Estd. 1962
"A++" Accredited by NAAC (2021)
with CGPA 3.52

SHIVAJI UNIVERSITY, KOLHAPUR

JOURNAL OF SHIVAJI UNIVERSITY : SCIENCE AND TECHNOLOGY

(Peer Reviewed Journal)

Volume-43, Issue-2 (July, 2017)

ISSN Science-0250-5347

JOURNAL OF SHIVAJI UNIVERSITY : SCIENCE AND TECHNOLOGY

(Peer Reviewed Journal)

Volume-43, Issue-2 (July, 2017)

ISSN Science-0250-5347

Estd. 1962
"A++" Accredited by NAAC (2021)
with CGPA 3.52

Shivaji University

Kolhapur 416 004 (INDIA)

JOURNAL OF SHIVAJI UNIVERSITY : SCIENCE AND TECHNOLOGY

(Peer Reviewed Journal)

Volume-43, Issue-2 (July, 2017)

ISSN Science-0250-5347

- Contact Details -
Prof. (Dr.) S. D. Delekar
Editor, Journal of Shivaji University : Science and Technology
and
Department of Chemistry
Shivaji University, Kolhapur 416 004 (India)
E-mail : editor.jscitech@unishivaji.ac.in
website : http://www.unishivaji.ac.in/journals/

Shivaji University, Kolhapur

JOURNAL OF SHIVAJI UNIVERSITY :
SCIENCE AND TECHNOLOGY

(Peer Reviewed Journal)

Volume-43, Issue-2 (July, 2017)

ISSN Science-0250-5347

- Editor -
Prof. (Dr.) S. D. Delekar
Journal of Shivaji University :
Science and Technology

- Published by -
Dr. V. N. Shinde
Ag. Registrar,
Shivaji University, Kolhapur 416004.

- Printed by -
Shri. B. P. Patil
Superintend
Shivaji University, Kolhapur 416004.

The Editor, on behalf of the Editorial Board of the Journal of Shivaji University : Science and Technology, Vol. No. 43 (2) whises to express his thanks to the contributing authors and the experts for acting as referees for the papers included in the issue.

Published : July, 2023

Journal of Shivaji University: Science and Technology
Volume-43 (2) (July, 2017)

INDEX

Department of Technology

Shivaji University, Kolhapur

Journal of Shivaji University : Science & Technology

Volume-43 (2) (July, 2017)

Design, Verification and Implementation of An Optimized 8-bit ALU with 16 Opcodes

Shamkumar B. Chavan[a,*], Rajanish K. Kamat[b]
[a]Department of Technology, Shivaji University, Kolhapur 416 004 (MS) India
[b]Department of Electronics, Shivaji University, Kolhapur 416 004 (MS) India
*Corresponding author: sbc_tech@unishivaji.ac.in

ABSTRACT
The Arithmetic Logic Unit (ALU) is any processor and controller's important unit that performs arithmetic and logic operations. This work focuses on designing, verifying, and implementing an optimized 8 bit ALU capable of performing 16 different operations. Based on ALU's operation, it generates carry, auxiliary carry, borrow and zero flag. The ALU design is scripted in VHDL. The test bench is created with various inputs and functionality is verified on the ISE simulator for various opcodes. The proposed ALU is configured in Xilinx FPGA and its functionality is validated. The paper further proposes different optimization techniques for the said ALU taking advantage of the bit-slice architecture such as Carry Look Ahead Adder for speeding up the carry propagation process, Dynamic bit slice, Bit slice register, Bit slice pipeline, Memory reuse and Bit map design.

KEYWORDS
ALU, Dynamic bit slice, Bit slice register, Bit slice pipeline, Memory reuse and Bit map design

……

1. INTRODUCTION

The Arithmetic logic unit (ALU) is the central unit of processors. The performance of ALU determines the speed of the processor. Many researchers have developed ALU using different techniques; the main focus is on speed improvement, the lower requirement of transistors and power optimization. The GDI-based technique is used for ALU implementation [1], resulting in low power consumption and fewer transistors for implementation. Another approach for implementation of Gdi based ALU is described [2], in which separate multiplexers are used to perform arithmetic and logical operations. It is implemented using 90nm and 45nm technology using cadence tools, and the speed in 45nm technology is found to be higher than 90nm. 8 bit ALU is implemented in 45nm technology using Mentor Graphics tools; the authors observed a reduction in power dissipation, area and time delay. Wong Hui et al. [3] designed low power ALU using the GDI technique; the authors found that the circuit complexity was reduced and speed improved. Booth algorithm multiplier

`

based 8 bit ALU is designed, and it is performance tested [4]; authors observed the improvement in operational speed compared to regular multipliers. The design is tested on a Spartan 2 device. For power saving purposes

Subthreshold Adiabatic Logic technique is used [5] for ALU implementation; in these separate entities of decoders, multiplexers are designed and then integrated to form the ALU. Using the SAL technique, simulation is performed using Cadence 45nm technology; the authors found a 40 dB reduction in power consumption. A Hybrid 8 bit ALU is designed [6], which is based on Gate Diffusion Technique (GDI) and Substrate biasing technique (SBT); authors observed the merits like less surface area, low power consumption and higher speed. Design approaches for 8 bit and 16-bit ALU are discussed [7].

2. DESIGN AND VERIFICATION

In this work, 8-bit ALU is designed to perform 16 numbers of operations. It provides 16-bit output. Further, it generates four numbers of flags like carry, auxiliary carry, borrow and zero flag. **Figure-1** shows the model of ALU under design. In **Table-1**, the opcodes and corresponding operations of ALU are described. The ISE generates optimized circuits for VHDL programs. The essential arithmetic and logical operators are used to design the ALU circuit.

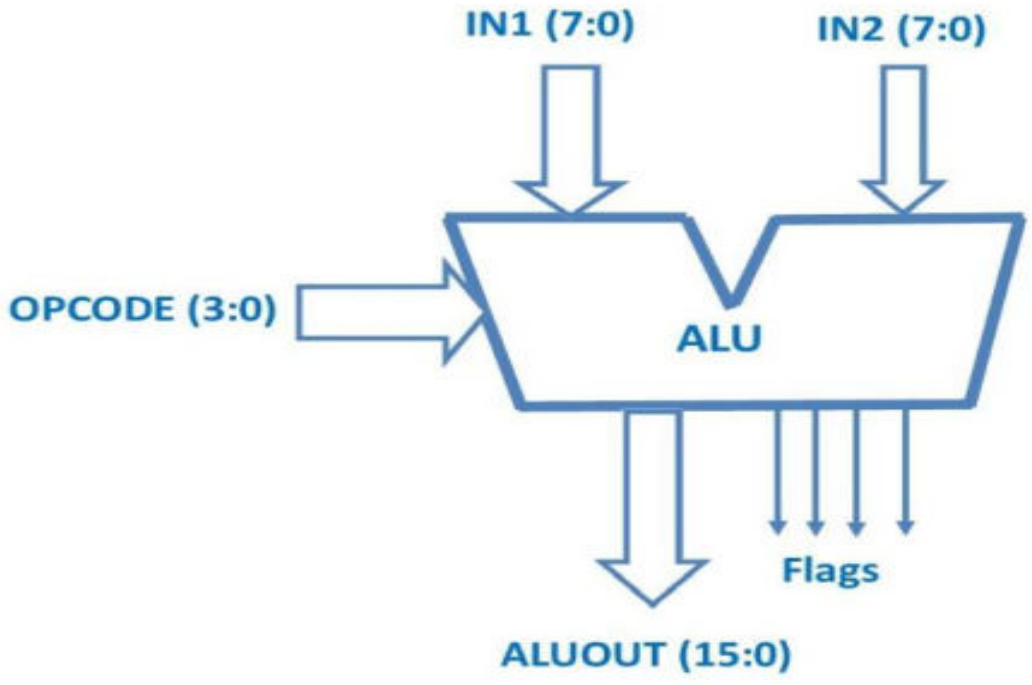


Figure-1. Model of 8-bit ALU with 4-bit opcodes.

Operations to be performed by ALU for every opcode are given in **Table-1**.

Table-1. ALU operations

Opcode	ALU operations
0000	Addition of two 8 bit inputs with flags update
0001	Subtraction of two 8 bit inputs with flags update
0010	Multiplication of two 8 bit inputs with flags update
0011	Division by 2 of IN1 vector
0100	AND operation between two 8 bit inputs
0101	OR operation between two 8 bit inputs
0110	Complement operation of IN1
0111	NAND operation between two 8 bit inputs
1000	XOR operation between two 8 bit inputs
1001	NOR operation between two 8 bit inputs
1010	XNOR operation between two 8 bit inputs
1011	Circular left shift by 1 bit of IN1
1100	Circular right shift by 1 bit of IN1
1101	Arithmetic comparison of 2 input vectors
1110	Nibble exchange of IN1, result outs at ALUOUT
1111	Exchange of input vectors, result outs at ALUOUT

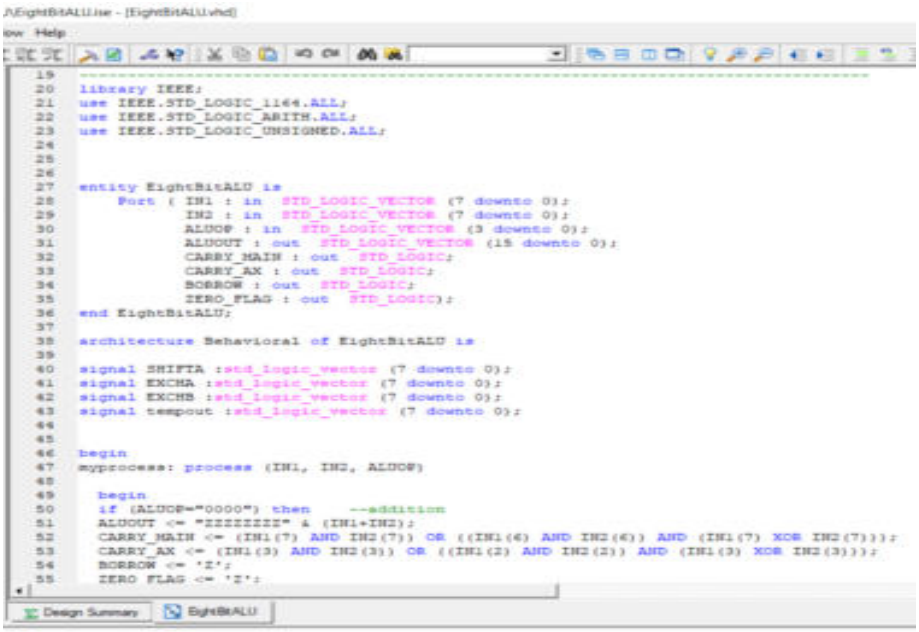


Figure-2. VHDL Code for proposed entity of ALU.

The proposed ALU performs required unique arithmetic and logical operation for a particular opcode as depicted in **Table-1**. Sixteen numbers of unique operations are assigned by opcodes. The code is written in VHDL language. **Figure-2** shows the code for entity with reference to the model in developed in **Figure-1**. The top view model of entity is shown in **Figure-3**. The RTL schematic is shown in **Figure-4**.

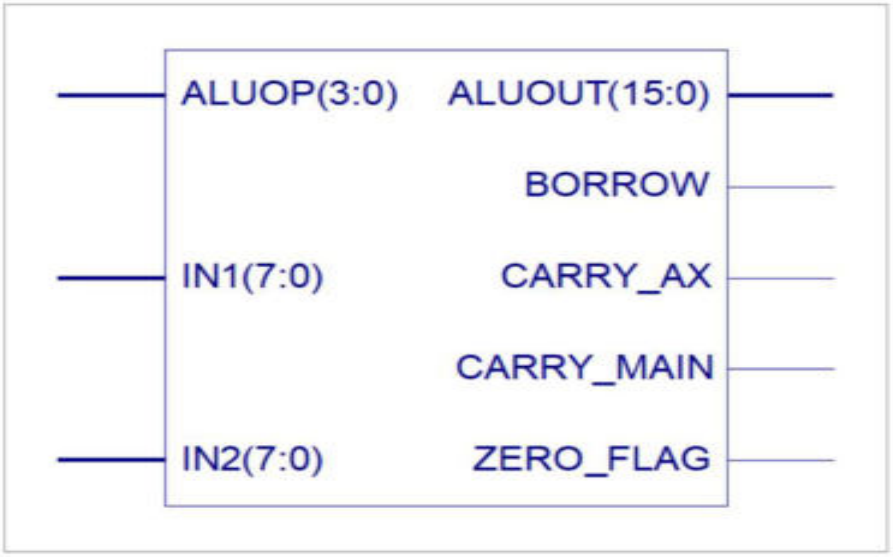


Figure-3. Proposed ALU entity.

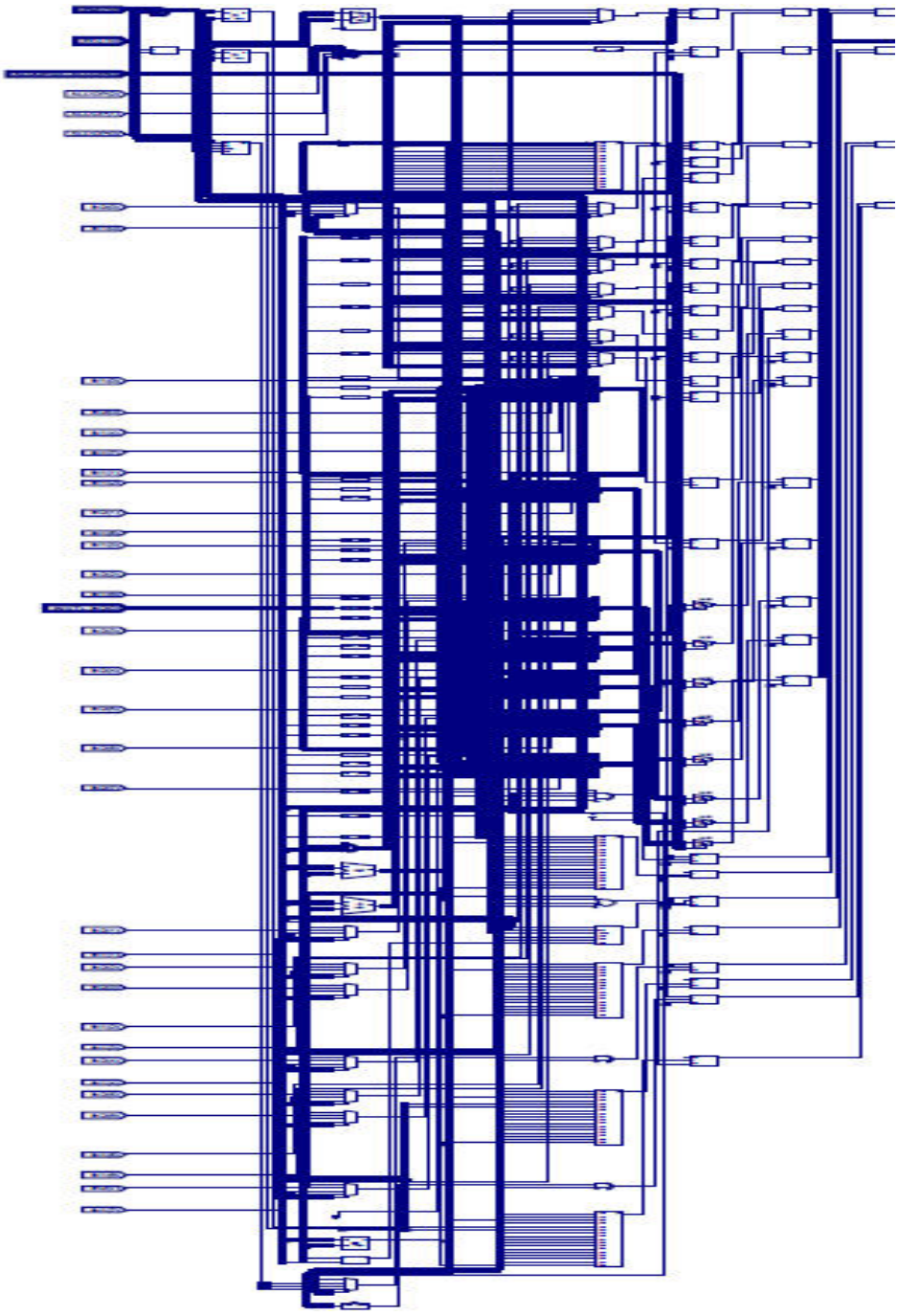


Figure-4. RTL schematic of proposed ALU.

The arithmetic and logical operations are performed using appropriate keywords in VHDL. Results are verified for input vectors of IN1 = 10101111 , IN2 = 11111111 and the opcode is changed from 0000 to 1111 (see **Figure-17**).

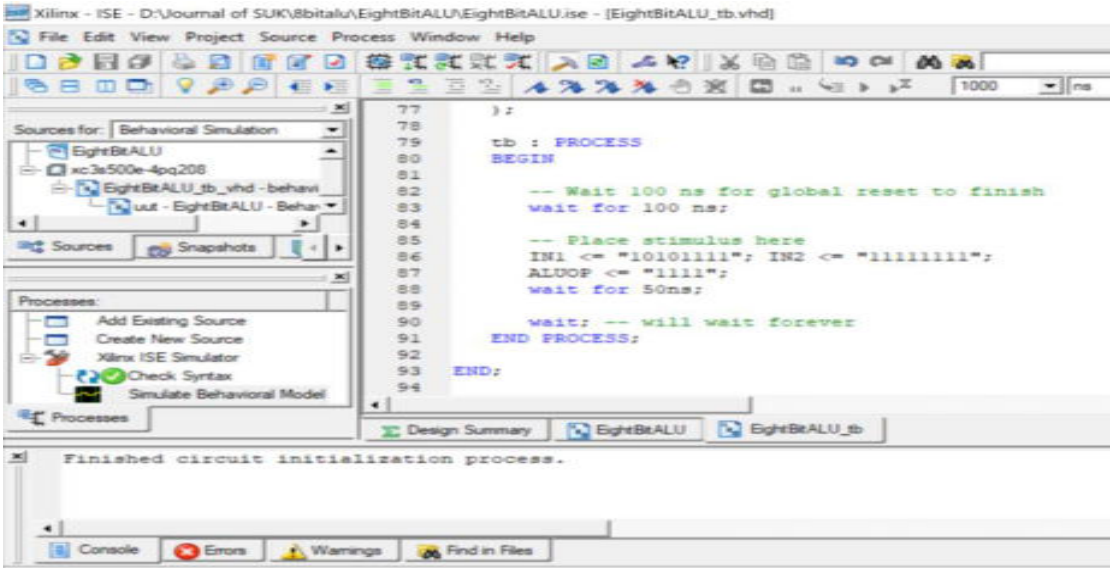


Figure-5. Test bench.

Case 1) Opcode – 0000 (Addition operation) (see **Figure-6**).

10101111 (AFH) => IN1

\+

11111111 (FFH) => IN2

---

1 10101110(1 AEH) => ALUOUT

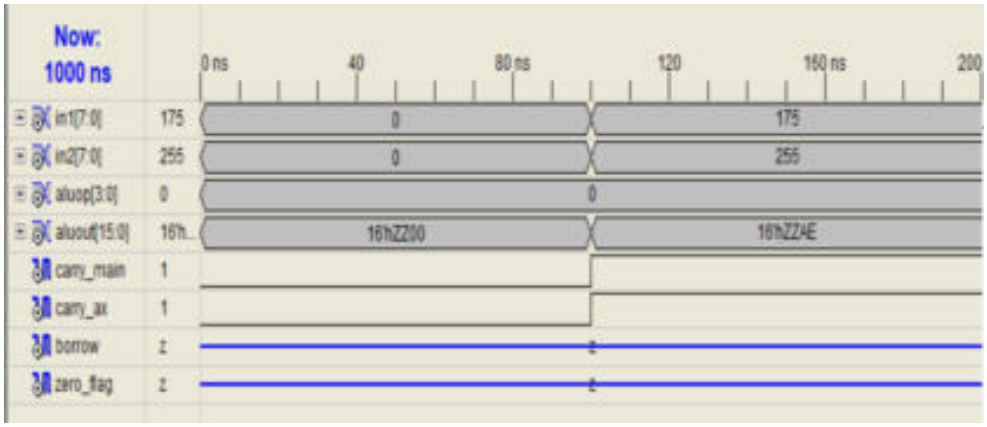


Figure-6. Addition operation.

Case 2) Opcode- 0001 (Subtraction operation) (see **Figure-7**).

10101111 (AFH) => IN1

-

11111111 (FFH) => IN2

---

1 10110000 (B0H) => ALUOUT

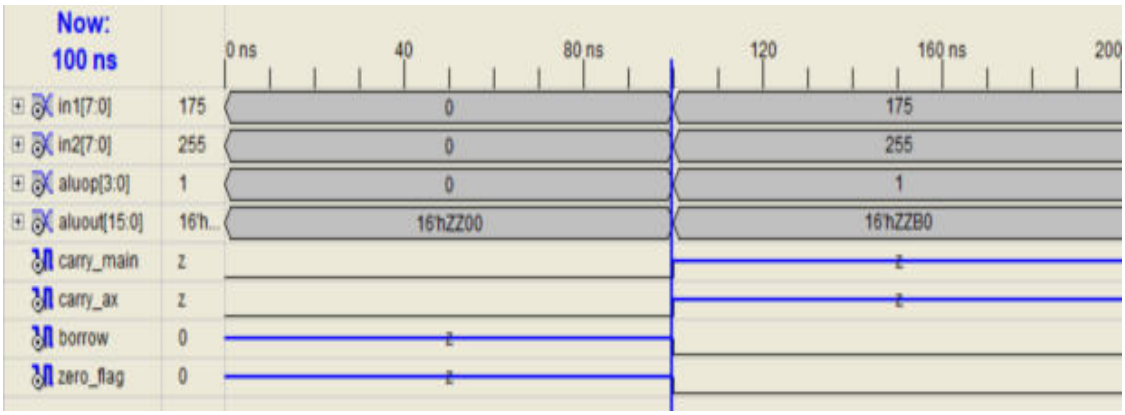


Figure-7. Subtraction operation.

Case 3) Opcode- 0010(Multiplication operation) (see **Figure-8**).

