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Esterification and Purification of Rubber Seed Oil for Biodiesel Synthesis

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Abstract: Rubber seed oil (RSO) is extracted from rubber seed kernel by using screw press and used as a feed stock for biodiesel synthesis via acid treatment. The yield of RSO from rubber seed kernel is about 36 % and free fatty acids (FFA) content of this oil is 9.288%. Due to high acid value of RSO, acid treatment of RSO has been carried out to reduce FFA and purification process is followed to synthesize biodiesel. Acid treatments (esterifications) of RSO are carried out to study the influence of: including molar ratios of methanol to RSO, quantity of sulfuric acid catalysts, reaction temperatures and reaction times. The best condition of acid treatment is molar ratio of methanol to RSO 6:1, 1% (vol. %) of sulfuric acid, temperature 50ºC, reaction time of 30 minutes and the yield of esterified rubber seed oil (ERSO) about 95%. The amount of FFA is reduced from 9.288% to less than 2% at the end of the acid treatment. ERSO obtained from the acid treatment is purified by using sodium hydroxide and methanol solution to synthesize biodiesel. The best yield of biodiesel about 89% is obtained when the operating condition of the purification process (neutralization and transesterification) is 9:1 molar ratio of methanol to ERSO, 0.5 wt. % of sodium hydroxide, temperature of 50ºC, reaction time of 30 minutes and stirring rate of 750 rpm. The prepared biodiesel from this study is analyzed and found that its properties meet within the limits of ASTM specifications of biodiesel.

Keywords: biodiesel, RSO, methanol, sulfuric acid, esterification, sodium hydroxide, transesterification

1. INTRODUCTION

Worldwide increasing oil crisis and reducing fossil fuel reserve act as a driving force behind the search of alternative fuels. The major portion of the total energy consumed worldwide is now coming from fossil fuel sources. Fossil fuel sources are non-renewable, and will be exhausted by near future. Biodiesel can be a wonderful replacement to conventional petro-diesel fuel, which can be produced from a renewable domestic resource [1].

Biodiesel derived from renewable plant sources is monoalkyl esters of long chain fatty acid which fall in the carbon range C_{12}-C_{22}. It has similar properties as mineral diesel. Various processes exist to convert vegetable oils (mainly triglycerides) into biodiesel. Transesterification of vegetable oils using alcohol in a catalytic environment is most commonly used method for producing biodiesel. The equilibrium conversions of Triglycerides (TG) is affected by various factors, namely, type of alcohol used, molar ratio of alcohol to TG, type of catalyst, amount of catalyst, reaction temperature, reaction time and feedstock quality (like free fatty acid content, water content etc.) [2].Biodiesel, however, is made from renewable resources, is biodegradable and nontoxic, and has a higher flash point than normal diesel. In addition, biodiesel increases lubricity, which prolongs engine life. Another significant advantage of biodiesel is its low emission profile and its oxygen content of 10-11%. In other words, biodiesel does not contribute to global warming. Many researchers reviewed and investigated the methods for the synthesis of biodiesel. Currently, most biodiesel is prepared using alkaline catalysts. Even though transesterification is feasible using base catalysts, the overall base – catalyzed process suffers from serious limitations that translate into high production costs for biodiesel. In particular, the total free fatty acids (FFA) content associated with the lipid feedstock must not exceed 0.5wt%. FFA which acts as a potential contaminant reacts with alkaline catalyst to form soap. Soap can cause glycerol separation problem [3]. The demanding feedstock specifications for base catalyzed reactions have led researchers to seek catalytic and processing alternatives that could ease this difficulty and lower production costs. Methodologies based on acid-catalyzed reactions have the potential to achieve this fact. The production of biodiesel from high FFA containing feedstock needs a treatment to convert the FFAs to ester. This treatment process is known as esterification. Numerous different vegetable oils (soybean oil, coconut oil or palm oil, etc.) have been tested as biodiesel in our country. In the present study, rubber seed oil, typical non-edible high FFA oil is considered as a potential feedstock for biodiesel production [4].

The annual rubber seed production potential in Myanmar is about 21,600 tons and from this tonnage of seed about 3,700 tons of oil could be obtained. At present rubber seed oil does not find any major applications. The purpose of the present study is to develop a method for the acid treatment of high FFA rubber seed oil to synthesize biodiesel. Thus, rubber seed oil is considered as a potential feedstock for biodiesel production in this study.

2. EXPERIMENTAL PROCEDURE

In this work, the following steps were contained.

(1) Preparation of the raw materials, rubber seeds
(2) Extraction of the rubber seed oil
(3) Analysis of the extracted rubber seed oil

(4) Acid treatment (esterification) of the rubber seed oil (RSO)
(5) Preparation of Base-Catalyst solution for esterified rubber seed oil (ERSO)
(6) Purification process of the ERSO to biodiesel synthesis
(7) Determination of the properties of the prepared biodiesel

2.1. Preparation of Raw Materials

Rubber seeds were discarded the damaged and discolored wet kernels and crushed the fresh kernels. The rubber seeds usually ripen during July, August, September and collection has to be well organized during this period. The seeds should be collected as fresh as possible, not allowing them to be on the ground for more than three days.

For this study, matured rubber seeds from Mayantaung Village in Kyaikto Township are purchased in July. These matured rubber seeds are partially sun dried and decorticated manually. The moisture contents of the shell and fresh/wet kernels are determined and their weights are measured to estimate the average composition of the fresh rubber seed. These wet kernels are not suitable for the extraction of oil. The kernels are sun dried for several hours and heated for about 30 minutes in oven to reduce the moisture content.

2.2. Extraction of the Rubber Seed Oil

Rubber seed oil (RSO) is obtained from the dried kernels by the method of mechanical extraction using a screw press. In carrying out the first pressing, no oil can be extracted. After the second run, the oil content obtained is not preferrable and so the operation is recycled until no more oil can be extracted.The extracted RSO and residual press cake are weighed and determined the moisture contents of them to estimate the composition of the dried kernels.

The residual cake, by-product of this process, can be used as an animal feed for its high nutritive value or as a fertilizer for containg nitrogen and potash.

2.3. Analysis of the Rubber Seed Oil

In this study, rubber seed oil was used as triglyceride source and methanol was used as alcohol source. The free fatty acid, acid value, moisture content, saponification value, peroxide value, iodine value, specific gravity, cloud point of rubber seed oil were analyzed and the result data are shown in Table 1.

Table 1. Characteristics of Rubber Seed Oil

Item	Result
Moisture content (vol%)	0.1779
Free Fatty Acid (as oleic acid %)	9.288
Acid Value	18.58
Saponification Value (g/100g sample)	184.253
Iodine Value (g/100g sample)	121.46
Peroxide Value (meq/kg)	0.6767
Specific gravity	0.92
Cloud point	4.5

2.4. Esterification of the Rubber Seed Oil

The acid-catalyzed esterification reaction of rubber seed oil are added into a 1 liter flat bottom flask and placed over a magnetic stirrer. The catalyst and methanol was added and stirred the mixture with stirring rate 750rpm. The reaction time is 30 min. After 30 min the mixture is poured into the separating funnel to remove the excess alcohol. In the excess alcohol, sulfuric acid and other impurities are included and then these are moved into the upper layer. Then the lower layer (ERSO) is separated to neutralize and transesterification.

Process Condition for preparation of Esterified rubber seed oil is shown in Table 2.

Table 2. Process Condition for Esterification Process

Alcohol to oil molar ratio	4:1,5:1,6:1,7:1,8:1
Acid catalyst (%)	0.3, 0.4, 0.5, 0.6, 0.7
Reaction temperature(˚C)	40, 45, 50, 55, 60
Reaction time, min	20, 30, 45, 60, 120
Stirring rate, rpm	750

2.5. Preparation of Base-Catalyst Solution

The catalyst Sodium hydroxide, 0.5wt% of the oil was first weighed and dissolved in methanol with the stoichiometric amount required for the reaction. It looks more than 15 min to form homogeneous solution.

2.6. Purification Process for Biodiesel

The base-catalyzed transesterification reaction of esterified rubber seed oil are preheated to the required reaction temperature of 45± 2˚C in the 1 liter flat bottom flask and placed over a magnetic stirrer. Meanwhile, catalyst dissolving methanol is added and stirred for 30 min with stirring rate 750 rpm. The reaction is stopped, and the products are allowed to separate into two layers. The lower layer, which contained impurities and glycerol, is drawn off. The ester remains in the upper layer. Methyl ester is washed by distilled water to remove the entrained impurities and glycerol. Lower layer is discarded and yellow color layer (known as biodiesel) is separate. The biodiesel layer is then heated to remove all the solvent and water. Table 3 shows the process conditions for biodiesel synthesis.

Table 3. Process condition for the preparation of Biodiesel

Alcohol to oil molar ratio	6:1, 7:1, 8:1, 9:1, 10:1, 11:1
Base to oil ratio (wt. %)	0.3, 0.4, 0.5, 0.6, 0.7
Reaction temperature(˚C)	40, 45, 50, 55, 60
Reaction time (min)	20, 30, 60, 120
Stirring rate (rpm)	400, 750, 800

3. RESULTS AND DISCUSSION

3.1. Effect of Molar Ratio to Acid Esterification

The results of yield percentage of esterified oil layer and FFA values are shown in Table 4. From Figure 3.1 for constant temperature (50˚C), constant time (30min), constant acid catalyst (0.5%) and stirring rate 750 rpm. In Figure 3.1, the good conversion and yield of oil layer is achieved vary close to the molar ratio 6:1. With further increase in molar ratio there is only improvement in the conversion efficiency but not in yield of oil layer. The esterification process reduces the viscosity of the oil. Also it has been found that the reduction in viscosity increases with increase in molar ratio.

Table 4. Yield% of RSO with different molar ratio

Expt.	MeOH:Oil	FFA (%)	Conversion (%)	Yield (%)
Expt.1	4:1	2.9	69	90
Expt.2	5:1	2.7	71	91
Expt.3	6:1	1.4	85	95
Expt.4	7:1	1.9	80	93
Expt.5	8:1	1.5	84	94

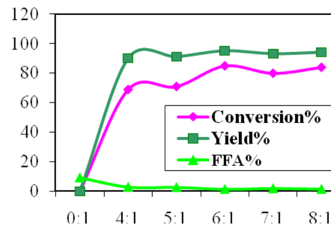

Figure 3.1. Conversion%, Yield% & FFA% of ERSO

3.2. Effect of Reaction Temperature

Four different variation of temperature are shown in Figure 3.3 and it has been found that 50˚C is the best and appropriate temperature at constant time (30min), constant catalyst (0.5%) and constant molar ratio (6:1). With increase in temperature the conversion percent gradually increase. High reaction temperature increase in darkness of the product esterified rubber seed oil (ERSO) and also increase the production cost of biodiesel. The maximum yield of ERSO is obtained at 50˚C. And then high reaction temperature effect the production cost. Table 5 shows the effect of reaction temperature on FFA and yield percent of ERSO.

