THIRD Year Project Report

Department of Power Engineering,

Jadavpur University

Under the supervision

Year 2023-24

Contents

Vision of the Institute:

Faculty of Engineering and Technology, Jadavpur University

To provide young minds an ambience and quality education in Engineering and Technology to contribute towards a better world.

Mission of the Institute:

- ❖ To nurture Engineering and Technological potential in undergraduate and post graduate students at their highest standard;
- ❖ To take up technological challenges of the State, Nation and beyond for ensuring social security and sustainable development;
- ❖ To provide infrastructure at par with international standard for quality training, research and development;
- ❖ To encourage collaborative activities across disciplines to take up global challenges;
- ❖ To enable young learners with legal and ethical awareness to meet challenges in Industry and academics or for setting up start-up ventures.

Department of Power Engineering

Vision of the department

To emerge as a globally recognized department in imparting quality education to produce successful Power Engineers.

Mission of the department

- To provide the students with the state of art of enabling technologies related to energy and power engineering to meet the global challenges
- To generate skilled human resources for sustainable development of the energy and allied sectors
- To facilitate the students to choose career in the industry, research and development, and entrepreneurship
- To impart legal and ethical awareness to the students for the inclusive development of the society

Program Educational Objectives (PEO)

Graduates of Electrical Engineering Program shall

- **PEO1:** Succeed in their career as globally employable power engineers and team leaders.

  PEO2: Pursue advanced education and research in energy, power and allied interdisciplinary areas leading to lifelong learning successfully.

  PEO3: Have ethical values, social commitment and leadership qualities towards application areas of electrical energy.

Program Specific Outcome (PSO)

PSO1: Interdisciplinary Domain Exposure: Interpret problems and apply enabling technologies to develop comprehensive solutions for the energy and power sectors.

PSO2: Economic and sustainable energy resources: Assess and analyze energy resources and formulate optimized solutions for sustainable development.

PSO3: Safe and secured energy: Recognize safety, control and management aspects of new generation energy technology.

Program Outcomes (PO)

PO1. Engineering knowledge: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO3. Design & Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO4. Investigation of Complex Problem: using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an under- standing of the limitations.

PO6. The Engineer and Society: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. **Life-long Learning**: Recognize the need for and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

ANIRBAN DAS 0020111501092

Project Outcome

1. Design an economic, user-friendly for welfare and benefit of the society.
2. Apply the theoretical knowledge of various subjects like Electrical measurements, Scattering Theory, Software engineering, Signal system for designing of the product.
3. Apply modern tools and websites like Arduino, ESP 266MODULE, other recent trending tools and thingspeak.com for implementing the project.
4. Coordinate among the team members, put together the individual efforts, interacting among team members and working as a unit for solving engineering problems.
5. Understand the different environmental problems and apply ethical principles and commit to professional ethics and norms of engineering practices.
6. Recognizing the need for, and have the preparation and ability to engage independent and life-long learning in the broadest content of technological change.
7. Plan the project for individual activities and combined activity of team as well as plan the cost to make it a less expensive product.

Project Outcome versus Program outcome (PO) Matrix:

Project Outcome No./POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1			3			3			2		2	
2	3	2	2	2					2		3	
3				2	3				2		3	
4									3	2	2	
5									2		2	
6							2	3	2		2	3
7									2		2	

CERTIFICATE OF APPROVAL

This is to certify that the project entitled "FINDING CORRELATION OF LIGHT INTENSITY WITH CONCENTRATION OF FOG FLOW ." in partial fulfilment of requirements for the award of B.E. degree in Power Engineering, submitted in the Department of Power Engineering at Jadavpur University, Kolkata, West Bengal is an authentic record of our own work carried out under the supervision of **PROF. RANJAN GANGULY**, Department of Power Engineering.

The matter presented has not been submitted by me/us in any other University / Institute for the award of B.E. Degree.

