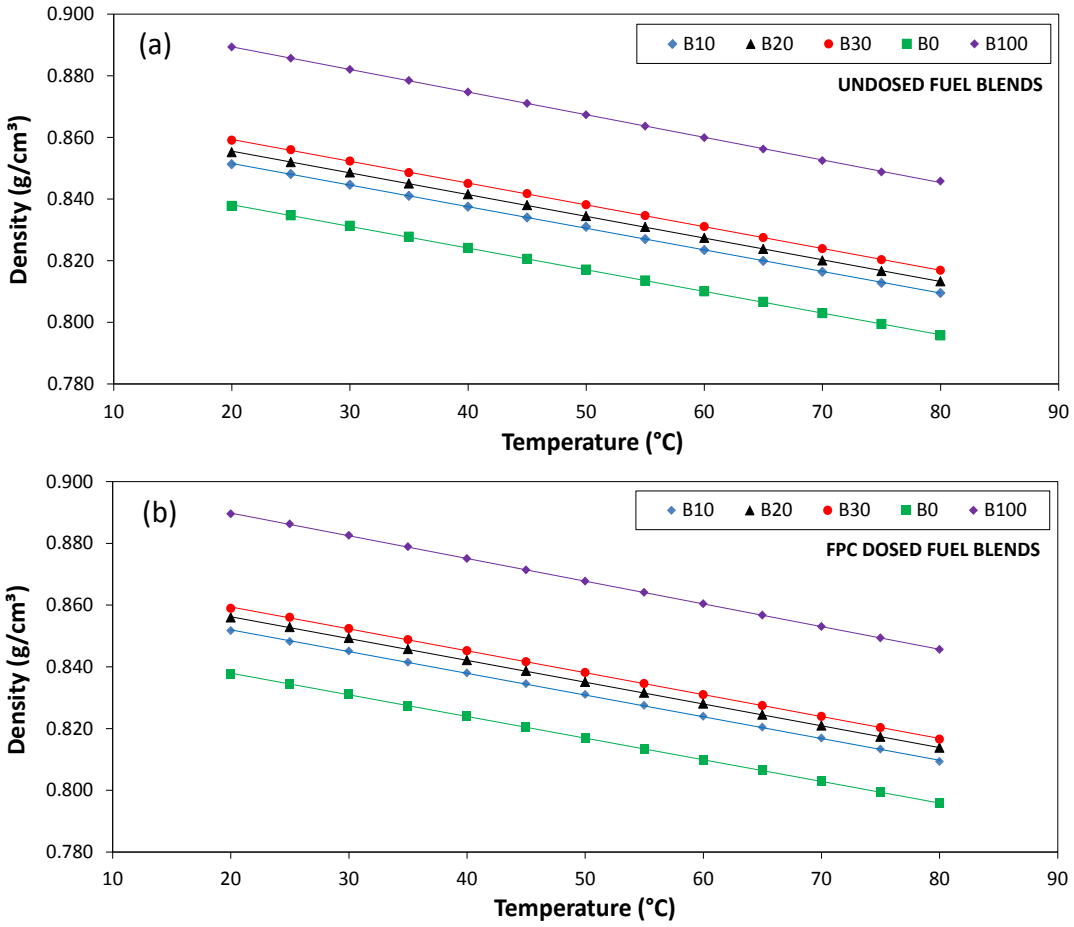

Fig. 1 : Fuel density as a function of temperature for the: (a) FPC undosed and (b) dosed Biodiesel-petro-diesel blends (B10-B30%, Vol %)

Table 1 : Density fitting curve coefficients for the FPC undosed and dosed Biodiesel-petro-diesel blends

FUEL BLEND	UNDOSED FUEL			FPC DOSED FUEL		
	Coefficients		Regression	Coefficients		Regression
	A	B	R^2	A	B	R^2
B100	-0.0007	0.9040	0.9999	-0.0007	0.9045	0.9999
B30	-0.0007	0.8735	0.9999	-0.0007	0.8736	0.9999
B20	-0.0007	0.8696	0.9999	-0.0007	0.8704	0.9999
B10	-0.0007	0.8656	0.9998	-0.0007	0.8660	0.9998
B0	-0.0007	0.8522	0.9999	-0.0007	0.8520	0.9999

Table 2 : Mean density comparative study for the FPC undosed and dosed Biodiesel-petro-diesel blends

FUEL BLEND	UNDOSED FUEL	FPC DOSED FUEL	COMPARATIVE STUDY
	Density (g/cm³)	*Density (g/cm³)*	*Std. Dev.*
B100	0.8674	0.8677	2.7305×10^{-4}
B30	0.8381	0.8381	3.6262×10^{-6}
B20	0.8353	0.8350	1.9001×10^{-4}
B10	0.8305	0.8309	2.4549×10^{-4}
B0	0.8171	0.8169	1.2293×10^{-4}

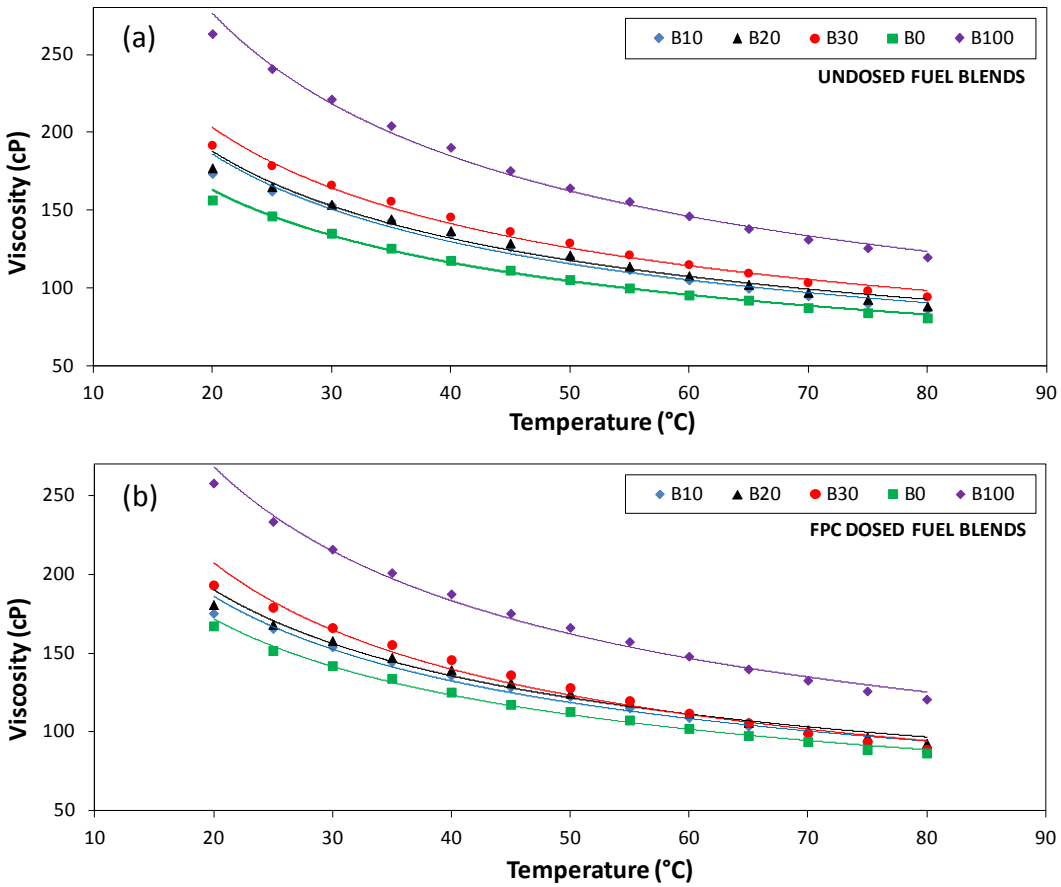

Fig. 2 : Viscosity data plotted as a function of temperature for the FPC dosed and undosed petro-diesel, diesel and relevant blends (B10-B30%, Vol %)

Table 3 : Viscosity model coefficients for the FPC undosed and dosed biodiesel-petro-diesel blends

	UNDOSED FUEL			FPC DOSED		
	Coefficients		*Regression*	*Coefficients*		*Regression*
FUEL BLEND	*C*	*d*	R^2	*c*	*D*	R^2
B100	1573.10	-0.580	0.9922	1397.10	-0.551	0.9903
B30	971.12	-0.522	0.9846	1140.90	-0.569	0.9767
B20	860.73	-0.508	0.9811	823.53	-0.489	0.9844
B10	879.95	-0.519	0.9766	812.27	-0.492	0.9821
B0	697.41	-0.485	0.9936	718.68	-0.478	0.9930

Table 4 : Summary of experimental data for flash tests of biodiesel-diesel blends

PROPERTY	BLEND CONDITION	FUEL BLEND				
		B0	B10	B20	B30	B100
Flash point (°C)	*Undosed fuel*	70	71	78.5	78.5	137
	FPC dosed fuel	69	74.5	76.5	78.5	124.5

Table 5 : Mean density comparative study for the FPC undosed and dosed Biodiesel-petro-diesel blends

	UNDOSED FUEL	FPC DOSED FUEL		ANOVA		t-Test	
BLEND	*Viscosity (cP)*	*Viscosity (cP)*	*Std. Dev.*	*F*	*F-critical*	*t-stat*	*t-critical*
B100	175.5077	174.2308	0.9029	722.55	2.604	-0.073	2.064
B30	134.6297	132.759	1.3228	494.14	2.604	0.146	2.064
B20	125.8077	129.2052	2.4024	266.422	2.604	-0.305	2.064
B10	123.6205	126.0923	1.7478	417.775	2.604	-0.073	2.064
B0	111.0923	118.1615	4.9987	54.7	2.604	-0.667	2.064

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Theoretical and Experimental Study of the Primary Stage of the Gasoline Fuel Spray

By Sadoun F. Dakhil, Qais A. Rishack & Bilal F. Sayhood
Technique College-Basrah, Iraq

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Symbols

GDI	Gasoline Direct Injection	UBHC	Unburn Hydro Carbon
SMD	Sauter mean Diameter	We	webber number
U	absolute velocity	u	axial velocity
h	film thickness at breakup	k	number of wave
k_s	max number of waves	m_l	mass of injected fuel
d_o	diameter of injector	k_v	discharge coefficient of nozzle
h_o	film thickness at nozzle tip	η,η_o	amplitude of wave, initial amplitude
ω_r	real part of growth rate	Ω	max growth rate
λ	wave length	π	constant ratio
$\rho_{l,g}$	density, liquid and gas	$\mu_{l,g}$	viscosity of liquid and gas
ν	kinematic viscosity	δo	film thickness

I. Introduction

The advantages of the gasoline direct-injection (GDI) engine over the port-injection engine are the improved fuel economy, reduced unburned hydrocarbons (UBH) and CO emissions, and more precise air-fuel ratio control. The injected gasoline consists three main stages (sheet, ligaments and finally drops) see Fig(1). The primary stage is an important part of the fuel injection which effects on the spray droplet diameter, penetration and shape of mixture[1]. Despite the large number of investigations carried out so far for droplet behaviour, while the primary stage is stilled not fully understood. The weak of understanding of the fuel sheet length and thickness needs further investigation.

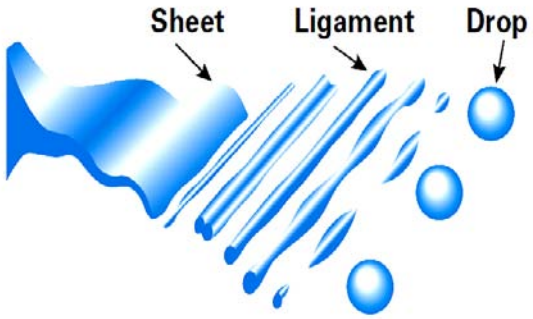

Figure 1 : Sheet disintegration and drop formation process[1]

In order to apply gasoline direct-injection system to the engine, the fuel injector of a GDI engine must be designed to produce well atomized spray at very short duration in comparison to the conventional gasoline engine. To solve these problems, many

Author α: Fuel and Energy Dept., Technique College-Basrah.
Author σ: Metallurgy dept., Engineering College-Basrah.
Author ρ: Missan Oil Company, Ministry of Oil.

researchers have investigated spray behaviour and atomization characteristics of high-pressure gasoline swirl injector for a direct injection gasoline engine. Recently, a comprehensive overview on the mixture formation and combustion control in a spark-ignited direct-injection gasoline engine was reported by Zhao *et a1*. (1995) [1]. In 2003, Kawahara [2] made an experimental investigation of primary spray structure under high pressure swirl injector which is used in gasoline direct injection engine, He used Ar-ion laser sheet and high speed video camera (1 Mfps). The objective of his work is to investigate the macroscopic and microscopic characteristics of gasoline injector for GDI engine by numerical approach applying the LISA (Linear instability Sheet Atomizer) breakup model and experimental method. The global spray behaviours such as spray tip penetration and spray data of fuel injector are captured by the Phase Doppler Anemometry, and the atomization characteristics such as spray droplet size and velocity distribution of the gasoline direct injector are measured by using phase Doppler Particle Analyzer system. The LISA breakup model is used to obtain the results of the numerical calculation. Based on the results of the calculation, the numerical results of models are compared with the experimental results such as spray shape, local SMD, axial mean velocity, and the distribution of the droplet breakup.

In the present work, the primary spray stage of injection theoretically and experimentally and the effects the pressure of the fuel injection –injector diameter and ambient pressure on the fuel speed- length and thickness of sheet.

II. The Primary Stage Model (LISA)

While a variety of models of secondary breakup has been proposed, and tested in CFD codes, a reliable model for primary breakup is yet to reveal. Linear instability sheet atomizer or LISA model is mostly used in direct injection, spark ignition engines. Primary region model used the integral nozzle flow parameter i,e: mass rate, initial velocity, orifice diameter to predict the initial drop size distributions. The model well known as wave model by Reitz [3]. For this model the pressure swirl atomizer is imposed to create, angular momentum on the liquid flow resulting the swirling motion. Centrifugal force is caused by swirling motion in the liquid spreads it out in the form of conical sheet as soon as leave the nozzle. A hollow cone spray is produced after the injector. This sheet is breakup to droplet by exposing to aerodynamic instabilities. The hydrodynamic mechanism process of this stage as:

III. Sheet Growth Rate

This model assumes that a two-dimensional, viscous, incompressible liquid sheet of thickness 2h moves with relative velocity U through an inviscid, incompressible gas medium. The liquid and gas have densities of ρ_l and ρ_g, respectively, the viscosity of the liquid is μ_l, and surface tension is σ. A coordinate system is used that moves with the sheet, and a spectrum of infinitesimal disturbances of the form [4].

$$\eta = \eta_{\circ} \exp\left(ikx + \omega t\right) \quad (1)$$

is imposed on the initially steady, motion-producing fluctuating velocities, and pressures for both the liquid and the gas. In Eq. (1) η_0 is the initial wave amplitude, $k=2\pi/\lambda$ is the wave number. The most unstable disturbance has the largest value of ω_r, denoted here by Ω, and is assumed to be responsible for sheet breakup (ligaments). Thus, it is desired to obtain a dispersion relation $\omega = \omega(k)$ from which the most unstable disturbance can be deduced.

Squire [5] has shown that two solutions for above equation to find growth rate (ω), or modes, exist that satisfy the liquid governing equations subject to the boundary conditions at the upper and lower interfaces. For the first solution, called the sinuous mode, the waves at the upper and lower interfaces are in exactly phase. On the other hand, for the varicose mode, the waves are π radians out of phase (see Figure 2). Clark and Dombrowski [6] used a second-order analysis to solve the equation of sinuous wave motion on a flat sheet and obtained a solution for liquid sheet length.