Table 5. Effect of reaction temperature on Yield% of RSO

Expt.	Temp (˚C)	FFA (%)	Conversion (%)	Yield (%)
Expt.6	40	2.5	74	87
Expt.3	50	1.4	85	95
Expt.7	60	1.9	79	90
Expt.8	70	1.7	82	89

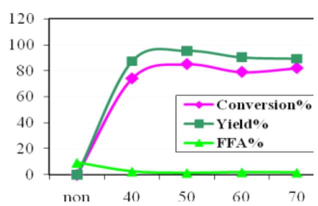

Figure 3.2. Conversion%, Yield% and FFA% of ERSO at different reaction temperature

3.3. Effect of reaction time to Esterification

The results of yield percentage of are shown in Table 6 and conversion percent and FFA are shown in Figure 3.3. From Figure 3.3, it has been found that the yield slightly decrease with increase in reaction duration after 30 min. Therefore, prolong reaction time is not suitable for ERSO preparation process. Therefore, prolong reaction time is not suitable for ERSO preparation process. Therefore, reaction time 30 min is the best to prepare ERSO.

Table 6. Yield% of RSO with different reaction time

Expt.	Time (min)	FFA (%)	Conversion (%)	Yield (%)
Expt.9	20	3.8	59	70
Expt.3	30	1.4	85	95
Expt.10	45	2.0	78	85
Expt.11	60	2.7	71	84
Expt.12	120	2.8	70	82

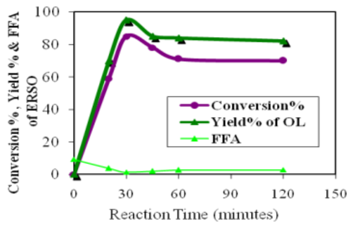

Figure 3.3. Conversion%, Yield% & FFA% of ERSO with different reaction time

3.4. Effect of Acid Catalyst Amount

The amount of acid catalyst used in the process also affects FFA and the conversion efficiency of the process. The catalyst amount is varied in the range of (0.25, 0.5, 0.75, 1 and 1.25% of sulfuric acid) are shown in Table 7. These percentages are volume fractions of the oil supplied for this reaction. The maximum yield of oil layer was achieved if the added catalyst amount was 1%. Increasing the catalyst amount can give the gradually increase conversion percent but be darken the color of ERSO. So, the appropriate catalyst amount for this process was 1% H_2SO_4.

Table 7. Yield% of RSO with different acid catalyst amount

Expt.	H_2SO_4	FFA (%)	Conversion (%)	Yield (%)
Expt.13	0.25	3.5	62	75
Expt.3	0.5	1.4	85	95
Expt.14	0.75	1.6	83	89
Expt.15	1.00	1.1	88	95
Expt.16	1.25	1.4	85	94

3.5. Effect of Molar Ratio to Purification

The effect of molar ratio on biodiesel yield was studied. The results of yield percentage of biodiesel are shown in Table 8. In this Table, six different variation of molar ratio at constant sodium hydroxide catalyst 0.5%, reaction temperature 50˚C, reaction time 30min and stirring rate 750 rpm. Molar ratio 9:1

gives the highest yield percent of biodiesel. The more methanol is added, the lower yield percent of biodiesel can give. In Figure 3.5, it shows that the maximum yield percent is obtained for the molar ratio 9:1. Therefore, the best and the appropriate molar ratio of the purification process is chosen as 9:1.

Table 8. Yield% of Biodiesel with different molar ratio

Expt.	Molar Ratio (MeOH:ERSO)	Yield% (Biodiesel)
Expt.15-1	6:1	70
Expt.15-2	7:1	73
Expt.15-3	8:1	85
Expt.15-4	9:1	89
Expt.15-5	10:1	80
Expt.15-6	11:1	58

3.6. Effect of Alkaline Catalyst Amount to Purification Process

The effect of catalyst percent on biodiesel yield was studied. Table 9 shows that, different variations of catalyst (0.3, 0.4, 0.5, 0.6 and 0.7%) at constant reaction temperature 50˚C reaction time 30min and stirring rate 750 rpm. The value of catalyst percent reached 0.5%, yield percent of biodiesel was 89%. Beyond the catalyst percent at 0.55, the yield percent of the biodiesel was decreased. It was due to the trace amount of soap formation in the reaction mixture. Moreover, the increase amount of catalyst was also resulted in higher salt and water concentration in the crude glycerin.

Table 9. Yield% of Biodiesel with different amount of alkaline catalyst

Expt.	NaOH (wt%)	Yield% (Biodiesel)
Expt.15-7	0.3	55
Expt.15-8	0.4	75
Expt.15-4	0.5	89
Expt.15-9	0.6	82
Expt.15-10	0.7	81

3.7. Effect of reaction temperature to Purification Process

The effect of reaction temperature on biodiesel yield is studied. According to the Figure 3.4 the reaction temperature was increased, the yield percent of biodiesel is decreased. If the lower the reaction temperature (below 50˚C), the yield percent of biodiesel will be decreased. Different kinds of temperature are shown in Table 10. Reaction temperature 50˚C is the best to give the highest yield of biodiesel.

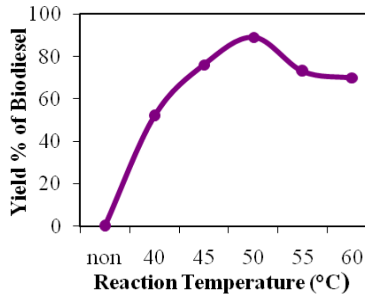

Figure 3.4. Yield% of Biodiesel with different reaction temperature

Table 10. Yield% of Biodiesel with different reaction temperature

Expt.	Temperature (˚C)	Yield% (Biodiesel)
Expt.15-11	40	52
Expt.15-12	45	76
Expt.15-4	50	89
Expt.15-13	55	73
Expt.15-14	60	70

3.8. Effect of reaction time on Purification process

In order to achieve perfect yield percentage of biodiesel, they must be needed to sufficient reaction time. Table11 shows different variation of reaction time studied. Reaction time 30min gives the highest yield percent of biodiesel 89%. If the reaction time is increased, the yield percent of biodiesel will be slightly decreased as shown in Figure 3.5.

Table 11. Yield% of Biodiesel with different reaction time

Expt.	Time (minutes)	Yield% (Biodiesel)
Expt.15-15	20	70
Expt.15-4	30	89
Expt.15-16	60	77
Expt.15-17	120	79

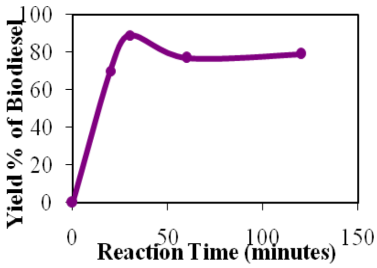

Figure 3.8. Yield% of Biodiesel with different reaction time

3.9. Effect of stirring rate on Purification Process

Mixing by stirring is very important for transesterification reaction, as oils or fats are immiscible with sodium hydroxide-methanol solution. The reaction can become diffusion controlled or poor diffusion between the phases results in a slow rate. Table 12 shows the different stirring rate was studied. Among them 750 rpm gives the highest yield percent of biodiesel.

Table 12. Yield% of Biodiesel with different stirring rate

Expt.	Stirring rate (rpm)	Yield% (Biodiesel)
Expt.15-18	400	80
Expt.15-4	750	89
Expt.15-19	800	62

3.10. Properties of Biodiesel from RSO Compared with ASTM Standards

The results of total, free and combined glycerol content and fuel properties of prepared biodiesel are shown in Table 13.

According to the Table 13 , carbon residue is higher than the specification. If the proper separation is conducted, the carbon residue value will be within the specification. From the color test, biodiesel is not being colorless. This color may be due to the color of the rubber seed oil. But its color does not predict fuel quality.

Table 13. The Properties of Crude Biodiesel Compared with ASTM Standard

Properties	ASTM D_{6751}	Biodiesel
Total glycerol %	0.24%	0.045
Free glycerol %	0.02%	0.006
Combined glycerol %	0.22%	0.089
Kinematic viscosity	1.9-6.0 cSt	4.56
Specific gravity	0.88	0.88
Flash point	100-170	100
Pour point	-15to 10 ˚C	+9
Carbon Residue	0.01wt%	0.048wt%
Total acid number	0.8	0.6
Free Fatty acid	-	0.0908
Cetane index	48.65	47.27
Copper strip corrosion	3Max:	1(a)
Initial boiling point	-	312 ˚C
Colour	-	L1.0

4. CONCLUSION

In this study, the production of fuel-quality biodiesel from rubber seed oil is investigated. Rubber seed oil˛s stir rate of 750 rpm is carried out. Initial free fatty acid and moisture content of rubber seed oil are 9.288% and 0.1779% respectively. In the esterification process, initial FFA content of the oil is reduced to less than 2%. In this process, different variations of methanol to oil molar ratio (4:1, 5:1, 6:1, 7:1, 8:1), acid catalyst (0.25%, 0.5%, 0.75%, 1%, 1.25%), reaction temperature (40˚C, 50˚C, 60˚C, 70˚C) and reaction time (20, 30, 45, 60, 120 min) are analyzed in order to obtain which one is the best. Excess addition of sulfuric acid gives darkens color of the esterify rubber seed oil. In this process, it has been also found that molar ratio 6:1, acid catalyst 1%, reaction temperature 50˚C and reaction time 30 min is the best. We were obtained the esterify rubber seed oil (ERSO) and it was included a few amount of acid catalyst. So, these ERSO is needed to neutralize. In this steps, neutralization and transesterification reaction was occurred simultaneously to form the best biodiesel. Different variation of methanol to oil molar ratio (6:1, 7:1, 8:1, 9:1, 10:1, 11:1), base to oil ratio (wt%) (0.3%, 0.4%, 0.5%, 0.6%, 0.7%), reaction temperature (40˚C, 45˚C, 50˚C, 55˚C, 60˚C), reaction time(20, 30, 60, 120min) and stirring rate (400,750, 800rpm) has been adopted in order to obtain the experimental conditions for the highest biodiesel yield of 89% is obtained by using methanol to oil 9:1, base to oil ratio ratio 0.5%, reaction temperature 50˚C, reaction time 30min and stirring rate 750rpm. Estimation of percent reaction completion gives 99.56%.