The names of the students are as follows: -

1. ANIRBAN DAS 0020111501092

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

PROF. RANJAN GANGULY
Project Supervisor
Dept. of Power Engineering

PROF.KAMAL KRISNA MANDAL
Head of the Department
Dept. of Power Engineering

ACKNOWLEDGEMENT

The Final Year project is a major career defining step for any engineering student’s life. It provides us with an opportunity to test our skills in the technological fields and put our imagination to innovation.

We are thankful to our former H.O.D, **PROF. RANJAN GANGULY** for letting us, choose a topic of our interest to work on.

We owe our sincere gratitude to our present H.O.D. and our Project Guide, **PROF. RANJAN GANGULY** for his unparalleled guidance, right from the moment of choosing a project under the given topic domain to its step by step progress and its completion. His contribution towards the compilation progress report is unavoidable as well.

Acknowledge any project funding source of the lab where the students have worked.

Acknowledge any other person who may have helped you in any way during your work.

_Signature____

ANIRBAN DAS

INTRODUCTION

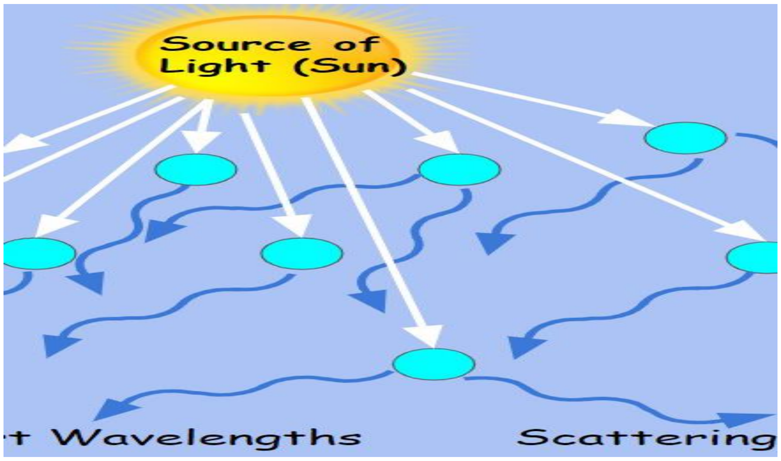
Brief overview of environmental sensing-"In a world increasingly affected by climate change and unpredictable weather patterns, the ability to monitor and adapt to environmental conditions is crucial. One of the challenges we face is the impact of fog, which often poses serious threats to visibility and safety in various applications. Fog, with its dense and opaque nature, significantly hampers visibility. Whether it's on roadways, at airports, or in industrial settings, navigating through fog can be perilous. Existing solutions have their limitations, prompting the need for a more advanced and reliable fog detection system. So there comes a question

Why can't we see clearly through the fog?

BACKGROUND PHYSICS

To answer the previous question, we have to know the scattering phenomenon of light. Scattering is the interaction of light with particles that are comparable in size with their wavelength. The small particles of fog scatter the light in all directions. The number of particles in fog is too high, so this happens on a large scale. So, the light reflected from the object is not able to reach our eyes and hence we are unable to see any obstacle in our way.

So, we chose red laser light as a light source in our experiment setup as it has the highest wavelength and suffers the lowest scattering and the presence of ambient white light will not affect our result. Then, we sense this light and measure the fog rate.



OBJECTIVE

A fog sensor serves to detect the presence of fog or mist within the tower. This detection is crucial for several reasons:

1. Efficiency: The presence of fog can impact the efficiency of the cooling tower by altering the airflow dynamics and affecting heat transfer processes. Detecting fog allows the system to adjust its operation to maintain optimal efficiency.

2. Safety: Excessive fog can lead to reduced visibility, which may pose safety hazards for personnel working around the cooling tower. Detecting fog allows for appropriate safety measures to be implemented.