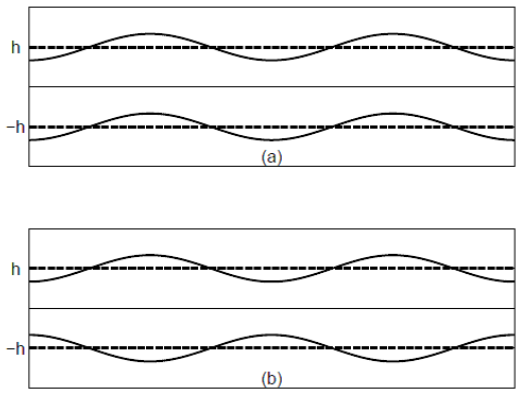

Figure 2 : Schematic of (a) antisymmetric or sinuous waves and (b) symmetric or varicose waves

To summarize, the theoretical analyses show that waves at the liquid surface are a major factor that causes liquid sheet instability and result ine disintegration. So, the present work is focused on growth of sinuous waves on the liquid sheet. Senecal et al [4] derived the dispersion relation for the sinuous mode from equation (1) to get the growth rate, which is given by:

$$\omega^2\left[\tan(kh)+Q\right]+\left[4\nu_l k^2\tan(kh)+2iQkU\right]+ 4\nu_l k^4\tan(kh)-4\nu_l^2 k^3 L\tan(kh)-2Q^2k^2+ \frac{\sigma k^3}{\rho_l}=0 \quad (2)$$

Where: $Q=\rho_g/\rho_l$ and $I=k^2+\omega/\nu_l$

ν is kinematic viscosity

The dispersion relation can further be simplified based on the wavelength of the wave. (i) Squire [5] assumed that long waves grow on the interfaces so that $\tanh(kh)=kh$. And in the limit of $Q \ll kh$ Eq (2) reduces to wave growth equation for long waves given by

$$\omega=-2\nu_l k^2+\sqrt{4\nu^2k^4}+\frac{QU^2k}{h}-\frac{\sigma k^2}{\rho_l h} \quad (3)$$

This relation is similar to Dombrowski and John's expression [7] *(ii)* For the short waves, which means $\tanh(kh)$ is approximated to unity. It is assumed that the growth rate is independent of the sheet thickness and in the limit of $Q<<1$, equation (3) reduces to:

$$\omega=-2\nu_l k^2+\sqrt{4\nu^2k^4+QU^2k^2-\frac{\sigma k^3}{\rho_l}} \quad (4)$$

If viscosity is neglected, Eq. (3) for long waves reduces to

$$\omega=\sqrt{\frac{QU^2k}{h}-\frac{\sigma k^2}{\rho_l h}} \quad (5)$$

And Eq. (4) for short waves reduces to

$$\omega=\sqrt{QU^2k^2-\frac{\sigma k^3}{\rho_l}} \quad (6)$$

To calculate maximum growth rate (Ω) for the inviscid long wave from Eq. (5), which occurs at a dimensionless wave number of $k_S h=1/2We_g$,

$$\left[\frac{\Omega h}{U}\right]_{long}=\frac{1}{2}\sqrt{QWe_g} \quad (7)$$

and the calculation maximum growth rate (Ω) for the short wave analysis, Eq. (6), which occurs at $K_S h=2/3We_g$,

$$\left[\frac{\Omega h}{U}\right]_{short}=\frac{2}{3}We_g\sqrt{\frac{Q}{3}} \quad (8)$$

To check the wave length condition, the critical *We* number must be used. The critical *We* is given by $We_g=27/16$. Above $We_g=27/16$, the fastest growing waves are short, and below 27/16, the wavelengths are long compared to the sheet thickness.

Eq. (1) shows that the growth rate of short waves is independent of the sheet thickness. When the amplitude of gasoline sheet reached the maximum value, the breakup happened. At that moment the growth rate becomes (Ω), amplitude becomes (η_b), the corresponding breakup time (t_b) and the breakup length *L*. When substitute equation (8) into (1) and neglecting the imaginary part to calculate (η_b), equation (1) becomes:

$$\eta_b=\eta_\circ\exp\left(\Omega t_b\right)$$

Which, it due to:

$$t_b=\frac{1}{\Omega}\ln\left(\frac{\eta_b}{\eta_o}\right) \quad (9)$$

The term ln (η_b/η_o) has an assigned value of 12 as suggested by [8].

IV. Sheet Velocity

The centrifugal motion of the liquid within the injector creates an air core surrounded by a liquid film. The thickness of the film, δ_o, is related to the mass flow rate by [9]:

$$m_l=\pi\rho_l u\delta_o\left(d_o-\delta_o\right) \quad (10)$$

Where: d_0 is the atomizer exit, m_l is the liquid mass flow rate, u the axial component of velocity at the exit and δ_0 is film thickness.

This quantity depends on internal details of the injector and is difficult to calculate from first principles. The sheet velocity, U_l, is assumed to be related to the injector pressure drop, ΔP, by

$$U_l=k_v\sqrt{\frac{2\Delta P}{\rho_l}} \quad (11)$$

Some researcher has noted that k_v is a function of the injector design and injection pressure. If the swirl ports are treated as nozzles, Eq. (11) is then an expression for the coefficient of discharge for the swirl ports, assuming that the majority of the pressure drop through the injector occurs at the ports. The coefficient of discharge for single-phase nozzles with sharp inlet

corners and an L/D of 4 is typically 0.78 or less and 0.88 [10].

Physical limits on k_v are such that it must be less than unity by conservation of energy, and it must be large enough to permit sufficient mass flow. To guarantee that the size of the air core is non-negative, the following expression is used:

$$k_v = \max\left(0.7\frac{4m_l}{\pi D_o^2 \rho_l \cos\theta}\sqrt{\frac{\rho_l}{2\Delta P}}\right) \quad (12)$$

where θ is the spray half-angle.

Assuming that the pressure drop is known, u_l is found from

$$u = U_l \cos\theta \quad (13)$$

V. Sheet Thickness and Length

The initial half-thickness h_o can be related to the film thickness (δ_o) within the nozzle diameter d_o, by the expression

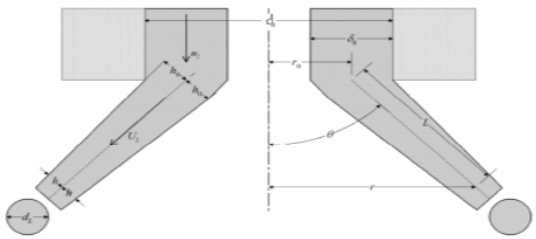

Figure 3 : Schematic showing the conceptual liquid flow at the cone angle and nozzle exit

$$h_o = \frac{1}{2}\delta_o \cos\theta \quad (14)$$

and the sheet length calculated by:

$$L = Ut \quad (15)$$

Then, the sheet half-thickness at L is given by:

$$h = \frac{2\delta_o[d_o - \delta_o]/\cos\theta}{2L\sin\theta + d_o - \delta_o} \quad (16)$$

Where: δ_o is the film thickness, measured perpendicular to the injector axis, at the nozzleexit.

VI. Drop Formations

The breakup occurs when the amplitude of the unstable waves is equal to the radius of the ligament; one drop will be formed per wavelength. In either the short wave or the long wave case, which are explained in eq. (2). At the point of breakup, fluid ligaments are formed with diameter calculated from the mass balance, as:

$$d = \sqrt{\frac{16h}{k_s}} \quad (17)$$

Where is the wave number corresponding to the maximum growth rate (Ω) and the sheet thickness (h) at the breakup location.

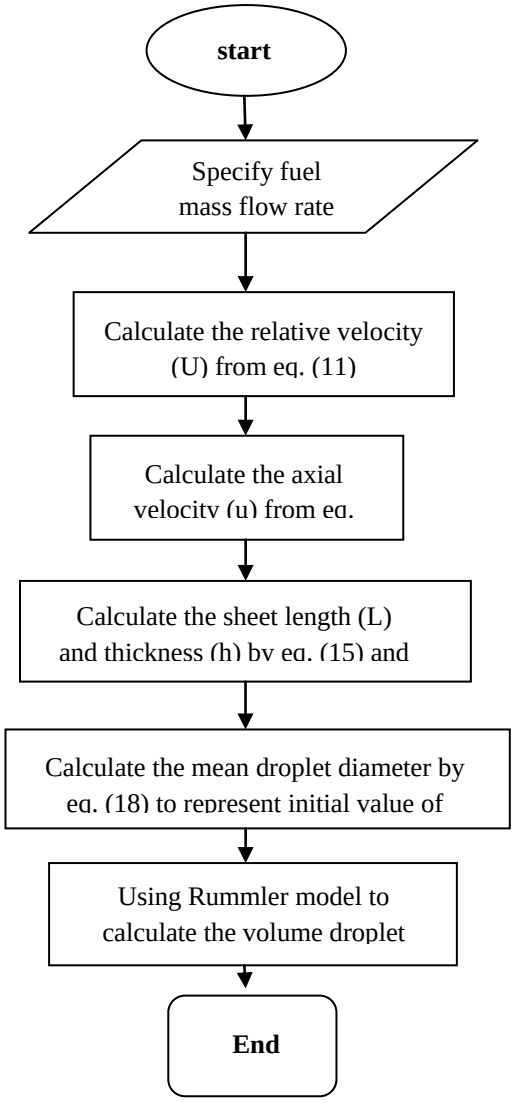

Figure 4 : Procedure of calculation primary stage of gasoline spray

As shown in figure (4), the ligaments break up once the amplitude of the unstable waves is equal to the radius of the ligaments, giving droplets with diameter:

$$d_D = \left(3\pi\, d_l^2 / k_l\right)^{\frac{1}{3}} \quad (18)$$

with

$$K_l = \left[\frac{1}{2} + \frac{3\mu_l}{2(\rho_l \sigma d_l)^{1/2}}\right]^{-\frac{1}{2}} \cdot \frac{1}{d_l} \qquad (19)$$

The physical mechanism of sheet disintegration proposed by [10] is adopted in order to predict the drop sizes (d_D) produced from the primary breakup process.

The procedure of calculation this stage of gasoline in primary stage was explained in the figure (5) below.

VII. Experimental Analysis

Laser Doppler Anemometry (LDA) is a non-intrusive absolute laser diagnostic system that is capable of recording the transient nature of a seeded flow-field. However, when applied to sprays the droplets the mselves act as the seeding particles. Phase Doppler Anemometry (PDA) is an extension of LDA that allows the simultaneous measurement of velocity component and droplet diameter size. This technique is used for other numerous applications but will be described here in relation to spray applications. First the principles of operation will be briefly explained, and then the method of data collection and post-processing techniques will be described.

Several techniques have been developed to measure properties of sprays such as the droplet size. Most techniques use radiation as a probe at optical wavelengths. In a two-phase injector, the sensitivity and dynamic range of such techniques must allow measurement of dense sprays with a droplet size distribution that may vary over one or two orders of magnitude.

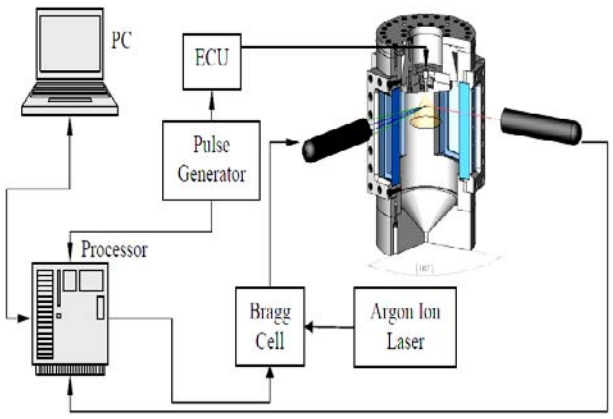

Figure 5 : Schematic of main components for PDA system

Phase Doppler Anemometry (PDA) is the standard technique for spray investigations [10, 11 and 12]. It gives both size and velocity information on individual droplets. The experiment was done under conventional ambient conditions (1 bar, pressure and 21 °C, temperature), fuel was a gasoline and injected at 10 MPa pressure and environmental temperature, the diameter f the nozzle is 0.2 mm.

The data was acquired at 5mm downstream the tip of nozzle, which expected exist of a parent drop d_D. Ten points in radially direction at 5mm downstream, the data was acquired.

This experiment was done in Laser laboratory of university of Cardiff in Wales, United Kingdom.

VIII. Results and Discussion

The paper concerned on study the effects of some parameters on primary spray characteristics like as liquid fuel sheet thickness, velocity and length which are described the initial value of the fuel spray droplet.

Figure (6) shows the effect of injection pressure on the sheet thickness of gasoline injected inside combustion chamber under conventional condition of air (1 bar pressure and 21°C). The results show that the sheet thickness decreases when the injection pressure of the gasoline is increased, this is due to the increasing in the axial and angular fuel velocity which is force the fuel outer side and increases the air core inside the nozzle.

Also, figure (6) showed the effects of the injector hole diameter on the sheet thickness of injected gasoline directly to combustion chamber, when increase the diameter of the injector, the liquid sheet thickness increased too. When increasing the diameter of the injector, the sheet velocity decrease and due to the increasing in thickness.

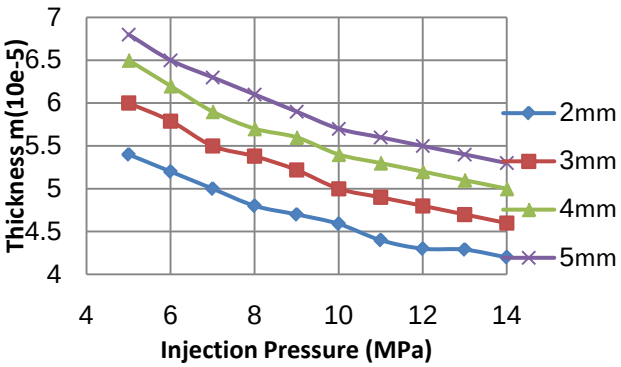

Figure 6 : effect of injection pressure with different nozzle diameters on half sheet thickness (h)

Figure (7), shows the effect of the injection pressure on the velocity of the fuel at the nozzle exit, which proportional by square root to the injection pressure, it is clear that in the equation (9). When the injection pressure is increased, the velocity was increased too.

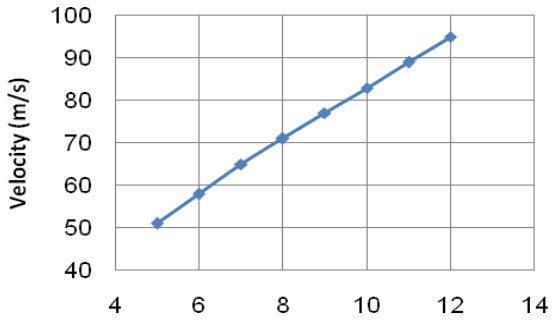

Figure 7 : effect of injection pressure on fuel velocity

Figure (8) presented the effect of fuel injected pressure on the liquid sheet length. From the figure, it's clear that the increasing the injection pressure affect to decreasing in the fuel sheet length due to increasing in the velocity and increase in the dispersion and growth rate which affects on increasing the wave amplitude then happening of the breakup. The fuel injection pressure play an important rule of spray mechanism. There is an limitation for increasing the injection pressure at gasoline engines due to the droplet size and mixture [4].

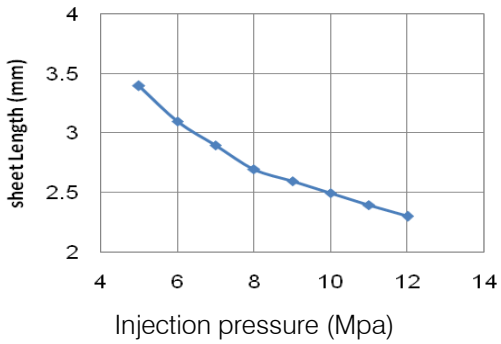

Figure 8 : Effect of injection pressure on fuel gasoline sheet length

The effect of the fuel injection pressure on the fuel sheet velocity was presented in figure (9). The results showed that an increasing in the fuel pressure caused the increasing in the fuel velocity due to increasing in the dragging force on the droplets. Which affects a fast transferring the momentum from the droplet to the surrounding air. There is no effect of the ambient pressure at high injection pressure.

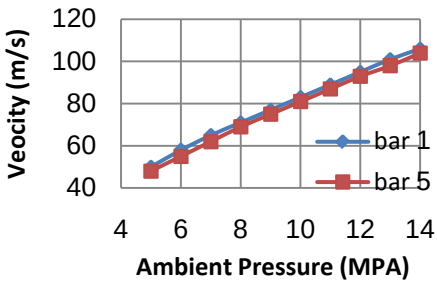

Figure 9 : The effect of Ambient Pressure on Sheet Velocity

Figure (10) showed the effect of the injection pressure on the liquid sheet thickness, where increase the pressure slightly decrease the thickness of the sheet due to the increasing the dragging force which decreasing the velocity which increased the ligament region and then droplet phenomena. Also low effect of the ambient pressure at high injection.

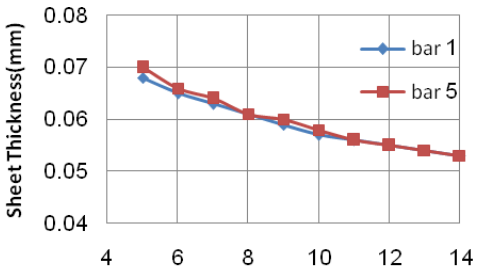

Figure 10 : The effect of Injection Pressure on Sheet Thickness

In the figure (11), the behaviour of the sheet length had a slightly decreased when increasing the injection pressures because of dependence of sheet length on thickness.

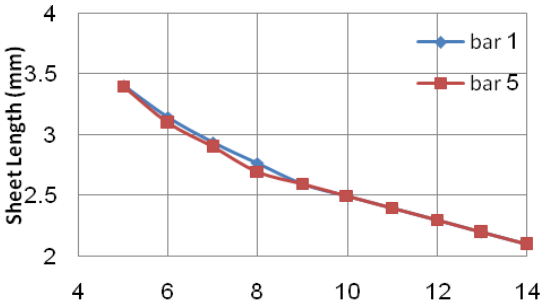

Figure 11 : The effect of Injection Pressure on Sheet Length

Figures (12, 13 and 14) showed the effect of the half angle of the spray (injector specification) on the axial velocity, thickness and length the fuel sheet at constant injection pressure. It clear that characteristic of spray were decreased in increased happened in fuel cone angle(theta) due to increasing in the centrifugal force and increased of the horizontal force, which decrease the axial velocity, sheet thickness and length of sheet as shown in the figure (3).