Most of the physical properties of biodiesel from rubber seed oil are found to be within the specified limits. The specific gravity, flash point, pour point, total acid number, kinematic viscosity, initial boiling point, cetane index and copper corrosion of product biodiesel meet the ASTM specifications (D_{6751}). Although the value of carbon residue is 0.048wt%, the result of free glycerol, total glycerol and combined glycerol are close to the ASTM specified limits.

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Home Automation and Surveillance: A review

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***Abstract*—Home automation and Surveillance systems are being consistently undergoing changes due to developments in electronics and communication fields. Right from telephone controlled home appliances and simple camera based system, the Home Automation and Surveillance today has entered the IoT era. Home automation makes life easier by providing all home appliances control at single point which is mostly a smart phone. Surveillance requirement is rapidly increasing in domestic and commercial applications due to its low cost and ease of deployment. This paper takes stock of how Home Automation and Surveillance systems have been changed and implemented. Home Automation and Surveillance related literature of last 7-8 years has been referred for the review.**

Keywords—*Home automation, Surveillance, Raspberry Pi, OpenCV, CCTV, ZigBee, XBee, SimpleCV, Cloud, Gamma ray etc.*

I. Introduction

The Surveillance and automation systems have become very important and indispensable for security reasons and energy conservation. Home automation and Surveillance system are in use since last 25-30 years. Initially systems were bulky and were not so sophisticated as they are today. Home Automation terminology includes the functioning of all household appliances. For example, a micro-controller based system can have the capability to control everything from Fan, air conditioning, lighting and overall electrical appliances. The home automation will help individual to monitor and control home appliances remotely through internet. This paper reviews how home automation and surveillance systems developed in last 8-10 years. Different techniques used for surveillance like OpenCV, SimpleCV, Gamma ray correction etc. are discussed and different home automation architectures have also been focused in the paper.

II. Literature Survey:

The brief review of techniques for developing Home automation and surveillance system using IoT based frameworks is presented below.

Dae-Man Han , 2010 (1) addresses a new smart home control system based on sensor networks to make home networks more intelligent and automatic. He developed smart home automation and home energy management system using IEEE 802.15.4 and ZigBee. It gathers sensing information using occupancy sensor, Passive InfraRed (PIR) Sensor and photo sensor.

Jihua Ye, 2012 (2) presented research work on adaptive smart home system. In this system, the central controller uses feedback information from household appliances to learn the habits and to adjust the system automatically. The system uses toddler (used to find out the operation rules of user) and correlation algorithms (used to find out the relation of operations) to learn the habits of the users.

G. V. Vivek , 2015 (3) proposes IoT services using WiFi-ZigBee gateway for a home automation system. A smart home automation is an integration of smaller electrical devices and communicates with each other with a central processing unit. ZigBee nodes communicate wirelessly to the coordinator which is connected to a Linux board at the receiver end or the control panel which is interfaced with a ZigBee transceiver, this transceiver module is designated as a coordinator. Coordinator receives the sensor data and sends the commands accordingly to the ZigBee nodes present at the sensing environment with in the node.

Vamsikrishna Patchava, 2015(4) proposed a system for Smart Home Automation technique with Raspberry Pi using IoT. Here system uses a Raspberry Pi module with Computer Vision techniques. Using this, system connected home appliances can be controlled through a monitor based internet. sensing and surveillance function is carried out by Raspberry Pi . Here intrusion detection is done using motion sensors and camera will record on motion detection.

Mattia Gamba, 2015(5) in their research paper has proposed a solution based on XBee a showed how XBee modules can be utilized to build up a scalable and fully customizable home automation system through an easy way to link any new device to the others. Furthermore, user interface in home automation has been addressed in state of the art approaches exploiting mobile devices use as portable home automation control tools.

Neel Oza, 2016(6) has proposed a low cost surveillance system. The proposed system is cloud based surveillance system for live video streaming This system provides the live streaming by using cloud, Raspberry Pi 2 module and FFMPEG based USB Camera. The proposed work has ability to control and live video streaming over the internet via cloud computing. Streaming and controlling is possible from anywhere over the world as well as can upload the data to cloud.

P Arun Chandra, 2016 (7) proposed model uses Raspberry Pi that counts the number of pulses detected by Light sensor module. The sensor is placed on the energy meter. The Raspberry Pi counts the number of pulses to calculate the energy consumption in kWh according to the conversion mentioned on the energy meter. This data is then sent to Google Spreadsheets using Google API. The spreadsheet can be accessed on a website and android app that were designed.

Virginia Menezes, 2015 (8) proposes the motion detection and tracking system for surveillance which uses Raspberry Pi and computer vision using SimpleCV (SimpleCV is an open source framework for building computer vision applications. It is a collection of libraries and software that can be used to develop vision applications.) to detect moving objects in the surveillance area, switch on the lights to capture images and streams the camera feed online using MPJG Streamer, which can be viewed by any authorized person on the go.

Setiya Purbaya, 2015 (9) proposes design of a system such as IP surveillance camera which based on an embedded system, with improved image recording feature by using gamma correction feature which integrates with cloud service . In the image correction mechanism, image quality improvement is measured using a histogram. Here image clarity is done using Gamma correction formula. Trade off has to be done while selecting value of Gamma (to be used in formula). The larger the gamma value (G), the image is going to be clearer. However, the image is also going to be blurred.

From Literature survey inference can be drawn out that their are many issues pertaining to development of IoT based system for Home automation and surveillance system. Some of the presented research works focus on automatic monitoring and controlling of home appliances [1, 10, 11], effective energy management [3, 15, 1], integration of different protocols [3, 12, 13] and security [14]. However, no single technological solution has been reported for smart home system that addresses all the above listed issues. Therefore, their is a huge potential for developing a generic framework and technological solution for IoT based Technology for smart home system that addresses all the issues.

III. Home Automation and Surveillance system design considerations:

Modularity : The different sub systems of the said system needs to have fair degree of individuality. Specially home appliance modules to connect them to IoT, surveillance module etc.

Plug & Play scalability : The appliance connecting module should be of plug & play nature making it easy for end users to implement the system.

Robustness : Each sub system should be fault tolerant and must have capability of providing services all the time.

Reconfigerable: If, for some reason subsystems of the system needs to be changed (e.g. upgraded/advanced version of controller), in such case the system must be reconfigerable.

Security : The system must be secure enough to allow access to authorised users only. It should not have security loopholes which can be used in some inadvertent manner.

Power Consumption : Since the system will control the electrical appliances in the house, it would be very much advantageous if the same system can be used to monitor power consumption status of the appliances to reduce unwanted power leakages, resulting in power saving.

Portable : The system must be portable so that the system can be disconnected and connected at new place as and when required.

Integration : Home automation and surveillance systems should be integrated together so as to have cost effective system using single central controller for automation and surveillance.

IoT Platform : Their are numerous IoT platform available for use which has provisions for connecting system modules to networks. Use of these IoT platforms also reduces development time and efforts by providing ready to use libraries for IoT based systems.

IV. CONCLUSION :

The literature review of the Home automation and surveillance shows that their are numerous techniques employed to design the home automation and surveillance systems. But need of the time is cost effective IoT based Home automation and Surveillance system. The smart phone based cost effective home appliance control system with power consumption monitoring and integrated surveillance features can make the system more effective and popular. Use of IoT platform for the system development can drastically reduce the system development time.

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Integrated Health Care System Using Cloud Computing

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Abstract: The Web Based Hospital Management which is a system that automates the retrieval of patients file and also provides a platform for patient to meet the doctor online and communicate with the doctor. The system would ensure the proper keeping of information and the retrieval of patient's information very easy. The project commenced with the investigation of the existing to see the problem on one hand and then propose a solution to the problem. We further carried out a literature review to acquire more knowledge from peoples work, and this helped enhanced the development of the system.

Furthermore, we did the systems analysis and methodology of the system and after we had a clearer picture of the system which made it very easy for us to go into the system design and implementation.
The system is designed for in Nigerian national hospitals but can be used by any hospital. The emergence of this newly developed system will solve the shortcomings of the existing system and also reduce time and resources incurred while using the manual system.

Keywords: Cloud, Computing, Automate, Hospital and Health

1. INTRODUCTION

The way some hospitals in this part of the world manage and carry out some activities especially those that concern patient's, is such that it poses lots of stress and fatigue to both the patient and the staffs in the hospital. In some hospitals, the activities like registration of patient in hospital are done manually. We have experienced situation where a patients has to register twice just because of loss of file in the hospital. We see cases where a patient forgot his hospital number or in ability of patient to talk to the severity of the ailment and the staffs has to go through a lot of stress to be able to retrieve a file and also due to improper keeping of information it has led to the failure of knowing the drugs that the patient in allergic to and administering the drug that is not compatible with body of the patient may worsen the heath of the patients. The worst is that some patients in critical condition have lost their life due to the long process of manually retrieving health history records (Case files) which would enable the doctor check past record to be able to detect the patients' problem and know the next action to take.

Also patients sometimes end up queuing up to see the doctor for minor cases there by worsening their health situation as a result of stress, wastage of time and fatigue to the patients and doctors. It also makes the documentation and retrieval of patient past information difficult, as well as waste time and resources. We also have problem with missing patient's files, inability of the current doctor attend to patients read the information in the file documented by the previous doctors. Akadiri et al (2009) confirmed that most sub Saharan African countries like Nigeria, have poor knowledge and utilization of ICT among their general populace.

Some patient find it very uncomfortable to interact with the doctors directly to give a full details of what is wrong with them due to humiliation and emotions that undergo in face to face setting, and as such the doctor will find it difficult to diagnose the ailment due to incomplete information given by the patient which will not aid in proper diagnosis and proper treatment of the patient. The reluctance of men to consult medical professionals and seek social support is amplified for prostate cancer sufferers, who at various stages in the course of the illness and its treatment might experience problems with sexual performance and continence resulting in a fear of humiliation, Hines, (1999).