3. Maintenance: Fog can also indicate potential issues within the cooling tower, such as leaks or malfunctions. By detecting fog early, maintenance personnel can investigate and address any problems promptly, preventing more significant issues from arising.

4. Water Conservation: In some cases, fog may indicate water loss or leakage within the cooling tower system. Detecting fog can help identify these leaks early, reducing water wastage and associated costs.

Overall, the objective of a fog sensor in a cooling tower is to ensure efficient operation, maintain safety, facilitate timely maintenance, and conserve resources.

Introduction to Fog and Visibility

Start by introducing the concept of fog and its impact on visibility. Discuss why visibility is crucial for various applications such as transportation, aviation, and safety.

Types of Fog and Their Characteristics

Describe different types of fog, including radiation fog, advection fog, and precipitation fog. Discuss their formation mechanisms and how they affect visibility differently.

Importance of Fog Sensors

Explain why fog sensors are essential for monitoring visibility in foggy conditions. Discuss how accurate visibility measurements can improve safety and efficiency in transportation and other sectors.

Review of Existing Fog Sensor Technologies

Provide an overview of existing fog sensor technologies, including:

- Optical sensors: Discuss how optical sensors use light scattering or absorption to measure visibility.
- Weather stations: Describe how traditional weather stations measure visibility using sensors such as forward scatter sensors or transmissometers.
- Lidar systems: Explain how lidar systems use laser beams to detect particles and measure visibility.

- IoT-based sensors: Discuss emerging Internet of Things (IoT) technologies for fog sensing, such as wireless sensor networks and remote monitoring systems.

Advantages and Limitations of Current Fog Sensors

Highlight the strengths and weaknesses of each type of fog sensor technology. Discuss factors such as accuracy, reliability, cost, and ease of deployment.

Working principle

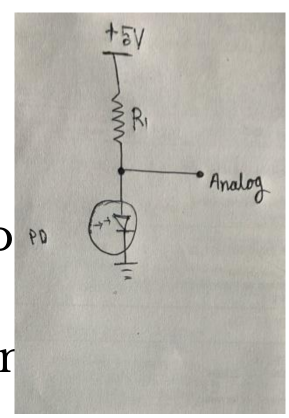
The fog sensor module operates on the principle of changes in light intensity due to scattering of light. When light passes through fog particles it interacts with light of similar wavelength and scatters it. Now we know that there is a direct relationship between number of fog particles and light intensity. So, by measuring the light intensity we can measure fog density if we know the direct proportional relation. Photo-diode sensor, alters conductivity, signaling the Arduino to generate different signal values, and we calibrate those signal values to Fog intensity.

DECSRIPTON OF THE PROJECT

This project has generally three steps which are described as follows:

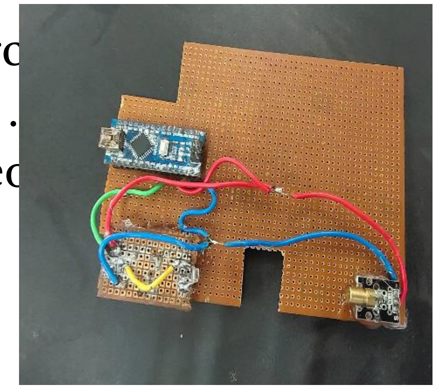
Creating Physical module:

1. Building fog sensor module: Fog sensor is no voltage
 divide circuit where I placed a fixed resistar LDR



(light dependent resistance) which generate the appropriate
voltage across it depending upon the light intensity. At the
junction resistance and LDR we take analog signal.

2. Building the setup: Align the light sourc
and kept fixed at 10 cm distance apart .
solder it to the dot board and connectec
board.



Arduino signal sensing

The Arduino receives generated signal from the fog sensor through a analog pin ,then it compare it to predefined thresholds, and generate proper sensing data accordingly. The laser source provide the required light intensity to the photo diode .As the fog flow concentration increases light intensity decreases at photodiode and vice-versa . The sensing value varies from 0-1024 .THE ARDUINO SIGNAL GIVES GREATER VALUE AT LESSER LIGHT INTENSITY AND VICE-VERSA. For eg. value 920 indicates higher fog concentration than 650.