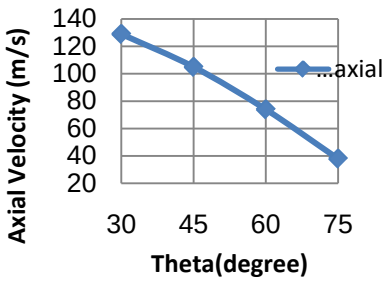

Figure 12 : The effect of the spray angle on axial velocity

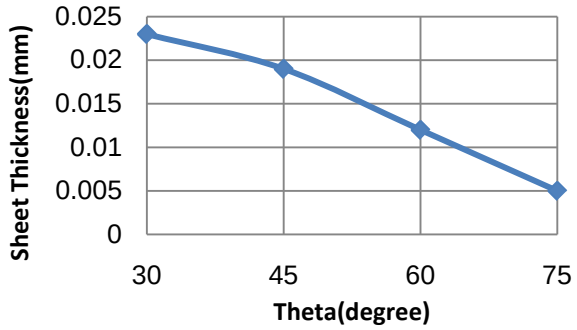

Figure 13 : The effect of the spray angle on sheet thickness

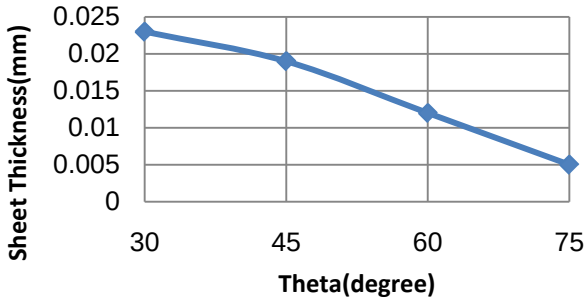

Figure 14 : The effect of the spray angle on sheet length

When made a compare between experimental acquired data of axial velocity and theoretical calculated results, as shown in figure (15), it explain that the experimental data was less than results which got numerically because of the air dragged and friction inside nozzle were neglected.

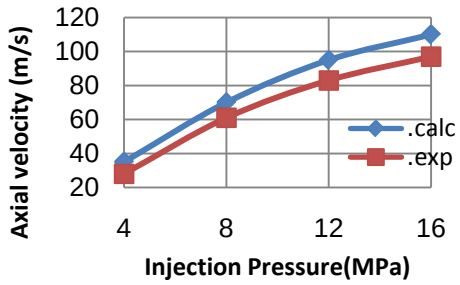

Figure 15 : comparison between experimental and theoretical axial velocity

Table of used parameters

Mass of fuel injected	9	mg
Injection duration	6	ms
Viscosity	3x10-3	N/s
Density	745	kg/m3
Surface tension	2.25	N/m
Injection pressure	5,…14	MPa
Spray half angle	60	degree
Nozzle diameter	0.2,…,0.5	mm

IX. Conclusions

- The primary sheet breakup seen to have the ability of describing and presenting the fuel spray typical in DISI engines. So from this research, we concluded that the increasing in injection of fuel pressure would made decreasing in length of sheet and thickness, but increasing the velocity.
- The strategy developed has been tested on simple case of swirl injector (pintle type) under the typical conditions predicted a quantitative results with a good agreement with a similar test cases of the experimental.
- The primary stage of the gasoline spray play an important role in fuel mixture condition. Both sheet length and thickness are affected on the rate of droplet evaporation and the time required to complete mixture. So high length and thickness of the fuel sheet mean the rate time of creating ligaments and droplet is high. Finally that delays the combustion process.
- Variable pressure injector is the main demand for the modern technology engine to provide the optimum sheet length and thickness the avoid knocking.

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Experimental Investigation & Modelling Studies for Different Tubes of Heat Exchanger using CFD

By Roshan. V. Marode & Ashok. J. Keche
MIT, India

Abstract- Shell and Tube Heat exchanger are the basic types of heat exchanger one of the fluids flow through a bundle of tubes enclosed by a shell. The outer fluid is forced through a shell and it flows over the outside surface of the tubes. Such an arrangement is employed where reliability and heat transfer effectiveness. In order to achieve the maximum heat transfer rate an analysis is made on single tube with two different fluids (Water and Al2O3-water based Nano fluid) in a shell and tube heat exchanger. With relate to same to have a maximum heat transfer rate this paper gives various optimal design solutions using computational techniques. To measure the performance of different designs, its model is suitably designed and fabricated so as to perform experimental tests. Thermal analysis has been carried out for different design with two fluids and on the basis of comparative results is made which one give the best heat transfer rates.

Keywords: heat exchanger, water, al2o3-water based,optimal design, thermal analysis, computational techniques.

GJRE-J Classification : FOR Code: 290901p

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Roshan. V. Marode [α] & Ashok. J. Keche [σ]

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Keywords: heat exchanger, water, al2o3-water based, optimal design, thermal analysis, computational techniques.

I. Introduction

In a Heat Exchanger, consists of bundle of tubes. One fluid flows through the tubes while the second fluid flows space between the tubes and shell. Tubes plays an important role while exchanging heat from hot fluid to cold fluid. Although they are not specially compact, their robustness and shape make them well suited for high pressure operations. They have larger heat transfer surface area to volume ratio than the most of common types of heat exchangers, and they are manufactured easily for a large variety of sizes and flow configurations. The main design objectives here are to accommodate thermal expansion, to furnish ease of cleaning, or to provide the least expensive construction.

To get robust, least expensive and technically sound design, we will be dealing with four different designs viz. "Circular Tube", "Elliptical type(Oval)", "Twisted type" and "Coil type" Along with construction issue we too come across the difficulties in improving heat transfer rates, which means to have high effectiveness, we were in flow to compromise the design and robustness. In order to achieve the maximum heat transfer rate an analysis is made on single tube for different designs with two different fluids (Water and Al2O3-water based Nano fluid) in a shell and tube heat exchanger. This paper shows how maximum heat transfer rate has been achieved by comparing four different designs and getting optimal design solutions using computational techniques. To measure the performance of different designs, its model is suitably designed and fabricated so as to perform experimental tests. Thermal analysis has been carried out for four different designs with two fluids and on the basis of comparative results is made which one give the best heat transfer rates. After the modification of design an experimental validation is carried out to validate the results from analysis.

Author α: Mechanical Engineering Department, MIT, Aurangabad (M.S), India. e-mail: roshan.marode@gmail.com
Author σ: Associate Professor, Mechanical Engineering Department, MIT, Aurangabad (M.S), India. e-mail: ashokkeche@gmail.com

II. Literature Review

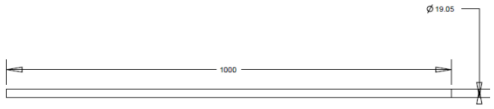
Ala Hasan [1] experimentally investigated five oval tubes and compared with that for a circular tube in a cross-flow way and concluded that oval tube gives higher heat transfer results. The outcome was taken for comparing results of oval and circular tubes which helped for optimized design. Abdul Kareem Abbas*et al* [2] shows heat transfer augmentation due to twisting parameter was investigated in a twisted tube of rectangular/square cross sectional area. Also swirling increases internal mixing process which enhances internal thermal equilibrium. The heat transfer coefficient also increases as Reynolds number increased as velocity components are increased. This relation shown was used as function and one of the parameter in design. Su Thet Mon Than *et al*[3]In this paper data is evaluated for heat transfer rate having spiral tubes and pressure drop and checking whether the assumed design satisfies all requirement or not by using computational techniques. Satisfied design found was used for coil type tubes for analysing the heat transfer rate.Jay J. Bhavsar*et al*[4]objective of this paper is to design and analyze of spiral tube heat exchanger. In this newly proposed design hot fluid flows in axial path while the cold fluid flows in a spiral path. The presented work was used in spiral tube designand has high heat transfer rate compared with helical coil heat exchanger and spiral plate heat exchanger.P. M. Deshpande *et al*[5]They studied horizontal spiral coil tube (HSTC) for various forces (viscous, buoyancy and centrifugal force)

acting on fluid element in coil; of which the centrifugal force is predominant and results in secondary flow. This phenomenon also depends on the physical properties of fluid at a given temperature. They also concluded that as the coil diameter reduces the curvature ratio increase that increases the pressure drop. Relation was used for designing coil type tubes.

III. Design of Tubes

a) Circular type tube

D_i=16.65mm
D_o=19.05mm
Thickness=t=18BWG
Length= 1000mm



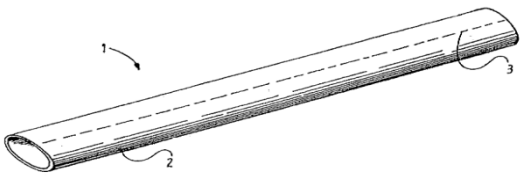
Source:

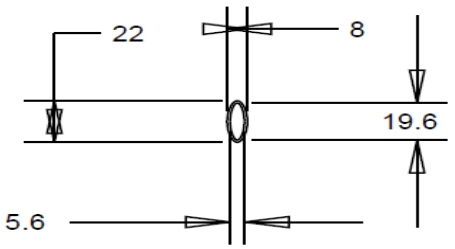
- Design of Heat Exchange equipment.
- Design shell and tube heat exchanger [Rajiv Mukherjee Engineers India Ltd.]
- Handbook of TEMA.

b) Elliptical Type Tube(Oval)

Source:

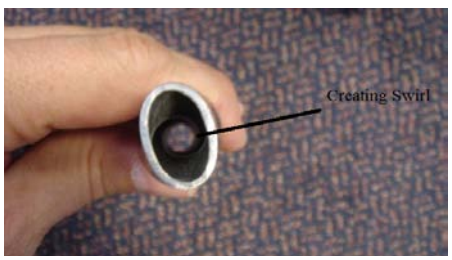
- Thermal-Hydraulic performance of oval tubes in a cross-flow air- *ALA-HASAN*
- Structural and Thermal Analysis of Heat Exchanger with Tubes of Elliptical Shape -Nawras H. Mostafa Qusay R. Al Hagag

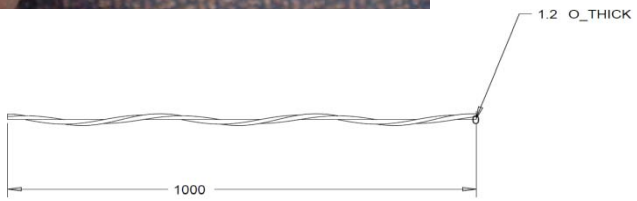




c) Twisted Type Tube

Length (L)=1000mm
Thickness (t)=1.2mm
Breadth of rectangular tube (b)=22 mm
Depth of rectangular tube (d) =8mm
No. of twists (Nt)=05(Each at 200mm)





Source:

- Twisted Tube Heat Exchanger Technology-*R. Donald Morgan*
- Twist parameter influence on heat transfer coefficient augmentation for a square twisted tube- *A. Kareem*

d) Coil Type Tube

Diameter (D_0) =3/4"=19.05mm

Length(L)=1000mm

Number of turns(n)=6

Thickness(t)=1.2mm

Effective coil diameter (D)=52mm

Pitch (p) for helical it is taken as $1.5D_0$≡30mm

To know the unknown parameter, D (Coil Diameter)

Equation is given by,

$$L = N\sqrt{(2\pi R)2 + (p)2}$$

$$1000 = 6\sqrt{(2\pi R)2 + (1.5x19.05)2}$$

$$\frac{1000}{6} = \sqrt{(2\pi R)2 + (1.5x19.05)2}$$

$$\frac{1000}{6} = \sqrt{(2\pi R)2 + 816.53}$$

$$\frac{26961.24}{4x\pi^2} = R^2$$

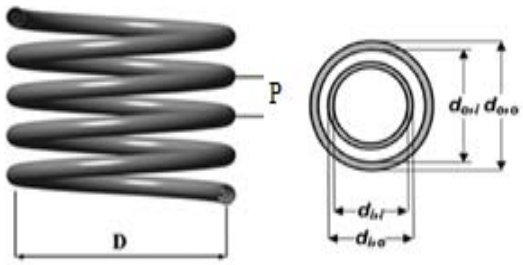
Therefore,

R = 26.13mm

D ≡ 52 mm

Source:

- ASME German AD-*Merkblatt*
- European pressure equipment directive (PED)
- Designing a helical-coil heat exchangers- *K. Ramchandra*



IV. Experimental Work

We achieved temperature range by placing thermocouple at 250 mm apart for four design tubes.

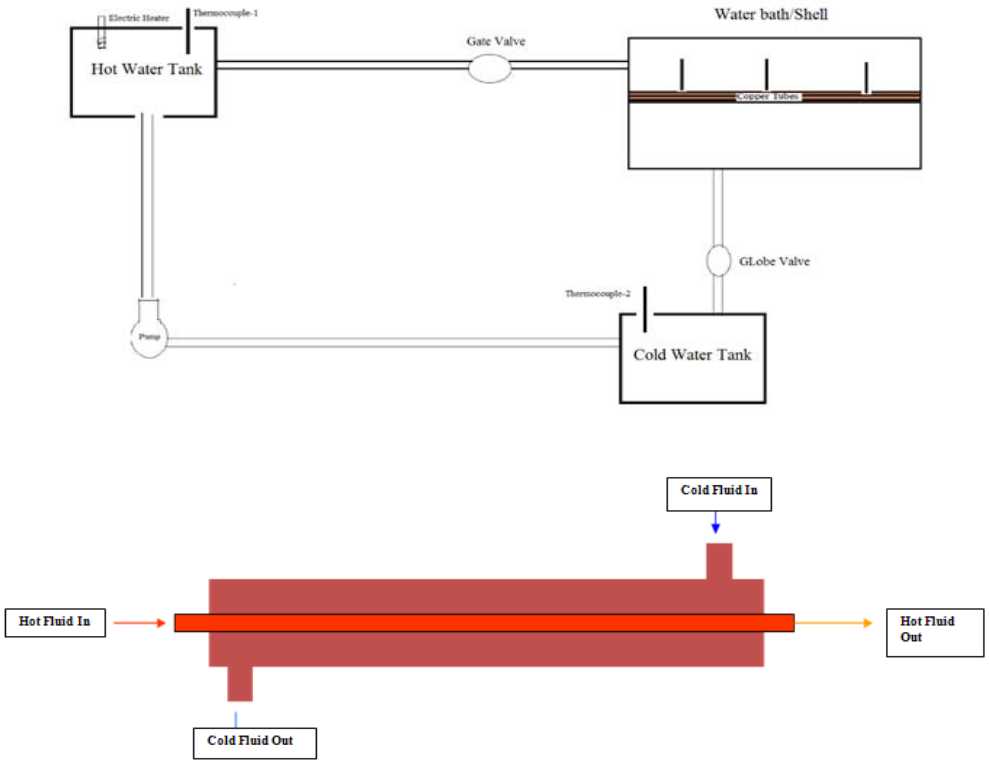
T_1 = Temperature at inlet of tube.

T_2=Temperature at a distance of 250mm from inlet.

T_3= Temperature at a distance of 500mm from inlet.

T_4= Temperature at a distance of 750mm from inlet.

T_5=Temperature at outlet of tube.



a) For (Water –Water as a fluid)

i. *For circular type*

Sr. No	Mass flow rate(Kg/sec)	Temperatures at different points of tube (^{0}C)				
		T1(At start 0mm)	T2(At 250 mm)	T3(At 500mm)	T4 (At 750mm)	T5(At 1000mm)
1	0.14	67	66.5	65.5	65	64
2	0.12	67	66.5	66.5	65	64
3	0.05	66.5	66	65	64.5	63.5

ii. *For Elliptical type*

Sr. No	Mass flow rate(Kg/sec)	Temperatures at different points of tube (^{0}C)				
		T1(At start 0mm)	T2(At 250 mm)	T3(At 500mm)	T4 (At 750mm)	T5(At 1000mm)
1	0.14	67.5	65	64.5	64	63.5
2	0.12	63	62.5	62	61	59.5
3	0.05	63	62	62	61.5	60

iii. *For Twisted type*

Sr. No	Mass flow rate(Kg/sec)	Temperatures at different points of tube (^{0}C)				
		T1(At start 0mm)	T2(At 250 mm)	T3(At 500mm)	T4 (At 750mm)	T5(At 1000mm)
1	0.14	64	62	60	58.5	56.5
2	0.12	56	54	53	52	51
3	0.05	58	57	56	54	53

iv. *For Coil type*

Sr. No	Mass flow rate(Kg/sec)	Temperatures at different points of tube (^{0}C)				
		T1(At start 0mm)	T2(At 250 mm)	T3(At 500mm)	T4 (At 750mm)	T5(At 1000mm)
1	0.14	68	68	67	65	63
2	0.12	65.5	65	64.5	62	58
3	0.05	61	60	60.5	58	56.5

V. Calculations for Heat Transfer Coefficient

a) For case I(water-water)

Fluid properties for water are:

μ=0.467xNs/

ρ=1000 kg/

Cp=4.18xJ/kg^{0}k

k_w=0.625w/m^{0}k

For Circular type:

$A_{c/s}$ = (π[d_0^2-d_i^2]

=(π[0.01905^2-0.01665^2]

=6.73x10^{-5}m^2

As Reynolds number for circular tube is given by,

$Re=\rho vd/\mu$ ..... (1)

to find V,

We know continuity equation,

Q=AxV

As density = mass/volume (ρ=m/vol.)