10101111 (AFH) => IN1

-

11111111 (FFH) => IN2

---

1 1010111001010001 (AE51H) => ALUOUT

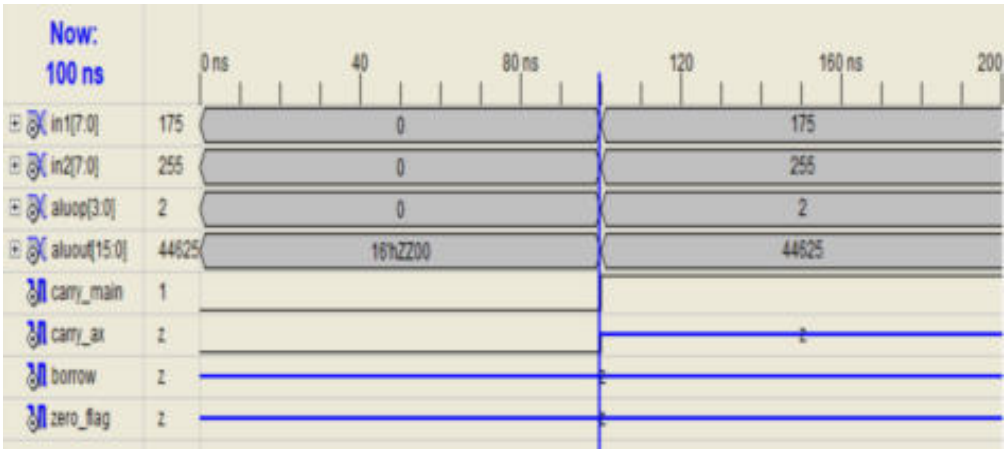


Figure-8. Multiplication operation.

Case 4) Opcode- 0011 (Division by 2 operation) (see **Figure-9**).

10101111 (AFH) => IN1

Arithmetic shift by 1 bit of IN1 is performed, result at ALUOUT is 01010111 (57 H)

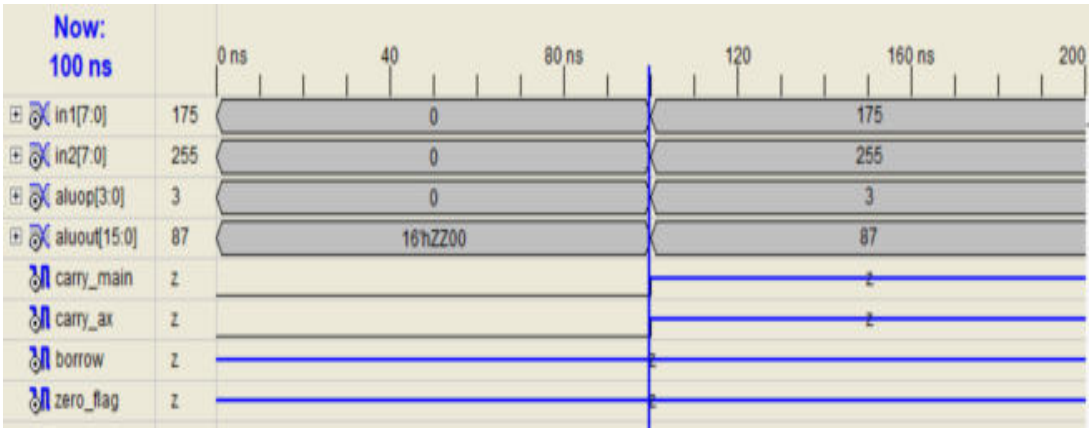


Figure-9. Divide by 2 operations.

Case 5) Opcode- 0100 (AND operation) (see **Figure-10**).

10101111 (AFH) => IN1

+

11111111 (FFH) => IN2

10101111 (AFH) => ALUOUT

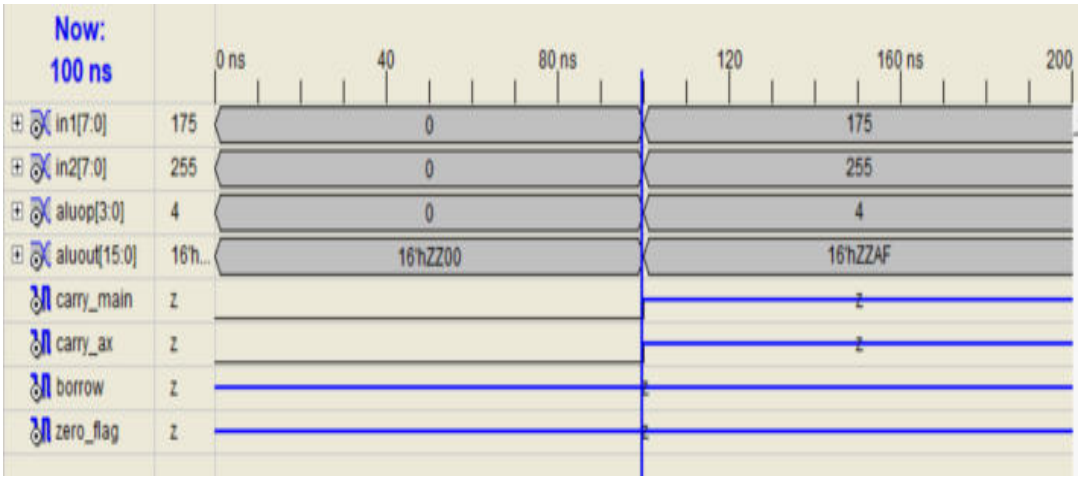


Figure-10. Logical AND operation

Case 6) Opcode- 0101 (OR operation) (see **Figure-11**).

10101111 (AFH) => IN1

+

11111111 (FFH) => IN2

11111111 (FFH) => ALUOUT

Figure-11. Logical OR operation

Case 7) Opcode- 0110 (Complement IN1) (see **Figure-12**).

Invert operation of IN1 is performed.

10101111 (AFH) => IN1

01010000 (50H) => ALUOUT

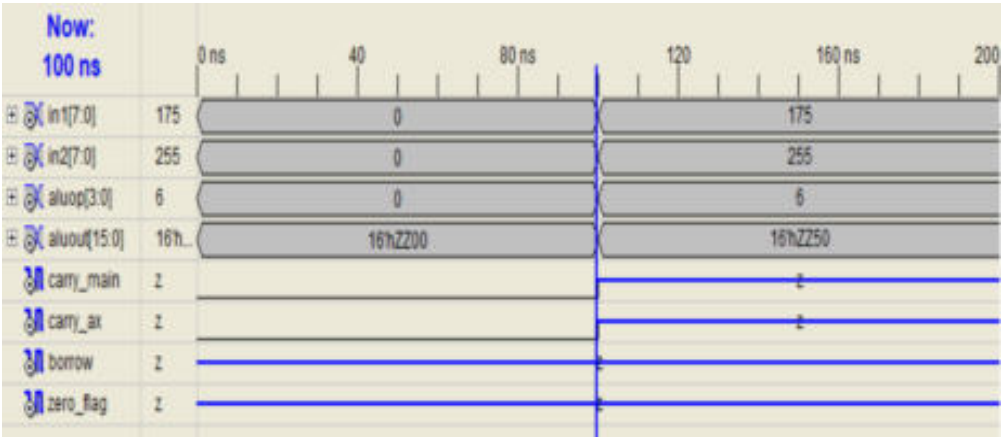


Figure-12. Complement operation

Case 8) Opcode- 0111 (NAND Operation) (see **Figure-13**).

10101111 (AFH) => IN1

+

11111111 (FFH) => IN2

01010000 (50H) => ALUOUT

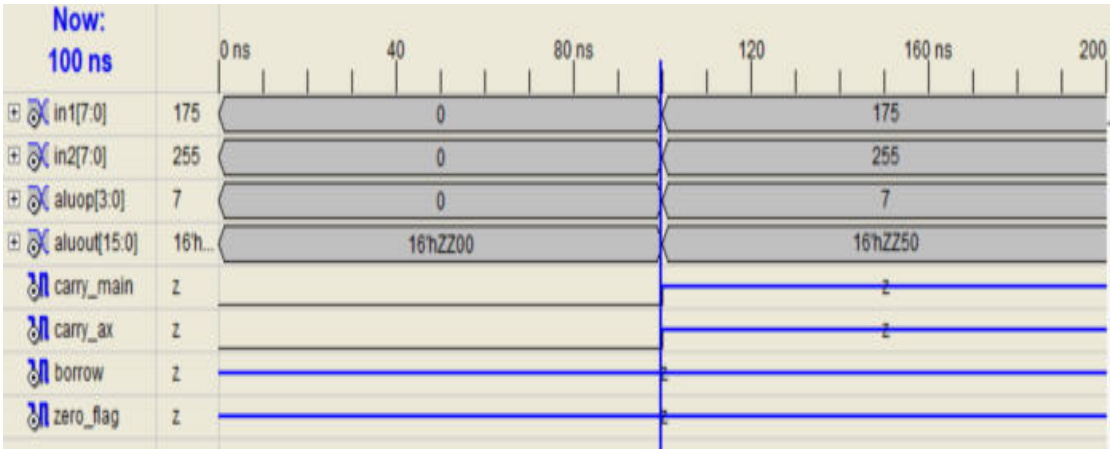


Figure-13. Logical NAND operation

Case 9) Opcode – 1000 (XOR Operation) (see **Figure-14**).

10101111 (AFH) => IN1

+

11111111 (FFH) => IN2

01010000 (50H) => ALUOUT

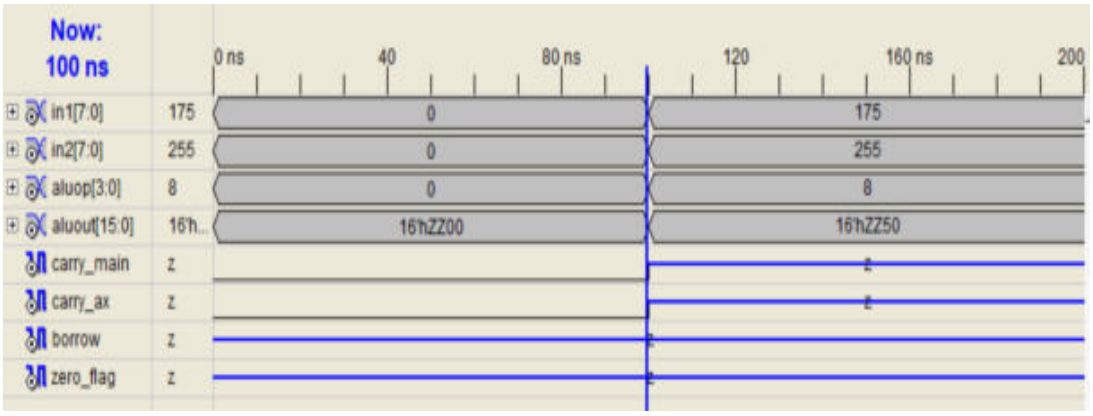


Figure-14. Logical XOR operation

Case 10) Opcode- 1001 (NOR Operation) (see **Figure-15**).

10101111 (AFH) => IN1

+

11111111 (FFH) => IN2

00000000 (00H) => ALUOUT

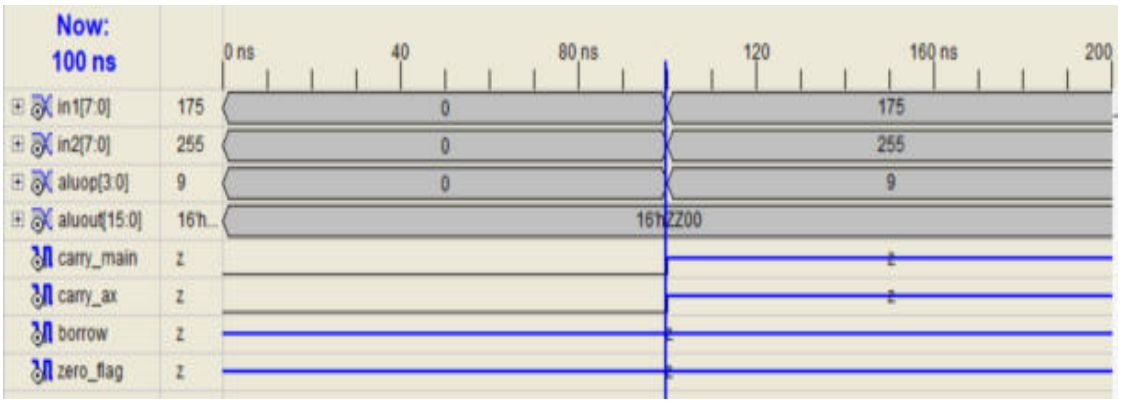


Figure-15. Logical NOR operation

Case 11) Opcode- 1010 (XNOR operation) (see **Figure-16**).

10101111 (AFH) => IN1

+

11111111 (FFH) => IN2

10101111 (AFH) => ALUOUT

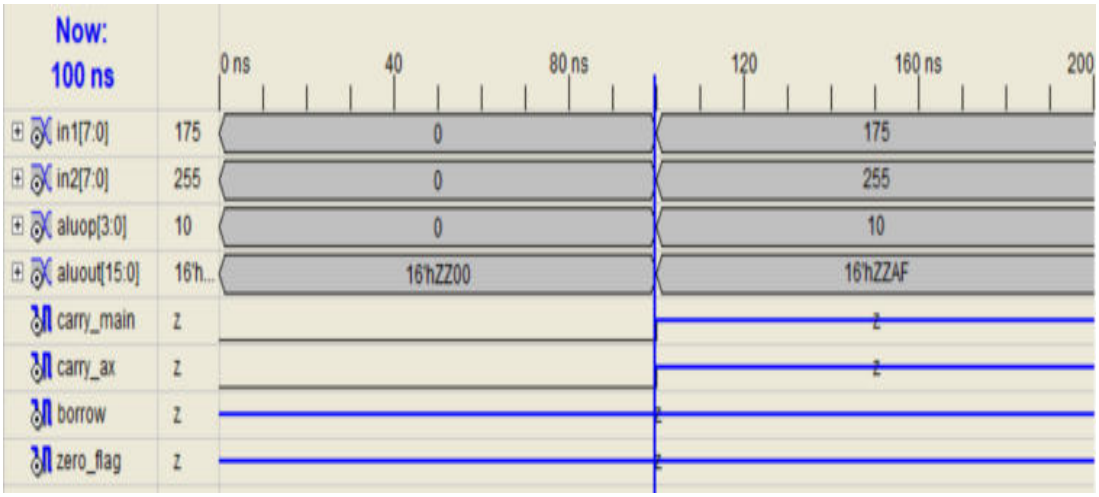


Figure-16. Logical XNOR operation.

Case 12) Opcode- 1011 (Left shift operation) (see **Figure-17**).

10101111 (AFH) => IN1

01011111 (5FH) => ALUOUT

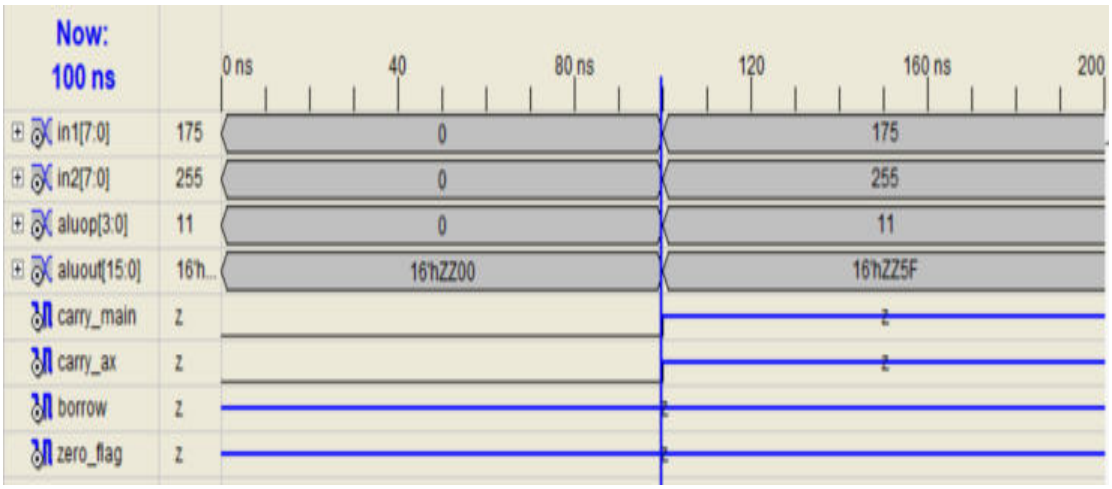


Figure-17. Left shift operation

Case 13) Opcode- 1100(Right shift operation) (see **Figure-18**).

10101111 (AFH) => IN1

11010111 (D7H) => ALUOUT

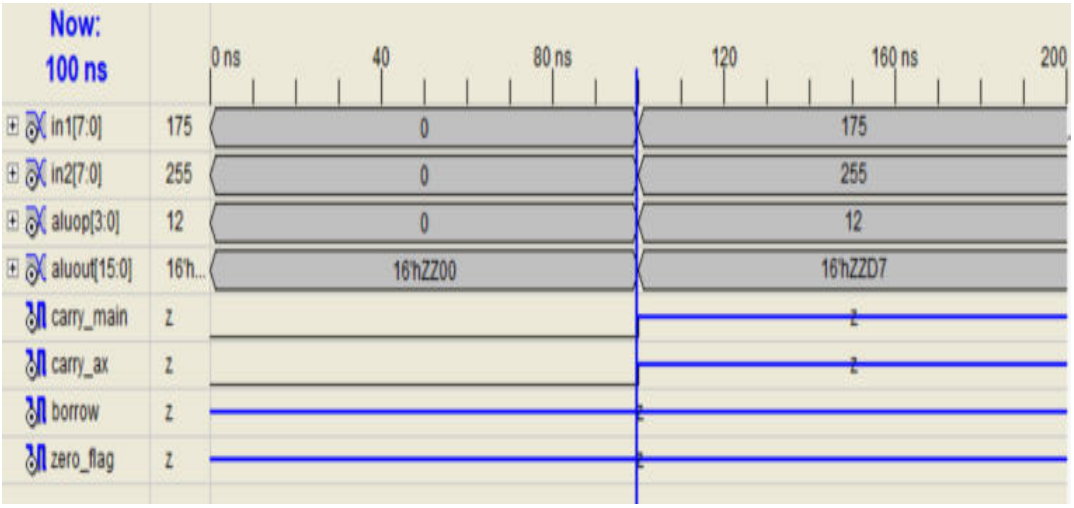


Figure- 18. Right shift operation

Case 14) Opcode- 1101 (Comparison operation) (see **Figure-19**).

IN2 is greater than IN1 , hence ALUOUT = IN2

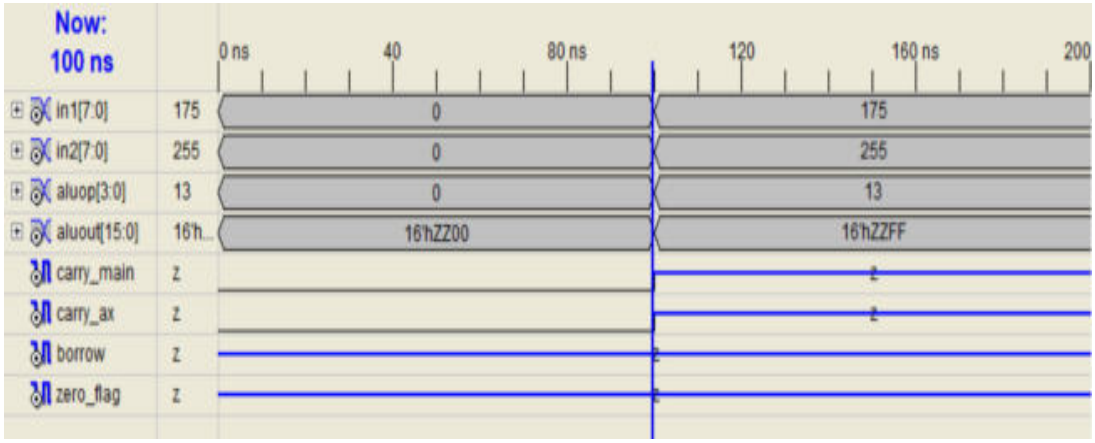


Figure-19. Digital comparison operation.

Case 15) Opcode- 1110 (Nibble exchange ofIN1) (see **Figure-20**).

10101111 (AFH) => IN1

11111010 (FAH) => ALUOUT

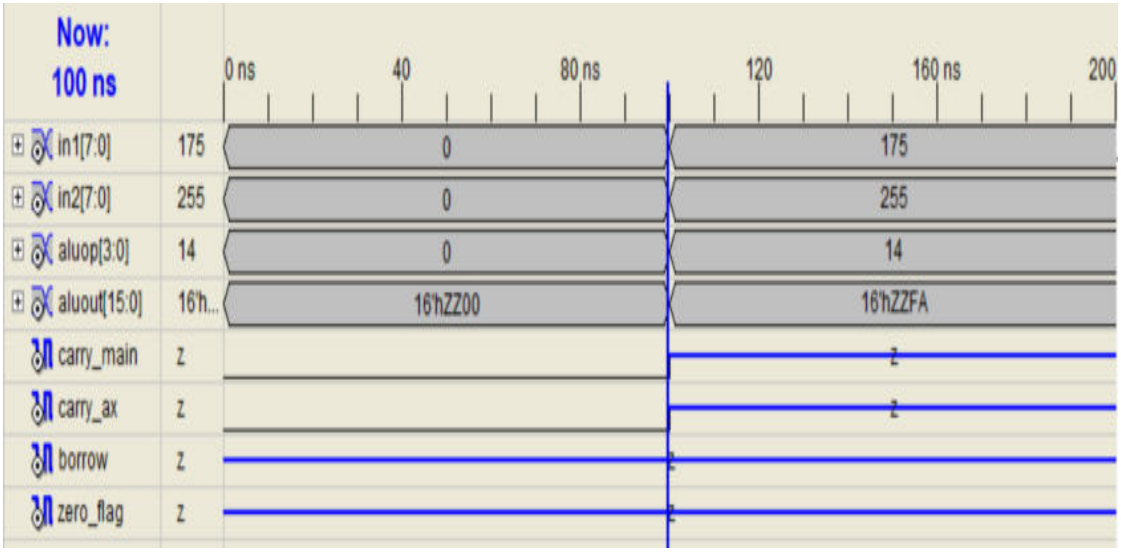


Figure-20. Nibble exchange operation.

Case 16) Opcode – 1111 (Exchange inputs) (see **Figure-21**).