However the rate at which technology is advancing and exploring all the opportunities information technology has provided, it is obvious that there is a light at the end of the tunnel. The Internet and other related technologies have change the way businesses operate and people work and how information systems support businesses, processes, decision making and competitive advantage, Bimal (2011). With the introduction of the computer System and information System, most of the activities we carry out today can be automated therefore, the process of registration of patient cannot be an exception.

As a result of the problems enumerated above, a hospital management system that incorporate biometric facilities for capturing and identification of patients, an online web application where patients can log in to meet the doctor and get remedial treatment for some critical ailment before going physically to the doctor will be developed to address the problems above. With this system in place, the records of patients can easily be retrieved using their biometrics even if the patient cannot remember his/her hospital number. Also patients can also get solution for common ailments online without passing through stress to see the doctor. Most importantly, this will reduce the death rate of patient.

2. REVIEW OF RELATED WORKS

Case Study One: Design and Implementation of Health Management System

Adegbenjo et al. (2012) opined that disease has been one of the humanity's greatest enemies. In the early years, most people were treated of illnesses by neighbors and friends in the confinement of their homes; which is costly both in energy usage, and the risk of damaging their bodies. This work aim at developing health management system capable of storing and retrieving the medical record of patients as well as diagnose, give health tips to patients and prescribe medication for five major diseases -Hepatitis, Malaria, Cholera, Tuberculosis and Typhoid. The system is to provide assistance to the human health expert in reaching logical conclusion about diagnosis of certain disease, and to create reference tool on the symptoms of the disease. This health management system comprises both management and expert system capable of diagnosing five major diseases and storing and retrieving the records of patients.

Meanwhile, Adegbenjo et al. (2012) listed three major problems associated with the conventional health care system which are:

1. Lack of immediate retrievals: It is very difficult to retrieve information .For instance, to find out about the patient's history, the user has to go through various registers.
2. Lack of immediate information storage: The information generated by various transactions takes time and efforts to be stored at right place.
3. Preparation of accurate and prompt reports: This becomes a difficult task since information needed may not be available as at when due.

These problems were considered using analysis and design and an expert system was developed. Expert systems have been found to be very useful in today's world driven by technology. When expert's knowledge is extracted and stored, such knowledge can be used to replace the expert in case of demise. Medical field benefits greatly from expert system. Knowing that specialties in the medical field cannot satisfy all the population; the knowledge of such specialist can be replicated and made use of in times of extreme necessity. As changes in business occur, so do requirements, hence, the system has been developed in such a way that it can be modified to accommodate new requirements. Though, this system has been developed using BUTH as case study, any health organization can adopt it. This is because it is indisputable that the use of a computerized Health Management System would enhance the effectiveness, accuracy of the patient records held by the health organization. This software has been designed to diagnose only five types of diseases- malaria, tuberculosis, hepatitis and cholera, and the system is not capable of carrying out any examination(s) on the patients. Adegbenjo et al. (2012) suggested that further works can be carried out incorporating several diseases, not only this; the system can be extended to carry out examination on the patients.

Case Study Two: Design of a Hospital-Based Database System (A Case Study of BIRDEM)

Khan et al. (2010) opined that as technology advances, information in different organizations can no more be maintained manually. There is a growing need for the information to become computerized so that it can be suitably stored. This is where databases come into the picture. Databases are convenient storage systems which can store large amounts of data and together with application programs such as interfaces they can aid in faster retrieval of data. An initiative was taken to design a complete database system for a hospital management such as Bangladesh Institute of Research and rehabilitation in Diabetes, Endocrine and Metabolic disorders (BIRDEM) in Dhaka so that its information can be stored, maintained, updated and retrieved conveniently and efficiently. The existing information in BIRDEM is partly computerized via databases only in patients' admissions, doctors' appointments and medical tests and reports sections. A partly slow and tedious manual system still exists in BIRDEM for example, in record of ambulances in service, assigning ward boys and nurses to rooms, the billing process and record of doctors' prescriptions etc. However, this paper outlines one complete database design for the entire BIRDEM hospital in which data maintenance and retrieval are in perfect harmony and speedy. Sample SQL-based queries executed on the designed system are also demonstrated.

Khan et al. (2010) developed a database which contains all the information needed to be maintained in a BIRDEM hospital. As we have computerized the entire system via a database, the maintenance is very convenient and efficient and also retrieval of data according to demand is speedy. The existing system of BIRDEM is partly manual and partly computerized and it becomes a tedious process to keep track of all the information partly in paper files and partly on computers. Therefore, our designed system is a good and useful implementation. We can further improvise it by enhancing its security. An initiative has also been taken to use Microsoft Visual Studio 2008 and the programming language C# for developing user friendly interfaces to the current database system. That way a software has been developed which is used to interface with the SQL Server and hence data accessed, retrieved and searched for far better in a more efficient and convenient form.

Case Study Three: Design and Implementation of Medical Information Systems For Managing and Following up Work Flaw in Hospitals and Clinics

Elmetwaly (2011) opined that the process of developing medical information systems is deemed to be one of the most critical objectives for professionals in this domain. It is known that any information systems are in need for development and processing in all contingent work problems. He proposed a system had been structured several years ago and had been experienced in several hospitals and clinics in Saudi Arabia. This research discusses how to utilize modern technologies available and how to use Oracle databases in saving all medical information and data that might be used. Design of this software allows easy and fast reach to information and hence fast execution of orders and easy recall for patients' information. One of the core objectives is to support receptionists, physicians, nursing, laboratory and radiology staffs in hospitals to exchange data and information is deemed to be one of the most important objectives and priorities. This is due to importance of time that helps decision makers implement necessary and most appropriate procedure for patient, especially if provided by internet. Oracle databases facilitates sharing required data and information easily and fast at any time and subject to authorities and powers vested to each user of such potential information systems. as a fundamental tool to analyze the data gathered by Hospital Information Systems (HIS) and obtain models and patterns which can improve patient assistance and a better use of resources and pharmaceutical expense

This research study deals with the problem of maintaining data, deemed to be one of the biggest problems of health entities. Most hospitals and clinic suffer loss of data saved in this databases and unavailability of strong cohesive information systems. Approach: Our need for such databases and information systems motivates us to seek solutions and technologies that might enable us accomplish and complete our works easily and fast. Results: Potential medical system is deemed as one of the unique systems that attempted to reach solutions for some problems faced by leaders and decision makers and by those concerned with medical information systems proposed systems has been structured utilizing Oracle database. Conclusion/Recommendations: Structure of this system focused on connecting it to internet, due to unlimited e-services provided by this international network that facilitates. Accordingly this facilitates exchange of medical information to all beneficiaries.

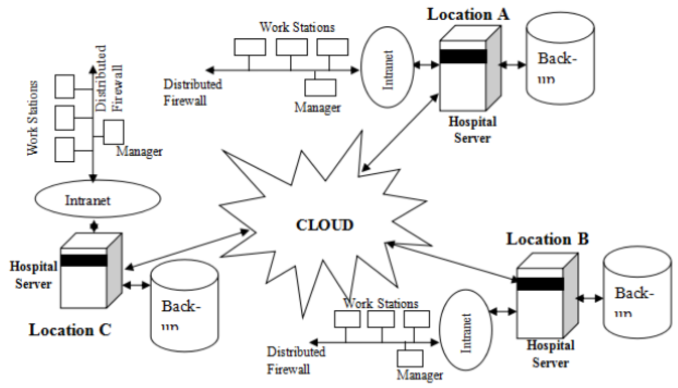
The core objective of potential electronic system is to facilitate process of data entry and following up patients files in hospitals and clinics. This system is designed based on Oracle databases due to its excellence in capacity of data volume, number of potential users who can access to the same database at any time. It is also distinguished with availability of following up and managing work flaw in hospitals and clinics easily and fast. The process of developing software is always in need for more effort to reach the desired objectives and hence facilitate procedures and shorten time and lessen effort exerted to reach desired objectives and conclusions.

Case Study Four: Design and Implementation of Hospital Management System

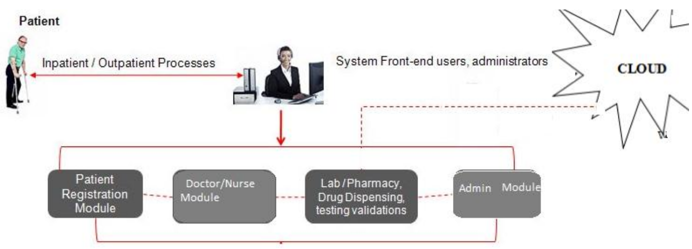
Adebisi (2015) developed an automated system that is used to manage patient information and its administration. This was with a view to eliminate the problem of inappropriate data keeping, inaccurate reports, time wastage in storing, processing and retrieving information encountered by the traditional hospital system in order to improve the overall efficiency of the organization. The tools used to implement the system are Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), Hypertext Preprocessor (PHP), and My Structured Query Language(MySQ).The Proposed system was tested using the information collected from Murab Hospital, Ilorin, kwara State , Nigeria and compared with the existing traditional hospital system. The design provides excellent patient services and improved information infrastructure.

3. METHOD

The methodology adopted in this study is Object Oriented Hypermedia Design Methodology. The activities that is involved in Object Oriented Hypermedia Design Methodology are Requirement gathering, conceptual modelling, navigational design, abstract interface design, and implementation. This methodology is suitable for web application because it promotes design reuse, component reuse and enables users to have a better understanding of the application. The separation of various parts of web development paves the way for reusability and parallel development, effectively shortening the application development time, Karimpoor, & Sadighi, (2008).Conceptual modelling are built using the well-known object oriented modelling which involves class, subclass, attributes and its relationship, the navigational model is built as a view over the conceptual model and abstract interface design includes the way the different navigational object will look like. These objects are classes which are made up of attributes and function. The advantage of modelling a system as object makes the design, modification and implementation of the system easy. Very large project have adopted the object oriented technology due to these reasons mentioned and also due to the ability to build large class library. Object-oriented design and development is a very popular approach in today's scenario of software development environment. This approach improves software productivity, reusability and flexibility of software systems.



System Architecture of the New System



4. RESULTS AND DISCUSSION

The objective of the design is to implement a web based hospital integration platform for Nigerian Hospitals. Efficiently captures patients' bio data and store it efficiently for reference purpose. The system enables patients to communicate with the doctor online once their account is credited. The system allows the identification and retrieval of patient's record using unique identification code. It enables patient to lay their compliant online get medical attention for minor cases online. It allows doctors to review patients past medical history. It maintains the security of patients' records. The system enables the pharmacist to access the medication administer to the patient by the doctor.