Therefore, m= A x ρ x V (1a)

For mass flow rate =m=0.14kg/sec

0.14 = Vx1000x6.73x10^{-5}

V= = 2.08m/s

V= 2.08 m/s

So,

Re = 74158.45

From Reynolds number, flow is turbulent.(Re>2000)

Correlation used for turbulent flow is;

$Nu = CRe^aPr^{b-m}$ (1b)

where C = 0.021 for gases,

= 0.023 for non-viscous liquids,

= 0.027 for viscous liquids

$Nu = CRe^aPr^{b-m}$

$= 0.023xRe^{0.8}Pr^{(1/3)}$ x1

$= 0.023x(74158.45)^{0.8}x(Pr)^{(1/3)}$ (1c)

Pr =μCp/k (Depend only on fluid properties)

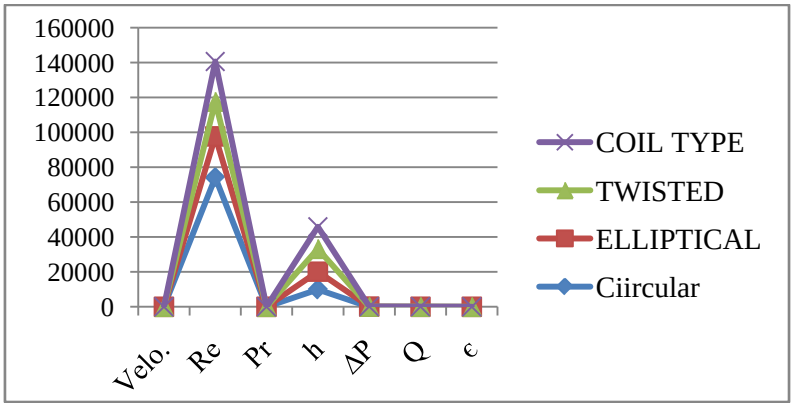
= 3.12

Equation 1c, → = 0.023 x (74158.45)$^{0.8}$x(3.12)$^{(1/3)}$

$\check{h}$ = 9932.08 w/m^2^{0}K

Likewise, calculated heat transfer rate for other three tubes are:

Sr. No.	Type of Design	V	Re	Pr	h	ΔP	Q	ϵ
1	Circular	2.08	74158.4	3.12	9932.08	31.18	19.6	0.35
2	Elliptical	1.7	23516.1	3.12	10213.7	54.91	19.22	0.24
3	Twisted	2.11	19952.4	3.12	13100.6	29.3	19.83	0.53
4	Coil	2.09	23032.5	3.12	12625.1	36.72	21.91	0.34



b) Calculated outcome of Case-II (AL2O3-Water as a Nano fluid):

Fluid properties for Al_2O_3- water (0.1 % concentration) are:

μ=0.35 cp=3.5xNs

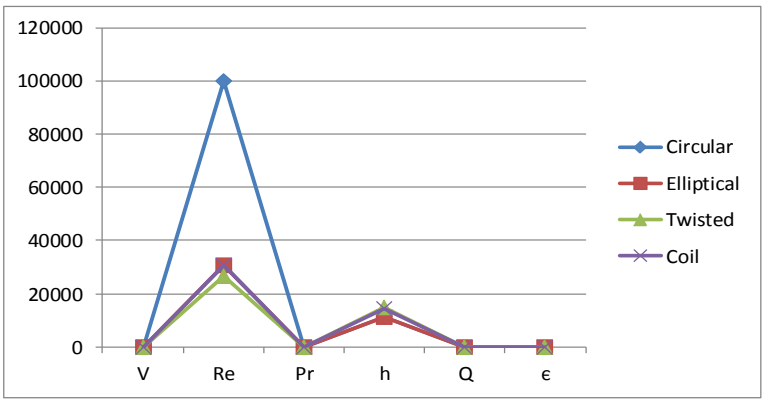
ρ=1022 kg/

Cp=3.1xJ/kg^{0}k

k=0.72w/m^{0}k,

Prandtl number obtained from calculation is common for all type of deign as fluid properties are common, viz 1.5.

Sr. No.	Type of Design	V	Re	h	Q	ϵ
1	Circular	2.06	100153.08	11399.20	20.63	0.38
2	Elliptical	1.63	30761.90	11427.08	20.16	0.30
3	Twisted	2.07	26563.12	14864.54	23.18	0.60
4	Coil	2.04	30617.95	14307.87	24.01	0.40



VI. Thermal Analysis of Tubes with two Different Media

Thermal Analysis is made by using Computational Fluid Dynamics. In this a compromise between the computer time and accuracy of the analysis is made. The various parameters set in analysis are given below:

Thermal modelling

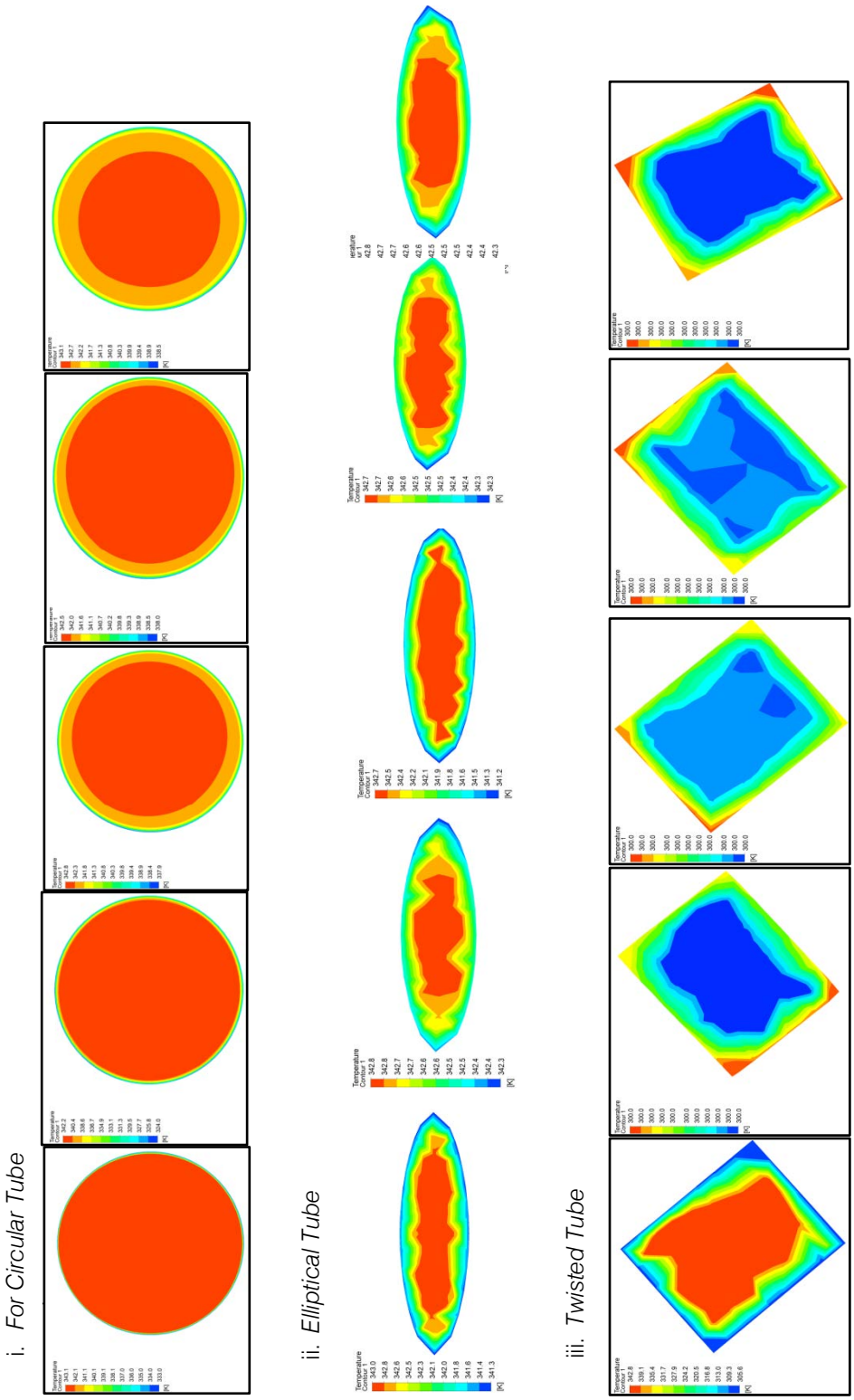
- Analysis type - Thermal h-method.
- Steady state or Transient State.

- Properties of the material
- Objective of analysis- to find out the temperature distribution in a tube at various cross sections for different design when the process of shell and tube is done.

a) CFD-Results of Case-I

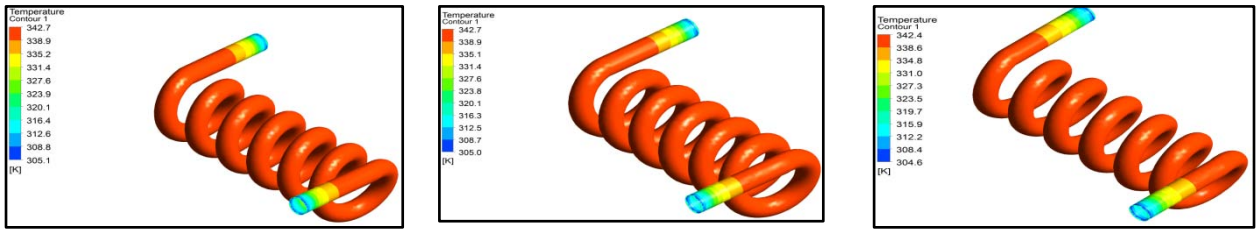
Mass flow rate: 0.14 kg/s

Temperature Contours

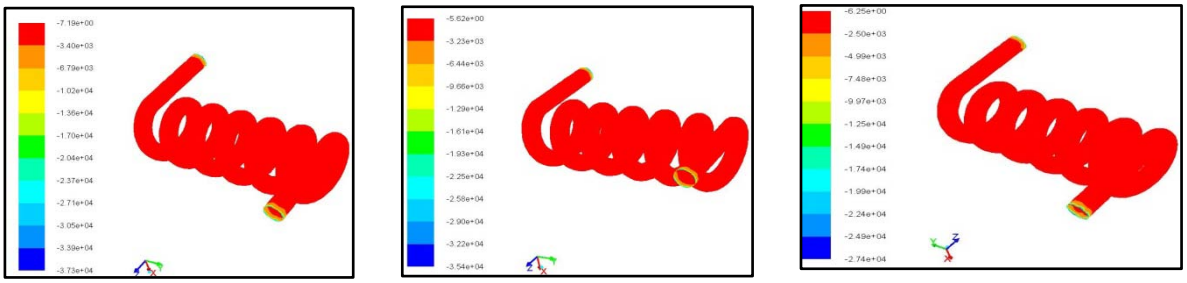


iv. *Coil Tube: (For three planes)*

a. Temperature Contours

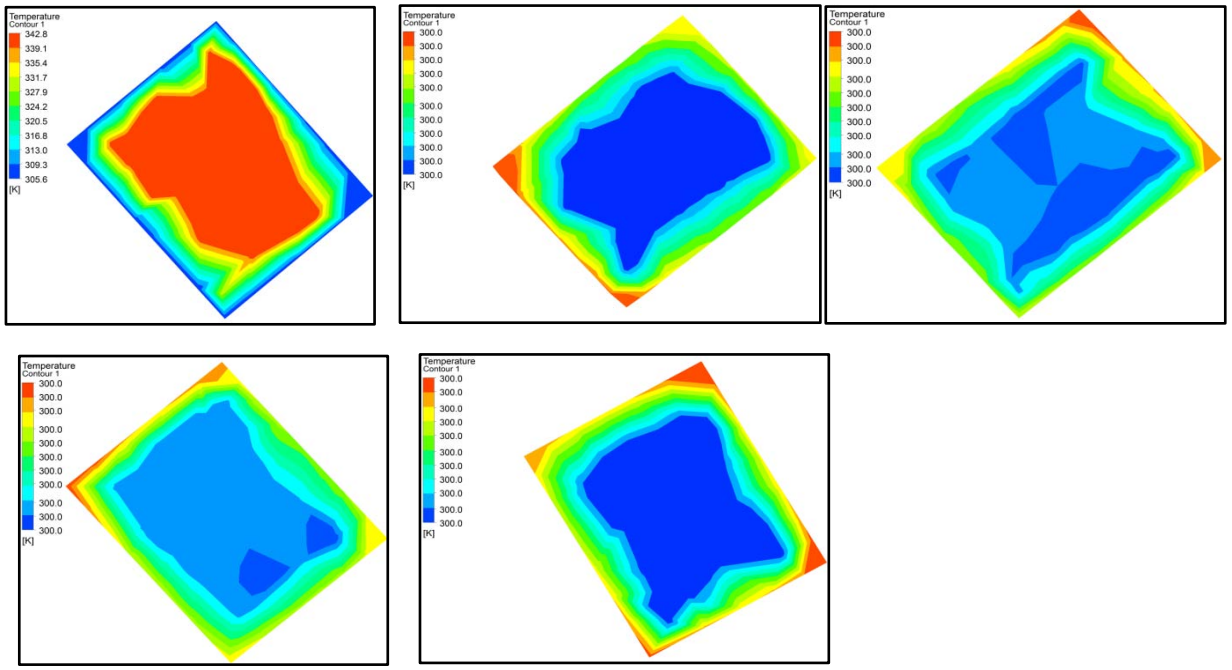


b. h-Contours for inner wall



b) CFD-Results of Case-II(Al_2O_3 as a Nano fluid)

We have focused only on twisted type tube as in above sequence of calculations we are getting high heat transfer rate and high effectiveness by calculation.



In above colourful diagram, if we compare d the twisted tube temperature contours with water as base fluid, an CFD analyst may observe that for 4th and 5th plane we are getting blue colour contours as compared to case 1, which directly shows the temperature gradient in above case is high along with effectiveness.

VII. Conclusion

This study shows the design and thermal analysis of different tubes. Experimentally, same designs are made and results are evaluated. With relate to same design tubes are thermally analysed in ANSYS

software and compared both the results. After comparing the result for both water-water(Case-I) and water-Al2O3(Case-II) for four different tubes we are in conclusion that twisted type of tube is giving high heat transfer coefficient as compared to other i.e 1.14 more. Along with effectiveness, twisted tube is at higher side by 1.17.So according to my research one should go for twisted tube.

However, a good understanding of the underlying principles of exchanger design is needed to use this software effectively. The possibility to increase in these characteristics using the latest technology and various methods has raised application range of these designs. Modified design tubes are having great applications due to their large heat transfer area and high heat transfer coefficients. They are used in many industrial processes like waste water treatment, refrigeration, wine and beer making, petroleum refining.

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Firewood-Stove Made in Rwandan Rock

By Munyaneza Jean De Dieu
Tumba College of Technology , Rwanda

Abstract- Since in developing country the most people use a lot of fuel wood and charcoal for cooking and heating which contribute in deforestation and pollution of atmosphere, both problems cause the global warming and climate change[1]. Design and fabrication of firewood-stove made in Rwandan rock is one way of solving these problems. From results of water boiling test that we did on firewood-stove made in Rwandan rock it gave an average of 34.75% as thermal efficiency which was greater than Nepalese (16.81%), rocket (16.21%), Darfour stoves (12.72%) as we have made the comparison with them in this paper. Even if the thermal efficiency of Ugstove and Stovetec were greater than that of this stove; our research found that firewood-stove made in Rwandan rock has the ability to conserve heat from burnt firewood until one hour after removing all firewood only small charcoal formed during cooking process stay in the combustion chamber.

Keywords: *stove made in volcanic rock, water boiling test, firewood.*

GJRE-J Classification : *FOR Code: 091599*

Strictly as per the compliance and regulations of :

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Due to this special property they have you can cook other meals without any new firewood during one hour like tea, rice, bananas, boiling water for drinking or washing purpose. This ability of heat conservation is a particularity of this stove only. These stoves emit less smoke and contribute to reduction of the indoor air pollution in the kitchen. It can be used within four years without any problem; no regular repair and maintenance required for this stove as they require on Nepalese and Darfour stoves. The cost of this new stove varied between 2.15$ to 4.3 $ in different part of Rwanda and from 2006 up to 2014; around forty thousand (40,000) of volcanic stoves were supplied in different part of Rwanda and many people benefit their advantages over existing stoves.

Keywords: stove made in volcanic rock, water boiling test, firewood.