10101111 (AFH) => IN1

+

11111111 (FFH) => IN2

1010111111111111 (AFFFH) => ALUOUT

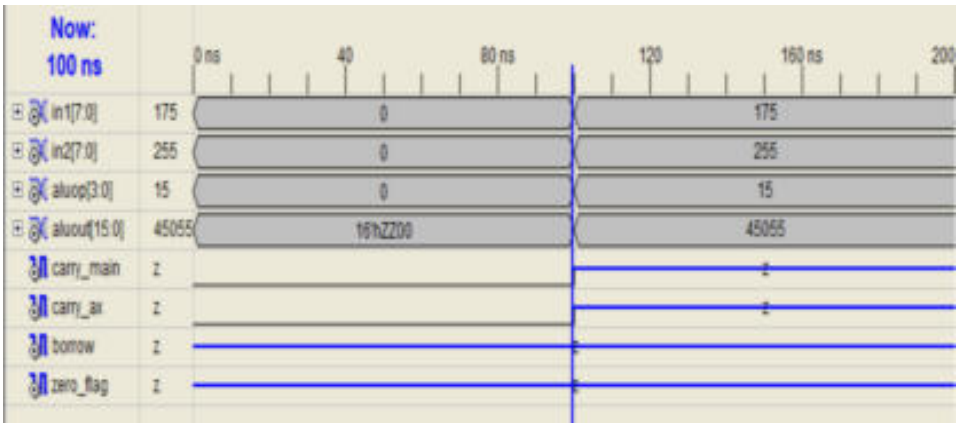


Figure-21. Exchange inputs operation.

3. RESULTS, CONCLUSION AND FUTURE WORK

The VHDL code is configured in Xilinx FPGA Spartan 3E family's device XC3S500E. The results of selected operations are shown in the figures.

Figure-22. Multiplication of inputs operation.

Figure-22 shows the multiplication result of 1010111001010001. **Figure-23** shows the result of IN1 divide by 2 operations i.e. 01010111.

Figure-23. Divide by 2 operations.

Figure-24. Logical XOR operation.

Logical XOR operation is shown in **Figure-24**. Left shift operation of IN1 is shown in **Figure-25**

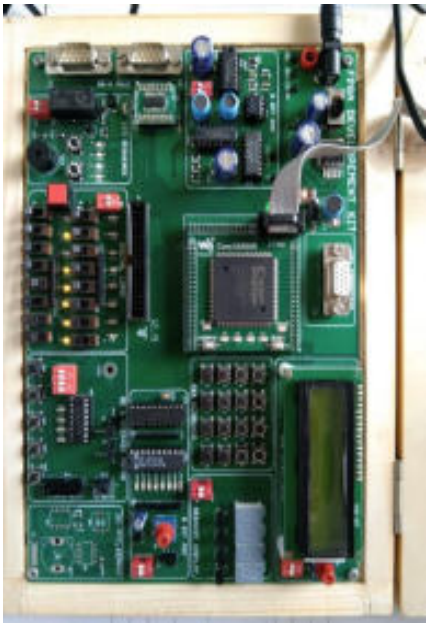


Figure-25. IN1 left shift operation.

Input exchange operation is shown in **Figure-26**.

Figure-26. Exchange inputs operation.

8-bit ALU capable of performing 16 various operations is designed, verified and tested on FPGA. Simulation and hardware results have shown that ALU works logically as desired. This work performs division by 2 operations, which can be extended to integer division of two 8-bit numbers. The total power consumed by the designed ALU core and implemented on the FPGA board is 830mWatts which is very advantageous.

The proposed design consumes a minimum amount of power compared to other designs. Therefore, the proposed design is better than other existing designs concerning power consumption, performance and size. For improving the speed of arithmetic and logic operations the presented design can be used for controllers and processors in ASIC design.

ACKNOWLEDGEMENT

This work is completed in Center of Excellence in Embedded systems and VLSI design Lab of Electronics & Telecommunication Engineering program. Authors are thankful to Shivaji University, Department of Technology, Kolhapur for providing necessary facilities for completion of this work.

REFERENCES

3. Sarkar, S., Chatterjee, H., Saha, P., Biswas M. (2020) International Conference on Trends in Electronics and Informatics, 4, 17-22.
4. Reddy, J. N., Tiwari, M., Reddy, V. (2021) Annals of Romanian Society of Cell Biology, 25, 3396- 3403.
5. Hui, W. S., Ruslan, S. H. (2021) Evolution in Electrical and Electronic Engineering, 2, 110-119.
6. Pasayat, P. K., Pradhan, M., Pasayat, B. K. (2013) International Journal of Engineering Research and Technology, 9, 1386-1393.
7. Ranjit, K. G., Chavan, A., Aradhya, H.V.R. (2017) Communications on Applied Electronics, 7, 39-43
8. Shreelakshmi, S. P. (2016) International Journal of Engineering and Technology, 3, 139-146.
9. Kantawala, M. (2018) International Journal of Engineering, Applied Sciences and Technology, 3, 30-34.

Design of Solar Photovoltaics Powered Internet of Things Based Weather Station

Ganesh S. Nhivekar[a,*], Shamkumar B. Chavan[b]
[a]Yashvantrao Chavan Institute of Science, Satara 415 001 (MS) India
[b]Department of Technology, Shivaji University, Kolhapur 416 004 (MS) India
[*]Corresponding author: drgsnhivekar@ycis.ac.in

ABSTRACT
Due to Internet of Things (IoT) technology, it is easily possible to monitor the data remotely. Nowadays IoT technology is widely used in monitoring the remote side parameters. In this work and IoT based weather station is developed to send the information of parameters like temperature and humidity. This tiny weather station is powered using PV module hence it can be implemented at remote places where solar energy is available. In this DHT 11 module is used to sense temperature and humidity. Node MCU ESP 8266 WiFi module is used for WiFi connectivity. This is low power system with average current consumption of 190 mA.

KEYWORDS
Weather station, IoT based system, Weather parameter monitoring

……

1. INTRODUCTION

Weather parameter monitoring is important aspect for human life. For applications like agriculture, forestry etc. monitoring weather parameters is important to understand the effect of weather on the crop yield. Statistical methods are used to study the previous records of weather parameters and to predict the future behavior. Nowadays artificial intelligence based many methods are used to forecast the behavior of the weather. There are many traditional and recently innovated techniques for monitoring the weather parameters. Microcontroller based parameter monitoring is most popular and gives correct results. Internet of things technology is also used to transmit the information from weather station to the end user. IoT technology helped to transmit the data efficiently and with low cost.

2. LITERATURE REVIEW

Nowadays IoT technology is used for many applications, hence use of IoT in weather monitoring will simplify the tasks. IoT based weather parameter monitoring system is designed in which temperature, humidity, pressure, raindrop and sunlight intensity are monitored [1] in this work Arduino microcontroller is used. An IoT based air pollution monitoring system is designed [2] to monitor the harmful gases in air and

the quality of the air. IoT based system is developed to monitor the indoor air quality [3]. In this the parameters like aerosol concentration, CO_2, CO, VOC etc are monitored to determine the quality of the air. The pollution of the air is monitored using the gas sensors, Raspberry Pi and IoT platform [4]. Arduino microcontroller-based system is designed to monitor the industrial pollution [5], in this syetm the gas sensor, temperature and noise are monitored and transmitted via WiFi device to remote node. The 16X2 LCD is connected to system for local displaying of parameters. Fifty five number of different IoT based systems which are used for pollution monitoring are studied and the results are presented [6]. In reference [7] Arduino microcontroller-based system is developed to monitor air quality, carbon monoxide and ozone. The stations are located at various nodes and via GSM network the data is sent to the central server station. The monitored parameters can be seen from remote node using computer or smart phones. The air pollution monitoring system based on IoT platform is described in [8]. Arduino microcontroller based system is designed to monitor levels of various gases [9]. A low cost Arduino microcontroller based system is designed using MQ series sensors for air quality monitoring [10]. Air quality of desired site is monitored using IoT system, the facility is created to monitor these parameters on web site [11]. Arduino based system is developed which uses gas sensors, smoke sensors and humidity sensors to monitor the air pollution [12]. 16 X 2 LCD is used to display the parameters. Environmental and sound pollution is monitored and transmitted using IoT technology in [13] in this MQ135 gas sensor is used for monitoring the air quality and CZN 15E is used for monitoring the noise level. A review is presented [14] and it is concluded that the IoT based system is good solution for effectively monitor the environmental pollution. Concentration of PM10 is monitored in a tunnel to determine the level of air quality [15]. Raspberry Pi microcontroller based system is designed by authors [4] to monitor the air pollution, in this system ESP 8266 is used for WiFi connectivity, 10 bit ADC MCP 3008 is used for analog to digital conversion, MQ2 gas sensor is used for gas sensing and MQ-7 sensor is used for CO concentration monitoring. Here [4] the work is divided in three different stages named air pollution detection, creation of interface and testing the performance of the system. The noise levels in environment are measured using noise sensor and transmitted to distant place via IoT technology [16], Arduino microcontroller is used for controlling the activities.

3. SYSTEM DESIGN

In this work small weather station is developed and implemented to monitor the weather parameters. IoT platform is used for sending the parameters. Arduino microcontroller board is used for monitoring and transmitting the data. DHT 11 sensor module is used for monitoring temperature and humidity. ESP 8266 WiFi module is used through which parameters are sent to cloud. The weather station is

powered using PV module hence it can be placed at remote locations like forest, agriculture etc. where electricity is not available.

System block diagram is shown in **Figure-1**. Node MCU 8266 is used having WiFi connectivity facility. 9V PV panel, rechargeable battery, DHT- 11 sensor are used for system design.

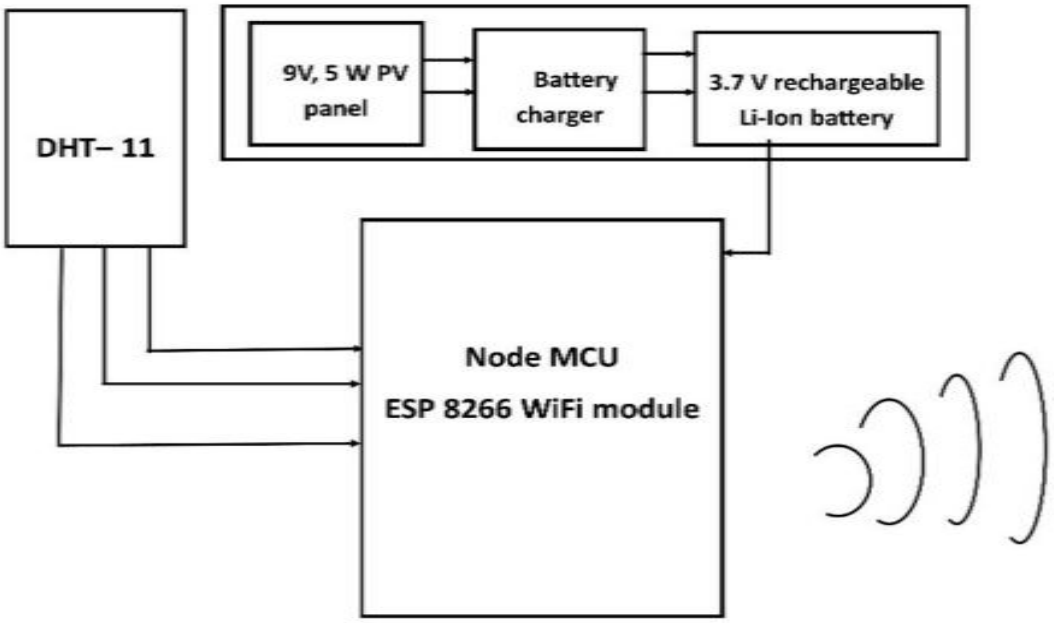


Figure-1. System block diagram.

For temperature and humidity sensing DHT-11 sensor is used. Node MCU reads parameters from DHT-11 and send these parameters to ThingSpeak cloud. The weather parameters monitors the data and sent after every 15 seconds interval to the field created in ThingSpeak cloud. The users can remotely monitor this data in graphical form.

Weather stations are remotely located hence there are issues of electric power at remote ends like agriculture field, forest etc. To overcome these power issues the system is operated on solar PV power. In this small PV panel of 9V, 5 W specifications is used. It continuously charges the Lithium Ion battery of 3.7V through the charger. The system is operated on 3.7V rechargeable battery supply. A flow chart of the system is shown in **Figure-2**. When power supply is made ON first the system connects to WiFi device. After getting the connectivity, system monitors the humidity and temperature data. If there is problem in getting connectivity and reading the data, then system continuously track for the same. After getting the WiFi

connectivity and the parameters, the data is formatted and sent to the ThinkSpeak cloud channel. The data is sent after every 15 seconds intervals.

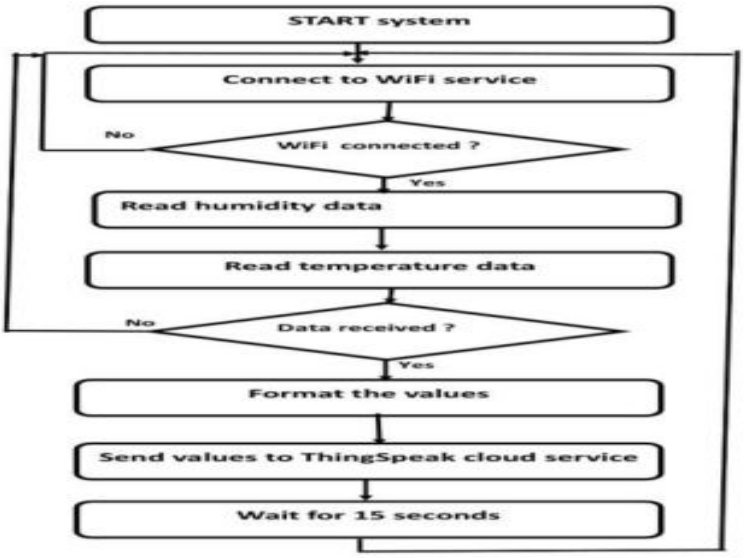
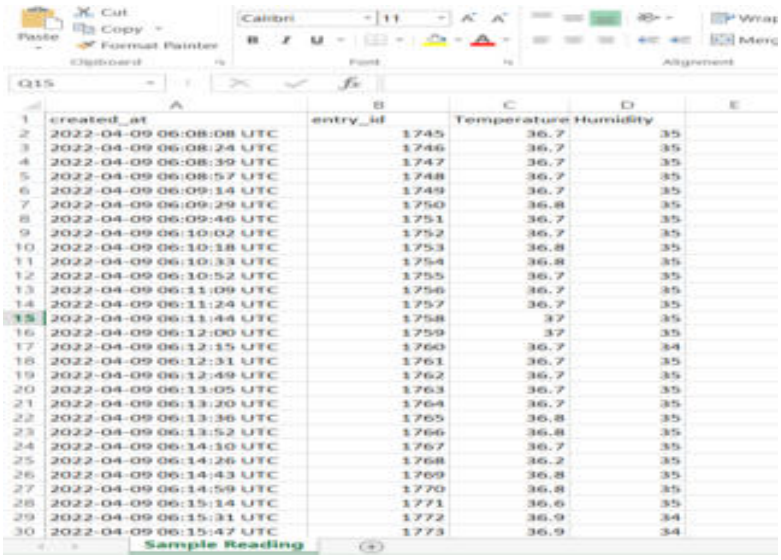


Figure-2. Flow chart.

4. RESULTS

A sample sheet of the humidity and temperature recordings is shown in **Figure-3**. The data is continuously updated. The GUI at user's end is as shown in **Figure-4**. Hardware of the system is shown in **Figure-5**.



	A	B	C	D	E
1	created_at	entry_id	Temperature	Humidity	
2	2022-04-09 06:08:08 UTC	1745	36.7	35	
3	2022-04-09 06:08:24 UTC	1746	36.7	35	
4	2022-04-09 06:08:39 UTC	1747	36.7	35	
5	2022-04-09 06:08:57 UTC	1748	36.7	35	
6	2022-04-09 06:09:14 UTC	1749	36.7	35	
7	2022-04-09 06:09:29 UTC	1750	36.8	35	
8	2022-04-09 06:09:46 UTC	1751	36.7	35	
9	2022-04-09 06:10:02 UTC	1752	36.7	35	
10	2022-04-09 06:10:18 UTC	1753	36.8	35	
11	2022-04-09 06:10:33 UTC	1754	36.8	35	
12	2022-04-09 06:10:52 UTC	1755	36.7	35	
13	2022-04-09 06:11:09 UTC	1756	36.7	35	
14	2022-04-09 06:11:24 UTC	1757	36.7	35	
15	2022-04-09 06:11:44 UTC	1758	37	35	
16	2022-04-09 06:12:00 UTC	1759	37	35	
17	2022-04-09 06:12:15 UTC	1760	36.7	34	
18	2022-04-09 06:12:31 UTC	1761	36.7	35	
19	2022-04-09 06:12:49 UTC	1762	36.7	35	
20	2022-04-09 06:13:05 UTC	1763	36.7	35	
21	2022-04-09 06:13:20 UTC	1764	36.7	35	
22	2022-04-09 06:13:36 UTC	1765	36.8	35	
23	2022-04-09 06:13:52 UTC	1766	36.8	35	
24	2022-04-09 06:14:10 UTC	1767	36.7	35	
25	2022-04-09 06:14:26 UTC	1768	36.2	35	
26	2022-04-09 06:14:43 UTC	1769	36.8	35	
27	2022-04-09 06:14:59 UTC	1770	36.8	35	
28	2022-04-09 06:15:14 UTC	1771	36.6	35	
29	2022-04-09 06:15:31 UTC	1772	36.9	34	
30	2022-04-09 06:15:47 UTC	1773	36.9	34	

Sample Reading

Figure-3. Record of parameters.

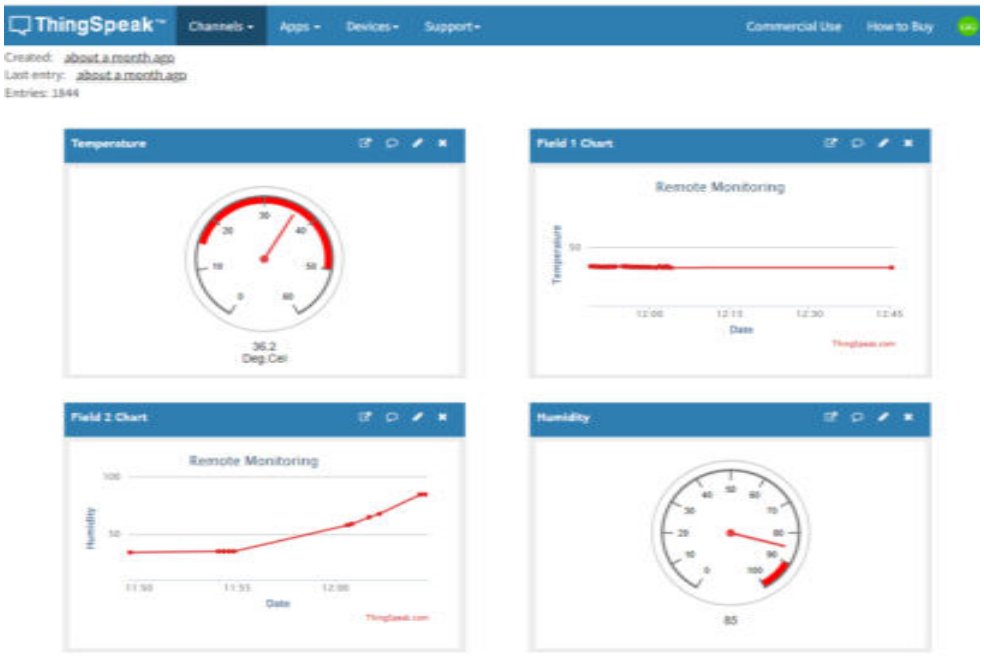


Figure-4. GUI on ThingSpeak.

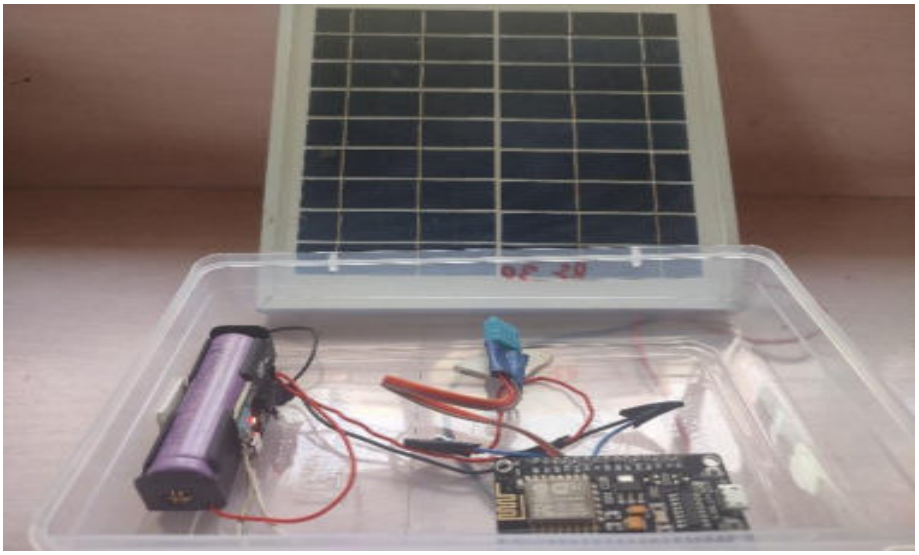


Figure-5. System hardware

5. CONCLUSION AND FUTURE WORK

The system developed here is low cost and low power. The average current consumption of the system is 190 mA. The given weather parameters can be

monitored from any location. The system can be implemented at agriculture, forestry site and solar power can be used to power the system. It is possible to develop complete weather station to monitor various parameters.

REFERENCES

1. Kodali, R.K., Mandal, S. (2016) International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 680-683.
2. Shah, H. N., Khan, Z., Merchant, A. A., Moghal, M., Shaikh, A., Rane, P. (2018) International Journal of Scientific and Engineering Research, 9, 62-66.
3. Jo, J.H., Jo, B.W., Kim, J.H., Kim, S.J., Yan, W.H. (2020) Journal of Sensors, 4, 1-20.
4. Anand, J. A, Praviss, Y.T.K., Venkstesh, P.K.K., Ramkumar, K. (2021) International Research Journal of Engineering and Technology, 8, 2458-2462.
5. Nandhkumar, S., Vengat, T.R., Ramkumar, R., Rakesh, K. (2020) Bioscience Biotechnology Research Communications, 13, 1450-1450.
6. Munera, D., Diana, T. V., Aguirre, J., Gomez, N.G. (2021) International Journal of Electrical and Computer Engineering, 11, 3470-3482.
7. Zulkifli, N.S.A., Satrial, M.R., Osman, M.Z., Ismail, N.S.N., Razif, M.S.M. (2020) Material Science and Engineering, 769, 012014.
8. Vamsi, P.V., Garg, A., Gupta, D.R. (2018) Journal of Network Communications and Emerging Technologies, 8 (4), 100-103.
9. Manikannan. G., Vijayalakshmi, T., Prabakaran, P. (2019) International Journal of Scientific Development and Research, 4, 28-37.
10. Kumar, K.B., Mukherjee, S., Sultana, P. (2019) Procedia Computer Science 165, 322–327.
11. Nirosha, K., Durgasree, B., Shirisha, N. (2017) International Journal of Current Engineering and Scientific Research, 4, 40-42.
12. Verma, D., Dhul, S., Saini, R., Dubey, R. B. (2018) International Journal of Innovative Research in Engineering & Management, 5, 116-120.
13. Chabra, G., Waghmare, K., Mandraha, L. (2019) Journal of Applied Science and Computations, 6, 899-904.
14. Shinde, S., Patil, P. (2019) International Journal of Computer Science and Network, 8, 406-412.
15. Jo, J.H., Jo, B.W., Kim, J. H., Choi, I. (2020) International Journal of Environmental Research and Public Health, 17, 1-12.
16. Agrawal, S., Oza, P., Ashishdeep, A. (2017) Advances in Wireless and Mobile Communications, 10, 819-822.