Login Page

I. **Create patient information form part A.**

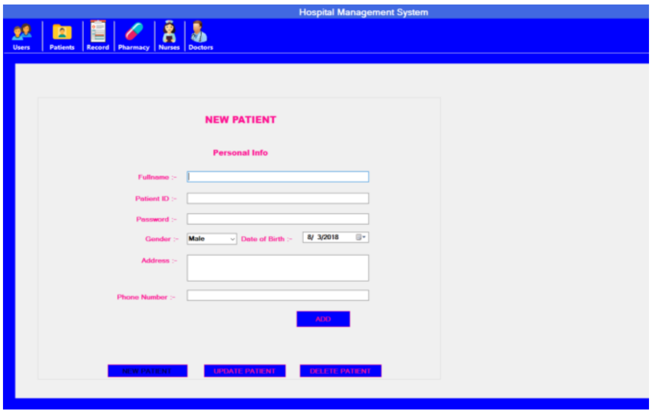


Figure 4.1 Create patient information form

This module deals with registering of new patients, for either OPD (Out-patient department) or IPD (In-patient department) and issuing unique identification numbers to the patients. These numbers are unique throughout the system. A patient is first registered at the OPD front office. If eventually the patient is admitted, the same number is used. The IPD / OPD identification number is used for tracking the medical records of the patient for any OPD visit or IPD admission.

All medical records of this patient are identified by this number. The number helps in a flexible search in finding the patient records. This number is assigned to the patient together with a patient card. The number will be used to track the patient record and medical history throughout the life cycle of the patent medical section.

II. II. Admin _create Department form

Figure 4.2 shows the create drug form. This form will be used by Admin to insert and modify records in the drug table.

Figure 4.2 Admin_ create drug form

This module is used to create a new staff in the hospital. When a Doctor, Nurse or any other staff is employed in the hospital, his or her information is entered into the system with a unique staff number.

III. **Diagnosis Form.**

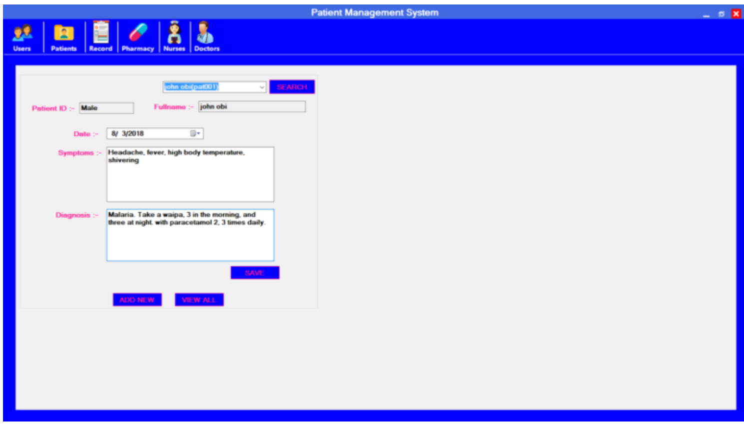


Figure 4.3 Diagnosis Form

The patients' diagnostic form is shown in Figure 4.3

Here all diagnosis is logged into the database serially according to the date and time. The doctor carrying out the diagnosis will have to provide his name, clinic or department, go through the previous diagnosis and then enter details of the new diagnosis.

IV. **User login form**

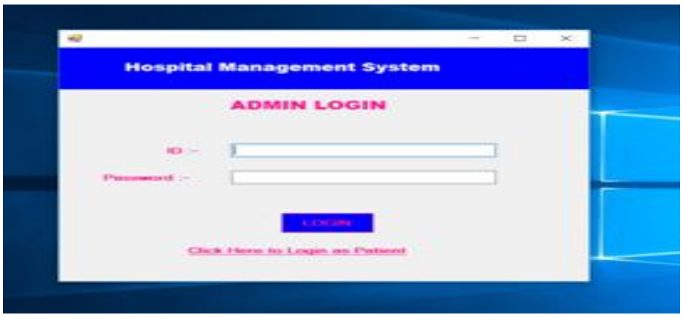


Figure 4.4 User login form

Figure 4.5 shows the user login form

When the software starts the user is presented with a log in page where he /she can enter login information (user name and password)

From the fields of the home page the user can choose a particular option. Menu items like admission, diagnosis, examination, laboratory, discharge, referral and death are selected by pointing with a mouse and clicking.

V. Patient login form.

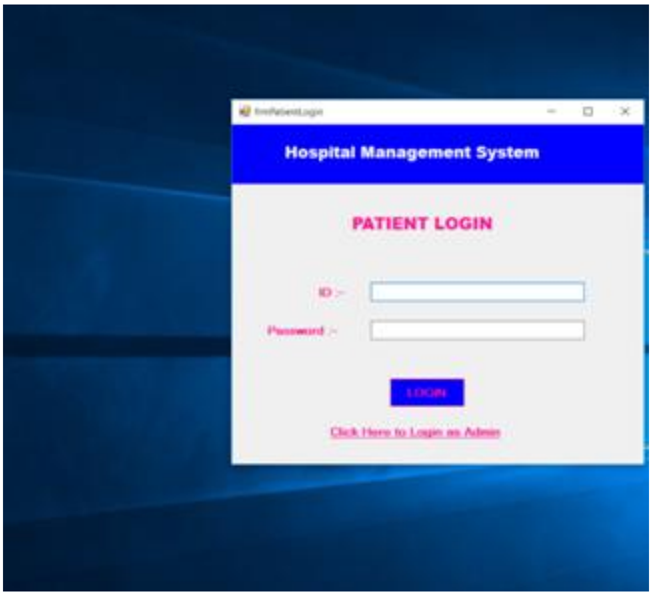
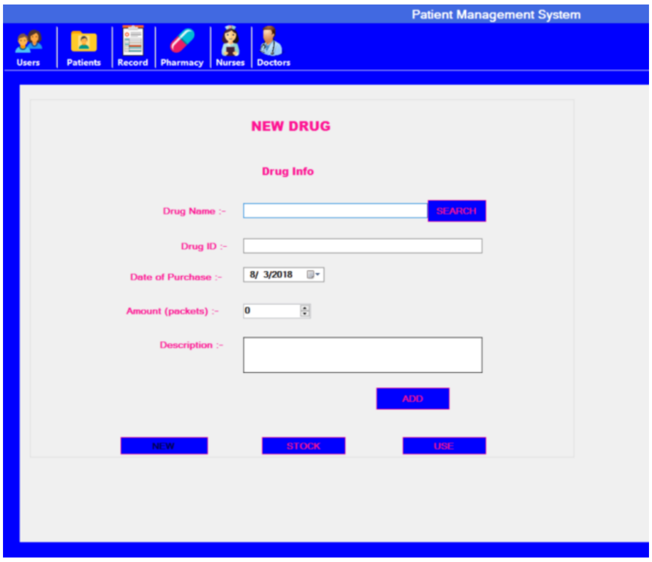


Figure 4.5 Patient login form

Figure 4.5 shows the patient login form This is the Login page for the Patient, when the logs in, he or she will be able to view his medical history and also will be able to book appointment with doctor by interacting with the doctor online.

VI Pharmacy form



The components of the Pharmacist module of the system include:

This module allows the pharmacist to create new drugs and also used to view drugs recommended by the doctor.

Patient module

The component of the student module of the system includes web pages that allows patient;

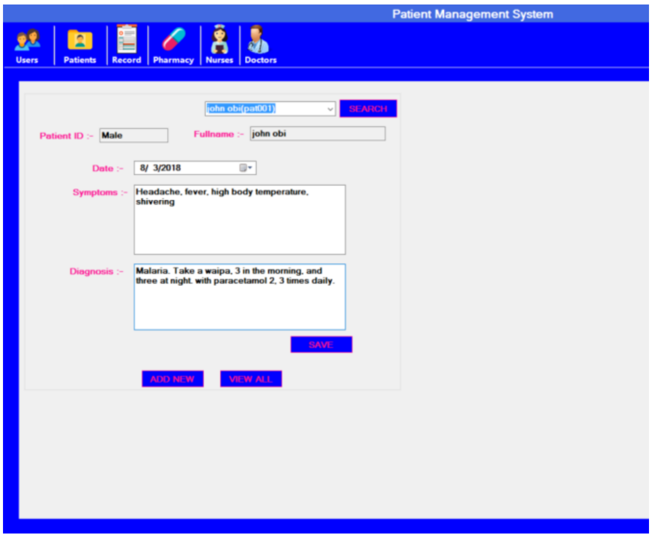
- A web page that allows patient view recommendation of the doctor online (live chat).
- A web page that allows patient enters complaints.

- This module deals with registering of new patients, for either OPD (Out-patient department) or IPD (In-patient department) and issuing unique identification numbers to the patients. These numbers are unique throughout the system. A patient is first registered at the OPD front office. If eventually the patient is admitted, the same number is used. The IPD / OPD identification number is used for tracking the medical records of the patient for any OPD visit or IPD admission.
- All medical records of this patient are identified by this number. The number helps in a flexible search in finding the patient records. This number is assigned to the patient together with a patient card. The number will be used to track the patient record and medical history throughout the life cycle of the patent medical section.

Diagnosis module

The components of the Pharmacist module of the system include:

- A web page that allows the pharmacist to view drugs prescribed by the doctor.



CONCLUSIONS

The system is developed to aid easy retrieval of patient file using the patient's unique code, provides platform to communicate with doctor online. It ensures the proper management of patient information. Finally system also reduces the queue of patient waiting to see the doctor for minor cases and reduces self-medication.

5.ACKNOWLEDGMENTS

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The Influence of Fluid Temperature on the Entrance Length of Developing Flow in the Upstream Pipe of Measuring Devices

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Abstract: The effect of temperature-dependent viscosity on the flow development behavior inside a circular pipe was studied. The development of centerline axial velocity is presented at different axial positions throughout the tail straight pipe of test section by measurements carried out experimentally using Pitot tube and computed numerically using ANSYS FLUENT 16 software code. The measurements were conducted for various flow rates depending on the control valve opening at two different temperature of fluid 30°c and 60°c. It was found that the computational results showed a good trend agreement with the experimental results. The influence of heat on the density and viscosity of fluid leads to increasing flow rate and Reynolds number. Therefore, it was observed that the hydrodynamic entrance length (Le) has been increased due to heating the fluid. The length Le was increased by 21.4% for the lower flow rate, which is more than the percentage obtained for the higher flow rate. The results also show that the values of centerline velocity for a fully developed region under heated conditions have been changed slightly compared to unheated conditions. Ultimately, a proper placement of the flow measuring device was determined to measure the flow rate accurately.