I. Introduction

Cooking stoves are most common devices for cooking and heating food by burning wood or fossil fuels. In regions where biomass is a traditional fuel for cooking, improved cook stoves can enhance indoor air quality, personal health, livelihoods, and the environment while substantially reducing greenhouse gas (GHG) emissions. Although ongoing efforts have successfully disseminated improved stoves that achieve many of these benefits, substantially greater emissions reductions are needed to comply with international guidelines for indoor air quality and to limit GHG emissions like black carbon [1]. Wood fuel contributes 86% to the primary energy balance and about 97% of Rwandan households are dependent on wood for cooking (NISR, 2008b). Regionally in East African Community (EAC) countries and DRC, the figures on wood fuel reliance are similar: Uganda 98%, Tanzania 96%, Kenya 90%, and the Democratic Republic of Congo (DRC) 95% (UNDP, 2009b)[1]. Due to above issues especially in Rwanda I have manufactured a precious stove made in volcanic rock for reducing firewood use, increasing efficiency, lowering emissions, and improving health.

Author: Tumba College of Technology (TCT), Kigali, Rwanda. e-mail: mujedo17@yahoo.fr

II. Literature Review

Around half of the world's population burns solid biomass fuels for cooking and heating needs. Throughout poor, rural areas of sub-Saharan Africa, biomass is the dominant fuel, and cooking is usually performed using a simple three-stone fire or “open fire”. Particularly in high-altitude areas, where nighttime temperatures are colder, cooking is often performed in poorly ventilated structures [2]. Incomplete combustion of these fuels and poor ventilation result in high indoor concentrations of health-damaging pollutants including particulate matter and carbon monoxide (Jetter and Kariher, 2009; Rehfuess, 2006). In addition, especially in regions where biomass is scarce, time and effort spent gathering firewood can be a substantial burden on households, particularly children and women (Rehfuess et al., 2006).

a) *Cooking test results of some stoves used in sub-Saharan Africa and America*

i. *Ugastove, StoveTec and Three-stone stove*

The Ugastove stove showed fuelwood savings of 46%, and the StoveTec showed fuelwood savings of 38%. In a region where fuel scarcity is a serious problem, fuelwood savings of 38 to 46% can have a large impact. The second key technical metric measured was cooking time. The three-stone fire required approximately 17 min to cook matooke. The Ugastove showed a statistically significant increase in cooking time of 27% over the 3-stone fire (22 min), whereas the StoveTec stove showed only a slight increase (18 min, or an additional 5%) which was not statistically significant[2].

Another study by Aprovecho found that the StoveTec stove reduced the global warming impact by 40–60% compared to the three-stone fire (MacCarty et al., 2008a). A comprehensive review of 50 different cookstove models by MacCarty et al. (2010) tested several different Rocket-type stoves, including the StoveTec model with and without various accessories, and found that, on average, the fuel use was reduced 33%, CO emissions by 75%, and PM emissions by 46%

in comparison to the three-stone fire. These findings on fuelwood savings can be combined with data on frequency of cooking various foods in village households to create a rough estimate of yearly fuelwood savings [2].

In the Uganda study area, households cooked plantains more than any other food, on average, 11 times per week. Across all 60 household tests, the average quantity of food cooked was 3.19 kg, and the average amounts of fuelwood used were 1.77 kg for the three stones fire, 0.92 for the Ugastove and 1.04 for the StoveTec. Thus, the average total fuelwood savings for use of the Ugastove in place of the three-stone fire was 0.85 kg/meal, which, multiplied by 11 meals per week and 52 weeks per year, comes to around 490 kg of fuelwood saved per year. The main user complaint with the Ugastove (over 80%) was the large increase in cooking time, a difference which was confirmed with technical measurements. Other unfavorable traits included the tendency of the metal shell of the Ugastove to become hot to the touch, making cooking difficult, as well as the Ugastove's bulky, tall, and top heavy design [2].

b) Nepalese, Darfour and Rocket stove

These three types of Stoves are the first used in Rwanda from 2006 in order to reduce deforestation rate and environmental degradation.

Table 1 : Summary of the Efficiency test (Data from report of Satish 2009)

Type of stove	Thermal efficiency, %		
	Cold	Hot	Average
Nepalese type	14.98	18.64	16.81
Darfour type	11.88	13.56	12.72
Rocket type	11.38	21.04	16.21

(Source: Activity report of Biomass expert Mr. Satish Aryal 2009, Rwanda)

c) Some stoves used in South America and Central America

A comparison was made of the thermal efficiency and emissions of the traditional three-stone fire and the "Plancha" improved stove-burning wood. Simultaneous measurements of efficiency and emissions of suspended particles and carbon monoxide were taken in order to incorporate both of these factors into a single standard of performance - emissions per standard task. These factors were measured during both a Water Boiling Test (WBT) and a Standardized Cooking Test (SCT). No statistical difference in efficiency between the Plancha and traditional stove was found. The Plancha required more time to perform both of the tests, and this difference was statistically significant (p=0.048) for the WBT. The Plancha emitted 87% less suspended particles less than 2.5 jim in diameter (PM2.5) and 91% less CO per kJ of useful heat delivered compared to the open fire during the WBT [3].The relative environmental performance of the Plancha improved during the SCT, resulting in a 99% reduction of total suspended particulate matter (TSP) emissions and a 96% reduction of CO emissions per standardized cooking task.

III. Methods

a) Case Study

Rwanda is a country located in Southern sub Saharan region in Africa, in exactly East Africa region with a population of approximately 11.4 million (2011) on total size of 26,338 square kilometers. Rwanda is located at 2 degrees south and 30 degrees east. At 433 inhabitants per square kilometer, Rwanda's population density is amongst the highest in Africa. In Rwanda, wood fuels represent 77% of all wood needs (GTZ, 2008). Almost 97% of all rural households use wood fuels as their cooking fuel, fuel wood accounts for 91% and charcoal for 6% (MININFRA, 2009a). The increasing overall demand for wood has put additional pressure on forest resources and reduced the capacity of forests to supply wood products sustainably. There is a permanent demand/supply imbalance[4]. Lack of access to modern fuels coupled with widespread poverty makes wood fuel the most accessible and often the only cooking fuel available to the majority of Rwandan households (Table) as well as cottage and agro-industries.

Table 2 : Main fuels used for cooking (% of households)

Province	Gas	Electricity	Fuel wood	Charcoal	Biogas	Agri-residues	Other
Southern	0.4%	0.4%	91.7%	4.3%	0.1%	2.5%	0.7%
Western	0.5%	0.9%	88.0%	9.5%		0.6%	0.5%
Northern	0.3%	0.3%	94.0%	3.8%		0.9%	0.7%
Eastern	1.1%	0.8%	94.5%	2.3%		0.5%	0.8%
Average	0.6%	0.6%	91.9%	5.1%	0.0%	1.1%	0.7%

Source: MININFRA, 2009

Our research took place in Northern Province, Musanze District especially in Shingiro Sector. The whole population of Shingiro Sector is 19,338 and living on the surface of53.41 km2. The focused population is 404 during 31 days. The data collected in our research presented us these results:

– 69.5% of population used traditional cooking stoves, 25.4% of population used improved cooking stoves and 5.1% of population used charcoal stoves.

– The burden of collection of wood for cooking food is approximately 88.6% and spent more than one hour in the collection of fuel wood.

– For the result from SHINGIRO HEALTH CENTRE showed that in 1273 patients per month, 295 patients suffer from diseases from indoor smoke.

– Deforestation rate at 252.6 ha of the total areas of the forest of SHINGIRO SECTOR, 4% of it are cut yearly.

b) The Objectives of the Project

The main objectives of this project are:

- Design and fabricate the improved cooking stove made in volcanic rock. These rocks that fill all requirements to be raw materials for ICS are located in Shingiro sector only.
- Supply the improved cooking stove made in volcanic rock to rural people which has thermal efficiency of more than15% and smokeless,
- Train cooperatives or individual people on how we fabricate the stoves made in volcanic rock through Muneza Biomass Engineering Company.

c) Methodology

In order to carry out the project, we referred on the collected data based on the questionnaires asked to the SHINGIRO Sector's Population; the site survey (engineering survey) results conducted in order to characterize the site and the theories of Stoves. During the site visits, most of the questions asked are related to know the types of stove used per family, location of Energy sources used by Shingiro's population, availability of firewood nearest the people of Shingiro sector and the identification of actual application of volcanic rock. Due to huge pressure on cutting forest in different areas of Rwanda as you see on the below table.

Table 3 : Wood Consumption Projections (baseline, t/yr)

Year	2005	2006	2007	2008	2009	2010
Firewood urban	81.916	86.831	92.041	97.564	103.417	109.622
Wood for charcoal urban	1.643.655	1.732.734	1.836.698	1.946.900	2.063.714	2.187.537
Firewood rural	2.805.431	2.871.907	2.939.317	3.007.623	3.076.787	3.146.761
Wood for charcoal rural	123.409	126.333	129.298	132.303	135.346	138.424
Industry, institutions	336.652	344.629	352.718	360.915	369.214	377.611
Total	4.982.063	5.162.434	5.350.072	5.545.305	5.748.478	5.959.956

Source: Vanderplas 2004

The survey shows that different stones or rocks locate in Shingiro Sector can increase the number of improved cooking stoves which are precious stove because have the ability to conserve heat from burnt firewood until one hour after removing all firewood only small charcoal formed during cooking process stay in the combustion chamber.

Pictures 1a: volcanic rock, *1b:* Stove made in volcanic rock, *1c:* Painted stove made in volcanic rock

d) Design and fabrication stove made in volcanic stove "RONDEREZAURUTARE"

The design principles on this new improved cooking stove made in volcanic rock were respect all international standards refer to actual stoves such as Canarumwe stove, Darfour stove and Nepalese stove, etc that are currently used in Rwanda. Only one differs from them is the material of construction.

For constructing the improved cooking stove made in volcanic rock, we follow these steps:

i. Select a good fragile volcanic rock which has 50 cm diameter and 40cm height dimensions (this fragile volcanic rock can be found underground in one meter of depth or aboveground).
ii. See if that selected volcanic rock has no cracks.
iii. Measure the external dimensions of ICS on volcanic rock so as to get cylindrical form.

iv. Form the volcanic rock to give it cylindrical form by using a machete and small ax.

v. Measure the dimensions of the top hole and height of combustion chamber by using a measuring tape and scriber on the cylindrical form.

vi. After getting a cylindrical form, start to dig a volcanic rock in order to get a combustion chamber by using a drill bit and hammer according to the given dimensions.

vii. Measure the dimensions of the feed hole (entrance) on the cylindrical form according the given dimensions.

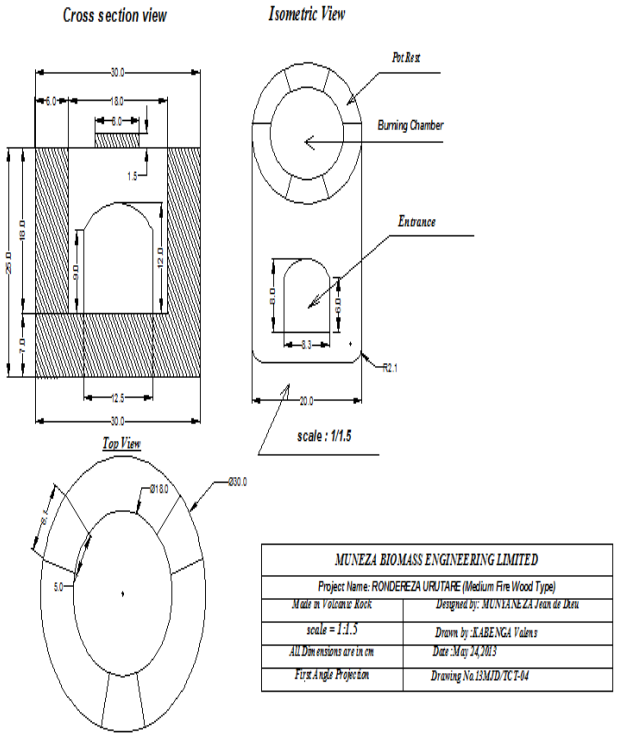
viii. Dig the entrance by using drill bit and hammer.

ix. Harmonizing the combustion chamber and entrance using the drill bit smooth fully.

x. Make on its top three support pot.

xi. Paint it and let the ICS for one day on the sun to be dried.

e) Drawing of medium type of firewood-volcanic stove (RONDEREZA URUTARE)



IV. Findings and Analysis

As the water boiling test is used to quantify thermal efficiency and firepower for any type of stove, we have made a WBT for stove made in volcanic rock (called RONDEREZA URUTARE in Kinyarwanda language) three times and we found the following results.

Table 4 : Summary of WBT for stove made in volcanic rock (RONDEREZA URUTARE) done MBE Ltd, 2012

S/N	Thermal efficiency %			
	Cold	Hot	Simmer	Average
Day1	24%	25%	54%	34.33%
Day2	25%	25.6%	53%	34.53
Day3	25.2%	26%	55%	35.4
Average	24.73%	25.53%	54%	**34.75%**

A well designed volcanic stove (RONDEREZA URUTARE) by respecting standards dimensions can have an average thermal efficiency of 34.75% and it has the ability to conserve heat from burnt firewood until one hour after removing all firewood only small charcoal formed during cooking process stay in the combustion chamber. Due to this special property it has you can cook other meal without any problem during one hour like tea, rice, bananas, boiling water for drinking or washing purpose.

- When you compare with Ugstove, StoveTec, Three-stone stove, Nepalese, Canarumwe and Darfour stove none can have this ability to conserve heat in one hour without firewood in the combustion chamber.
- The lifetime of RONDEREZA URUTARE is greater than of Nepalese, Darfour. It can be used within four years without any problem
- No regular repair and maintenance required for volcanic stove as they require on Nepalese and Darfour stoves.
- Its design allows being smokeless stove and contributing to reduction of indoor air pollution in the kitchen.

Pictures 2 : volcanic stoves (RONDEREZA URUTARE) in the painting process at Muneza Biomass Engineering Company site

V. Conclusion

During our research project we faced different problems of cooking energy in Rwanda (especially in rural areas) such as health problem, environment problem and scarcity of fuel wood (fuel for cooking) caused by the use of traditional (three stone stove)

stove in cooking activities and a rapid increased number of Rwandan population, various researches have been carried out to make the stove which can save the fuels and bring good health condition processes. The main objective of this project was to construct an efficient and smokeless stove made in volcanic rock which can replace the open air stove for the following reasons:

People using three stones suffer from respiratory disease, eye ailment caused by smoke and risk of scads due to open fire. There is high pressure of cutting trees in different areas of Rwanda which contribute to global warning as the number of Rwandan populations increased. There is a lot of volcanic rock for making this type of stove in volcanic region (Musanze District) which is a simple and cheap technology and does not require special skills as well as a big investment in terms of money and machine.

So the project of construction of improved cooking stove made in volcanic rock come out with the following solutions: The ICS made in volcanic rock consumes less firewood and the efficiency is higher than other types of stove (Nepalese type its thermal efficiency is 16.81%, Darfour type its thermal efficiency is 12.72% and rocket type its thermal efficiency is 16.21%). It avoids the diseases from smoke and offer good health to their users. The cost of this new stove varied between 2.15$ to 4.3 $ in different part of Rwanda and from 2006 up to 2014; around forty thousand (40,000) of volcanic stoves were supplied in different part of Rwanda and many people benefit their advantages over existing stoves.

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Investigation of Window Effects and the Accurate Estimation of Spectral Centroid

By Venkata Krishna Rao M
Vidya Jyothi Institute of Technology, India

Abstract- The spectral centroid is one of the useful low level features of a signal that was proposed for speech-music classification, speech recognition and musical instrument classification, and was also considered one of the low-level features to describe the audio content in MPEG-7 Content Description and Interface Standard. When the spectral centroid is computed from practical data, the estimate is different from the true expected theoretical value. Moreover, the behavior of the estimation error, when computed from finite length data i.e. from a short segment of signal would of high interest because most of the classification algorithms use dynamic features as the signals are nonstationary. In this paper, windowing effects on the spectral centroid estimation are investigated considering some well structured signals that appear frequently in speech and audio content. A novel algorithm is proposed to counter the window effects and better estimation of spectral centroid.

Keywords: spectral centroid, MPEG-7, sum of sine waves, band limited impulse train, STFT, peak detection.

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Investigation of Window Effects and the Accurate Estimation of Spectral Centroid

Venkata Krishna Rao M

Abstract- The spectral centroid is one of the useful low level features of a signal that was proposed for speech-music classification, speech recognition and musical instrument classification, and was also considered one of the low-level features to describe the audio content in MPEG-7 Content Description And Interface Standard. When the spectral centroid is computed from practical data, the estimate is different from the true expected theoretical value. Moreover, the behavior of the estimation error, when computed from finite length data i.e. from a short segment of signal would of high interest because most of the classification algorithms use dynamic features as the signals are nonstationary. In this paper, windowing effects on the spectral centroid estimation are investigated considering some well structured signals that appear frequently in speech and audio content. A novel algorithm is proposed to counter the window effects and better estimation of spectral centroid.

Keywords: Spectral Centroid, MPEG-7, Sum of Sine waves, Band Limited Impulse Train, STFT, Peak detection.