Utilization of Guar Gum and Xanthan Gum Powder as Stabilizer in Whipping Cream

Madan M. Sanadi[a], Shital A. Patil[a], Arvind B. Madavi[a,*], Akshaya K. Sahoo[a]
[a]Department of Technology, Shivaji University, Kolhapur 416 001 (MS) India.
*Corresponding author: arvindmadavi@gmail.com

ABSTRACT
The process for the preparation of whipping cream by adding guar gum powder and xanthan gum powder was investigated. The study was carried out by the addition of gaur gum powder and xanthan gum powder for foamability and foam stability. Purified guar gum powder (G.G.) and xanthan gum powder (X.G.) were used as a stabilizer in whipping cream at level of 0.1%, 0.2%, 0.3%, and 0.4% respectively. It was found that, addition of the gaur gum powder 0.4% had given more stability than xanthan gum powder. Combination of guar gum and xanthan gum powders in different parameters can be successfully added in whipping cream. (G.G:X.G) of (6:4) concentration of (0.4%) both powders shows high stability than other levels. In further study in which investigate the effect of icing sugar on foam stability of whipping cream was shows that no any causes effect on stability of whipped cream. Thus whipped cream have received superior foamability and foam stability produced by incorporation of 0.4% of guar gum and xanthan gum powder in different percent (6:4). Whipping cream showed sensorial analysis up to 28th days. So the outcome of these study showed, addition of gums improve stability and quality of whipping cream over the storage period.

KEYWORDS
Guar gum, Xanthan gum, Stabilizer, Whipping cream.

……

1. INTRODUCTION

Air is dispersed in a liquid continuous phase to form foams. Foams are found in bakery products, such as desserts, ice creams, whipped cream, confectionary and beverages. Whipped cream and aerated chocolates are only two examples of items where food aeration plays a significant role. The creation of air bubbles as the dispersed phase and their stabilization by the adsorption of an adequate surface active material at the air-water interface are requirements for the formation and stabilization of foams, which is similar to that of emulsions. Phase separation (drainage), coalescence, and disproportionation cause stability to be lost (in which air diffuses from small bubbles into large bubbles). Foam stability needs to be maintained for a much longer for items like ice cream and bread because the foam phase also significantly contributes to the sensory qualities of the food [1]. At the air-

water interface, fat globules stabilize the air cells created by the whipping process. The fat clumps form as a result of the globules attachment to air bubbles during whipping. As whipping goes on, air cells get smaller and more common, fat continues to clump, and the foam gets bigger and more solid. If whipping is continued, the fat bunches eventually become so large that they rupture the lamellae that surround the air cells. Air bubbles start to mix, their invasion decreases, and stirring happens. Many scientists concur that the presence of stabilizers and emulsifiers, cream temperature, homogenization and pasteurization conditions, and fat level all affect the functional qualities of whipping creams [2]. Guar gum, also known as Gum cyamopsis or guar flour, is made from the embryonic seed of the Cyamopsis tetragonaloba (L) Taub guar plant (syn. Cyamopsis psoraloides). A straight chain of (1→4) connected β-D-mannopyranosyl units with (1→6) connected α-D-galactopyranosyl buildups serving as side chains make up the majority of the large sub-atomic weight polysaccharides that make up guar gum. The ratio of mannose to galactose is about 2:1. The range of atomic weights is 50,000–8,000,000. The described guar gum no longer contains the cell structure and includes more galactomannans. The gum has an uninteresting flavour and is a free-flowing, white to yellowish white powder. Natural solvents cannot dissolve guar gum. Without warming, the gum dissolves in cold water to form an incredibly thick solution. Guar gum arrangements are completely stable in the pH range of 4.0 to 10.5 and have a buffering limit. A small amount of sodium borate added to guar gum's aqueous solution will cause it to expand, creating a gel [3]. It has long been common practice to employ xanthan gum (XG) in the food, drug, and cosmetic sectors. XG served as a stabilizing and reducing agent. In order to prepare GNP, it was necessary to determine the impact of numerous formulation and process variables, including temperature, reaction time, gum concentration, gum volume, and gold concentration. The ruby-red, XG stabilized XGNP was produced using 5 ml of XG aqueous solution (1.5 mg/ml). The response time was 3 hours while the ideal temperature was 80 °C. The synthesized nanoparticle has a zeta potential of -29.1 mV and a mean particle size of 15-20 nm. Under a variety of pH, electrolyte, and serum conditions, the colloidal stability of DXGP was examined. It was discovered that nanoparticles were stable in the pH range of 5 to 9 and at a NaCl concentration of up to 0.5 M. Nanoparticles in serum demonstrated notable stability for up to 24 hours. During toxicity studies, nanoparticles were found biocompatible and non-toxic [4]. Up to a concentration of around 0.5%, guar gum solutions behave as non-Newtonian solutions. Guar configurations demonstrated pseudo-plastic behavior. Evident consistency grew with gum attention. The temperature of 60 °C was the most extreme in the plot of consistency vs expanding disintegration. This behavior was linked to variations in the sub-atomic structure of the polymers that had been set at utterly disparate temperatures. The consistency of mixtures of xanthan and gum was different from that of each individual gum. On the consistency of blend

arrangements, the effects of polysaccharide fixation (1.0, 1.5, and 2.0 kg m^{-3}), xanthan/guar gum proportion (1/5, 4/2, 3/3, 4/2, and 5/1) and different temperature (25, 40, 60, and 80 °C or each gum) were considered [5]. In this paper, we studied on foamability and foam stability of whipping cream at different temperature, concentration.

2. MATERIALS AND METHODS

2.1. Materials

Guar seed, xanthan gum powder, fresh heavy cream (fat content 30-40 %), icing Sugar, and vanilla flavor were purchased from the local market of kolhapur city, Maharashtra, India.

2.2. Preparation of Guar Gum Powder

For 10 hours, guar seeds were steeped in distilled water. The seeds were swelled, and the hull (outer layer) and endosperm (middle layer), which was separated into two sections, could be readily removed. Using a milling machine and sieves (a 0.4 mm mesh sieve), the endosperm components were oven dried at 100°C for 20 minutes before being removed and stored in polyethylene bags.

2.3. Different Treatment Prepared with Varying Different Concentration of Guar Gum and Xanthan Gum Powder in Whipping Cream

Whipping cream was ready with joining of various grouping of guar gum, thickener and combined guar and Xanthan gum powder. Guar gum and Xanthan gum powder used in whipping cream at level of 0.1, 0.2, 0.3, and 0.4 percent respectively. Whipped cream prepared by incorporation combination of guar gum and xanthan gum powder in different parameters such as Guar gum: Xanthan gum powder (2:8) ,(4:6), (6:4) and (8:2).

2.4. Preparation of Whipping Cream by Incorporating of Guar Gum and Xanthan Gum Powder

Fill a bowl with cool heavy whipping cream. Keep the bowl in a bowl of cold water to regulate the temperature since doing so helps the cream retain its fluffy texture at low temperatures. Whipping the cream for two minutes at high speed. Adding guar or xanthan gum powder to cream as it is being whipped. Once it has doubled in volume, add icing sugar to whipped cream. Whipping the cream by hand once more until it thickens and achieves a delicate peak [6].

2.5. Foamability

An important concept explaining the evolution of foam is overrun. Given that the gas was integrated into the framework, this value addresses the volume increase. In the equation below, it can be written as % overrun [7].

$$\%\ Overrun = \frac{(Wt.100mlSolution)-(Wt.100mlfoam)}{(Wt.100mlfoam)} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

2.6. Foam stability

Foam stability was measured immediately after foam formation on the basis of height declension of cream of whipped cream after one hour. The whipped cream kept at 40 °C for 1 hr. Each treatment was repeated two times [8].

2.7. Scanning electron microscope

A JEOL SEM (JSM 5910; japan) operating at an accelerating voltage of 10 kv was used to analyze the surface morphology of powder [4].

2.8. Sensory evaluation

The prepared samples were evaluated for sensory parameters such as color, flavor, taste, and overall acceptability using 9point hedonic scale by a panel of ten semi trained panel members [9].

3. RESULTS AND DISCUSSION

3.1. Foamability

3.1.1. Foamability of Dairy Whipping Cream by Incorporation of Guar Gum Powder

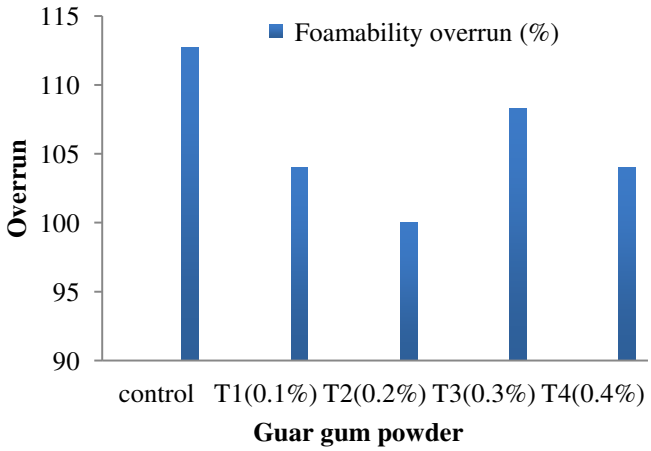


Figure-1. Foamability of whipped cream by guar gum powder.

Figure-1 represent the foamability of whipped cream by incorporated of guar gum powder. As per the result the T_3 (0.3%) given the highest foamabilty which has

108.33%. Guar gum affected slightly negatively on the foamability. This outcome could be explained by the polymer's capacity to thicken the cream and so raise its perceived viscosity. Since aqueous media with higher viscosities have a reduced tendency to incorporate air, solutions with lower apparent viscosities typically have larger foaming capacities. Thus, the smaller the foam volume formed. It was found that a larger concentration of guar gum tended to present a more stable kinetic foam with regard to the stability of the foam over time.

3.1.2. Foamability of Dairy Whipping Cream by incorporation of Xanthan Gum Powder

Figure-2 shows the effect of xanthan gum level on the overrun of whipped cream. It was found that, T_2 (0.2%) given more foamabilty which has 104.08% than other concentration and T_3 (0.3%) and T_4 (0.4%) given the same foamabilty. Xanthan gum level showed no significant effect on the overrun of whipped cream. Similar increases were also found for emulsion with other xanthan gum levels. The overrun is a metric that reveals the amount of gas in the whipped cream or the gas holdup.

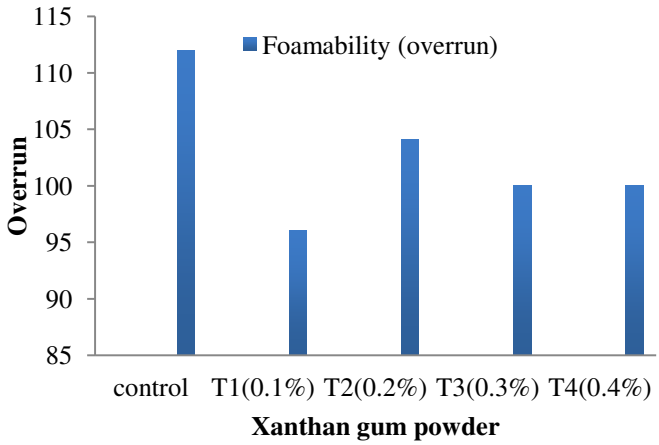


Figure-2. Foamability of whipped cream by xanthan gum powder.

The xanthan gum level showed no apparent increase of overrun. It indicated that 0.2% of xanthan gum level was sufficient for the inhibition of air elapse. Maximal overrun corresponds to maximal stability and stiffness of the foam. All the air bubbles at this case are encapsulated by coalesced fat droplets which distribute evenly at the air/slurry interface. Large amounts of air can be included into the emulsion with xanthan gum during whipping. This air incorporates into the bubbles due to xanthan gum's thickening effect, making it difficult for time to pass [10].

3.1.3. Foamability of Dairy Whipped Cream by incorporation of both Guar Gum and Xanthan Gum Powder in Different Parameters

Figure-3 shows, whipped cream prepared by incorporation combination of guar gum and xanthan gum powder in different parameters such as Guar gum: Xanthan gum powder (2:8) ,(4:6), (6:4) and (8:2). As per the conducted result, the T_2 was gave the good foamability which has 112.76% as compared to other parameters. The use of 0.4% guar gum in a stabilizer combination including xanthan gum provided the most suitable overrun to the whipped cream.

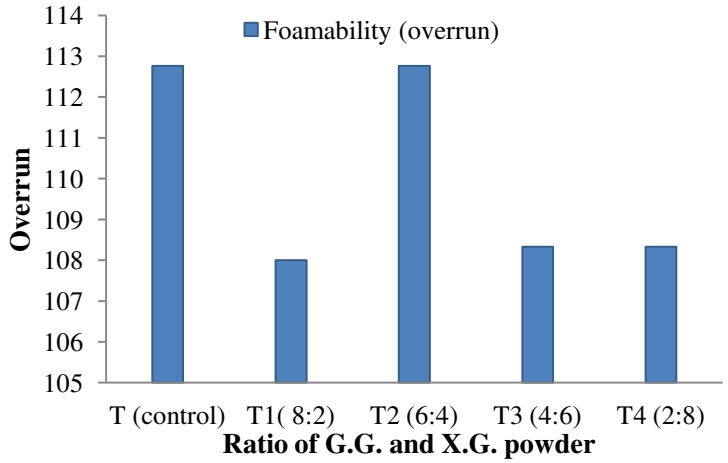


Figure-3. Foamability of whipped cream by incorporation of both Guar gum and Xanthan gum powder.

3.2. Foam Stability

3.2.1. Foam Stability of Dairy Whipped Cream of Incorporated Guar Gum Powder at 40 ^{O}C

Table-1 represents the foam stability of whipped cream by incorporating of different percentage of guar gum powder. The initial foam height of whipped cream was 6.3 cm and others foam height of cream after declension of cream at 40 ^{O}C after one hour. As per the result T_4 was given a good stability of cream. Guar gum is a non-ionic galactomannan that has the ability to create extremely viscous solutions with Mw of 106 Da. Guar gum powder must have particles that are roughly orders of magnitude smaller than the droplets for stabilization to be successful. The droplets are suitably surrounded by the particles. The range of effective particle sizes includes tiny nanometer, micrometer, and foam that has been successfully stabilized. The size of the particles, which are stabilized by the coalescence of nanodroplets of fat, does correlate with the size of the fat droplets generated in stable foam cream [11]. Guar

gum is mostly added to foaming colloidal systems to raise the continuous phase's viscosity and slow the liquid's passage through the thin layer that forms on the surface of the air bubble. As a result, it lessens the rate of drainage and bubble coalescence, which tends to make multiphase systems more stable.

Table-1. Foam stability of dairy whipping cream of incorporated guar gum powder.

G.G. powder Incorporated in whipping cream (%)	Height of whisked cream (cm)	Declension height (cm) after 1 hr
T control	6.3	3.3
T_1 (0.1%)	6.3	3.5
T_2 (0.2%)	6.3	4.6
T_3 (0.3%)	6.3	5.4
T_4 (0.4%)	6.3	5.7

3.2.2. Foam Stability of Dairy Whipping Cream of Incorporated Xanthan Gum Powder at 40 ^{O}C

Table-2. Foam stability of dairy whipping cream of incorporated xanthan gum powder.

X.G powder Incorporated in whipping cream (%)	Height of whisked cream (cm)	Declension height (cm) after 1 hr
Control	6.3	3.3
T_1 (0.1)	6.3	3.4
T_2 (0.2)	6.3	3.9
T_3 (0.3)	6.3	4.5
T_4 (0.4)	6.3	4.6

Table-2, shows the foam stability of whipping cream by added different amount of X.G. powder (%) in whipping cream. As per the result T_4 (0.4) was gave the excellent stability of whipping cream at 40 ^{O}C. The height of cream make volume to 6.3 cm and after 1 hours the declension in whipped cream height shows the stability of cream and melting the cream in 1 hour. Xanthan gum is a stiff high molecular weight anionic polysaccharide that can form highly viscous solutions [12].

3.2.3. Foam Stability of Whipping Cream of Different Parameters of Combined Gaur Gum and Xanthan Gum Powder at 40 ^{O}C

Foam stability of whipping cream of different parameters of combined G.G. and X.G. powder as shown in **Table-3**. T_2 was containing the 6 part of guar gum and 4 part of xanthan gum powder. Others samples were same as T_2 but in descending and ascending parameters.T_2 gave excellent stability of cream. The use of 0.4% guar gum in a stabilizer combination including xanthan gum provided the most suitable properties for the whipped cream [13]. The impact of polysaccharide focus (8:2,6:4,4:6 and 2:8) guar gum/thickener powder proportion at 40 ^{O}C on the consistency of arrangements of combinations were examined. The most elevated viscosities were observed, when 6:4 was utilized along with a proportion of guar gum: thickener powder [5].

Table-3. Foam stability of whipping cream of guar gum and xanthan gum powder at 40 ^{O}C.

G.G and X.G powder Incorporated in whipping cream (%)	Height of whisked cream (cm)	Declension height (cm) after 1 hr
T (control)	6.5	3.3
T_1(8:2)	6.5	6.0
T_2 (6:4)	6.5	6.2
T_3 (4:6)	6.5	6.1
T_4 (2:8)	6.5	5.9

3.3. Selection of Whipped Cream on the basis of their overrun and Stability at 40^{O}C temperature for Further Studies

As per the overall result of above-mentioned tables, final optimized sample of guar gum and xanthan gum powder in whipped cream was selected on basis of foamability and stability of creams. **Figure-1** was shown the foamability of whipping cream T_3 sample was given 108.33 % of foamability by incorporating of guar gum powder. **Figure-2** shows the T_2 sample was given 104.08% foamability by incorporating of xanthan gum. **Figure-3** shows the T_2 (6:4) was given foamability of whipped cream. In **Table-1**, T_4 was given higher foam stability which incorporated by guar gum powder. **Table-2** shown the also T_4 sample given higher stability of cream at 40 ^{O}C. **Table-3** shows T_2 given higher foam stability of cream as compare

other samples. As per the discussed result the selected optimized sample was T_2 (6:4).

3.4. Effect of Different Amount of Icing Sugar in Whipping Cream

Foam stability of whipping cream of different amount of icing sugar on stability of whipping cream as shown in **Table-4**.The analytical work shown that, not merely effect of an icing sugar on whipping cream. T_2 and T_3 gave the 6.3 cm stable height also gave fluffy structure and texture to the cream. T_4 was gave stability but cream became the very viscous. The combinations of guar gum powder, xanthan gum powder and sugar reduced emulsions that were stable to creaming before whipping and stable foams after whipping. The high concentration of sugar was affected on viscosity of cream, it was produced more viscous structure to whipped cream. As per result revealed that T_4 was given high stability as well as high viscous to the cream. T_3 given the good stability as well as a fluffy structure to whipped cream.

Table-4. Effect of different amount of icing sugar on stability of whipping cream.

% of icing sugar	Height of whipped cream	Height of cream after declension
T_1 (25%)	6.5	6.2
T_2 (50%)	6.5	6.3
T_3 (75%)	6.5	6.3
T_4 (100%)	6.5	6.4

3.5. Scanning Electron Microscope

3.5.1. Guar Gum Powder

SEM images of guar gum revealed a variety of irregularly sized rod-shaped particles as well as a small number of spherical-shaped particles, which were all distinguished by their hydration properties. The observed disparities in hydration could be explained by the shape and size features because they could possibly affect the rate of hydration.

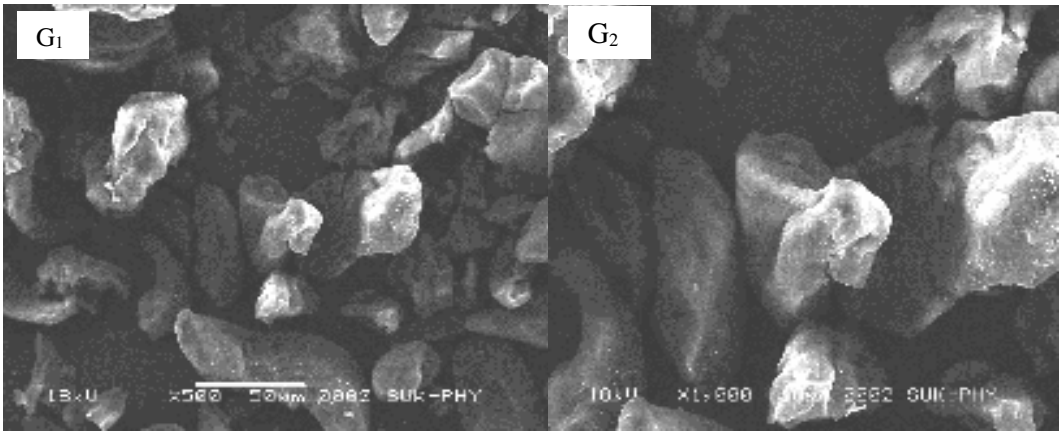


Figure-4. Scanning electron microscopy of guar gum powder at 500× magnification (G_1) and 1000 × magnification (G_2).

The SEM images of finest sieved fractions, shown in **Figure-4** at G_1 and G_2, though comparable to unfractionated samples, showed more of lower particle size. Both of them also showed a few spherical shaped particles.

3.5.2. Xanthan Gum Powder

The xanthan gum particle size distribution, as shown in **Figure-5** by scanning electron microscopy revealed multiple rod-shaped particles of irregular sizes along with a few spherical shaped particles, which was reflected in their varied hydration characteristics. The morphology of the xanthan gum's surface was fibrous. Fibers appeared to exist in a variety of related forms. Scanning electron microscope image of a structure with a fibrous surface shape. These fibers appeared more homogeneous and their thickness decreased.