Keywords: Developing pipe flow; Hydrodynamic entrance lengths; fully developed; Heating effect; CFD; Flow meter; Calibration.

1. INTRODUCTION

Accurate flow measurement has an appreciable and significant influence on the management of any type of fluid systems which daily measures rates of heated fluids. Any error in the measurements may cost the consumer lots of money if the error has not been corrected. For this reason, there is interest to find any information that improves the accuracy of flow measurements.

Particularly, the hot fluid is used in critical applications such as thermal fluid system, calibration systems, and crude oil transportation. As the fluid temperature rises, fluid viscosity and density decreases. The average speed of the molecules in a liquid increases with raising the fluid temperature. Consequently, the fluidity tends to be fast. The Reynolds number changes due to the change in velocity, density, and viscosity. For example, the high viscosity of crude oil causes high-pressure drop along pipelines. This requires larger energy and a higher cost of transportation. The heating of the crude oil is one method of several technologies used to improve flow properties. The heated crude oil is transported economically, but the flow rate must be measured accurately.

Therefore, it is of interest to find the effect of fluid temperature on the development of the entrance length for developing flow in a pipe. This hydrodynamic entrance length is defined as the distance of pipe required to have flow with constant velocity profile, after which installation of the flow measuring device is recommended. The accurate flow measurement in a circular pipe is located at the fully developed region. The starting location of the fully developed flow is determined by many criteria. The most commonly used criterion is the location where the centerline axial velocity reaches 99 percent of the fully developed value [1],[2]. Knowledge of the entrance length of the pipe before the fully developed flow region upstream of the measuring device is important. The non-varying velocity profile in the axial direction has long been recognized to get steady flow without any fluctuations in order to achieve a chance for accurate flow measurements [3].

Developing laminar flows in circular tubes have been studied for two different types of oil while the tube is subjected to constant heat flux. For the same wall heat flux, the effect of viscosity variation on the development of centerline axial velocity is greater at low Reynolds number because of the lower velocities. The effect of viscous dissipation consistently increases with Brinkman number of constant heat flux $Br = (\mu u^2/q_w D)$, which is a dimensionless number related to heat conduction from a wall to a flowing viscous fluid, where μ is the dynamic viscosity, u is average flow velocity, q_w is the wall heat flux and D is the pipe diameter [4].

Shivani T. Gajusingh and M. H. K. Siddiqui [5] provided the comparison of velocity profiles of flow in the presence and absence of bottom heating wall of a square channel under the same operating conditions at varies mass flow rates. The results showed that both mean streamwise velocity and velocity profiles are affected by wall heating. Furthermore, the influence of wall heating on the flow behavior is different for laminar and turbulent flows. The magnitudes of mean streamwise velocity component for the unheated conditions are greater than that for heated conditions when the heat was added from below for turbulent flow cases, but the opposite trend is observed for laminar flow cases in the close vicinity of the wall. The results also showed that the laminar flow becomes turbulent with heat addition due to a reduction in density and viscosity of the fluid.

Nicholl [6] studied the effects of heating on a fully turbulent boundary layer for stable and unstable stratification at low Reynolds numbers of air in a wind tunnel. The difference between the temperatures of the wind tunnel wall and free stream ranged from 20 to 100 °C. He observed that for unstable case (heated floor or roof), the mean velocity near the inlet upstream of the heated plate are larger in magnitude with respect to the velocities further far downstream of the heater.

Keisuke and Masamoto [7] studied the effect of unstable thermal stratification on the flow structure in the wall region between horizontal parallel plates. They measured longitudinal velocity (velocity in horizontal x-direction), vertical velocity (velocity in the vertical y-direction) and temperature fluctuations in the wall region of fully developed turbulent flow for a range of Reynolds and Richardson numbers. They observed that in the wall region of $y^+ < 50$, the longitudinal velocity fluctuations increase with an increase in the instability of stratification (Richardson number) but the vertical velocity fluctuations decrease in the region of $y^+ < 75$. In the outer region of $y^+ > 100$, the longitudinal velocity fluctuations are almost constant. The trend of the vertical velocity fluctuations increases with increasing instability of stratification, on the contrary, the case at region $y^+ < 75$. They also found that unstable stratification has no effect on the temperature fluctuation in the region of $y^+ < 25$ but the intensity of temperature fluctuations increases slightly with the Richardson number in the outer region. The wall coordinate, y^+ is a dimensionless distance and an accurate way of determining the distance from the wall to specific data point in the velocity profile.

This literature survey indicates that the flow structure and velocity are highly affected by the addition of heat to the fluid. Consequently, the required length for developing the flow along the pipe is affected by heating the fluid.

Lynn et al [8] used S-type Pitot tube to obtain fluid velocity profiles and average velocity at the center of high water tunnel facility (HWTF, High pressure water tunnel facility) at low flow rates with velocity range 5-30 cm/s and compared the Pitot tube measurements with the Particle imaging velocimetry (PIV) measurements in the center of the HWTF to confirm the Pitot tube results in this region. It was found, as shown in Figure 1, that the Pitot tube results showed satisfactory trend and agreement with PIV results.

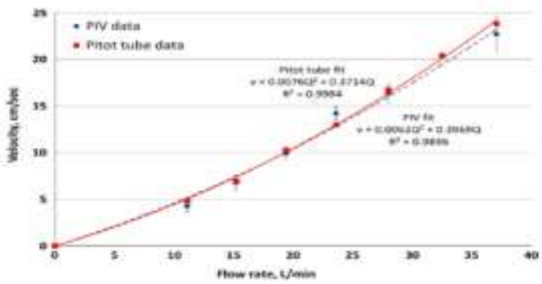

Figure 1 Verification of Pitot tube velocity accuracy by comparing it with PIV measurement [8].

Boetcher and Sparrow [9] demonstrated the error of Pitot tubes for measurements of low flow rate by experimental study at low Reynolds number. They showed that the viscous effect becomes considerable for Re < 100 causes a change of the pressure coefficient $C_p = (p_{stag} - p_{\infty}/0.5\,\rho v_{\infty}^2)$ by 2%. this change corresponds to 2-5% velocity error for Re < 50. The pressure coefficient is a parameter used to study the flow of incompressible fluids such as water, where p_{stag} is the stagnation pressure , p_{∞} is free stream static pressure , ρ is the fluid density and v_{∞} is the uniform flow velocity.

Buscarini, et al [10] showed that the calibration coefficient C_d of pitot tube used to correct the value of velocity using this equation $V_i = (C_d\sqrt{2\Delta p/\rho})$, where V_i is the velocity at point i, ΔP is the measured differential pressure between total pressure and static pressure at point i and ρ is the fluid density. They found that the value of C_d varies with Reynolds number, usually most variation happens at lower Reynolds numbers and the C_d may be greater than 1.0. For high Reynold number, the C_d varies between 0.88 and 0.86 with a mean value of 0.87.

Sotero and Brentan [11] computed the water flow rate based on the centerline velocity which was determined using Pitot tube and compared the results of the physical model with results of computational fluid dynamics (CFD) model to obtain a correction factor. They calculated the average flow velocity $V_{m_{CFD}}$, and the centerline velocity $V_{c_{CFD}}$ from the CFD model and defined a correction factor from the ratio $K_{CFD} = (V_{m_{CFD}}/V_{c_{CFD}})$. Through the actual measurements of the centerline velocity $V_{c_{physical}}$ by Pitot tube, they obtained an actual average velocity from the equation $V_{m_{physical}} = (V_{c_{physical}} * K_{CFD})$ and then the flow rate Q may be equal $Q = (V_{m_{physical}} \times A)$.The study showed an alternative way for computational flow rate based on centerline axial velocity measured using Pitot tube and the correction factor obtained from velocity profile modeled with CFD. The CFD model used to predict the behavior of installation and allow measurement of actual flow rate.

This literature survey shows that the Pitot tubes are used widely in the water flow measurement and calibration of flow meter in water supply companies. The advantage of Pitot tubes is that they can be used for wide range of pipe diameters and they can be easily installed and do not require interruptions or removal of the measuring device, which allows the calibration of the flow meters in the field [12], [13]. Therefore, using Pitot tubes to measure the centerline axial velocity at different axial positions is a matter of practice. This review also indicates that the calibration coefficient C_d is varying and depending on Reynolds number but in general $C_d = 1$ is accepted for an ordinary flow of most practical engineering purposes. For low flow rates the C_d value may be greater than 1.0 because of the viscosity effect.

2. GOVERNING EQUATIONS

The flow is considered to be incompressible, steady, and the fluid flows symmetrically in the pipe. The two dimensions of governing equations are:

The continuity equation

$$\frac{\partial(v_x)}{\partial x} + \frac{1}{r}\frac{\partial(rv_r)}{\partial r} = 0$$

The momentum equations

x-component

$$\rho\left(v_x\frac{\partial v_x}{\partial x} + v_r\frac{\partial v_x}{\partial r}\right) = -\frac{\partial p}{\partial x} + \mu\left(\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_x}{\partial r}\right) + \frac{\partial^2 v_x}{\partial x^2}\right)$$

r-component

$$\rho\left(v_x\frac{\partial v_r}{\partial x} + v_r\frac{\partial v_r}{\partial r}\right) = -\frac{\partial p}{\partial r} + \mu\left(\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_r}{\partial r}\right) + \frac{\partial^2 v_r}{\partial x^2}\right)$$

The energy equation

$$\rho\, C_p\left(v_x\frac{\partial T}{\partial x} + v_r\frac{\partial T}{\partial r}\right) = -p\ div\ v + \left(\tau_{xx}\frac{\partial v_x}{\partial x} + \tau_{rx}\frac{\partial v_x}{\partial r} + \tau_{xr}\frac{\partial v_r}{\partial x} + \tau_{rr}\frac{1}{r}\frac{\partial(rv_r)}{\partial r}\right) + div\left(K_f\, grad\, T\right)$$

where v_x and v_r are the velocity components in x and r directions respectively, ρ is the density of fluid, p is the static pressure, μ is the fluid viscosity, C_p is the specific heat at constant pressure, T is the absolute temperature, v is fluid velocity in the spatial coordinate, τ_{xx},τ_{rx},τ_{xr} and τ_{rr} are the viscous stresses and K_f is the thermal conductivity of fluid. The CFD simulations were based upon the standard two-equation k-ε turbulence model which is the most suitable for turbulent flows in a channel or pipe flow [14].