Data processing

- Firstly, we store the sensor data of several trials at different concentration setting of the fogger (keeping the air flow rate constant).
- Then we calculate the mass flow rate of the fogger at different concentration setting.

- Then we measure the air flow velocity of the fogger at the outlet and then measure the area of the pipe at the outlet .
- Then we calculate Fog flow concentration.

Calibration:

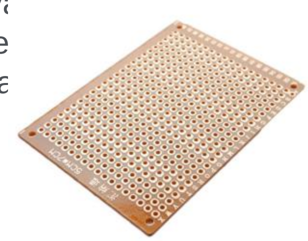
In this step, we find the mean of all the trials of and calculate the respective errors of these data. And we plot the mean sensor value with mean flow concentration along with respective error bar and make the best fit of the scatter points.

Once we approximate equation of the best fit we can estimate we can approximate the concentration of the fog flow with a degree of error by taking the sensor value while maintaining the distance of sensor and light source at 10 cm.

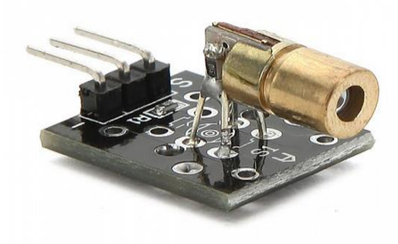
DETAILS OF COMPONENTS REQUIRED

- **Arduino Nano:** It is a microcontroller-based device with 16 digital pins that can be used for various purposes. It can be used for almost every task, from minor to massive industrial-scale projects. It can also be used for prototyping and developing new applications.

- **Dot board**: It is a material for prototyping electronic circuits (also call DOT PCB). It is a thin, rigid sheet with holes pre-drilled at standard interva across a grid, usually a square grid of 0.1 inches (2.54 mm) spacing. The holes are ringed by round or square copper pads, though bare boards a also available.



- **Light sensor using photodiode:** The photodiode can detect ma.., different light sources, including visible light, infrared, and ultraviolet. The photodiode produces a larger current when it is exposed to more light, which increases the output voltage of the circuit. Selecting the best current-to-voltage op amp is vital to system performance.



- **Laser module 650nm 5V**: These multimode 650nm laser bars provide efficient and bright laser light output. Applications include Industrial, Illumination, Laser Projectors, and Imaging. Medical applications include photodynamic therapy and aesthetic treatments.

- **Fogger**: It is a device that helps generate fog for testing and calibrating fog sensors. It produces fog in contro environments, allowing researchers or technicians to assess performance of fog sensors under various conditions. This typ fogger is not designed for pest control or disinfection but specific for creating realistic fog conditions for sensor testing development.

CALCULATION:

Mass flow rate calculation :

In this step we measure the change of weight of water with respect to the time and we take these reading several times at a particular fog flow rate and take the mean of all these data to get mean mass flow rate of the water.

Concentration Calculation

Let M_w be the mass flow rate of water and M_a be the mass flow rate of the air . V_{mix} be the velocity of the air fog mixture and A be the cross-section of pipe. So, the concentration (C)of the flow can be written as :