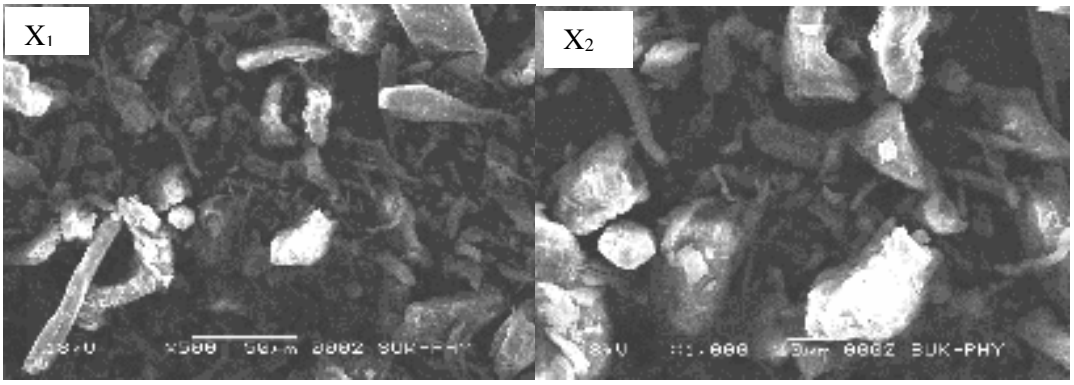


Figure-5. Scanning electron microscopy of xanthan gum powder at 500× magnification (X_1) and 1000 × magnification (X_2).

3.6. Effect of Icing Sugar on Sensory Attributes of Prepared Whipped Cream

The graph revealed that the sensory evaluation of whipping cream incorporated with icing sugar in different percentage(25%,50%,75% and 100% respectively) and added some amount table spoon of vanilla flavor as per required as shown in **Figure-6**. Control sample was contained icing sugar without guar gum and xanthan gum powder. 75% of icing sugar was selected for final product on the basis of overall acceptability of sensory evaluation.

Table-5 shown that, the sensory evaluation was conducted on the basis of storage behavior of whipped cream for 28th days. The sensory card shows the sensorial marks were decreasing pattern as decreasing in pH value. Foam stability was more at pH 5 and 6.

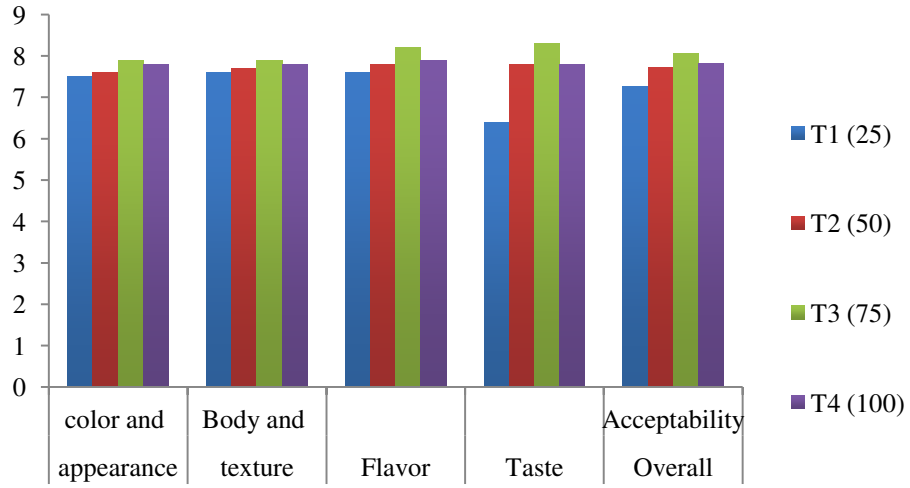


Figure-6. Effect of icing sugar on sensory attributes of prepared whipped cream.

Table-5. Sensorial evaluation of whipping cream.

Storage Days	Colour And Appearance	Body And Texture	Flavor	Taste	Overall Acceptability
0	8.1	7.9	8.2	8.5	8.1
7	7.9	7.7	7.8	8.0	7.85
14	7.7	7.6	7.5	7.9	7.6
21	7.6	7.4	7.2	7.7	7.47
28	7.4	7.3	7.0	7.5	7.3

4. CONCLUSION

Foamability and foam stability of whipped cream using guar gum, xanthan gum powder and icing sugar were studied. Ratio of guar gum and xanthan gum powder were given more foamability and foam stability at 6:4. On the basis of sensory evaluation such as color and appearance, body and texture, flavor, taste and overall acceptability it was concluded that 75 % icing sugar was accepted in whipped cream. The conducted sensory evaluation during storage shows that the whipped cream was acceptable till 28^{th} days.

REFERENCES

1. Day, L., Golding, M. (2016) Encyclopedia of Food Chemistry, 15, 125-129.
2. Shamsi, K., Che Man, Y. B., Yusoff, M. S. A., Jinap, S. (2002) Journal of American Oil Chemists Society, 79, 583-588.
3. Kawamura, Y. In FAO/WHO, Guar gum chemical and technical assessment, Food and Agriculture Organization, United Nations, (2008) pp.1-4.
4. Anjum, F., Bukhari, S. A., Siddique, M., Shahid, M., Potgieter, J. H., Jaafar, H. Z., Zia-Ul Haq, M. (2015) Bioresources, 10, 1434-1451.
5. Casas, J. A., Mohedano, A. F., García Ochoa, F. (2000) Journal of the Science of Food and Agriculture, 80, 1722-1727.
6. Flay, B., Banyas, S., Garron, M. In More Than 100 Recipes from Food Network's Ultimate Cooking Challenge, New work, (2010) pp.12.
7. Wang, Z., Zhang, S., Vardhanabhuti, B. (2015) Journal of Food Science, 80, 1893-1902.
8. Singh, A., Benjakul, S., Kijroongrojana, K. (2018) Food Hydrocolloids, 77, 286-296.
9. Rana, R., Kaur, P. (2016) International Journal of Current Research, 8, 24997-25001.
10. Qiang Zhong, Z., Mou Ming, Z., Bao, Y., Chun, C. (2009) Food Chemistry, 116, 624-628.
11. Hunter, T. N., Pugh, R. J., Franks, G. V., Jameson, G. J. (2008) Advances in Colloid and Interface Science, 137, 57-81.
12. Jarpa-Parra, M., Tian, Z., Temelli, F., Zeng, H., Chen, L. (2016) Food Hydrocolloids, 61, 903-913.
13. Guven, M., Karaca, O. B., Kacar, A. (2003) International Journal of Dairy Technology, 56, 223-228.

Development of Protein-Rich Tomato Soup Premix by Utilization of Spirulina Powder and Whey Protein Concentrate Powder

Prajkta.S. Patil[a], Shital.A. Patil[a], Iranna.S. Udachan[a,*]
Department of Technology, Shivaji University, Kolhapur 416 004 (MS) India.
*Corresponding author: isu_tech@unishivaji.ac.in

ABSTRACT
Instant soup premix being nutrient-rich and convenient food can cater to increasing consumer demands. The aim of the present work was to develop a protein-rich tomato soup premix by replacement of tomato powder at the level of 0.5%, 1%, 1.5%, and 2% with spirulina powder and replacement of corn starch with whey protein concentrate powder (WPC) at the levels of 5%, 10%, 15%. The protein content of the developed tomato soup premix was improved from 5.8% to 6.6% due to optimized levels of 1% of spirulina powder. This was further improved to 13.6% by optimization of whey protein concentrate powder at 10%. Sensory analysis of 1% spirulina powder and 10% whey protein concentrate powder was optimized for the development of a protein-rich tomato soup premix. The shelf life of the developed protein-rich tomato soup premix was stable for 3 months at room temperature.

KEYWORDS
Instant premix, Protein-rich spirulina powder, Tomato soup premix, Whey protein concentre powder.

…….

1. INTRODUCTION

Malnutrition is defined as "a condition of nutrition in which a deficit or excess, of energy, protein, and micronutrients has detectable negative consequences on tissue/body form (body shape, size, and composition) and function, as well as the clinical outcome". This definition, however, does not take into account the reason for unintended weight loss in the event of malnutrition. Malnutrition is characterised by a lack of energy balance and protein, which can hinder the proper functioning of many physiological processes. Malnutrition afflicted about 14% of the world's population in 2008 [1].

Spirulina has incredible health benefits for children who are malnourished. It is high in beta-carotene, which can help prevent blindness and eye disorders by overcoming the effects of vitamin A deficiency. It also meets the daily dietary requirement for beta-carotene, which can help prevent blindness and eye diseases. In

an infant's diet, the protein and B-vitamin complex provides a significant nutritional boost. It is the only dietary item, aside from breast milk, that contains significant levels of essential fatty acids, essential amino acids, and GLA, all of which aid in hormone regulation [2].

Tomatoes (*Solanum lycopersicum*) are high in phytochemicals and nutrients like lycopene, potassium, iron, folate, and vitamin C, among others. Tomatoes also include antioxidants like beta-carotene and phenolic substances including flavonoids, hydroxycinnamic acid, chlorogenic acid, homovanillic acid, and ferulic acid, in addition to lycopene and vitamin C. Tomatoes are an important part of a balanced diet because they may be eaten raw or cooked and retain their nutritional value. Over 80% of all commercially farmed tomatoes are consumed in the form of processed foods like juice, soup, and ketchup. A diet high in tomatoes and tomato products is known to provide a number of health benefits, many of which are due to the antioxidant content of tomatoes [3].

Whey protein, which accounts for 20% of total milk protein, is made up of various proteins, including *-lactoglobulin (-LG), -lactalbumin (-LA), heavy- and light-chain immunoglobulins (Igs), bovine serum albumin (BSA), lactoferrin (LF), lactoperoxidase, and glycomacropeptide (GMP)*. During the cheesemaking process, whey may also contain proteose-peptone components and low-molecular-weight compounds generated by the enzymatic breakdown of caseins. Whey protein contains all 20 amino acids, including all nine necessary amino acids, and is a good source of sulphur amino acids, which are important antioxidants and precursors to the potent intracellular antioxidant glutathione, as well as in one-carbon metabolism. It has three to four times the amount of cysteine that other proteins have. Cysteine is required for the manufacture of glutathione, a tripeptide that acts as an antioxidant, anticarcinogen, and immunological stimulant. It's also important for the regulation of whole-body protein metabolism, which leads to variations in body composition. Leucine is an essential component of tissue growth and repair. Leucine, isoleucine, and valine are believed to act as metabolic regulators in protein and glucose homoeostasis, as well as lipid metabolism and weight management [4].

2. MATERIALS AND METHODS

2.1. Raw Materials

Tomatoes were obtained from the local market and subjected to the necessary pre-treatments, such as washing, grading, and sorting. Spirulina powder, whey protein concentration powder (WPC-70), milk powder, corn starch, citric acid, xanthan gum, and other spices and condiments were obtained from local Kolhapur markets.

2.2. Physico-chemical Parameters of Raw Materials

The proximate analysis like moisture, ash, fat, protein, and crude fiber were conducted by the method given by Ranganna, (1979) [5] and AOAC, (2000) [6].

2.3. Color

Colour measurement was carried out by the method given by Robertson (1976) [7], colour measurement was done with a Hunter colour measuring system and stated as of L*, a*, and b*. L* shows of lightness, ranging from white to black. a* values indicated red to green colour components, whereas b* values showed yellow to blue colour components.

2.4. Bulk Density

The bulk density of the tomato soup premix was evaluated by weighing the premix and calculating the volume. 5 gm of the sample was placed in a 10 ml graduated measuring cylinder. Bulk density was obtained by dividing the mass of the mixture by the volume occupied in the cylinder [8].

2.5. Water Activity

Water activity was measured using a water activity meter after the tomato soup premix was poured in the sample container upto $3/4^{th}$ level and kept inside the sample chamber [8].

2.6. Angle of Repose

During the estimation of angle of repose different powdered and granulated sample were kept on flat surface and measure the angle [9].

2.7. Ascorbic Acid Content

The ascorbic acid content of the sample was estimated by titration method according to AOAC (2000) [6].

2.8. Carotenoid Content

Determination of Carotenoid content was carried out by the method given by Rangana, (2003) [5].

2.9. Preparation of Tomato Powder

Tomatoes with a firm, sound texture and nice flavour were picked, and the surface was cleansed with water to remove any dust and debris. The tomatoes were blanched for 30 seconds at 100°C and then sliced with a stainless-steel knife. Tomato slices were spread out on stainless steel trays and dried for 8 hours at 70°C in a mini tray dryer. These slices were ground into fine powder after cooling and sieved through mesh sizes of 36 mm to create consistent powder. The prepared tomato powder was

packed in HDPE laminated Aluminum pouches and was stored at room temperature [10]

2.10. Preparation of Protein-Rich Tomato Soup Premix

Figure-1 shows the flow chart for preparation of protein-rich tomato soup premix.

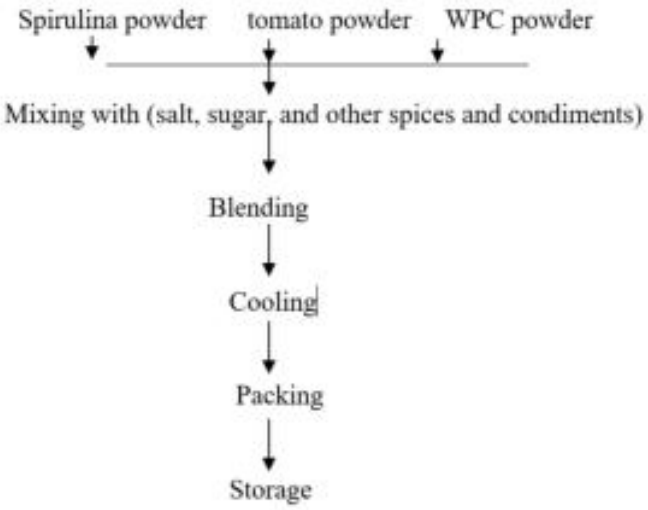


Figure-1. Flowsheet for development of protein-rich tomato soup premix [11].

Table-1. Optimization of spirulina powder in the development of protein rich tomato soup premix.

Ingredients (g)	SP1	SP2	SP3	SP4
Tomato powder	26.5	26	25.5	25
Spirulina powder	0.5	1	1.5	2
Sugar	23	23	23	23
Salt	10	10	10	10
Corn Starch	15	15	15	15
Milk powder	5	5	5	5
Onion powder	4	4	4	4
Garlic powder	4	4	4	4
Coriander powder	2	2	2	2
Black pepper powder	2	2	2	2
Chilli powder	3	3	3	3
Kasuri methi powder	2	2	2	2
Cumin powder	2	2	2	2
Citric acid	0.5	0.5	0.5	0.5
Xanthan gum	0.5	0.5	0.5	0.5

2.11. Optimization of Spirulina Powder in the Development of Protein-Rich Tomato Soup Premix

Optimization of the developed tomato soup premix was carried out using spirulina powder of 0.5%, 1%, 1.5% and, 2% respectively as shown in **Table-1**. According to FSSAI standards, 2016 the daily consumption of phycocyanin in spirulina powder is 50-250 mg per day. Hence, the range of spirulina powder used during the development of protein-rich tomato soup premix was in the range of 0.5-2%

2.12. Optimization of Whey Protein Concentrate Powder and Corn Starch for the Development of Protein-Rich Tomato Soup Premix

Optimization of the developed tomato soup premix was carried out as shown in **Table-2** using whey protein concentrate powder of 0%, 5%, 10% and, 15% respectively. Corn starch was optimized at 15%, 10%, 5% and, 0% respectively. Sample WPC1 contains 15gm of corn starch and no amount of WPC powder. According to the result reported by Novokshanova *et al.,* 2021 [12], starch was replaced by WPC as the viscosity and thickening capacity of WPC were nearly the same as corn starch. The soup premix (20gm) was disintegrated in 180ml lukewarm water with continuous mixing which was followed by increasing the temperature to boiling and holding for three minutes according to the method suggested by, Chavan *et al.,* 2015 [13].

Table-2. Optimization of whey protein concentrate powder and corn starch for the development of protein-rich tomato soup premix.

Ingredients (g)	WPC1	WPC2	WPC3	WPC4
Tomato powder	26	26	26	26
Spirulina powder	1	1	1	1
Sugar	23	23	23	23
Salt	10	10	10	10
Corn Starch	15	10	5	0
WPC	0	5	10	15
Milk powder	5	5	5	5
Onion powder	4	4	4	4
Garlic powder	4	4	4	4
Coriander powder	2	2	2	2
Black pepper powder	2	2	2	2
Chilli powder	3	3	3	3
Kasuri methi powder	2	2	2	2
Cumin powder	2	2	2	2
Citric acid	0.5	0.5	0.5	0.5
Xanthan gum	0.5	0.5	0.5	0.5

3. RESULTS AND DISCUSSION

3.1. Physical Analysis of Raw Material

The physical analysis of tomato powder, spirulina powder and, whey protein concentrate was carried out and the results are shown in **Table-3**.

Table-3. Physical analysis of tomato powder, spirulina powder, and Whey protein concentrate powder.

Sr. no	Parameters		Spirulina powder	Tomato powder	WPC powder
1.	Color	L^*	25.25	51.04	86.56
		a^*	-4.20	22.51	0.0423
		b^*	6.97	20.42	11.97
2.	Bulk density (g/ml)		0.81 ±0.45	0.34 ± 0.02	0.37±0.32

3.2. Physical Analysis of Tomato Powder, Spirulina Powder, and Whey Protein Concentrate Powder

Tomato powder, spirulina powder, and WPC powder were tested for a variety of physical qualities. The colour spirulina powder, tomato powder, and WPC powder were measured by hunter colourimeter by L*, a*, b* values, and bulk density, as shown in **Table-3**. Spirulina powder, tomato powder, and WPC powder had bulk densities of 0.81±0.45, 0.34±0.02, and 0.37±0.32 gm/ml, respectively. The above values of tomato powder, spirulina powder, and WPC powder were in close agreement with the earlier results reported by Jayathunge *et al.,* (2012) [14], Sharoba (2014) [15], and Rathour *et al.,* (2017) [16].

3.3. Physicochemical Analysis of Tomato Powder, Spirulina Powder, and WPC Powder

The proximate characteristics of tomato powder, spirulina powder, and WPC were analyzed and results were calculated. The chemical composition of food includes moisture, ash, and carbohydrate. Tomato powder (7.25±0.91) had a higher moisture content than spirulina powder and WPC powder. Tomato powder had a high amount of ash level (7.8±1.2) than spirulina powder and WPC powder. When compared to other powders, WPC powder had a high protein content (69.98±0.31). Tomato powder has the highest amount of crude fibre value (8.5±1.9). The values of tomato powder, spirulina powder and WPC powder were in close agreement with the earlier results reported by Jayathunge *et al.,* (2012) [17], Sharoba (2014) [18], and Aastha, *et al.,* (2017) [19], as shown in **Table-4**.

Table-4. Physicochemical analysis of tomato powder, spirulina powder, and WPC powder.

Parameter (%)	Tomato powder	Spirulina powder	WPC powder
Moisture	7.25±0.91	5.5±0.91	3.05±0.08
Ash	7.8±1.2	7.62±0.21	3.41±0.03
Protein	3.2±.95	63.5±1.09	69.98±0.31
Fat	6.8±0.54	6.82±0.21	5.85±0.07
Carbohydrate	74.95±1.3	16.92±0.11	17.71±0.04
Crude fiber	8.5±1.9	8.31±0.29	-
pH	6.67 ± 0.14	4.24 ± 0.10	6.68±0.09

WPC= Whey Protein Concentrate powder

3.4. Sensorial Attributes for Optimization of Tomato Powder and Spirulina Powder for the Development of Protein-rich Tomato Soup Premix

The sensory analysis for the developed soup premix using tomato powder and spirulina powder is given in **Figure-2**. Sample SP4 had the lowest sensory score for all attributes. Sample SP2 had high sensory scores than all other samples making it all acceptable. Sample SP4 had tomato powder and Spirulina powder in a ratio of 25.0:0.2 whereas sample SP2 has tomato powder in the ratio 26.0:0.1.

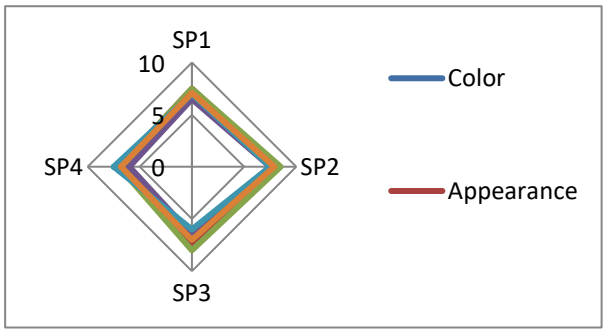


Figure-2. Sensorial attributes for optimization of tomato powder and spirulina powder for the development of protein rich tomato soup premix.

SP1= Tomato powder: Spirulina powder = 26.5:0.5;

SP2= Tomato powder: Spirulina powder = 26.0:0.1;

SP3= Tomato powder: Spirulina powder = 25.5:1.5;

SP4= Tomato powder: Spirulina powder = 25.0:0.2

3.5. Sensory Attributes for Optimization of Corn Starch and Whey Protein Concentrate Powder for the Development of Protein Rich Tomato Soup Premix

The sensory analysis for developed soup premix using whey protein concentrate powder and corn starch is given in **Figure-3**. Sample WPC2 had the lowest sensory score for all attributes. Sample WPC3 had high sensory scores than all other samples making it all acceptable. Sample WPC2 had whey protein concentrate powder and corn starch in the ratio 10: 05 whereas sample WPC3 has tomato powder in the ratio 05: 10.

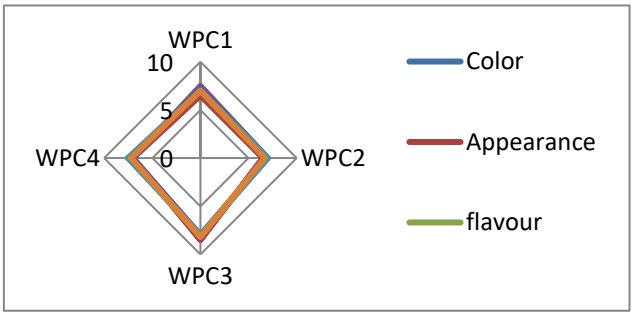


Figure-3. Sensory attributes for optimization of corn starch and whey protein concentrate powder for the development of protein-rich tomato soup premix.