3. MODELING DETAILS

The geometry of the presented two-dimensional problem is shown in Figure 5. The pipe boundaries consist of a wall, centerline axis, inlet, and outlet. The inlet pipe to the test section has a length L_d with diameter d followed by a diffuser section of length L while the tail straight pipe of the test section has a length L_D with diameter D. The reference point of the x-axis origin starts at the end of the diffuser. The dimensions of the test section are listed in Table 1.

Table 1. Dimensions of the test section

Pipe	
Diameter d	1.905 cm (0.75 inch)
Diameter D	3.810 cm (1.5 inch)
Length L_d	15 cm
Length L_D	165 cm
Length L	5 cm

The mesh generation and size are an important step to control the time-consumption of the CFD simulation. The grid independence test and its reflection on the centerline velocity of the fully developed flow with several grid sizes from coarse to very fine mesh are listed in Table 2.

Table 2. Mesh independence of computational domain

Grid no.	Gird size (m)	No. of meshing element	Centerline velocity of a fully developed region (m/s)
1	1.59E-03	53756	1.472
2	1.06E-03	94538	1.476
3	9.07E-04	119398	1.482
4	7.93E-04	144092	1.482

The variation of centerline axial velocity V_{cent} of the four mesh cases is plotted along the x-direction of the tail straight pipe L_D of test section compared with each other as shown in Figure 2, where the plot begins with x = 23cm. The results of the mesh independence test should follow the similarity of the nearest value. The two finest grid distribution seems to follow the same tendency in a sufficient manner. It has assumed that the grid with N=119398 is sufficient for acceptable accuracy of the solution. The grid distribution is displayed for the geometry of the test section in Figure 3.

Adequate boundary conditions which describe the fluid flow physics must be defined in the CFD solver. For the inlet boundary, the computed initial values of the velocity for each flow rate are indicated in table 3. For the outlet boundary of the model, the value of outlet gauge pressure is considered 100 kPa as the mean value. The wall is stationary, no-slip conditions are applied. The centerline is set to be the x-axis, where the origin starts from the end of the diffuser. The water is used as a working fluid.

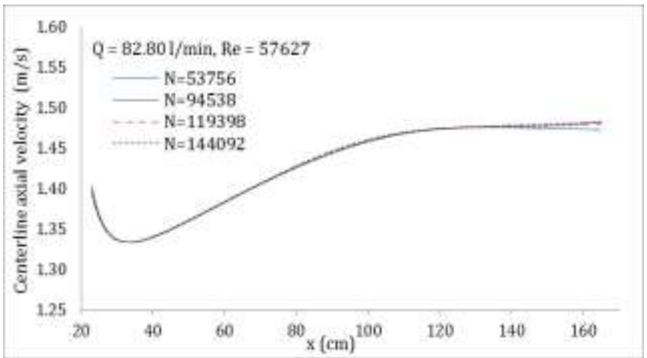

Figure 2 Comparison of centerline axial velocity development for different meshes

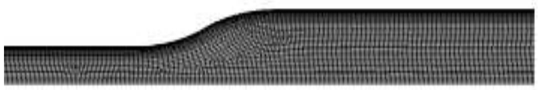

Figure 3 Mesh distribution of computational domain

4. EXPERIMENTAL WORK

A schematic diagram of the used facility to perform the experiments is shown in Figure 5. The system consists of a closed loop circuit. The main components of the system are storage tank, centrifugal pump, flow meter, and test section. The electric heater is located inside the stainless steel storage tank. The fluid is circulated in a closed loop by stainless steel centrifugal pump of 750-watt motor power. A positive displacement flow meter was used to measure the flow rate. The test section is placed between a reference positive displacement meter and meter under test. Five L-type Pitot tubes were installed at five different positions to measure centerline axial velocity as shown in *Figure 6* and *Figure 7*. The pitot tubes are connected to an inverted U-tube manometer.

The variation of centerline axial velocity was investigated under unheated and heated conditions through the tail straight pipe of test section. The hydrodynamic entrance length L_e to a fully developed region has been determined downstream of diffuser section, where L_e starts at the tail straight pipe inlet of test section, just after the end of the diffuser section where x is taken to be zero. This study was carried for three cases of flow rates related to the orifice size of the valve. Case I refers to 34% valve opening, case II refers to 51% valve opening, case III refers to a fully opening of the valve. For each case, two flow rates are measured corresponding to the same valve opening, one for unheated conditions and one for heated conditions as shown in

Table 3. The temperature of the water T is the main difference between unheated and heated conditions. Its impact on the flow rate and Reynolds number is shown in Figure 8 and Figure 9 respectively.

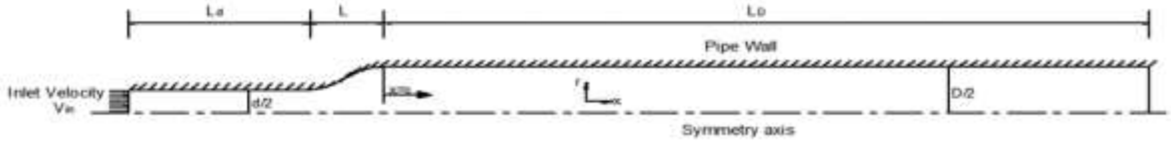

Figure 4. Line diagram of the computational domain

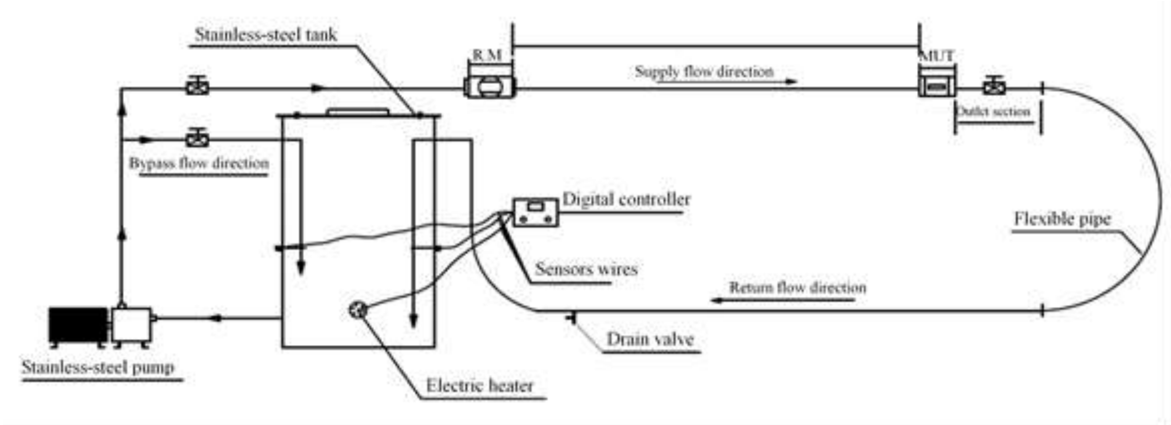

Figure 5. Schematic diagram of the flow meter calibration system.


Figure 6.Test section.

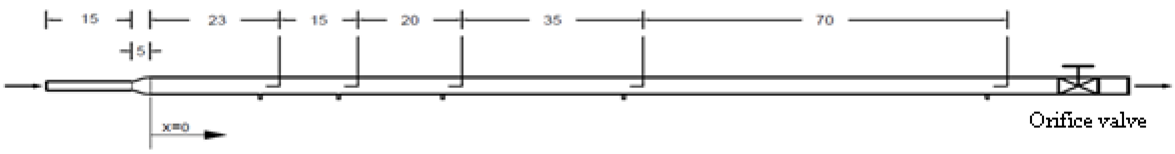

Figure 7. The layout of the test section

Table 3. Flow characteristics

Case		I	II	III
Valve opening (%)		34	51	100
Measured flow rate Q (l/min)	Unheated	60.30	71.10	82.80
	Heated	61.40	72.90	84.90
Average inlet velocity V_{in} (m/s)	Unheated	3.53	4.16	4.84
	Heated	3.59	4.26	4.97
Reynolds number *Re* $Re = \frac{\rho V_{in} d}{\mu}$	Unheated	41967	49484	57627
	Heated	72191	85712	99821

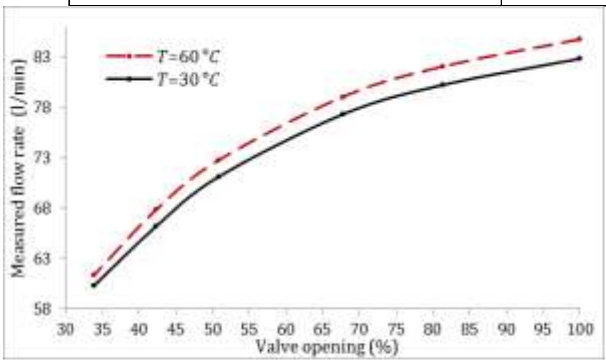

Figure 8. Measured flow rate versus orifices of the valve.

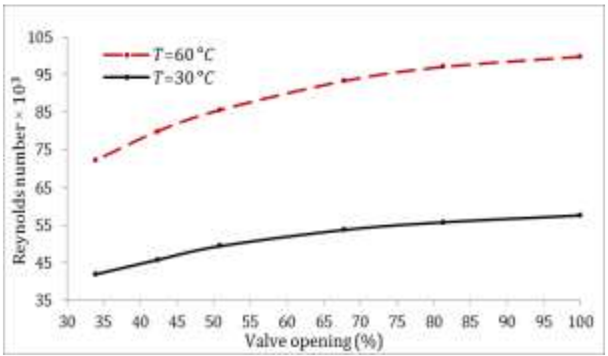

Figure 9. Reynolds number versus orifices of the valve for unheated and heated conditions.