$$C = \frac{Mw + Ma}{A * Vmix}$$

Now $M_a <<< M_w$, so we can neglect M_a

$$C = \frac{Mw}{A * Vmix}$$

1																
2		full					full-1					full-2				
3	Mass(in gm)	Run-1(in sec)	Run-2(in sec)	Run-3(in sec)	Run-4(in sec)	Run-5(in sec)	Run-1(in sec)	Run-2(in sec)	Run-3(in sec)	Run-4(in sec)	Run-5(in sec)	Run-1(in sec)	Run-2(in sec)	Run-3(in sec)	Run-4(in sec)	Run-5(in
4	0.5	4	7	9	7	9	7	7	8	8	8	6	8	7	8	6
5	0.5	6	5	5	5	6	6	9	6	6	6	10	6	7	11	7
6	0.5	7	7	7	6	8	8	11	10	7	7	7	6	11	9	11
7	0.5	4	5	4	4	7	6	7	7	8	6	11	8	11	6	10
8	0.5	6	4	7	8	4	8	8	8	8	7	9	9	6	10	8
9	0.5	10	6	6	6	5	10	6	9	7	8	8	10	9	7	9
10	0.5	7	9	5	4	4	7	9	6	7	5	7	7	8	6	10
11	0.5	8	4	6	10	8	6	7	8	7	10	8	9	6	9	6
12	0.5	4	10	5	5	4	9	6	7	8	9	9	11	6	7	8
13	0.5	5	4	5	7	8	7	8	10	8	8	10	9	10	8	6
14																
15																
16		0.25	0.142857143	0.111111111	0.142857143	0.111111111	0.142857143	0.142857143	0.125	0.125	0.125	0.166666667	0.125	0.142857143	0.125	0.166666
17		0.166666667	0.2	0.2	0.2	0.166666667	0.166666667	0.111111111	0.166666667	0.166666667	0.166666667	0.1	0.166666667	0.142857143	0.090909091	0.142857
18		0.142857143	0.142857143	0.142857143	0.166666667	0.125	0.125	0.090909091	0.1	0.142857143	0.142857143	0.142857143	0.166666667	0.090909091	0.111111111	0.090909
19		0.25	0.2	0.25	0.25	0.142857143	0.166666667	0.142857143	0.142857143	0.125	0.166666667	0.090909091	0.125	0.090909091	0.166666667	0.1
20		0.166666667	0.25	0.142857143	0.125	0.25	0.125	0.125	0.125	0.125	0.142857143	0.111111111	0.111111111	0.166666667	0.1	0.125
21		0.1	0.166666667	0.166666667	0.166666667	0.2	0.1	0.166666667	0.111111111	0.142857143	0.125	0.125	0.1	0.111111111	0.142857143	0.111111
22		0.142857143	0.111111111	0.2	0.25	0.25	0.142857143	0.111111111	0.166666667	0.142857143	0.2	0.142857143	0.142857143	0.125	0.166666667	0.1
23		0.125	0.25	0.166666667	0.1	0.125	0.166666667	0.142857143	0.125	0.142857143	0.1	0.125	0.111111111	0.166666667	0.111111111	0.166666
24		0.25	0.1	0.2	0.2	0.25	0.111111111	0.166666667	0.142857143	0.125	0.111111111	0.111111111	0.090909091	0.166666667	0.142857143	0.125
25		0.2	0.25	0.2	0.142857143	0.125	0.142857143	0.125	0.1	0.125	0.125	0.1	0.111111111	0.1	0.125	0.166666
26	Avg Flow rate(in gm/sec)	0.089702381	0.090674603	0.089007937	0.087202381	0.087281746	0.069484127	0.066251804	0.065257937	0.068154762	0.070257937	0.060775613	0.062521645	0.065182179	0.064108947	0.064743
27	Avg flow concentation rate	157.3861278	159.0919275	156.1676995	152.9997859	153.1390348	121.9124574	116.2412273	114.4974507	119.5800374	123.2701346	106.6330496	109.6965266	114.3645312	112.4815056	113.5954
28	Mean flow concentation Rate			155.757					119.100					111.354		

Sensor Value Calculation:

In this step we noted the sensor value at few sew seconds of interval and we take these reading several times at a particular fog flow rate and take the mean of all these data to get mean value of flow rate of the water.