WPC1= Corn starch: WPC = 15: 00

WPC2= Corn starch: WPC = 10: 05

WPC3= Corn starch: WPC = 05: 10

WPC4= Corn starch: WPC = 00: 15

3.6. Physicochemical Analysis of Tomato Soup Premix

The moisture content of tomato soup premix with 1% spirulina powder and 10% whey protein concentrate powder was comparable with the control premix. It was analyzed that TSP with 1% spirulina powder and 10% WPC powder had more moisture content of 9.1±0.05% than TSP with 1% spirulina powder and control sample. A high amount of protein leads to an increase in the water-holding capacity because of the hydrophilic characteristics of proteins [20]. The ash of protein-rich TSP with 1% spirulina powder and 10% WPC powder was more than TSP with 1% spirulina powder and control soup premix. The ash of protein-rich TSP with 1% SP and 10% WPC powder was 4.4±0.04% while that of TSP with 1% spirulina powder was 3.3±0.02% respectively. The protein content of the control premix was 5.8±0.4% which was increased to 6.6±0.7% with the optimization of spirulina powder as 1% which further improved to 13.6±0.15% with optimisation of 1%spirulina and 10% WPC (see **Table-5**).

The carbohydrate content of the control soup premix was 80.42±1.2% which was more than TSP with 1% spirulina and TSP with 1% spirulina and 10% whey protein. The crude fibre content of the control premix was 4.1±0.09% while that of TSP with 1% spirulina powder was 4.36±0.07% and protein-rich TSP with 1% spirulina powder and 10% WPC powder was 4.34±0.10% respectively.

Table-5. Physicochemical analysis of developed protein-rich tomato soup premix.

Parameter	Control	TSP with 1% spirulina powder	SP with 1%spirulina and 10% WPC
Moisture (%)	8.6±0.07	8.7±0.09	9.1±0.05
Ash (%)	3.1±0.03	3.3±0.02	4.4±0.04
Fat (%)	2.08±0.02	2.12±0.04	2.78±0.02
Protein (%)	5.8±0.4	6.6±0.7	13.6±0.15
Carbohydrate (%)	80.42±1.2	79.28±1.1	70.12±1.2
Crude fiber (%)	4.1±0.09	4.36±0.07	4.34±0.10

TSP= tomato soup premix

3.8. Storage Study of Protein-Rich Tomato Soup Premix

The microbial quality of tomato soup premix in total plate count, yeast & mould count is shown in **Table-6**. The total plate count was 0.1×10^3 on the 30th day for the protein-rich tomato soup premix. On the 90th day, TPC was 3.2×10^3 which was acceptable. TPC of tomato soup premix was stable and acceptable at day 30 and day 90. The microbial quality with respect to mould & mould indicated the absence of microbial load during the storage period of day 45 after that it reached 0.76×10^2 on

Table-6. Storage condition effect on microbiology of HDPE laminated Al pouches at room (28±5ºC) temperature.

Days	Parameter	
	Total plate count (cfu/g)	Yeast and mould (cfu/g)
0	ND	ND
15	ND	ND
30	0.1×10^3	ND
45	0.7×10^3	ND
60	2.0×10^3	0.1×10^2
75	2.6×10^3	0.3×10^2
90	3.2×10^3	0.76×10^2

day 90 which was because of less moisture content in the products in the period of storing that hindered the fungi. Hence the tomato soup premix was microbially stable for up to 90 days a room temperature. The tomato soup premix was suitable to be aerobically stored in HDPE laminated aluminium pouches at room temperature (28±5ºC) for a period of 90 days without any deterioration in its quality and acceptability.

4. CONCLUSION

Protein-rich tomato soup premix was developed by utilization of tomato powder, spirulina powder, whey protein concentrate (WPC), corn starch etc. The final optimization of the developed soup premix contained 1% spirulina and 10% whey protein concentrate. The protein content due to the addition of spirulina powder increased from 5.8% to 6.6% due to addition of 1% spirulina powder which further was increased to 13.6% due to the addition of 10% whey protein concentrate powder along with 1% spirulina powder. The shelf life of the developed product was stable for a period of 3 months. The developed product could be beneficial for people with malnutrition.

ACKNOWLEDGEMENT

The authors deeply appreciate the Department of Technology, Shivaji University, Kolhapur for providing support to carry out the research work.

REFERENCES

1. Younis, K., Ahmad, S., Badpa, A. (2015) Journal of Food Processing and Technology, 6, 2.
2. Sharoba, A. M. (2014) Journal of Food and Dairy Sciences, 5, 517-538.
3. Collins, E. J., Bowyer, C., Tsouza, A., Chopra, M. 2022 Biology, 11, 239.
4. Solak, B. B., Akin, N. (2012) Journal of Food Science and Engineering, 2, 129
5. Ranganna, S. In Manual of analysis of fruit and vegetable products, Tata McGraw-Hill, New Delhi. (1979) pp.634.
6. Horwitz, W. and Latimer, G.W. In Association of official analytical chemists. Gaithersburg, MD, USA. (2000).
7. Robertson, A. R. (1977) Color Research & Application, 2, 7-11.
8. Sarkar, B., Upadhyay, S., Gogoi, P., Das, A., Hazarika, M., Rahman, Z., Datta, A. (2019) Journal of Entomology and Zoology Studies, 7, 24-30.
9. Peleg, M., Bagley, E.B. In IFT basic symposium series (USA). AVI Publishing, Las Vegas, Nevada, (1983) pp.293-324.

10. Kumar, V., Singh, S., Singh, B. R., Chandra, S., Samsher, S. (2016) Journal of Applied and Natural Science, 8, 1157-1163.
11. Ray, S., Saha, R., Raychaudhuri, U., Chakraborty, R. (2016) Technical Sciences/University of Warmia and Mazury in Olsztyn, 19, 199-213.
12. Novokshanova, A. L. V., Ganina, V. I., Ababkova, A. A., Kuzin, A. A. (2021) Current Research in Nutrition and Food Science Journal, 9, 550-563.
13. Chavan, R., Bhatt S., Kumar A. (2015) International Journal of Engineering Research, 3, 35-48.
14. Jayathunge, K. G. L. R., Kapilarathne, R. A. N. S., Thilakarathne, B. M. K. S., Fernando, M. D., Palipane, K. B., Prasanna, P. H. P. (2012) Journal of Agricultural Technology, 8, 765-773.
15. Sharoba, A. M. (2014) Journal of Food and Dairy Sciences, 5, 517-538.
16. Rathour, A. K., Rathore, V., Mehta, B. M., Patel, S. M., Chauhan, A., Aparnathi, K. D. (2017) Journal of Food Processing and Preservation, 41, e12882.
17. Jayathunge, K. G. L. R., Kapilarathne, R. A. N. S., Thilakarathne, B. M. K. S., Fernando, M. D., Palipane, K. B., Prasanna, P. H. P. (2012) Journal of Agricultural Technology, 8, 765-773.
18. Morsy, O. M., Sharoba, A. M., El-Desouky, A. I., Bahlol, H. E. M., Abd El Mawla, E. M. (2014) Annals of Agricultural Science, Moshtohor, 52, 329-342.
19. Aastha, D., SM, G., Neelam, U., Ruchika, B., Ashish, K. S., Rana, J. S. (2017) Madridge Journal of Food Technology, 2, 92-98.
20. Wilding, P., Lillford, P. J., Regenstein, J. M. (1984) Journal of Chemical Technology and Biotechnology, 34, 182-189.

Development of Traditional Roat and Its Shelf-Life Study

Tanzila A. Kazi[a], Arvind B. Madavi[a], Shripal M. Gaikwad[a], Siddharth M. Lokhande[a,*], Shital A. Patil[a]

[a]Department of Technology, Shivaji University, Kolhapur 416 004 (MS) India.

*Corresponding author: sml_tech@unishivaji.ac.in

ABSTRACT

Traditional foods are gaining popularity among recent consumers in a new avatar now with long shelf life and new quilting ways. Control roat was prepared with 50% durum wheat & semolina, 25% jaggery, 10% wheat flour, 10% milk, 5% ghee, 3% sugar, 10% dry fruits, 0.5% spices mix and 0.5% baking powder. The dough was formed and it is kept for 10 - 12 hours. Then dough was molded in appropriate size and baked at 220 ^{0}C for 15 mints. For the improvement in protein content and Fibre content prepared roat, emmer wheat semolina was incorporated for the partial replacement of durum wheat semolina in the proportions of 10, 20, 30 and 40%. Higher replacement of emmer wheat semolina shown better results for its physicochemical and sensorial properties. 40% replacement of emmer wheat semolina showed increased in protein content and dietary fibre content in the range between 12.52 %to17.86 %and 2.51 % to 4.31 %.

KEYWORDS

Shelf life, Roat, Durum wheat, Semolina, Jaggery, Fibre content & Emmer wheat.

…….

1. INTRODUCTION

Dietary inspirations and the country's significant immigration and mingling have both improved Indian food. India has their own kind of food that is mostly prepared on a remarkable occasions like religious festivals and social events. Best combinations of spices and flavorings in the Indian foods has made it popular in worldwide. A newavatar's request for traditional cuisine has started to appear. Due to abundant availability of almost all nutrients, traditional meals aid in improving people's nutritional state on large extent. Besides they form a principal income and employment particularly the vulnerable and marginalized areas besides it can help overcome malnutrition. Hence these foods need to be popularized. The market for the bakery items is increasing owing to growing urbanization. Cookies one of the popular baked products arrived in the world from different countries. They are made by using three essential ingredients sugar, flour and fat along with other secondary ingredients to form dough of desired consistency. Wheat flour being main ingredient due to its favorable rheological properties. Cookies have wider consumption base fairly long shelf-life and it is appealing for protein incorporation and other nutritional enhancements due to its added simplicity and high detectability. Besides cookies represent largest order of snacks. Roat is one such type of the cookies made

with whole wheat suji as primary ingredient, along with ghee, dry fruits, jiggery, milk and spices. It forms the healthiest and nutritive cookies. Root is prepared using emmer wheat which is the foremost domesticated crop cultivate on large scale, which has now become minor crop; cultivated only in borderline areas. Various products like godihuggi, puranpoli, upma, & rava-idli are prepared using emmer wheat semolina in southern India

2. MATERIALS

1.1. Materials

Emmer wheat semolina, ghee, durum wheat semolina, dry fruits, poppy seeds, milk, nutmeg, illayechi & mace. Raw materials & ingredients were procured from local market of Kolhapur, (MS) India.

1.2. Preparation of Roat

Control sample was prepared by creating a homogenous solution, milk, grated jiggery, and melted ghee were combined. Durum semolina was then gradually added in little portions. Spices and more dry fruits were included. After being worked for 10 to 12 hours while being covered with a moist cloth, the dough was separated into manageable sections and given the appropriate shape. Then each roat was covered with poppy seeds and baked at baking temperature (see **Figure-1**). Emmer wheat semolina 10%, 20%, 30%, & 40% kept constant [1].

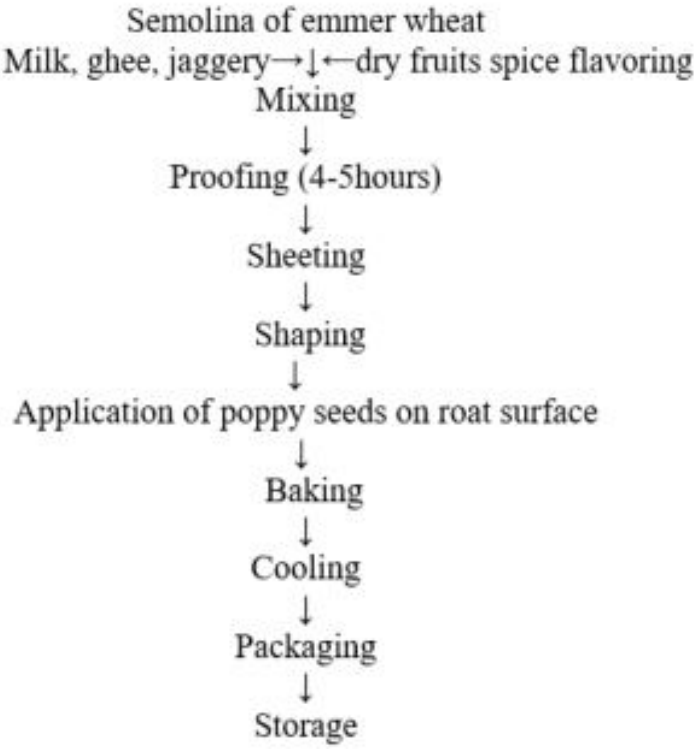


Figure-1. Process flowsheet for preparation of roat [2].

Table-1. Optimization of semolina of emmer wheat in roat.

Ingredients (gm.)	Control	A1	B1	C1	D1
Semolina of durum wheat	50	40	30	20	10
Semolina of emmer wheat	-	10	20	30	40
Jaggery	25	25	25	25	25
Wheat flour	10	10	10	10	10
Dry fruits	10	10	10	10	10
Spices	0.5	0.5	0.5	0.5	0.5
Baking powder	0.5	0.5	0.5	0.5	0.5
Ghee	5	5	5	5	5
Sugar	3	3	3	3	3
Milk	10	10	10	10	10

Control, A1:10% EWS, B1:20% EWS, C1:30% EWS & D1:40% EWS.

Table-1 indicates optimization of semolina of emmer wheat for roat preparation. The control sample was created by DWS, and its optimization was completed by adjusting the quantity of EWS. The lowest amount of EWS, 10 gm, is present in sample A1, and the maximum amount, 40 gm, is present in sample D1. Samples B1 and C1 each contain 20gm and 30gm of EWS. The maximum amount of DWS, or 40gm, is found in sample A1, and the lowest amount, or 10gm, is found in sample D1. DWS amounts in samples B1 and C1 are 20gm and 30gm, respectively. All samples have the same additional components.

3. ROAT QUALITY EVALUATION

3.1. Color Value

The color of control sample with 0 % durum wheat semolina and other optimized samples were done using Hunter Lab Colorimeter after calibrating it with basic tiles in black and white. In terms of L*, a*, and b*, the final results were presented [3].

3.2. Sensory Analysis of Prepared Roat

Sensory evaluation of control sample and optimized samples by replacing durum wheat semolina with emmer wheat semolina in proportions of 10%, 20%, 30%, 40%. With the help of 9-point hedonic scale, sensory qualities such as, taste, flavor, texture, sight and general appeal were evaluated [4].

3.3. Proximate Analysis

The proximate analysis of control sample and final sample selected based on sensory evaluation was done by standard AOAC methods [5].

3.4. Storage Study

The prepared final product was evaluated for storage study at a regular interval of 7, 15, 30 and 45 days in different packaging material that is HDPE and laminated aluminum pouches. Total plate count was determines by standard methods using agar medium, pH 7.0±0.1 by following pour plate technique and incubating at 37^0 C for 24 hours finally count was measured by using bacteriology colony counter. Yeast and mould count was done by incubating the sample at the correct dilution on Rose Bengal Agar Base, pH 7.20.1, for up to 24 hours. Count was measured by using bacteriological colony counter [6].

4. RESULT & DISCUSSION

4.1. Color Value

Table-2. Colour Analysis of control and optimized samples.

Sample	Colour		
	L*	a*	b*
Control	25.42	10.42	11.13
A1	25.55	12.42	12.03
B1	30.10	15.85	19.59
C1	32.63	16.46	22.66
D1	32.79	17.45	21.90

Control, A1:10% Semolina of emmer wheat, Bl:20% Semolina of emmer wheat, C1:30% Semolina of emmer wheat. D1:40% Semolina of emmer wheat

Effect of substitution of DWS by EWS on the colour of the roat are presented in **Table-2** with the increase in replacement of DWS by EWS from 0 to 40% affects colour value of roat. The lightness is indicated by 1* value increased from 25.55 to 32.79. This colour be due to the colour of emmer wheat semolina. The increase in the value with increase in replacement could be due to the dark colour of emmer wheat semolina. The red and yellow colour indicated by a* and b* value. These values increased from 10.42 to 17.45 and 11.13 to 21.90 respectively. These increase in mainly due to the brownish yellow colour of the Emmer wheat semolina after baking [7].

4.2. Sensory Analysis

Sensory attributes of control and roat replaced by EWS **Figure-2** shows, it can be seen that with replacement of durum wheat semolina by emmer wheat semolina the appropriate texture and taste and overall acceptability goes on increasing. It was seen maximum for replacement of 40% [8].

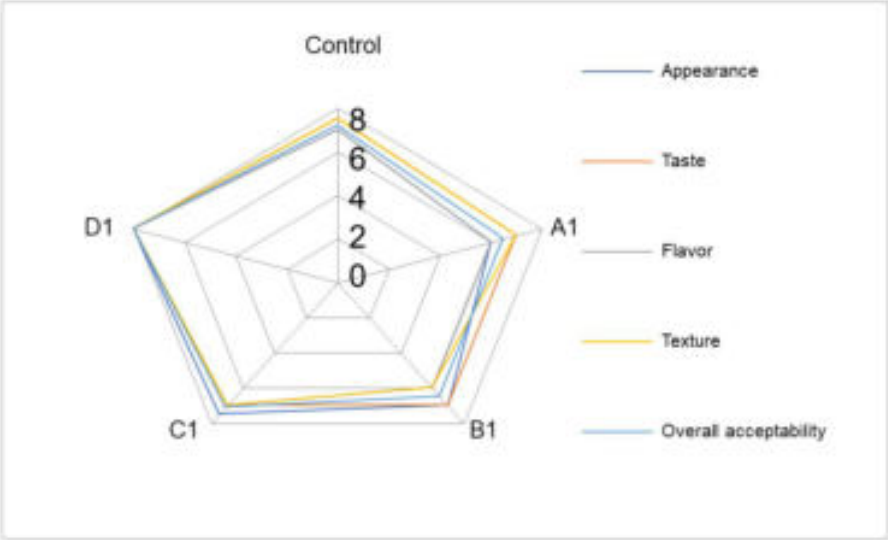


Figure-2. Sensory Analysis of prepared roat (Control, A1:10% EWS, EWS-20 % EWS, C1:30%, EWS, & D1:40% EWS).

4.3. Proximate Analysis

Table-3 shows the proximate parameters evaluation of control and end product.

Table-3. Proximate parameters evaluation of control and end product.

Variable (%)	Control Sample	Final product
Moisture	6.08±0.02	6.12±0.02
Ash	0.8±0.05	1.0±0.07
Protein	12.52±0.08	17.86±0.04
Fat	5.89±0.01	6.55±0.02
Crude fiber	2.51±0.02	4.31±0.02
Carbohydrate	64.160±.02	75.72±0.01
Energy value	404.27±0.07(K cal)	416.01±0.02(K cal)

4.4 Storage Study

For healthy cookies samples, the highest allowed level for TPC is 10000 CFU/ml, and for yeast it is 1000 CFU/100ml.and mould counts, according to the FSSAI's 2018 gazette. The microbiological count in healthy cookies is displayed in **Table-4**. Yeast, Mold, and TPC counts in the rat up to the seventh day, expansion does not exist. Slight microbial damage was observed after 7^{th} day up to 30 days. However microbial damage was found to be more in HDPE than laminated aluminum pouches [9].

Table-4. Storage analysis of finished product.

Wrapping material	Storage period	TPC (CFU/gm)	Yeastmold count(cfu/gm)
HDPE	0	0	0
	7	$0.2x10^3$	0
	15	$5 x10^3$	$1x10^2$
	30	$9 x10^3$	$2.5x10^2$
Laminated Aluminum poches	0	0	0
	7	$0.1 x10^3$	0
	15	$4.5x10^3$	$0.9x10^2$
	30	$8x10^3$	$2.2x10^2$

5. CONCLUSION

Enhancement of fiber and protein content in the cookies which are deprived of it DWS was substituted by EWS. Texture, taste and appearance were critically affected while sensory and color analysis. Replacement up to 40% level of EWS was optimized. 40% replacement level of DWS, protein content improved from12.5 to17.86% whereas fiber content was improved from 2.51 to 4.31 which were comparable with traditional roat. Storage study indicated that roat were acceptable upto30 days which were comparable to market samples.

REFERENCES

1. Vatsala, C. N., Haridas Rao, P. (1990) Indian Miller, 11, 3-8.
2. Watharkar, R. B., Thorat, M. R., Shanediwan, A. N. (2012) Food Science Research Journal, 3, 146-148.
3. Akinwande, B. A., Ade-Omowaye, B. I. O., Olaniyan, S. A., Akintaro, O. O. (2008) Nutritional and Food Science Journal, 38, 473-481.
4. Amerine, M.A., Pongborn, R.M. Roessler, E.B. In Principles of Sensory Evaluation of Food, Elsevier, New York. (1965) pp.30-128.
5. Horwitz, W. and Latimer, G.W. In Association of official analytical chemists. Gaithersburg, MD, USA. (2000).
6. Bureau of Indian Standards, In Method for detection and estimation of yeast and mold count: Indian standards institution, BIS, New Delhi. (1990) pp.1-3
7. Ajibola, F.C., Oyerinde, O.V., Adeniyan, S. O. (2015) Journal of scientific research and report, 7, 195 –206.
8. Ranganna, S. In Manual of analysis of fruit and vegetable products, Tata McGraw-Hill, New Delhi. (1979) pp.634.
9. Sarkar, B., Upadhyay, S., Gogoi, P., Das, A., Hazarika, M., Rahman, Z., Datta, A. (2019) International Journal of Livestock Research, 7, 24-30.

Study on Solar Water Distillator

Pruthviraj M. Desai[a], Sahil K. Soni[a,*], Pravin A. Prabhu[a], Mahendra N. Vhatkar[a], Mahesh N. Jadhav[a]

[a]Department of Technology, Shivaji University, Kolhapur 416 004 (MS) India.

*Corresponding author: sahilsoni2752000@gmail.com

ABSTRACT

Water storages are important factor in our daily routine because of lots of pollution we are facing the shortage of the water which we can drink directly so it is very important to remove the pollutants from water. Extracting salt from wear using a solar cell is among the various techniques available salt removal. The limit for researchers is that they are continuously trying to improve the quality of solar water distillation by continuously improving the factors which are necessary for example thermal material, depth, angle of inclination by using trial and error method and if the results are in favor, then this method is implemented if it is not in favor then again it is important to make continuous improvement and which is very economical variable option.

KEYWORDS

Distillators, Basin, Reflectors, Radiations, Absorbers.

……

1. INTRODUCTION

Water is the elixir of life. Water coves about one third of the water the face of the earth. About 97% are salty sea water and 2% are concentrated in glaciers thus, the remaining 1% of water needed to survive. There is a problem of pure drinking water shortage is areas such as where water is not that much available and hence there is a big problem so it is very necessary to take observation on such problem is highly dependent on water is made available. The necessity of feeding plants water cannot be highly compressed. Solar water distillation is a process used for purifying water. Solar is still a simple tool to remove salt from the suns water the sun is motion less it may have a one slope or two slope as shown on **Figure-1**. The solar still in its lower part contains insulated container protective material to reduce heat loss in the environment. The container contains an absorber plate, which is covered with black layer of paint to increase the efficiency of the distillation because it absorbs maximum amount of heat from sunlight to convert water in the form of steam in shorter period of time. If the design is proper then it will be proper utilization of solar radiations in collection line.