I. Introduction

The spectral centroid (SC) is one of the low level spectral domain features of a signal useful in signal classification or identification applications. The spectral centroid has been proposed by researchers in several applications like estimating the timbral brightness of music [1], for discriminating between the speech and the music [2,3,4], Speaker Recognition [5], Noisy Speech Recognition [6,7], Identification of Musical Instruments [8]. The spectral centroid was also incorporated as one of the Audio Low level features for audio content in MPEG-7 multimedia standard [9]. In [10], an AR(2) model based dynamic estimation of spectral centroid of a Narrowband Acoustic Doppler Volume Backscattering Signal was proposed.

The spectral centroid represents the "center of gravity" of the magnitude or power spectrum of a signal. Perceptually, the spectral centroid is a measure of the brightness of a sound. The unit of such a centroid would be the unit of frequency, Hz. Intuitively, the spectral centroid of a single tone signal is the frequency of the tone itself. Similarly, the spectral centroid of a signal having two equal amplitude real sinusoids is the mean frequency of two sinusoids.

Author: Vidya Jyothi Institute of Technology, Hyderabad, India.
e-mail: mvk_rao@hotmail.com

Mostly, the natural or real signals (e.g. speech, voice, audio, etc) are nonstationary in nature. Classification of such signals requires extraction of dynamic features that change with time. When spectral centroid is considered a promising feature, it is estimated dynamically from short segments of signal (one value of each segment), and the spectral centroid vector thus obtained for the entire signal becomes a feature vector for the classification system. The estimation of the spectral centroid from a short segment of signal data is a challenging task due to the windowing effects. In the literature, to the best of the knowledge of the author, .no systematic study results were reported on the finite data effects on the estimation of spectral centroid.

In this paper, a systematic study is carried out on the estimation of spectral centroid from finite data of different lengths. The windowing effects on the estimation error are investigated considering certain deterministic signals that appear frequently in speech and audio content. A novel algorithm is proposed to counter the finite window effects and for better estimation of spectral centroid. Well structured signals are used to make the bench marking easy, nevertheless the algorithm can be applied on any kind of real signals.

The remainder of the paper is organized as follows. The mathematical basics of spectral centroid are introduced in the section II. Short time fourier transform (STFT) for estimating the magnitude spectrum of the signal dynamically is presented in section III. The proposed algorithm along with the flowchart is discussed in section IV. Section V discusses the details of simulations and the test signals used in the simulations. Section VI presents the results and discussions on the findings. Finally conclusions on the research work are drawn in Section VII.

II. Spectral Centroid

Mathematically, the spectral centroid of a continuous time signal *y(t)* is given by

$$SC = \frac{\int_0^\infty f\, Y(f) df}{\int_0^\infty Y(f) df} \quad (1)$$

where $Y(f)$ is the one-sided magnitude spectrum of the signal *y(t)*.

The counter part of the discrete time signal *y(n)* is given by

$$SC = \frac{\sum_{n=0}^{N-1} n \cdot |Y(n)|}{\sum_{n=0}^{N-1} |Y(n)|} \quad (2)$$

where $Y(n)$ is the one-sided power spectrum of the signal *y(n)*.

For example, the magnitude spectrum of a tone signal of unit amplitude and frequency *F* is an impulse at *F* Hz on the frequency axis. The spectral centroid of this signal is *F* Hz Itself. Similarly, the magnitude spectrum of a signal consisting of two tones of equal amplitude and frequencies F_1 and F_2 contains two equal amplitude impulses at F_1 Hz and F_2 Hz on the frequency axis. The spectral centroid of this signal is the mid frequency of F_1 and F_2 i.e. $(F_1 + F_2)/2$ Hz. If the amplitudes of two tones are not equal, then the spectral centroid is biased towards the higher amplitude tone. Figure 1 describes the centroid concept for several cases of F_1 and F_2. The F_1 and F_2 values are selected as the integer multiples of 10.77Hz (44100Hz/4096) i.e. from the set {0, 10.77, 21.53, … , 5480.20, …, 11025, … , 11401.83 …, 22028.47, 22039.23, 44100/2) Hz, where 44100Hz is the sampling frequency of a CD quality audio signal. In each case, the sum of amplitudes is selected to be unity. This is to make the amplitude spectrum resemble a probability function. The figure 1(a) shows a sine wave of frequency 5840.20Hz and unity amplitude. Naturally the SC is also the same frequency 5840.20Hz. In figure 1(b) the signal consists of two sine waves of frequencies: 5840.20Hz and 11401.83Hz, and equal amplitude of 0.5. Here the SC is the mean of the two frequencies i.e. 8441.02Hz. In figure 1(c) the signal consists of two sine waves: 5840.20Hz (amp: 0.70) and 11401.83Hz (amp: 0.30). Here the SC (7256.69Hz) shifts towards the left from the mid (mean) value because the first sine wave amplitude is high. In figure 1(d) the signal consists of two sine waves: 5840.20Hz (amp: 0.15) and 11401.83Hz (amp: 0.85). In this case, the SC (10513.59Hz) shifts towards the right from the mid value. Because the second sine wave amplitude is high.

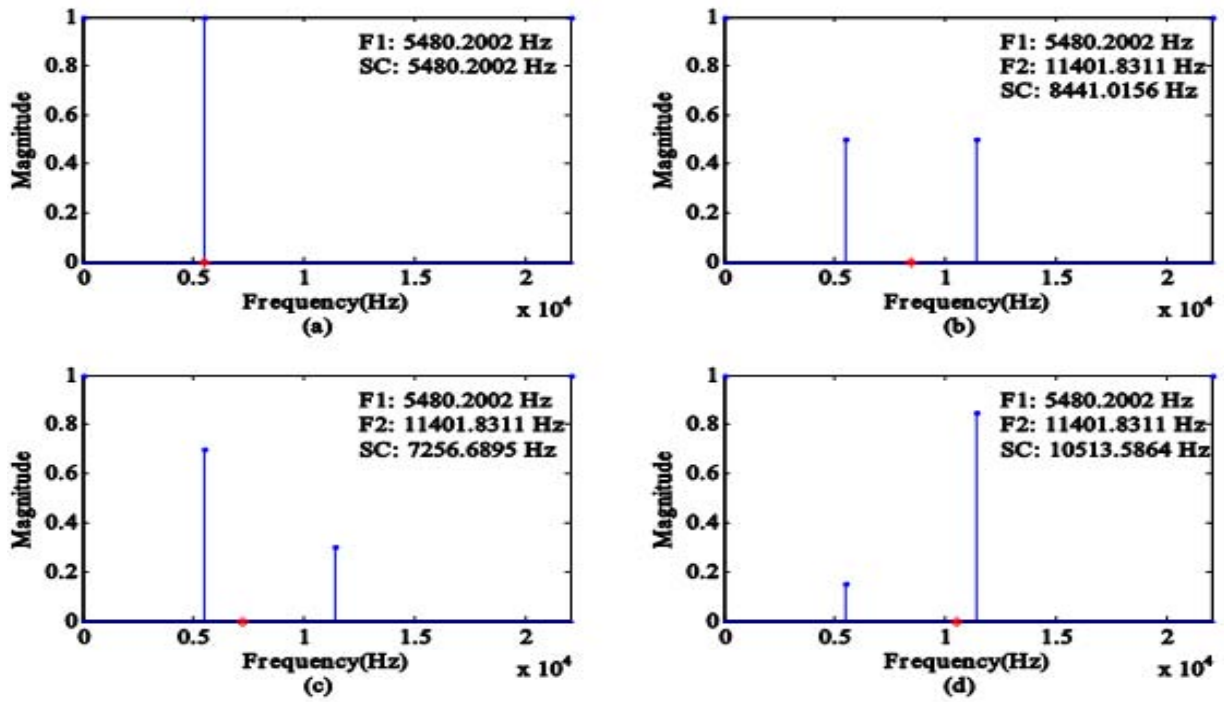

Fig. 1 : Description of Spectral Centroid. For cases of F_1 and F_2 are given in (a) through (d). In each case the sum of spectral amplitudes are selected to be unity. The spectral centroid in each case is shown as red colored star mark

III. Short Time Fourier Transform

When fourier transform is applied on short segments of data to dynamically analyze the signal, it is called short time fourier transform (STFT). To carry out the the short term analysis of a signal, the given signal *x(n)* is divided into overlapping frames of size *N*, each frame is weighed by a window function *w(k)*, typically a hamming or a hanning window and analyzed by using the Fourier Transform. A matrix is formed by arranging the short time fourier transform (STFT) coefficients as

columns and is popularly known as a spectrogram, given by

$$S(k,l) = \frac{1}{MW_nN}\left|\sum_{n=0}^{N-1} x\,(n+lM)\,w(n)e^{-j\frac{2\pi nk}{N}}\right|^2$$

$$0 \le k \le K-1, 0 \le l \le L-1 \qquad (3)$$

where k is the discrete frequency index, l is the time frame index, M is the hop size, K is the total number of bins of ones-sided STFT and L is the total number of frames. The spectral centroid is computed from the magnitude spectrum of each frame of signal, thus yielding a SC vector of length L., and is given by

$$SC(l) = \frac{\sum_{k=0}^{K-1} k \cdot S(k,l)}{\sum_{k=0}^{K-1} S(k,l)} \qquad 0 \le l \le L-1 \qquad (4)$$

IV. Proposed Algorithm for Spectral Centroid Estimation

The input signal data is segmented into overlapped frames of frame size (W) with 50% overlap i.e. with a hop size of W/2. For each frame, Short Time Fourier Transform (STFT) is computed using FFT algorithm with Nfft points between [0,Fs/2]. The one-sided magnitude spectrum is computed from the FFT output.

The algorithm for computing the Spectral Centroid is given in figure 2. When the steps in the dashed boxes ***A, B*** and ***C*** are eliminated, then the algorithm computes the spectral centroid using the equation (4) directly and it called the direct method here.

In the proposed method, a threshold ***STH*** is applied on the magnitude spectrum of each frame (operation: ***A***) and a peak detection algorithm is applied on the spectral coefficients above the threshold (operation: ***B***). Once the peaks are detected, magnitude spectrum is modified keeping only the peak values and making all other coefficients zero. The spectral centroid is then computed using this modified magnitude spectrum (operation: ***C***). In this way the junk spectral coefficients (artifacts) which are produced due to finite data are get rid of from the computation process resulting in more accurate estimation of spectral centroid.

V. Simulations

The DFT spectrum is computed with 4096 points; thus for a sampling frequency of 44100Hz, the spectrum is computed with a resolution of /4096=10.76Hz and the frequency grid is (0, 10.77, 21.53, … , 11025, …, 22028.47, 22039.23, 22050)Hz.

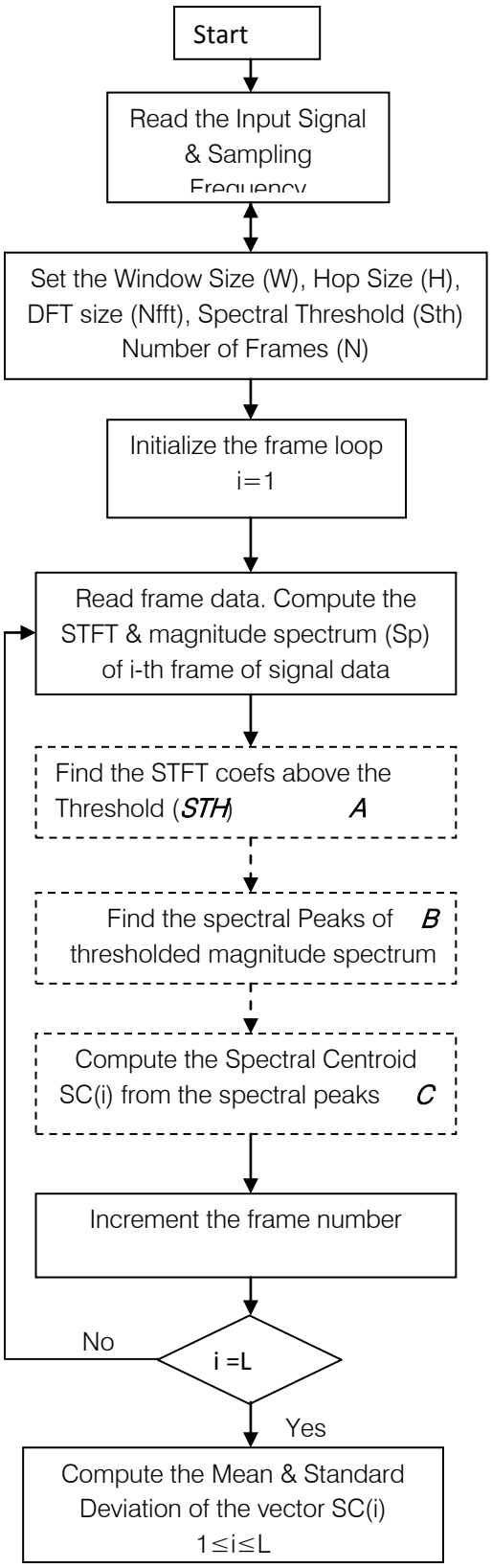

Fig. 2 : Flowchart of Proposed Algorithm for Spectral Centroid Estimation

The algorithm is tested on the three categories of simulated test signals:

- Tones
- Sum of Tones
- Band Limited Unit Impulse Trains

a) Test Data Set:1 (Tones)

In the first category, a set of 41 sine wave signals of frequencies: 96.9Hz, 635.23Hz, 1173.56Hz, … , 21091.77Hz, 21630.10Hz with a uniform spacing of 538.33Hz and random amplitudes in the range [0,1] are generated. These spot frequencies are selected so as to coincide with the DFT grid points on the frequency line (0 - Fs/2) i.e. 0Hz - 22050Hz, where Fs=44100Hz.

b) Test Data Set:2 (Sum of Tones)

In the second category, a sum of 5 or 10 or 50 sine waves of distinct frequencies are generated. In each case, the sine waves are separated with a uniform spacing of 10.76 Hz or 96.90Hz or 495.26Hz. These spacing are selected so as the generated frequencies coincide with the DFT grid points. In each set of 5 or 10 or 50 frequencies. the first frequency is taken from one of the 41 spot frequencies of the first category, the total number of composite signals generated under this category is 41 x 3 x 3 =369.

c) Test Data Set:3 (Band Limited Unit Impulse Trains)

In the third category, a set of Band Limited Unit Impulse Trains (BLUITs) each with a different fundamental frequency is generated. The frequencies of 41 sine waves of first category are used as fundamentals, thus we get 41 sets of BLUITs. The spectral envelope of each BLUIT can be constant (i.e. 0dB/Octave) or decay at a rate of 12dB/Octave. The Fundamental frequencies and number of harmonics in each BLUIT (=0.5 F_s/F_0) are given in the table 2. The number of harmonics for the BLUIT nos: 21-41 is one i.e. the fundamental itself and hence not considered in the simulations and hence are not listed in the table 2.

As there are two cases of dB/octave rates, a total of 2 x 20 = 40 BLUITs form this category of test signals are generated.

Thus the total data set comprises 450 (=41 + 369 + 40) differently structured test signals.

VI. Results

In this section, the results obtained by applying both the direct and proposed methods are presented. The performance comparison of both the methods is also given.

Table 1 : Frequencies of Band Limited Impulse Train used in evaluating the proposed algorithm

BLUIT no	Fundamental Frequency	Number of Harmonics
1	96.90	227
2	635.23	34
3	1173.56	18
4	1711.89	12
5	2250.22	9
6	2788.55	7
6	3326.88	6
7	3865.21	5
8	4403.54	5
9	4941.87	4
10	5480.20	4
11	6018.53	3
12	6556.86	3
13	7095.19	3
14	7633.52	2
15	8171.85	2
16	8710.18	2
17	9248.51	2
18	9786.84	2
19	10325.17	2
20	10863.50	2

The SC estimation results of Test Set-1 (Tones) signals of frequency spanning from 96.8994 Hz to 21630.1025Hz of 0.5 sec duration (hamming window size is 512, Fs=44100Hz) for both direct and proposed methods are given in Table.2. Each row in the table 2 corresponds to the estimated SC vector of a particular tone frequency of duration 0.5 seconds of full length signal corresponding to a total of 22050 samples. Both the mean (μ) and standard deviation (σ) of this estimated spectral centroid vector is computed and given in the 3rd column of the table 2.

The estimated errors for direct method are large at both the lowest and the highest frequencies in the range. For the lowest (start) frequency the error is negative and for the highest (end) frequency it is positive. It means the direct method over estimates the SC at lower frequencies and under estimates at the higher frequencies. This is because of the fact that for lower frequencies, the spectral mass distribution on either side of the tone frequency is unevenly distributed and is more on the right (higher frequency) side.Hence, the estimated values shift towards the higher side of the frequency axis.

Similarly, for higher frequencies, the estimated values shift towards the lower side of the frequency axis. As the frequency of the tone is spanned from the lowest frequency (96.8994Hz) to the highest frequency 21630.1025Hz), the mean error (μ) reduces and becomes zero at the middle of the range i.e. at tone frequency approximately equal to Fs/4. At this frequency, the mean error changes its sign from negative to positive value, builds up and again reaches its maximum at the highest frequency (please see the 4th

column of the table 2). For each tone, the standard deviation (σ) is also computed.