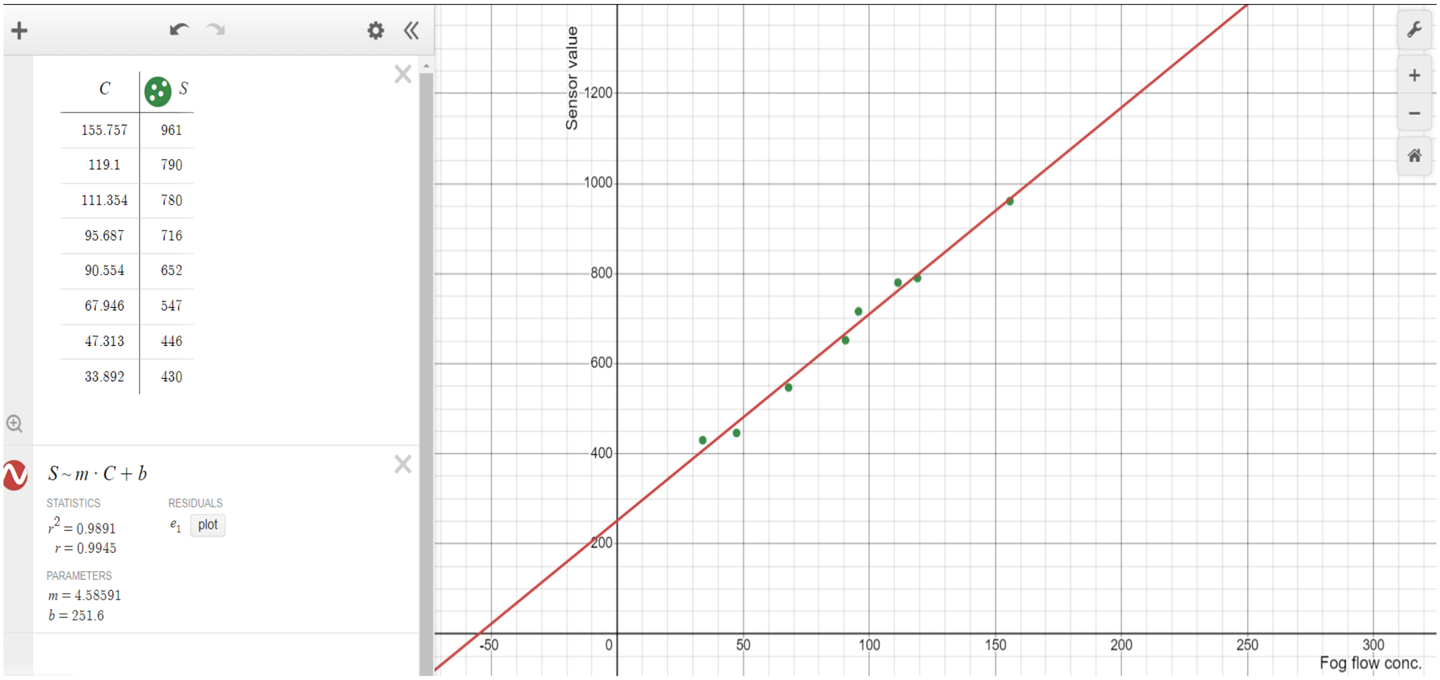
No flow					full flow					full flow-1					
145	166	192	201	132	975	969	968	941	970	770	811	776	790	852	793
144	130	141	131	135	1010	964	909	938	1010	800	803	796	838	855	742
150	230	220	139	148	920	997	983	968	942	750	756	818	817	851	756
145	188	155	151	199	924	960	945	1011	992	755	795	819	742	795	810
151	164	193	192	162	915	949	964	912	972	833	825	749	829	801	744
148	181	143	176	139	962	913	1001	927	915	830	786	821	827	802	758
147	171	159	188	142	957	1018	927	1014	905	750	758	742	761	858	754
173	172	147	197	213	945	986	956	934	912	741	783	755	799	770	735
153	229	161	184	159	1018	980	1014	908	956	787	810	771	773	766	744
327	221	146	151	226	1009	902	1004	932	926	768	809	761	747	775	758
147	187	162	144	140	1017	905	993	978	1020	756	770	824	797	705	758
150	213	196	191	210	934	930	977	974	918	789	827	823	816	690	772
159	138	170	173	149	962	1022	951	978	954	795	759	801	766	676	756
156	200	193	147	134	977	994	970	976	993	770	761	807	804	671	790
150	192	167	220	179	903	943	958	908	966	786	767	745	803	733	819
152	185	134	139	219	1011	986	900	1017	938	744	804	788	811	776	782
151	212	212	145	225	905	982	989	994	973	798	782	765	806	768	757
152	181	140	132	206	971	916	976	994	1021	812	828	804	756	859	776
151	159	184	134	183	995	900	928	982	947	746	780	807	832	807	795
150	134	171	191	170	936	989	946	909	988	813	750	833	835	816	786
149	198	207	204	190	993	994	981	1012	905	760	776	832	780	847	829
157	135	196	215	132	987	935	904	908	956	743	790	763	786	849	796
150	193	223	189	184	1011	1014	908	990	936	838	802	791	834	767	829
156	134	215	225	133	951	915	1005	918	917	827	823	839	837	818	733
151	209	139	201	153	990	928	940	1001	983	757	757	772	824	826	785
153	180	164	160	162	920	949	1016	942	1002	803	764	808	804	842	753
152	171	164	169	145	903	991	997	945	968	836	840	756	787	841	756
153	213	139	132	160	932	943	1009	1010	900	756	796	767	788	848	780
164	210	228	162	156	991	1022	908	955	897	742	743	776	812	782	745