1.1. Objectives

1. Efficiently produce the water which is required for human being per day with required quality at optimum cost.
2. Efficiently produce purified water for drinking using renewable sources.
3. To use renewable form of energy that is solar energy for business purpose.
4. Easy to interface with the natural resources.
5. To make system compact as well as portable.

1.2. Literature Review

i.The research was done by Prof. Alpesh Mehta, Arjun Vyas, Nitin Bodar and Dharmesh Lathiya on design of solar distillation system [1]. They recorded maximum evaporation in the period of 11:15 am to 1:30 pm. the maximum temperature they achieved was 530◦ C at 1:30 pm and then the temperature decreases. They purified 1.5 liters of water by adding 14 liters of brackish water to their solar distiller. The TDS level of purified water obtained by them was 81 PPM.

ii. A research was done by Pankaj Kalita, Anupam Dewan and Sangeeta Borah at center for energy, Indian institute of technology, Guwahati [2]. They reviewed recent developments in solar distillation unit. They emphasised to present a comprehensive review of the effects of various operating parameters, such as solar intensity, wind velocity, ambient temperature, water-glass temperature difference, free surface area of water, absorber plate area, temperature of inlet water, glass angle and depth of water, on the performance of solar distillation units. They reported 3.5l per m^2 in the passive solar still.

iii. The research was done on Designing, fabrication and performance analysis of solar still for purification of water by S.L.Jadhav, B. L. Chavan and S.S Patil at Dr. Babasaheb Ambedkar Marathwada University, Aurangabad [3]. They fabricated four solar stills of different capacities. They analyzed rate of distilled water production. The highest was recorded between 11:30 am to 12:30 noon. The recorded pH was 7 of distilled water. The TS, TDS, TSS, sulfates, phosphates and chlorides were reduced to zero after the solar distillation in all the four solar stills.

iv. The research was done by Amitava Bhattacharyya on solar stills for distillation of water in rural households at Nanotech Research Facility, PSG Institute of Advanced Studies, Coimbatore [4]. He upgraded the solar still version by capillarity skills, which gives high output. The heart of capillarity still is fabric which facilitates high evaporation of water at minimum heating and cost-effective manner.

1.3 Block Diagram

Figure-1 shows the block diagram for water distillator.

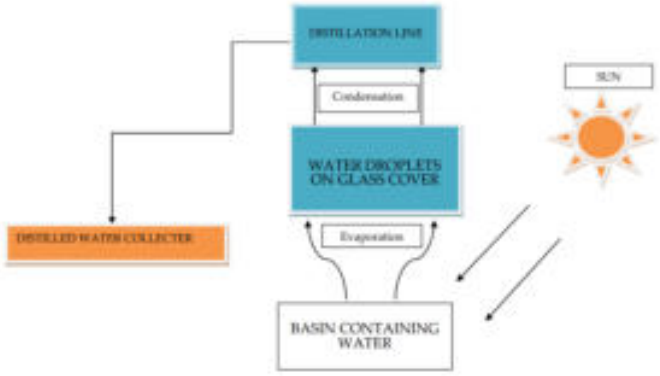


Figure-1. Block Diagram

1.4. Description

The basic aim of the process is to obtain purified water from the waste water source by using solar power. There are two main process which are to be carried out viz. Evaporation and condensation. The sun which is natural source of heat is used for evaporation of water. Water from the storage basin starts evaporating when the water reaches its boiling point due to heat absorbed by solar radiation. Evaporated content will start lifting upward due to its low density where it strikes on the glass which is fitted inclined on the water basin. After striking, the water vapor begins to condense due to heat exchange between vapors and surrounding atmosphere. Due to inclined structure of glass, condensate starts dripping to the lower side at which collectors are placed. Finally, the condensate which is purified water is collected by the collector.

2. BODY STRUCTURE

Figure-2 shows the water basin model.

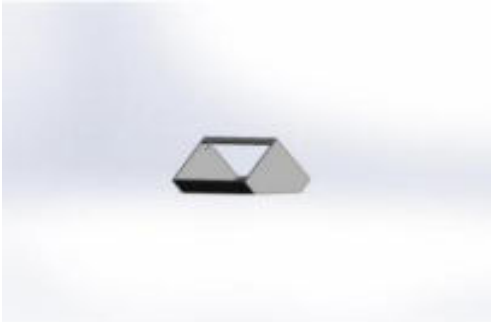


Figure-2. Water Basin.

1. Frame: It is a structure of material MS with L shaped angles (45mm*45mm) and length, width and height of 100cm, 83.8cm and 15cm respectively. It provides support to the storage section of the water.
2. Water Basin: It is a storage device used for storing waste water. The basin used is of Aluminium sheet with dimensions of 100cm*97cm*30cm
3. Thermal plate: It is a plate of aluminium sheet coated with black colour and barium pentaoxide. The purpose of coating is to absorb maximum heat from the solar radiations. The thermal plate is of 100 cm*97cm.
4. Glass: It is used to refract solar radiation towards water basin section. It also performs as a striking medium for water vapor. The glass is of 8mm in thickness, 100 cm long and 90 cm wide.

Figure-3 shows the project assembly.

Figure-3. Project Assembly

2.1. Working

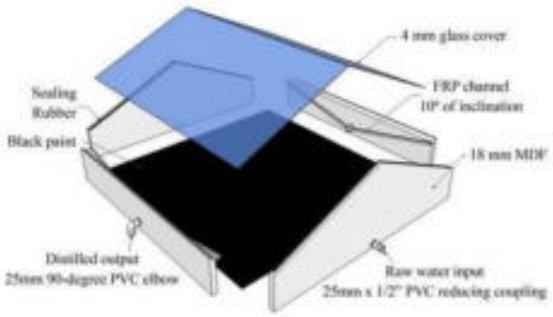


Figure-4. Working Model

Figure-3 shows the working model of water distillator. This project is very useful at the places where there is need of pure water and there is lack of facilities. The basic principle of solar water distillator is distillation takes place through solar energy which is renewable form of energy. Basically, it works on two scientific theories that are evaporation and condensation. The salts that are present in the water do not get removed without evaporation so to make the water free from salt we need to evaporate it. When solar radiations are absorbed by thermal plate the plate present at the base on which there is water gets heated up when it crosses the boiling temperature of the water that is 100 degree Celsius the water starts evaporating after getting evaporated the vapor generated gets settle on the glass that present at the top of the basin because the glasses in direct contact with surrounding air which is having low temperature that water vapor so water gets condensed at the glass so because of that vapor is converted into water droplets that are free from sales and other impurities because the glass is fitted as a slope due to inclination water droplets slides over the glass and gets collected at the outlet of the basin from which we are going to collect the pure water. Then the pure water is collected in a container for further use this is nothing but the actual working of the project.

3. SCIENTIFIC CONCEPTS

1. Evaporation: It is a stage when the liquid starts to convert into water vapor or gases form. When the temperature of water gets above 100 degrees Celsius. The temperature of water present in basin is raised using sun light, solar energy. It is very important process for the purification of waste water present in the basin. All the bad impurities and bacteria can't survive high temperature.
2. Condensation: Condensation is the state where the high temperature water which is heated up by using evaporation gets cooled. It is totally naturally cooled system. Water vapor gets converter to water i.e., reverse of evaporation. Condensation is the process in which gas molecules are converted into liquid.
3. Thermal Efficiency: It is the ratio of the water which is processed (after distillation) to water supplied to input of solar energy.

Heat Transfer: There are two modes of heat transfer External and Internal.

A) External heat transfer – This type of heat transfer includes the transfer between outer surfaces of solar distillator with the atmosphere.

B) Internal heat transfer – This type of heat transfer includes the transfer of energy between water surface and the glass cover present at the top of distillator.

4. RESULTS

4.1. Input

Filled Content (in liters)

1. Natural Water 2 liters
2. Contaminated Water 2 liters

Processing time (in minute)

1. 180
2. 180

4.2. Output

Quantity of content at outlet (in liters)

1. 1.3 liters
2. 1 liter

5. CONCLUSION

The conclusion is carried out by performing different quality test and performance test and by literature survey:

1. Efficiency of the solar water distillators is totally depending upon the intensity of solar radiations and it is improved by providing reflectors into it.
2. As we increase the area of distillators then the rate at which water is getting evaporated will also increased and hence the capacity of distillatory to evaporate water will also be increased.
3. It is important for basin to provide coating with some anticorrosive paint to prevent it from corrosion it is not prevented there are chances of distillatory may get damaged due to corrosion.
4. It is necessary to keep the head of water as low as possible so it will drastically improve the efficiency of the project.
5. When insulation is provided properly it will not allow steam to flow directly to atmosphere hence project gives maximum efficiency.
6.

ACKNOWLEDGEMENT

This work has been completed as a part of major project “Solar Water Distillator”. The authors are grateful for the guidance and support from the Mechanical Engineering program, Department of Technology, Shivaji University, Kolhapur.

REFERENCES

1. Mehta, A., Vyas, A., Bodar, N., Lathiya, D. (2011) International Journal of Advanced Science and Technology, 29, 67-74.
2. Kalita, P, Dewan, A., Borah, S. (2016) Indian Academy of Sciences Sadhana, 41, 203-223.
3. Jadhav, S.L, Chavan, B.L, Patil, S. S. (2011) Innovative Systems Design and Engineering, 2, 1-7.
4. Bhattacharyya, A. (2013) International Journal of Environment and Sustainability, 2, 21-30.

Applications of Number Theory in Asymmetric Cryptography

Snehal S. Karande[a,*], Hanmant P. Salunkhe[a,b]
[a]Department of Mathematics, Shivaji University, Kolhapur 416 004 (MS) India.
[b]Department of Technology, Shivaji University, Kolhapur 416 004 (MS) India.
*Corresponding author: snehal.karande77@gmail.com

ABSTRACT
This age of hackers and viruses in electronic fraud, security is paramount. To provide security and protect valuable info we can use cryptography. This review paper describes the importance and application of mathematical method Number Theory in asymmetric cryptography. Number Theory widely used in asymmetric cryptography. The concepts of Number Theory like addition modulo, multiplication modulo, divisors, congruence, Benzout theorem, Chinese reminder theorem, Lagrange's theorem, Euler's toient function and Euler's theorem are mostly used in asymmetric cryptography to make more complex encoding and decoding. In this paper we will discuss and study how to use these concepts of Number Theory in Asymmetric cryptography which provide confidentiality, integrity, non-repudiation and authentication of valuable data or information.

KEYWORDS
Asymmetric cryptography, Congruence, Cryptography, Eulerstoient function.

……

1. INTRODUCTION

Cryptography is the method of protecting information and communications through the use of codes so that merely those for whom the data is wished-for can study and process it. More generally, cryptography is about constructing and analysing agreement that protect other parties or the public from reading personal massage/information. Cryptography is the study of methods to convey and collect the underground messages [1]. The basic concept of cryptographic system is to cipher information or data in order to get confidentiality of the information in a way that an unofficial person would be not capable to derive its meaning [2]. It is closely related with encryption and decryption process. The process of transforming original messages/data/information from readable to unreadable format is called encryption. Whereas reverse process is called decryption. The original message is called plain text whereas encrypted version of message is called cipher text. Cipher text is scrambling data. Cryptography is broadly classified into main three types:

1.1. Symmetric Key Cryptography

Symmetric key cryptography is also called secret key or shared key cryptography. It is an encryption system where the sender and receiver of message use a single common key to encrypt and decrypt messages [3]. The entities communicating through symmetric encryption must exchange the key so that it can be used in decryption process.

1.2. Hash Functions

There is no use of any key in this algorithm. A hash function is an achievable mapping from the set of all binary sequences to the set of binary sequences of some fixed length [4]. A Hash Function is arithmetic function that converts a mathematical input value into another compacted mathematical value. The input to the Hash Function is of random length but output is always of permanent length. And third type of cryptography is Asymmetric key cryptography. We will discuss this type in brief.

2. ASYMMETRIC KEY CRYPTOGRAPHY

Diffie-Hellman was one of the first Asymmetric Key cryptosystem invented. Asymmetric Key Cryptography is also called public key cryptography. Asymmetric key cryptography involves a pair of keys known as a public key and a private key, which are connected with an entity that needs to endorse its identity electronically or to sign or encrypt data. Each public key is published and corresponding private key is kept secret. Data that is encrypted with the public key can be decrypted only with the corresponding private key [5, 6].

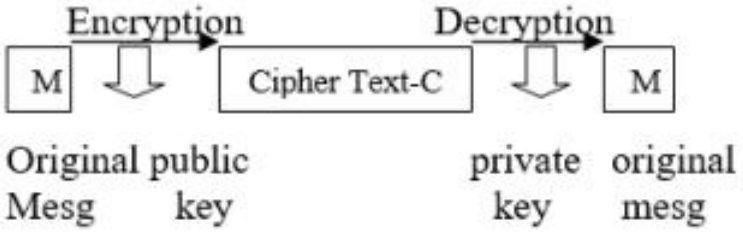


Figure-1. Indicates of how can freely distribute the public key.

Figure-1 indicates that how can freely distribute the public key so that only owner of private key can read data that was encrypted with public key. In general, to send encrypted data to someone, you must encrypt data with that person's public key and the person receiving data decrypts it with only corresponding private key. Suppose that message M was encrypted with the well-known public key. To decrypt the cipher textC we need private key. Sometimes we prefer to encrypt using private key and decrypt using public key.

2.1. Importance of Asymmetric Cryptography

The need of confidentiality has always existed [7]. Asymmetric cryptography offers confidentiality and better security because it uses two different keys — a public key which only gets used to encrypt messages, making it secure for anyone to have, and a private key to decrypt messages that never desires to be shared.

2.2. Advantages

- If data is transmitting on anxious channel, but key cannot disturb among sender and receiver.
- Separate key is used for encryption and decryption; even if encrypted message is stolen by attacker, he/she cannot decrypt the message.
- It provides authentication, confidentiality, data integrity, access controls [8], non-repudiation and availability.
- Easy to use for user.

2.3. Disadvantages

- Asymmetric key uses more resource as compare to symmetric key cryptography.
- More mathematical calculations required.

3. IMPORTANT CONCEPTS OF NUMBER THEORY USED IN ASYMMETRIC CRYPTOGRAPHY-

Number Theory is one of the interesting, easy and useful branches of mathematics, but it has turned out to be one of the most useful when it comes to computer security [9]. Number Theory plays an essential role in asymmetric cryptography. Many concepts of number theory are used in asymmetric cryptography; here we discuss some basic and important concepts of number theory which are widely used in asymmetric cryptography.

3.1. Prime Numbers

A positive integer p is said to be a prime if it has only two factors 1 and p itself.
For Example: Primes are 2, 3, 5, 7, 11, 13, 17,19,23,29 …

3.2. Divisors

A positive integer x is said to divide an integer y if there exist an integer c such that x*c=y and written as x | y.

For Example: 3 |15 as 15 = 3*5 but 4 do not divide 15 as there does not exist any integer c such that 15 = 3*c.

3.3. Greatest Common Divisor

Let x and y be two positive integers then an integer d is called greatest common divisor of x and y if d | x and d | y i.e. d is common divisor of x and y. And if any integer c is such that c | x and c | y then c | d i.e. any other common divisor of x and y will divide d it is denoted by (x, y) =d.

For Example: (25, 30)=5.
Two numbers x and y are said to relatively prime or coprime if their greatest common divisor is 1 i.e. (x, y) =1.
For Example: 11 and 13 are coprime.

3.4. Modular Arithmetic

The value of a mod n is a reminder when a divides n.

For Example: i) a=15, n=3 then 15 mod 3 = 0 ii) a=15, n=4 then 15 mod 4 = 3

Congruence: Let x, y be two integers and n are any positive integer then x is said to congruent to y modulo n if n divides difference of x & y that is n/ (x-y). It is denoted by x≡y (mod n).
For Example: 29 ≡ 8 (mod 7), 60 ≡ 0 (mod 15).

Properties of Modular:

i) (x(mod n)+y (mod n))mod n = (x+y)mod n.
ii) (x(mod n)-y (mod n))mod n = (x-y)mod n.
iii) (x(mod n)*y (mod n))mod n = (x*y)mod n.
iv) Commutative law-
(x+y)mod n = (y+x)mod n.
(x*y)mod n = (y*x)mod n.
v) Associative law- ((x+y) +z)) mod n = (x+(y+z))mod n.
((x*y)*z)) mod n = (x*(y*z))mod n.
vi) Identity law- (0+x) mod n = x mod n.
(1*x) mod n = x mod n.

3.5. Euler's 'ϕ' Function

An arithmetic function Euler's Toitent function 'ϕ ' is defined as ϕ(n) = number of positive integers less than or equal to n and co prime to n i.e. ϕ(n) = number of positive integers 'a' such that n≤a≤1 and g.c.d. (a,n)=1.

For Example: ϕ(15) = 8 as primes relative to 15 are given by 1, 2, 4, 7, 8, 11, 13, and 14. And ϕ(pq) = ϕ(p)ϕ(q), where p and q are relatively prime.
Some basic properties of congruence are given below: [10]

(1) a≡b(mod m) iff b ≡a (mod m)
(2) a≡b+c (mod m) iff a-c ≡b (mod m)
(3)$a_1 \equiv b_1 (\text{mod } m)$ and $a_2 \equiv b_2 (\text{mod } m)$ then $a_1 + a_2 \equiv b_1 + b_2 (\text{mod } m)$ and $a_1 - a_2 \equiv b_1 - b_2 (\text{mod } m)$
(4) a≡ b (mod m) and c is any integer then ca≡cb(mod m)
(5) a ± mk≡a(mod m), where k is any integer

4. CAESAR CIPHER KEY CRYPTOGRAPHY

The Caesar cipher technique is one of the most basic and simplest methods of encryption technique used by Julius Caesar. It is simply a type of substitution cipher and is also called a shift cipher or additive cipher. In this method replacing each letter of the alphabet with the letter standing three places further down the alphabet [11].
For example: with A shift of 3, A would be replaced by D, B would become E and so on.
The method is actually named after Julius Caesar, who in fact used it to communicate with his officials. Thus, to cipher a given text we require an integer value, known as shift which shows the number of position each letter of the text has been moved down. The encryption can be represented using modular calculation by first transforming the letters into numbers, according to scheme, A=0, B=1, C=3, Z=25.

A	B	C	D	E	F	G	H	I	J	K	L	M
0	1	2	3	4	5	6	7	8	9	10	11	12

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
13	14	15	16	17	18	19	20	21	22	23	24	25

Algorithm-
1. For each plaintext we use letter P and for cipher text use letter C.
2. C = E(P,k) mod 26 = (P+k) mod 26 (E=Encryption, k = 3 = key in Caesar cipher)
3. P = D(C,k) mod 26 = (C - k) mod 26 (D=Decryption, k = 3 = key in Caesar cipher)

Example: Encrypt ‘conference’ using Caesar Cipher.
Solution:

P	C	o	n	f	E	R	E	n	c	e
C	F	R	Q	I	H	U	H	Q	F	H

Since encryption is C = (P+3) mod 26

For c(2) For o(14)
C = (P+3) mod 26 C = (P+3) mod 26
C = (2+3) mod 26 C = (14+3) mod 26
C = 5 mod 26 C = 17 mod 26
C = 5 C = 17
C = F C = R Plaintext (P): conference
text (C): FRQIHUHQFH
Now the decryption is

C	F	R	Q	I	H	U	H	Q	F	H
P	C	o	n	f	E	R	E	n	c	e

Since decryption is P = (C-3) mod 26
For F(5) For R(17)
P = (C-3) mod 26 P = (C-3) mod 26
P = (5-3) mod 26 P = (17-3) mod 26
P = 2 mod 26 P = 14 mod 26
P = 2 P = 14
P = c P = o
Cipher text(C): FRQIHUHQFH and plain text (P) = conference.

5. RSA PUBLIC KEY CRYPTOGRAPHY

RSA encryption algorithm is type of asymmetric key encryption algorithm. It is most common asymmetric key algorithm and is widely used to secure sensitive data, particularly when it is being sent over an insecure network such as the internet, named after its inventor Rivest, Shamir and Adelman (RSA).RSA algorithm uses following procedure to generate public key and private key [12].

1. Select two prime numbers a and b where a not equal to b. Calculate n= a*b.
2. Calculate $\phi(n) = (a-1)*(b-1)$
3. Choose a number e, such that $1 < e < \phi(n)$ and n is relatively prime to $\phi(n)$ i.e. g.c.d(e, $\phi(n)$) = 1. The specified pair of numbers n and e forms the RSA public key and it is made public.(e is public key).
4. Private Key d is calculated from the numbers a, b and e. The mathematical relationship between the numbers is as follows –

   $d*e \bmod \phi(n) = 1 \Rightarrow d*e = 1 + k\phi(n)$

   $\Rightarrow d = \frac{1 + k\phi(n)}{e}$; k=1,2,3….

The above formula is the basic formula for absolute Euclidean Algorithm, which takes a and b as the key parameters.

5. **Encryption Formula**–If n = a*b, then the public key is {e,n}. A plain text message M is encrypted using public key {e, n}. To find cipher text from plain text following formula is used to get cipher text C.

C = M^e mod n(M must be less than n)

6. **Decryption Formula** –To determine the private key {d,n}, we use the following formula to calculate d

M = C^d mod n

Example:

Step1. Choose a = 13, b =11 and e = 13

Step2. Find n = a*b = 13*11 = 143

Step3. $\phi(n) = (a-1)*(b-1) = (13-1)*(11-1) = 12*10 = 120$

Step4. Select e = 13, gcd (13, 120) = 1

Step5. Calculate, d*e mod $\phi(n) = 1 \Rightarrow d*e = 1 + k\phi(n) \Rightarrow d = \frac{1 + k\phi(n)}{e}$; k=1,2,3….

i.e 13* d mod 120 = 1$\Rightarrow$ d = $\frac{1 + k120}{13}$

k =1, d =$\frac{1 + 120}{13}$ = 9.30

k =2, d =$\frac{1 + 240}{13}$ =18.53

k =3, d =$\frac{1 + 3600}{13}$ = 27.76

k =4, d =$\frac{1 + 480}{13}$ = 37 (stop to calculate at whole number)

Step6. Public key = {13, 143}, private key = {37, 143}.

i.e public key = {e, n}, private key = {d, n}.

Step7. Find cipher text using formula C = M^e mod n (M<n). C = cipher text, M = plain text/message, e = encryption key and n = number of blocks.

Encryption: Plain text = M = 13 where M <n

C = M^e mod n =13^{13} mod 143 = 52

C =52 i.e cipher text = 52

Step8. M = C^d mod n. Plain text/message M can be obtain using given formula. Where, d = decryption key.