The estimation results of the proposed method for the same set of signals are given in the 5th and the 6th columns of table 2. This method exactly estimates the SC and hence both the mean (μ) and standard deviation (σ) are zeros. The spectral threshold *STH* is chosen as the 0.02 fraction of the maximum value of the magnitude spectrum, which corresponds to about -14 dB down the peak value. This is approximately the side lobe level (SLL) of the spectrum of rectangular window. For other windows the SLL is always less than -13dB, though the main lobe width is more compared to that of a rectangular window, which anyway does not affect the peak detection process.

The estimation results of table 2 are also shown in figure 3(a) for both direct (solid line) and proposed (dashed line) methods are shown. For direct method, the RMS range of the estimated Centroid is marked as red vertical lines at each point. For the proposed method the estimated value is exactly equal to true value, hence the RMS range is zero. Thus no red vertical lines are seen on the dashed line. The figure (b) shows the similar results for window size is 256.

Table 2 : Spectral Centroid of Test set-1 (Tones) signals estimated by direct and proposed methods

Tone no	True Spectral Centroid (Hz) (1)	Spectral Centroid (Estimated by Direct Method)(Hz) (2)	SC Est. Error (Direct Method) (Hz) (1) – (2)	Spectral Centroid (Estimated by Proposed Method) (Hz) (3)	SC Est. Error (Proposed Method) (Hz) (1) – (3)
1	96.8994	634.033 ± 103.2825	-537.13	96.8994 ± 0	0
2	635.2295	1107.9746 ± 114.8693	-472.75	635.2295 ± 0	0
3	1173.5596	1608.3049 ± 107.8578	-434.75	1173.5596 ± 0	0
4	1711.8896	2117.5429 ± 99.1608	-405.65	1711.8896 ± 0	0
5	2250.2197	2623.4037 ± 94.3929	-373.18	2250.2197 ± 0	0
6	788.5498	3131.4122 ± 89.3034	-342.86	2788.5498 ± 0	0
7	3326.8799	3642.626 ± 86.5037	-315.75	3326.8799 ± 0	0
8	3865.21	4158.9111 ± 81.3724	-293.7	3865.21 ± 0	0
9	4403.54	4669.3952 ± 79.7196	-265.86	4403.54 ± 0	0
10	4941.8701	5183.2597 ± 76.1674	-241.39	4941.8701 ± 0	0
11	5480.2002	5698.366 ± 75.0958	-218.17	5480.2002 ± 0	0
12	6018.5303	6217.31 ± 71.2696	-198.78	6018.5303 ± 0	0
13	6556.8604	6730.1438 ± 70.2138	-173.28	6556.8604 ± 0	0
14	7095.1904	7247.1104 ± 67.5403	-151.92	7095.1904 ± 0	0
15	7633.5205	7764.439 ± 66.7206	-130.92	7633.5205 ± 0	0
16	8171.8506	8283.9504 ± 64.5743	-112.1	8171.8506 ± 0	0
17	8710.1807	8797.6702 ± 64.3643	-87.49	8710.1807 ± 0	0
18	9248.5107	9316.0265 ± 63.4916	-67.52	9248.5107 ± 0	0
19	9786.8408	9834.3672 ± 63.363	-47.53	9786.8408 ± 0	0
20	10325.1709	10353.7776 ± 62.7943	-28.61	10325.1709 ± 0	0
21	10863.501	10867.8735 ± 62.924	-4.37	10863.501 ± 0	0
22	11401.8311	11387.1281 ± 63.1554	14.7	11401.8311 ± 0	0
23	11940.1611	11905.6919 ± 63.1063	34.47	11940.1611 ± 0	0
24	12478.4912	12424.4625 ± 63.3744	54.03	12478.4912 ± 0	0
25	13016.8213	12938.3795 ± 63.3481	78.44	13016.8213 ± 0	0
26	13555.1514	13457.8904 ± 64.7948	97.26	13555.1514 ± 0	0
27	14093.4814	13975.7026 ± 65.3201	117.78	14093.4814 ± 0	0
28	14631.8115	14493.3087 ± 67.2566	138.5	14631.8115 ± 0	0
29	15170.1416	15006.592 ± 67.9661	163.55	15170.1416 ± 0	0
30	15708.4717	15525.9341 ± 71.2219	182.54	15708.4717 ± 0	0
31	16246.8018	16042.2271 ± 72.4166	204.57	16246.8018 ± 0	0
32	16785.1318	16557.6751 ± 75.7913	227.46	16785.1318 ± 0	0
33	17323.4619	17069.2012 ± 76.9287	254.26	17323.4619 ± 0	0
34	17861.792	17586.7432 ± 81.2453	275.05	17861.792 ± 0	0
35	18400.1221	18099.7754 ± 83.0062	300.35	18400.1221 ± 0	0
36	18938.4521	18610.6458 ± 87.3431	327.81	18938.4521 ± 0	0
37	19476.7822	19118.961 ± 90.5547	357.82	19476.7822 ± 0	0
38	20015.1123	19632.1551 ± 97.5527	382.96	20015.1123 ± 0	0
39	20553.4424	20138.8757 ± 102.7702	414.57	20553.4424 ± 0	0
40	21091.7725	20639.2884 ± 109.3145	452.48	21091.7725 ± 0	0
41	21630.1025	21136.0545 ± 116.1857	494.05	21630.1025 ± 0	0

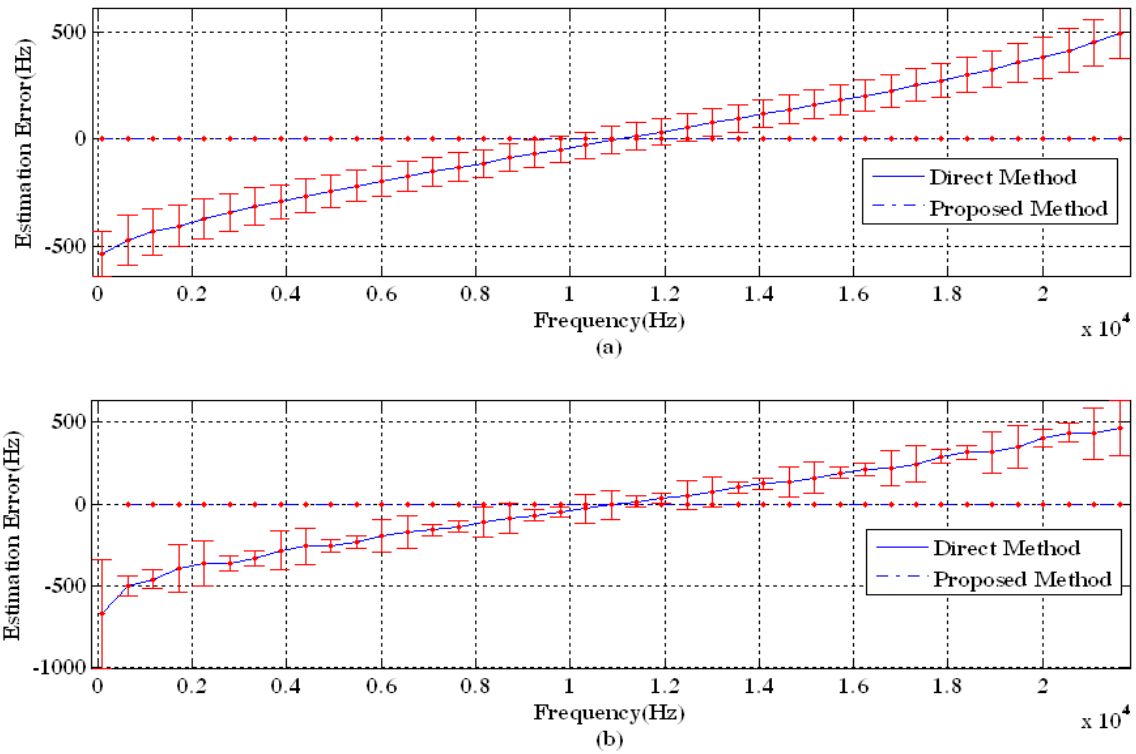

Fig. 3 : SC Estimation Error of Test set: 1 (tone) signals of frequency spanning from 96.8994 Hz to 21630.1025Hz of 0.5 sec duration (a) for window size of 512). (b). for window size of 256

The estimation error follows a regular pattern for window size of 512 sample compared to the error for 256 sample window. This is due to the fact that the data has become too short to get a meaningful estimate. However, the error is almost symmetric around the middle frequency i.e. Fs/4. This symmetry would be disturbed if the window size is further reduced. The error becomes more for lower frequencies, as more number of cycles of the signal are not included in the short segment. So the window size is to be carefully selected based on the lowest frequency under consideration so that considerable number of signal cycles are included in the window. The figure 4 provides magnitude spectrum of a single frame of tone signals of frequencies: 96.8994 Hz, 10863.501Hz and 21630. 1025Hz (on the left side) and the corresponding estimated spectral centroid vectors (on the right side). The estimation errors (i.e. true SC - mean of estimated SC vector) are -537.13Hz, -4.37 (almost zero) and +494.05Hz for the three tone frequencies. Similar plots for window size of 256 samples are shown in figure 5.

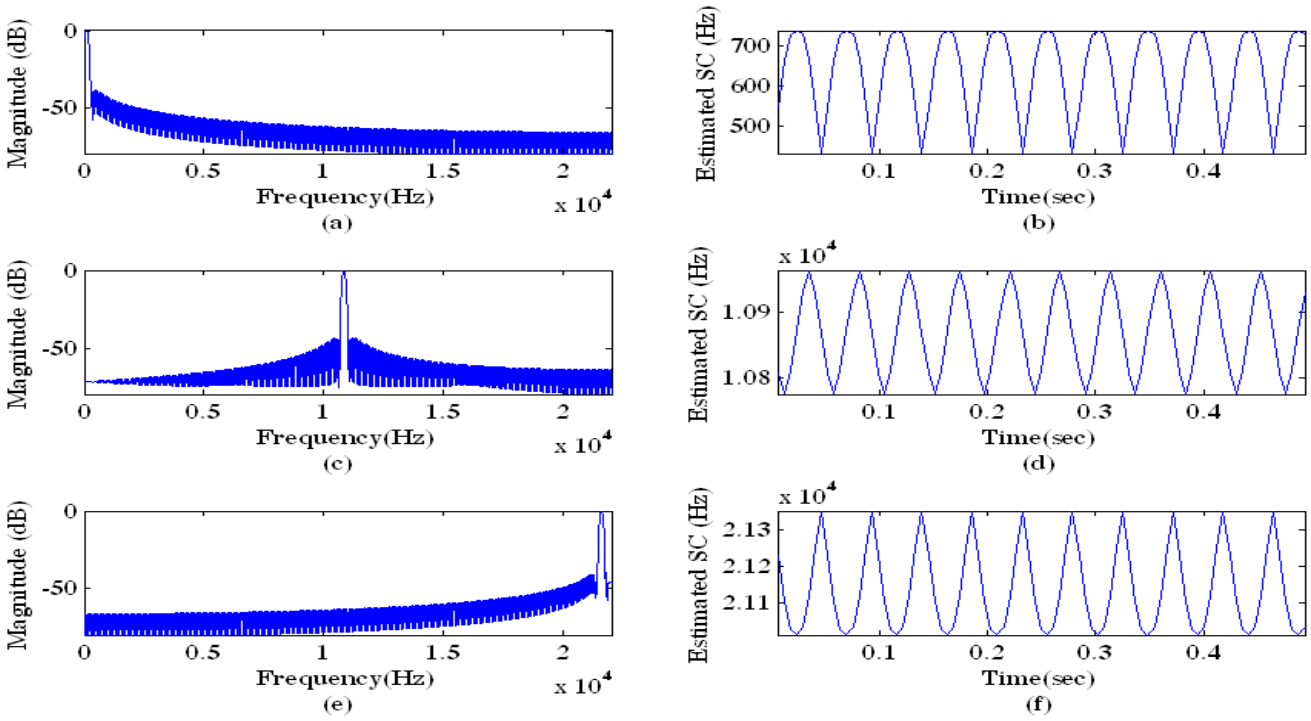

Fig. 4 : Magnitude spectrum of a single frame of tone signals of frequencies: 96.8994 Hz, 10863.501Hz and 21630.1025Hz on the left side (a), (c) and (e) for window length of 512 samples. Corresponding estimated spectral centroid vectors on the right side (b), (d) and (f)

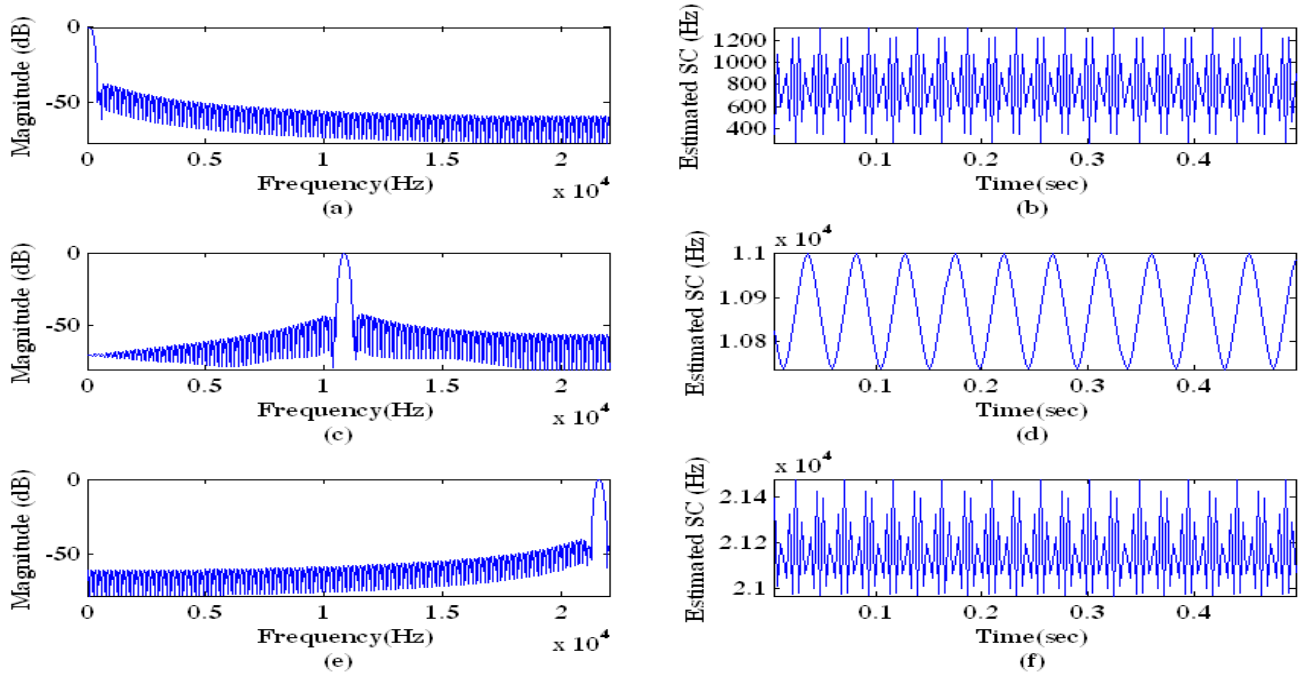

Fig. 5 : Magnitude spectrum of a single frame of tone signals of frequencies: 96.8994 Hz, 10863.501Hz and 21630.1025Hz on the left side (a), (c) and (e) for window length of 256 samples. Corresponding estimated spectral centroid vectors on the right side (b), (d) and (f)

The results of Test set: 2 (sum of Tones) with a tone spacing of 200Hz are shown in figure 6 for (a). 512 sample window and (b) 256 sample window. The results of Test set: 2 with a tone spacing of 100Hz are shown in figures 7 for (a). 512 sample window and (b) 256 sample window. Similarly, figure 8 gives the results of Test set: 2 for a tone spacing of 500Hz for 512 and 256 sample windows.