The test procedures during the experiments are described as follows:

1. The tank was filled with working fluid.
2. The fluid was heated by using an electric heater to raise its temperature up to the required value. To compensate any heat losses a digital controller was used to set and preserve the fluid temperature at a constant value.
3. The pump was turned on and the fluid was forced through the closed loop circuit.
4. The positive displacement flow meter was adjusted to measure the flow rate. The desired flow rate was achieved using the orifice valve.
5. After steady-state conditions were achieved and during the test run, the fluid temperature in the test section was recorded using thermocouples, the center line axial velocity was recorded using Pitot tubes and the average flow rate was recorded using a positive displacement meter. All these parameters were recorded simultaneously.
6. The same procedures were repeated for all cases at different temperatures.

5. RESULTS AND DISCUSSION

The development of centerline axial velocity was measured experimentally along the tail straight pipe of test section at five different axial positions and compared with the numerical results. The flow enters the test section with specified velocity and then the centerline axial velocity decreases dramatically due to enlargement of diameter, and then increases gradually to reach asymptotically a constant value at the so-called fully developed flow.

The variation of centerline axial velocity for unheated conditions is presented experimentally and numerically in Figure 10, where the flow rate was 60.30 l/min and Reynolds number was 41967. The fully developed experimental centerline axial velocity is 1.04 m/s while the computed numerical value is equal to 1.09 m/s. It was observed that the location of fully developed region starts approximately at $L_e = 117cm$. For heated condition, where the measured flow rate was 61.40 l/min and Reynolds number was 72191 for the same valve opening as unheated case, the centerline axial velocity is presented in Figure 11 and Figure 12. The effect of heating on the centerline axial velocity is very small. The fully developed experimental centerline axial velocity is 1.03 m/s while the computed numerical value is equal to 1.09 m/s. It was observed that the hydrodynamic entrance length L_e has been increased to more than 142 cm downstream of the expansion section due to the heating effect.

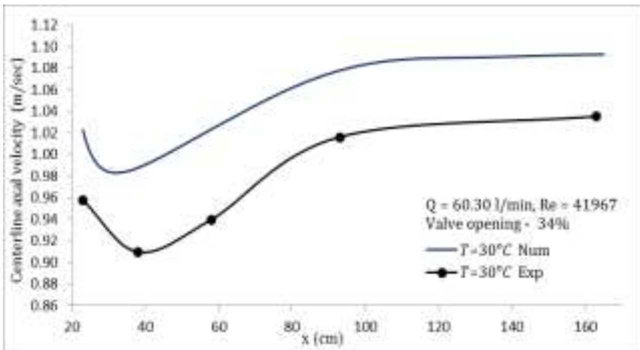

Figure 10. Centerline axial velocity development for unheated conditions of Case I.

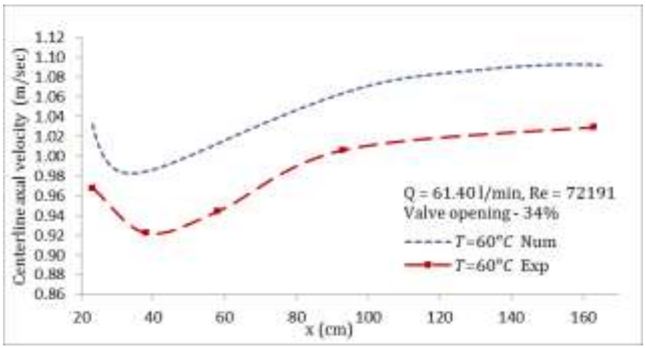

Figure 11. Centerline axial velocity development for heated conditions of Case I.

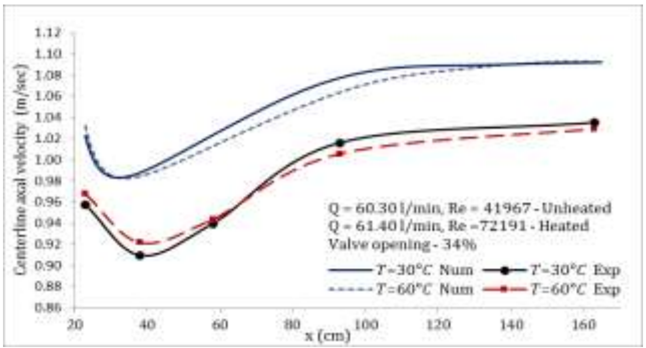

Figure 12. Centerline axial velocity development for unheated and heated conditions of Case I.

The variation of centerline axial velocity for unheated and heated conditions of case II is presented experimentally and numerically in Figure 13. For unheated conditions, where the flow rate was 71.10 l/min and Reynolds number was 49484, the fully developed experimental centerline axial velocity is 1.22 m/s while the computed numerical value is equal to 1.28 m/s. It was observed that the location of a fully developed region starts approximately at $L_e = 121\ cm$. For heated conditions, where the flow rate was 72.90 l/min and Reynolds number was 85712 for the same valve opening as unheated case, the effect of heating is extremely small on the centerline axial velocity. The fully developed experimental centerline axial velocity is 1.21 m/s while the computed numerical value is equal to 1.28 m/s. It was observed that the hydrodynamic entrance length has been increased to more than 144 *cm* downstream of the expansion section due to heating effect.

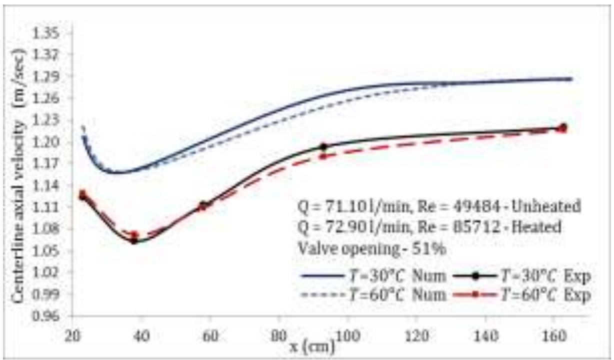

Figure 13. Centerline axial velocity development for unheated and heated conditions of Case II.

The variation of centerline axial velocity for unheated and heated conditions of case III is presented experimentally and numerically in Figure 14. For unheated conditions, where the flow rate was 82.80 l/min and Reynolds number was 57627. The fully developed experimental centerline axial velocity is 1.36 m/s while the computed numerical value is equal to 1.48 m/s. It was observed that the location of a fully developed region starts approximately at $L_e = 133\ cm$. For heated conditions, where the flow rate was 84.9 l/min and Reynolds number was 99821 for the same valve opening as unheated case, the effect of heating is also extremely small on the centerline axial velocity. The fully developed experimental centerline axial velocity is 1.38 m/s while the computed numerical value is equal to 1.49 m/s. It was observed that the hydrodynamic entrance length has been increased to more than 154 *cm* downstream of the expansion section due to the heating effect.

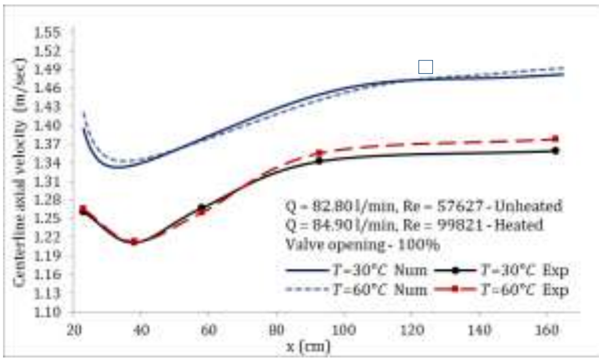

Figure 14. Centerline axial velocity development for unheated and heated conditions of Case III.

The change of the hydrodynamic entrance lengths L_e is determined from $x = 0$ as a function of the measured flow rate for all cases as presented in Figure 15. It is observed that for heated cases, L_e was increased by 21.4% for case I, 19.5% for case II, and 16.1% for case III. The increase of the flow rates due to heating is about 1.7% to 2.3% for all cases.

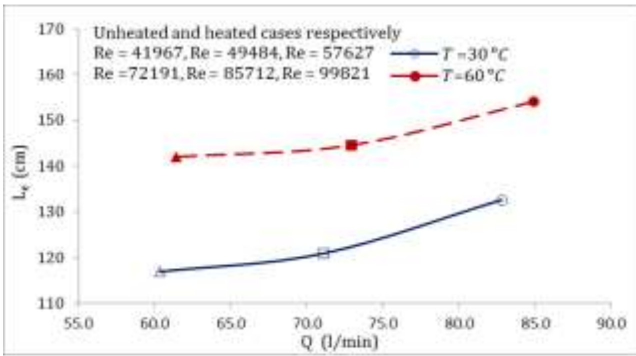

Figure 15. Hydrodynamic entrance length L_e as a function of measured flow rate (Indirectly valve opening) for heated and unheated conditions. case I (△), Case II ( ), Case III (○). Open symbols: unheated conditions; filled symbols: heated conditions.

6. CONCLUSION

An experimental and numerical study was conducted to investigate the influence of heat on the hydrodynamic entrance length of developing pipe flow. The development of centerline velocity is presented at different axial positions throughout the tail straight pipe of test section by measurements carried out experimentally using Pitot tube and computed numerically using ANSYS FLUENT 16 software code. Flows were simulated with a lengthy tail pipe L_D to cover the developing and fully developed flow region. The measurements were conducted for various flow rates in case absence and presence of heat. It was found that the computational results show a good trend agreement with the experimental results. The results have been shown that the influence of heat on density and viscosity lead to increasing flow rate and Reynolds number, that is why the hydrodynamic entrance length has been increased. The L_e increased by 21.4% for case I, 19.5% for case II and 16.1% for case III. The results also show that the magnitude of the centerline axial velocity for the fully developed region under heated conditions has been changed slightly compared to unheated conditions. For heated water up to 60°C, the recommended distance of the hydrodynamic entrance length is equal to 45D, it has been determined as a proper placement of the measuring device to measure the flow rate accurately for all cases.

Nomenclature

Q	Measured flow rate
A	Cross section area
v_x	Component of velocity in x direction
v_r	Component of velocity in y direction
v	Fluid velocity in the spatial coordinate
x	Axial coordinate along the pipe
r	Radial coordinate across the pipe
C_p	Specific heat at constant pressure
T	Absolute temperature of fluid
$\tau_{xx}, \tau_{rr}, ..$	Viscous stresses
K_f	Thermal conductivity of fluid
N	Number of Meshing element
L_d	length of the inlet pipe
L	length of the diffuser section
L_D	length of the tail straight pipe
D	Diameter of the tail straight pipe
d	diameter of the inlet pipe
Re	Reynolds number
ρ	Density of fluid
V_{in}	Average inlet velocity
μ	Dynamic viscosity of fluid
L_e	Hydrodynamic entrance length

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