Decryption: M = C^d mod n = 52^{37} mod 143 = 13

M =13 i.e plain text/message = 13.

6. CONCLUSION

Number theory plays an important tool in asymmetric cryptography to hide information. Many tools on number theory like primes, divisors, congruence's, Euler's ϕ function plays an important role in asymmetric cryptography to generate public and private key for security purpose. Basics of Number Theory like Primes, congruence's, Euler's ϕ function is used in Caesar cipher cryptography and RSA public key cryptography to generate keys for security purpose.

ACKNOWLEDGMENT

We are thankful to Shivaji University, Kolhapur and Library of Shivaji University, Kolhapur for providing study material.

REFERENCES

1. Singh, P., Singh, A., Jhamb, S. (2017) International Journal of Advance in Research Science and Engineering, 6, 117-121.
2. Mohammed Quadir, A, Nurhayat, V. (2019) Institute of Electrical and Electronics Engineers 2019, 7th International Symposium on Digital Forensics and Security (ISDFS)-Barcelos, Portugal, 2019, 1-6.
3. Chandra, S, Paira, S, Alam, S, Sanyal, G, (2014) Institute of Electrical and Electronics Engineers, International Conference on Electronics Communication and Computational Engineering, 83-93.
4. Mirviaziri, H., Jumari, K., Ismail, M., Hanapi, M.Z. (2007) 5th Student Conference on Research and Development, 1-6.
5. Das, A., In Book on public key cryptography, Dorling Kindersley India Pvt. Ltd, edited by Das, A. (2009) pp.2-5.
6. Galbraith Steven, D. In Book on Mathematics of Public key Cryptography. (2018) pp.27-29.
7. Pointcheval, D. In Number Theory and Public-Key Cryptography, Combinatorial and Computational Mathematics, World Scientific Publishing, New Jersey. (2001) pp.1-25.
8. Al-Shabi, M. A. (2019) International Journal of Scientific and Research Publications, 576-589.
9. Jahan, I., Asif, M., Rozario Liton, J. (2015) American journal of Engineering Research (AJER), 4, 145-149.
10. Koblitz, N. In Book on A Course in Number Theory and Cryptography, New York: Springer Verlag edited by Koblitz, N. (1994) pp.83-87.
11. Luciano, D., Prichett, G. (1987) The College Mathematics Journal, Taylors and Francis group, 18, 2-17.
12. Buchanan, W., Woodward, A. (2017) Journal of Cyber Security Technology, 1, 1-22.

Modeling and Analysis of Navier-Stokes Equation: An Application Perspective

Vikas D. Kamble[a,b,*], Surendra D. Thikane[a], Hanmant P. Salunkhe[c]

[a] Department of Mathematics, Shivaji University, Kolhapur 416004 (MS) India

[b] Karmayogi Institute of Technology, Shelve Pandharpur, Dist Solapur 413304 (MS) India

[c] Department of Technology, Shivaji University, Kolhapur 416004 (MS) India

*Corresponding author: vikasdkamble@gmail.com

ABSTRACT

An efficient way for solving 2-D Naver-Stokes equation for in-compressible fluid flow is proposed. The problem Chosen here is cavity flow and expflow type which typically have exact solution. These polynomials are steady, exits in space, with zero velocity boundary conditions on unit square. The results offered here are presented in the form of graphs by using mathematical simulations indicating velocity fields. The work is found to be yielding an accuracy significantly when compared with other well known test problems. The degree of polynomial used during work is of degree two. The important part of this work that nonlinear terms are treated explicitly having extra energy stability. Similar type of work can be extended to 3D problems to develop multi-dimensional approach.

KEYWORDS

Error Estimation, 2-D Navier-Stokes, Finite element, stabilization, expflow, cavity problem.

……...

1. INTRODUCTION

In Physics Navier-Stokes equation usually used to describe the motion of fluid by using certain partial differential equations. They were developed in several decades progressively while building number of theories. This equation mathematically express conservation of mass and momentum for fluid flow. Frequently they describe equation of state relating the parameters like pressure, temperature and density. Navier-Stokes equation if found to be applicable in the area like scientific and engineering interest. They can be used to model the conditions like water flow in a pipe, ocean currents, weather forecasting etc. They found in different forms referred as Full or simplified which help to design air craft , blood flow in vessels , design of power stations , analysis of pollution conditions and many more. When this equation is used along with Maxwell equations it helps to study and model Magneto-hydrodynamics (MHD) characteristics.

In-compressible Navier stokes equation are widely known as mathematical tool for describing in-compressible fluid flow. Its applications are used to solve real time problems in 2D and 3D. The system of equations presented here are framework that can be modeled to solve any 2D equations lastly. The equations presented as momentum and impressibility relations.

Different solutions have been proposed using computational fluid dynamics and lot of work has been carried out on design aspect and analysis also on implementation of various schemes for numerical solutions.

One of the prime issues in solving Navier-Stokes equation [1] is the treatment of non-linear terms. Three types exists which are fully explicit (Fully non-linear), semi-explicit (elliptical type with variable coefficient) and explicit (generalized type). The answer to these issues is rigorous convergence analysis with error estimation and use of parameters like velocity and pressure.

Shih T.M, Tan C.H and Hwang B.C (1989) [2] has tested various schemes for different grid arrangement on bench-marking problem on 2D Navier stokes flow. Accuracy of various conceptual grid arrangement were presented. They have found higher accuracy as compared with existing solution. The solution presented were found to be simple.

Kengni Jotsa A.C & Pennati V.A (2015) [3] has presented a cost-effective solution of 2D Navier Stokes equation for in-compressible fluid flow. Nonlinear convection terms were used for characteristics and approximation by polynomial of degree two iterative solvers was applied. The author has suggested to extend the work for 3D also.

Li X. and Shen J. (2019) [4] has presented a numerical scheme based on Scalar Auxillary Variable (SAV) and Marker Cell Scheme (MAC) for construction of Navier-Stokes equation. Here nonlinear term is considered to stable in terms of energy. Error analysis were carried out to indicate velocity and pressure approximations are accurate in second order w.r.t time and space. Experimentation was presented for verification.

2. MATHEMATICAL FORMULATION AND EXPLANATION

Navier-Stokes equation is nothing but a partial differential equation describing flow of in-compressible fluid. This equation was formulated by Leonhard Eular in 18^{th} century. In 19^{th} century Claude-Louis-Navier introduced viscosity as more realistic and difficult problem of fluid flow. George-Gabrial-Stokes introduced vortices and turbulence parameters in to the work done Stroke. Finally this work was clubbed together and presented as Navier-Stokes equations.

A well known bench marking problem i.e. lid driven cavity flow is being considered. The singularity at two corners where moving lid remains contact with the wall, velocity is either zero or unity at that corner changes the total result.

The recirculating cavity flow driven by shear and body forces are governed by Shih T.M, Tan C.H and Hwang B.C (1989). **Figure-1** shows the schematic for bench marking issue.

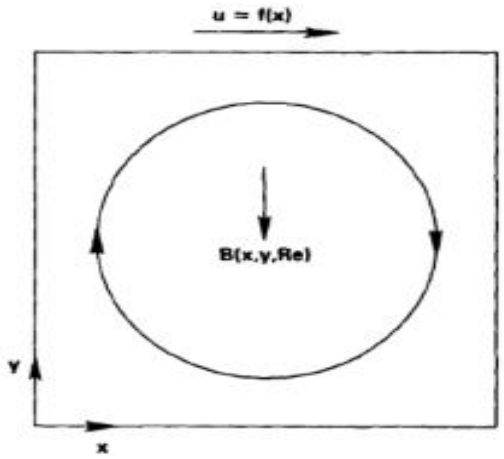


Figure-1. Schematic for Bench Marking issue.

$$\nabla \cdot u = 0 \quad (1)$$

$$u \cdot \nabla u = \frac{1}{Re}\nabla^2 - \frac{\partial p}{\partial x} \quad (2)$$

and

$$u \cdot \nabla v = \frac{1}{Re}\nabla^2 - \frac{\partial p}{\partial x} - B(x, y, Re) \quad (3)$$

The boundary conditions for velocities u and v Dirichlet's type it mean zero everywhere except along top of the Jiang S and Ou Y.B (2011)surface where

$$u(x, 1) = 16(x^4 - 2x^3 + x^2) \quad (4)$$

Above equation indicate $u(0,1) = 0\ and\ u(1,1)$.which drops ambiguity of specifying the top corners velocities as in stranded lid driven flow problem.

The force described on a body in the y direction is given by

$$B(x, y, Re) = -\frac{8}{Re}[24F(x) + 2f'(x)g''(y) + f'''(x)g(y)] - 64[F_2(x)G_1(y) - g(y)g'(y)F_1(x)] \quad (5)$$

Where

$f(x) = x^4 - 2x^3 + x^2,$

$g(y) = y^4 - y^2$

$f'(x) = 4x^3 - 6x^2 + 2x$
$f''(x) = 12x^2 - 12x + 2$

$F(x) = \int f(x)\,dx = \int (x^4 - 2x^3 + x^2)\,dx$

$F(x) = \frac{x^5}{5} - 2\frac{x^4}{4} + \frac{x^3}{3} = \frac{x^5}{5} - \frac{x^4}{2} + \frac{x^3}{3}$

$F(x) = 0.2x^5 - 0.5x^4 + \frac{x^3}{3}$

$f(x)f''(x) = (x^4 - 2x^3 + x^2)(12x^2 - 12x + 2)$
$= 12x^6 - 12x^5 + 2x^4 - 24x^5 + 24x^4 - 4x^3 + 12x^4 - 12x^3 + 2x^2$
$= 12x^6 - 36x^5 + 38x^4 - 16x^3 + 2x^2$
$[f'(x)]^2 = (4x^3 - 6x^2 + 2x)^2$
$= 16x^6 + 36x^4 + 4x^2 - 48x^5 - 24x^3 + 16x^4$
$= 16x^6 - 48x^5 + 52x^4 - 24x^3 + 4x^2$

$F_1(x) = f(x)f''(x) - [f'(x)]^2$
$= 12x^6 - 36x^5 + 38x^4 - 16x^3 + 2x^2$
$-16x^6 + 48x^5 - 52x^4 + 24x^3 - 4x^2$
$= -4x^6 + 12x^5 - 14x^4 + 8x^3 - 2x^2$

$[f(x)]^2 = f(x) \cdot f(x)$
$= (x^4 - 2x^3 + x^2)(x^4 - 2x^3 + x^2)$
$= x^8 - 2x^7 + x^6 - 2x^7 + 4x^4 - 2x^5 + x^6 - 2x^5 + x^4$
$= x^8 - 4x^7 + 6x^6 - 4x^5 + x^4$ (5a)

$F_2(x) = \int f(x)f'(x)\,dx$
$= \int (x^4 - 2x^3 + x^2)(4x^3 - 6x^2 + 2x)\,dx$
$= \int (4x^7 - 6x^6 + 2x^5 - 8x^6 + 12x^5 - 4x^4 + 4x^5 - 6x^4 + 2x^3)\,dx$

$$= \int (4x^7 - 14x^6 + 18x^5 - 10x^4 + 2x^3)\, dx$$
$$= 4\frac{x^8}{8} - 14\frac{x^7}{7} + 18\frac{x^6}{6} - 10\frac{x^5}{5} + 2\frac{x^4}{4} = \frac{x^8}{2} - 2x^7 + 3x^6 - 2x^5 + \frac{x^4}{2}$$
$$= \frac{1}{2}[x^8 - 4x^7 + 6x^6 - 4x^5 + x^4]$$
$$= 0.5[x^8 - 4x^7 + 6x^6 - 4x^5 + x^4] \quad (5b)$$

$F_2(x) = 0.5\,[f(x)]^2$

$g(y) = y^4 - y^2$
$g'(y) = 4y^3 - 2y$

$g''(y) = 12y^2 - 2$

$g'''(y) = 24y$

$$G_1(y) = g(y)g'''(y) - g'(y)g''(y)$$
$$= (y^4 - y^2)(24y) - (4y^3 - 2y)(12y^2 - 2)$$
$$= 24y^5 - 24y^3 - [48y^5 - 8y^3 - 24y^3 + 4y]$$
$$= 24y^5 - 24y^3 - 48y^5 + 32y^3 - 4y$$
$$= -24y^5 + 8y^3 - 4y$$

And the major focus is on f(x) and g(y) denote the derivative w.r.t x and y [1]. The exact solution to the combined effect of shear and body force driven cavity flow exist and it is known to be

$$u(x,y) = 8f(x)g'(y)$$
$$= 8(x^4 - 2x^3 + x^2)(4y^3 - 2y) \quad (6a)$$

$$v(x,y) = -8f'(x)g(y)$$
$$= -8(4x^3 - 6x^2 + 2x)(y^4 - y^2) \quad (6b)$$

And

$$p(x,y,Re) = -\frac{8}{Re}[F(x)g'''(y) + f'(x)g'(y)]$$
$$+ 64F_2(x)\{g(y)g''(y) - [g'(y)]^2 \quad (6c)$$

The equation given below were treated for in compressible Navier-Stokes equation.

$$\frac{\partial u}{\partial t} + u.\nabla u - v\Delta v + \nabla p = f \quad in\ \Omega\ \times J\,, \tag{7a}$$

$$\nabla \cdot u = 0 \quad in\ \Omega\ \times J\,, \tag{7b}$$

$$u = 0 \quad in\ \partial\Omega\ \times J \tag{7c}$$

Where Ω is open bounded boundary R^d (d = 2, 3),
J = (0, T], (u, p) represent unknown velocity and pressure

$L^m(\Omega)$ be the standard Banach Space with norm.

$$\|v\|_{L^m(\Omega)} = \left(\int_\Omega |v|^m \, d\Omega\right)^{\frac{1}{m}}$$

For easiness assume

$$(f, g) = (f, g)_{L^2(\Omega)} \quad \int_\Omega fg \ d\Omega$$

$L^2(\Omega)$ inner product , $\|v\|_\infty = \|v\|_{L^\infty(\Omega)}$. And $W_p^k(\Omega)$ be the standard Sobolev space

$$W_p^k(\Omega) = \{g: \|g\|_{W_p^k(\Omega)} < \infty\}$$

Where

$$\|g\|W_p^k(\Omega) = \left(\sum_{|\propto|\leq k} \|D^\propto g\|_{L^p(\Omega)}^p\right)^{\frac{1}{p}} \tag{8}$$

3. RESULT AND DISCUSSION

Solution of Navier-Stokes equation is one of the greatest unsolved problems in scientific fields, even though it has immense importance in the field of Science and Engineering. Still there is lot of scope in solution to different properties of these equations.

A stranded cavity test was carried out with modification in mathematical formulation to generate a velocity field of on a regular grid in 2D. An exponential flow was tested with modifications in mathematical representation to generate velocity field and viscosity. Grid were generated using number of x-values and y-values with high (1) and low (0) ranges. The output of the grid was evaluated based on the outcome of x and y coordinates.

Unit fluid density (rho) and Kinematic Viscosity (nu) were used in the simulation part for correctness of the problem. N are the nodes carried for the

evaluation. By using the coordinates of the nodes with concurrent time initial u(n) and final v(n) velocities along with real pressure p(n) were estimated.

The second order polynomials were used to calculate this cavity flow problem. Scaling factor for velocity vector was formulated. Navier-Stokes velocity field were stored using N evaluation Points. The stored files used to draw the variation of the using real N coordinated of the evaluation points. **Figure-2** and **Figure-3** show the cavity fluid flow simulation result and Exp Fluid flow simulation result, respectively.

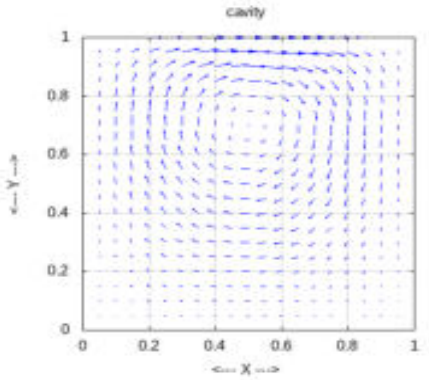


Figure-2. Cavity Fluid Flow Simulation Result.

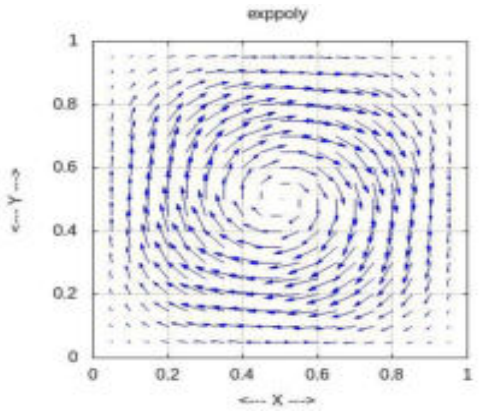


Figure-3. Exp Fluid Flow Simulation Result.

4. CONCLUSION

In this paper an effective and approach for solution of 2D incompressible Navier-Stokes has been presented. This technique approaches to better stability and accuracy and computational efficiency. The approach is found to be systematically accessible and solution. Instead of central finite differences if higher order derivative are

computed the solution will become significant as compared with single order derivatives. Griding can be a good option if accuracy is not a big deal. Such type of work will be helpful for computational fluid dynamics (CFD) for modeling the flow of fluid. Reader may try for realistic animations including predictions by identifying flow in the cells, computing new velocities as the particle move ahead by using appropriate geometry. Time varying viscosity may be helpful for developing prototype for a product development.

Appendix: List of Symbol

Re: Reynold's Number
P: Pressure
u: Initial Velocity
v: Final Velocity
t: Time
ρ: Fluid Density
η: Kinematic Viscosity
F= external body force
n= units
Ω= domain
C= Positive constant
$L^2(\Omega)$= Inner product
$W_p^k(\Omega)$= standard Sobolev Space

ACKNOWLEDGMENT

We are thankful to Shivaji University, Kolhapur and library of Shivaji University, Kolhapur for providing study material.

REFERENCES

1. Shen, J., Ou, Y.B. (2011) Journal des Mathatiques Pures et Appliquees, 96, 1-28.
2. Shih, T.M., Tan, C.H., Hwang, B.C. (1989) International Journal of numericalmethod in Fluids, 9, 193-212.
3. Kengni Jotsa, A.C., Pennati, V.A. (2015) Engineering Applications of Computational Fluid Mechanics, 1, 66–83.
4. Li, X., Shen, J. (2019) SIAM Journal Numerical Analysis, 58, 2465-2491.

Estd. 1962
"A++" Accredited by NAAC (2021)
with CGPA 3.52

SHIVAJI UNIVERSITY, KOLHAPUR

JOURNAL OF SHIVAJI UNIVERSITY : SCIENCE AND TECHNOLOGY

(Peer Reviewed Journal)

Volume-43, Issue-2 (July, 2017)

ISSN Science-0250-5347

JOURNAL OF SHIVAJI UNIVERSITY : SCIENCE AND TECHNOLOGY

(Peer Reviewed Journal)

Volume-43, Issue-2 (July, 2017)

ISSN Science-0250-5347

Estd. 1962
"A++" Accredited by NAAC (2021)
with CGPA 3.52

Shivaji University

Kolhapur 416 004 (INDIA)

JOURNAL OF SHIVAJI UNIVERSITY : SCIENCE AND TECHNOLOGY

(Peer Reviewed Journal)

Volume-43, Issue-2 (July, 2017)

ISSN Science-0250-5347

- Contact Details -
Prof. (Dr.) S. D. Delekar
Editor, Journal of Shivaji University : Science and Technology
and
Department of Chemistry
Shivaji University, Kolhapur 416 004 (India)
E-mail : editor.jscitech@unishivaji.ac.in
website : http://www.unishivaji.ac.in/journals/

Shivaji University, Kolhapur

JOURNAL OF SHIVAJI UNIVERSITY :
SCIENCE AND TECHNOLOGY

(Peer Reviewed Journal)

Volume-43, Issue-2 (July, 2017)

ISSN Science-0250-5347

- Editor -
Prof. (Dr.) S. D. Delekar
Journal of Shivaji University :
Science and Technology

- Published by -
Dr. V. N. Shinde
Ag. Registrar,
Shivaji University, Kolhapur 416004.

- Printed by -
Shri. B. P. Patil
Superintend
Shivaji University, Kolhapur 416004.

The Editor, on behalf of the Editorial Board of the Journal of Shivaji University : Science and Technology, Vol. No. 43 (2) whises to express his thanks to the contributing authors and the experts for acting as referees for the papers included in the issue.

Published : July, 2023

GUIDELINES FOR CONTRIBUTORS

1] **Journal of Shivaji University : Science & Technology** is the publication of Shivaji University, Kolhapur (Maharashtra, India), being published twice a year. It is an academic peer reviewed ISSN approved Journal.

2] The Journal welcomes research articles based on original research, review papers, research communication/notes by the faculty and research scholars working in various fields of Science and Technology. Articles/Papers can be submitted in English language only.

3] The length of manuscripts should not exceed 6000 words for review article, 5000 words for research article, 2000 words for research communication and 1000 words for research note.

4] The article/paper must accompany an **abstract not exceeding 200 words.**

5] During writing and submission of a manuscript, please follow the author guidelines arakble on the home page of Journal of Shivaji University: Science and Technology.

6] All the sources of literature referred to while writing the article/paper must be properly cited in the text. The serial numbers of End Notes, if any, must also be indicated within text at appropriate places.

7] The listing of references must follow the standard format.

8] Tables, charts, maps, figures etc. should be placed at appropriate places in the text of the article/paper and must be numbered serially with suitable headings. The tables should be referred to by their numbers within the text. Art-work for maps, figures and charts should be provided separately, if necessary.

9] Only articles evaluated and approved by the subject Experts/Referees/Departmental editorial board are considered for their publication in the Journal. The referees evaluate Article/ Paper drafts in term of structure and organization of paper/argument, originality of the research, appropriateness of abstract and introduction, literature review, methodology and data sources, data/evidence and conclusions, and quality of language.

10] The name of the author/co-author of the article being submitted should mentioned on the first page of the article/paper below title of that article. An asterisks (*) is used for defining corresponding author/s of a manuscript.

11] For any other information and for inquiries regarding submitted articles/papers preferably use e-mail communications. **(E-mail : editor.jscitech@unishivaji.ac.in)**

12] Manuscript should be sent to email of the Editor (**editor.jscitech@unishivaji.ac.in**) {or associate editor of the concerned subject}, Journal of Shivaji University: Science and Technology, Kolhapur with e-copy only (single M.S. word as well as PDF file).

Only research articles/review papers/research communication/notes prepared strictly in accordance with the above guidelines will be sent to referees for their evaluation and opinion about their acceptability or otherwise. We do not send back rejected articles.