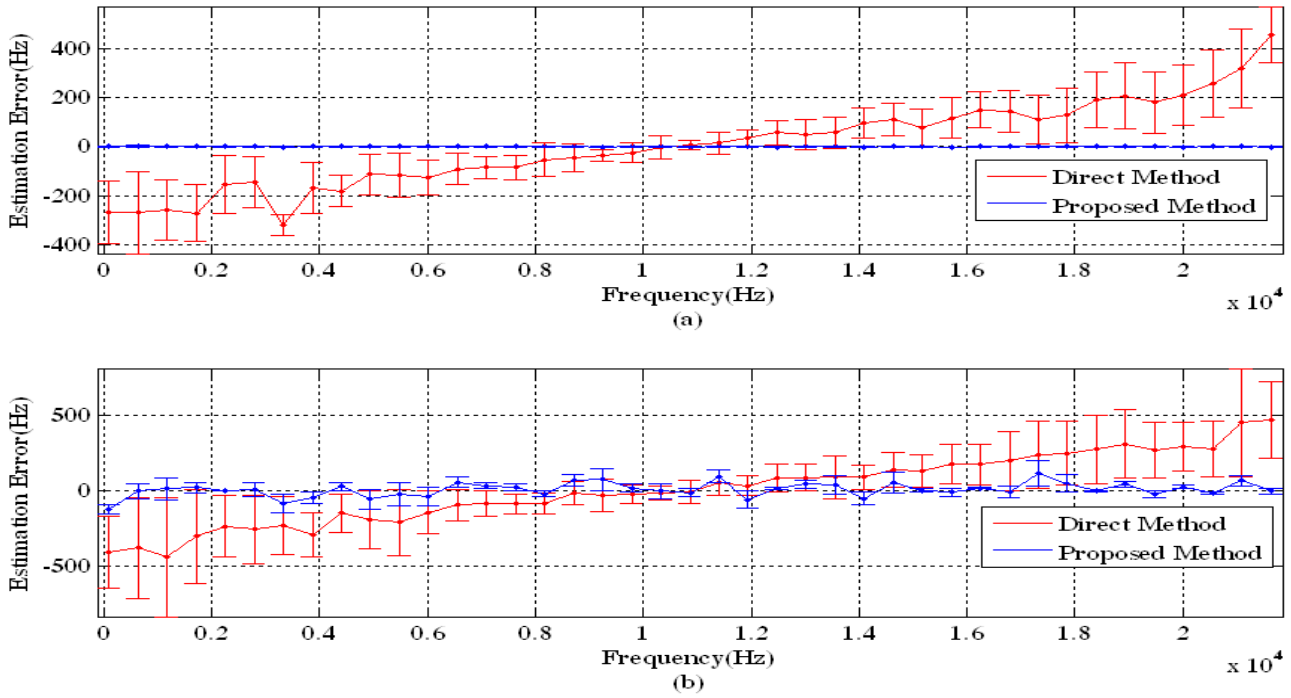

Fig. 6 : (a). SC Estimation Error of Test set: 2 (sum of tones with a frequency spacing of 200 Hz) signals of lowest frequency spanning from 96.8994 Hz to 21630.1025Hz of 0.5 sec duration (window size is 512) for both direct (solid line) and proposed (dashed line) methods. (b). Same as (a) for window size is 256

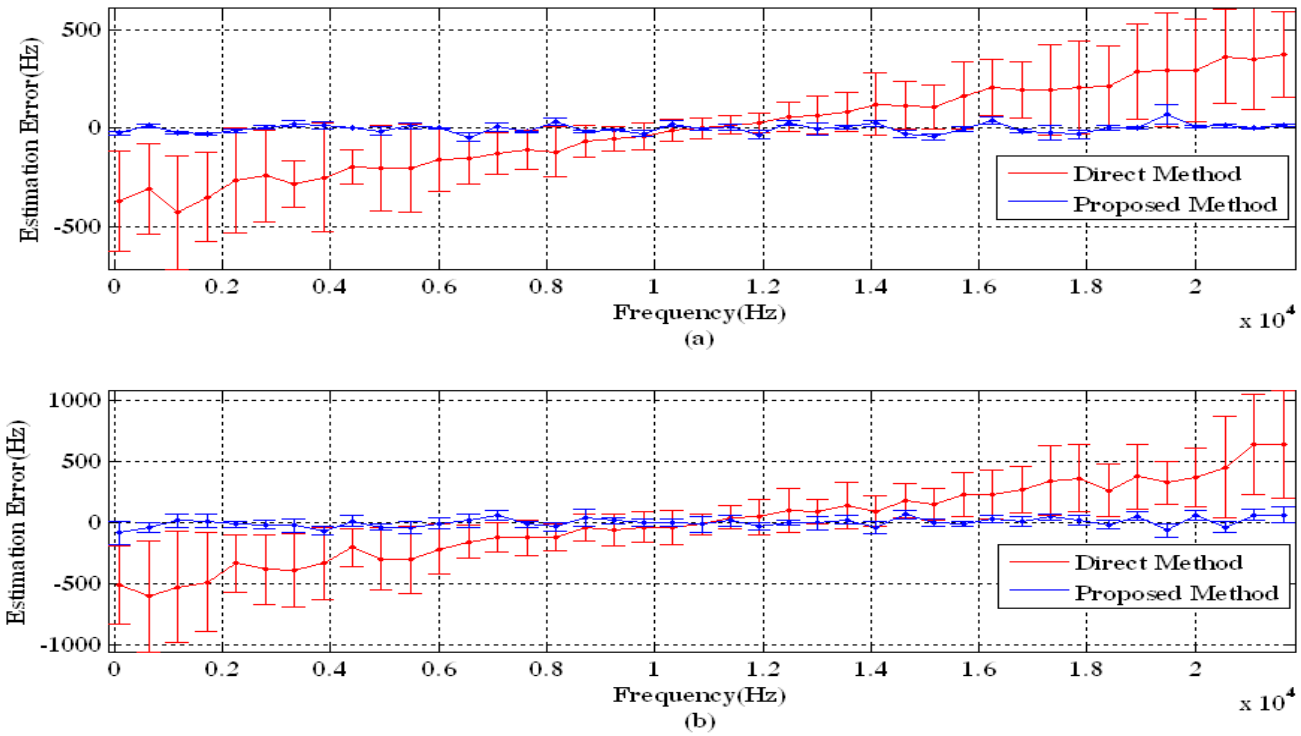

Fig. 7 : (a). SC Estimation Error of Test set: 2 (sum of tones with a frequency spacing of 100 Hz) signals of lowest frequency spanning from 96.8994 Hz to 21630.1025Hz of 0.5 sec duration (window size is 512) for both direct (solid line) and proposed (dashed line) methods. (b). Same as (a) for window size is 256

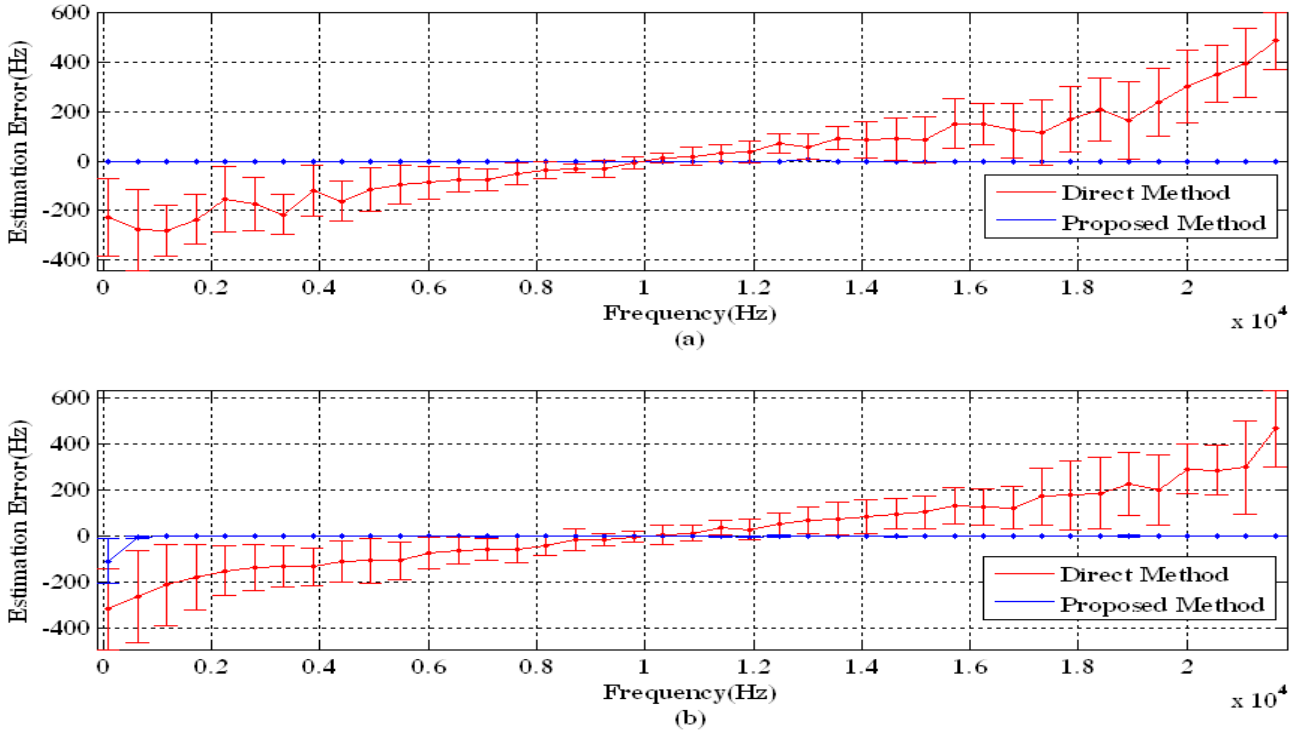

Fig. 8 : (a). SC Estimation Error of Test set: 2 (sum of tones with a frequency spacing of 500 Hz) signals of lowest frequency spanning from 96.8994 Hz to 21630.1025Hz of 0.5 sec duration (window size is 512) for both direct (solid line) and proposed (dashed line) methods. *(b).* Same as (a) for window size 256

The results say that the estimation using the proposed is always better than that of the direct method. The accuracy is extremely well for larger spacing of tone frequencies, the reason being the better separation of. spectral peaks.

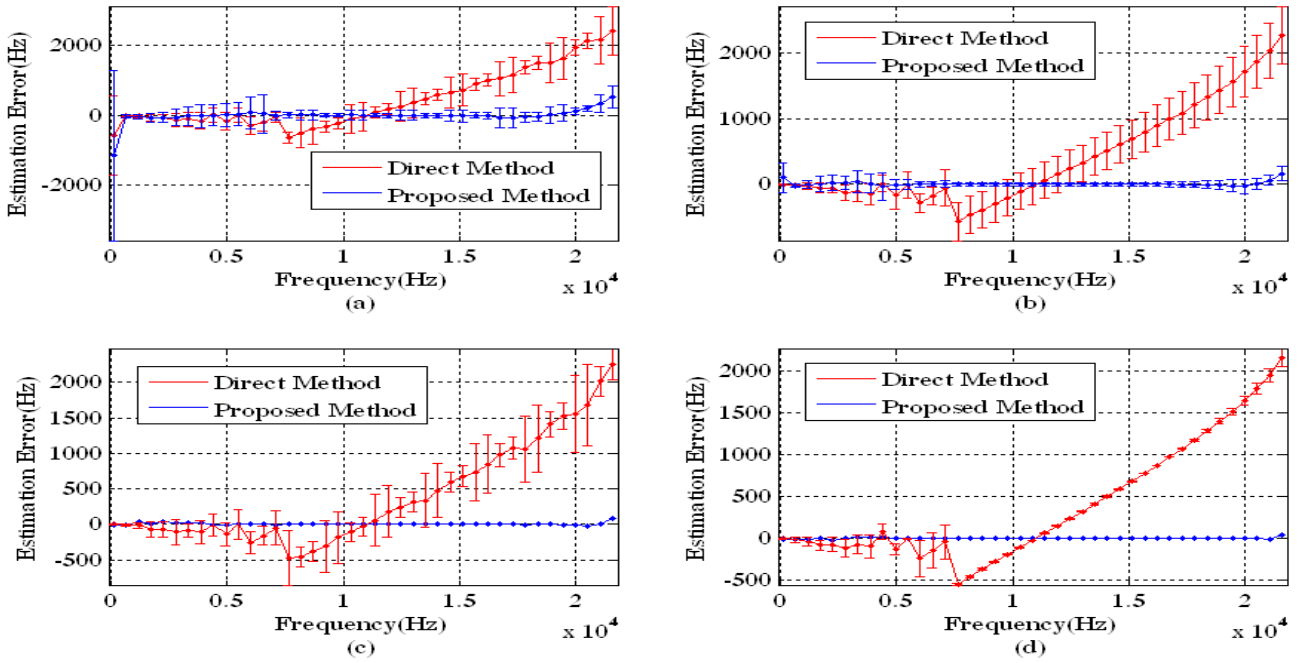

Fig. 9 : SC Estimation Error of Test set: 3 (BLUITs with a fundamental frequency spanning from 96.8994 Hz to 21630.1025Hz of 0.5 sec duration; spectral slope 0 dB/Octave) for both direct (red line) and proposed (blue line) methods for (a). 256 sample window (b). 512 sample window (c). 768 sample window (d). 1024 sample window

Figure 9: shows the estimation results for Test set: 3 (BLUITs) with a fundamental frequency spanning from 96.8994 Hz to 21630.1025Hz of 0.5 sec duration and spectral slope of 0 dB/Octave) for window sizes of 256, 512 768 and 1024 samples. Again results are extremely well for proposed method compared to those of the direct method, while the direct method fails even for larger window sizes. In figure 10, the estimation errors for Test set: 3 (BLUITs) signals of spectral slope of –12dB/Octave are shown for window sizes of 256, 512, 768 and 1024 samples. It can be observed that in all cases, mean error drastically low compared to that of direct method. More over, as the window length increases, the standard deviation of estimation error reduces faster for the proposed method compared to that of the direct method. (first two lines are rearranged properly)

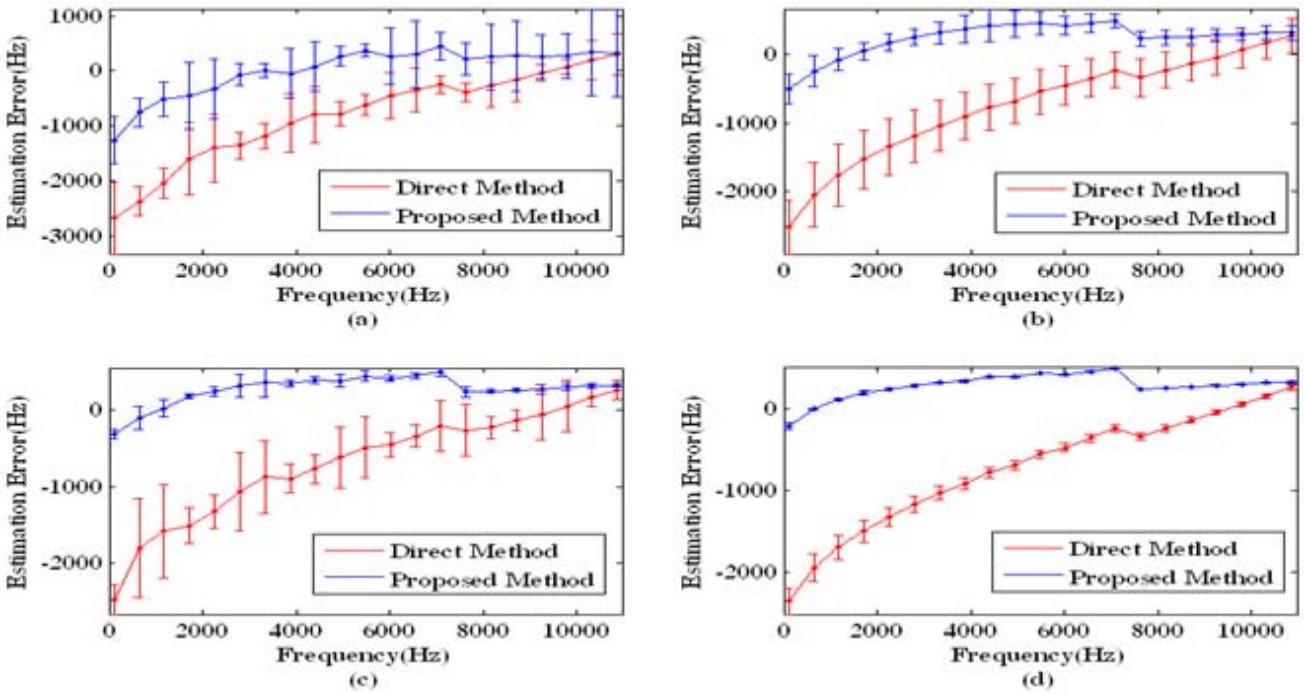

Fig. 10 : SC Estimation Error of Test set: 3 (BLUITs with a fundamental frequency spanning from 96.8994 Hz to 21630.1025Hz of 0.5 sec duration; spectral slope -12 dB/Octave) for (a). 256 sample window (b). 512 sample window (c). 768 sample window (d). 1024 sample window

VII. Conclusions

In this paper, windowing effects on the spectral centroid estimation are investigated considering three types of well structured signals: Tones, Sum of Tones and Band Limited Unit Impulse Trains. These test signals are considered because they appear frequently in speech and audio content. The spectral centroid is estimated using two methods: (1). the direct method using the equation 4. (2). The proposed method that uses threshold and peak detection on the magnitude spectrum. The proposed algorithm is shown to estimate the spectral centroid more accurately compared to direct method for all the signals under consideration and for all window lengths.

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The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.

(II) Choose corresponding Journal.

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Page Size: 8.27" X 11'"

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- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
- Abstract Font size of 9 Bold, "Abstract" word in Italic Bold.
- Main Text: Font size 10 with justified two columns section
- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be three lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
- Numbering of Second Main Headings (Heading 2) must be in Alphabets, Italic, and Font Size of 10.

You can use your own standard format also.
Author Guidelines:

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

1. GENERAL

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Scope

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Complete support for both authors and co-author is provided.

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Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

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The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

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It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

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Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

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Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

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Abstract, used in Original Papers and Reviews:

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Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

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Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

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For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

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TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

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7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

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11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

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15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

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21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

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33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

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Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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