flow Data In Data Out Settings Manifest

RESULTS and OUTPUT

Mean Sensor value	Max	Min	Error(+)	Error(-)	Mean concentration value	Max	Min	Error(+)	Error(-)
961	961	959	0	2	155.757	159.092	153	3.335	2.757
790	794	786	4	4	119.1	123.27	114.497	4.17	4.603
780	782	777	2	3	111.354	114.364	106.633	3.01	4.721
716	718	713	2	3	95.687	98.177	93.265	2.49	2.422
652	660	648	8	4	90.554	97.086	83.864	6.532	6.69
547	555	536	8	11	67.946	70.759	65.561	2.813	2.385
446	448	443	2	3	47.313	50.332	45.414	3.019	1.899
430	433	428	3	2	33.892	35.92	31.502	2.028	2.39

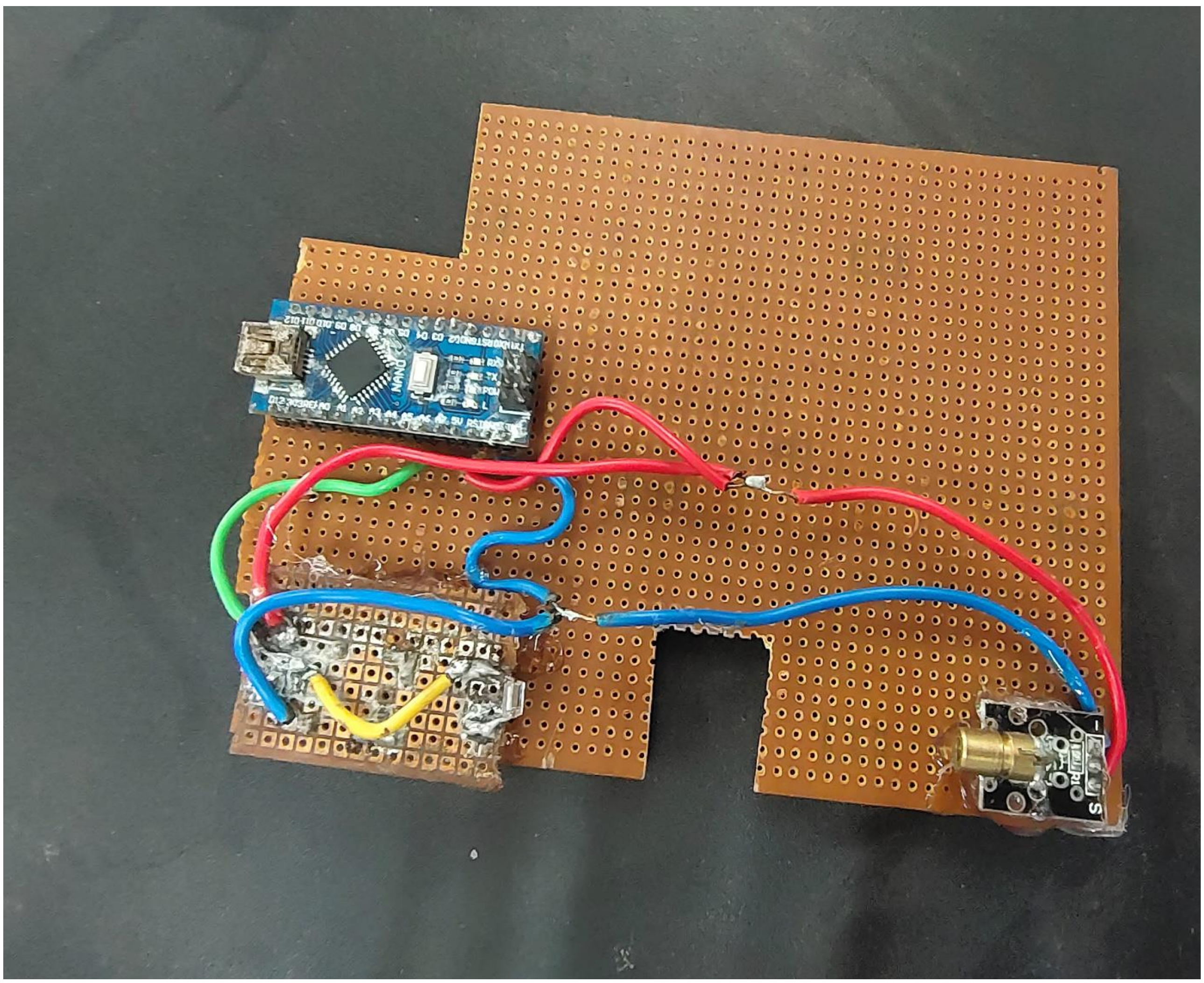
Scatter Plot with error bars



Best fit plot with approximate equation

In this graph we can see that this relation is linear in nature .So in any condition of fog flow when can get the approximate fog flow concentration when the light source and fog sensor are kept at 10 cm apart from each other. And thereby, we can calculate the mass flow rate of fog.

PHOTOGRAPH / SCREENSHOT OF ACTUAL MODEL/PRODUCT



APPLICATIONS

- **Power Plants:** Ensure the actual flow rate of water droplets comes out in the direct-type colling tower, and thereby helping in measuring makeup water required for cooling purposes.

- **Outdoor Lighting Systems:** Activate/deactivate lights based on fog density.
- **Environmental Monitoring:** Gather data on fog occurrences for research purposes.

CONCLUSIONS AND FUTURE SCOPE

The Arduino Power Fog Sensor provides an effective solution for power management in fog-prone environments. By integrating this sensor into relevant systems, operators can enhance safety and optimize resource usage.

In near future we can do these following advancements:

- **Machine Learning Integration:** Incorporating machine learning algorithms for continuous improvement in fog detection based on historical data and evolving environmental conditions.
- **Multi-Sensor Fusion:** Exploring the integration of multiple sensors, such as cameras and environmental sensors, to provide a comprehensive view of fog conditions.

List of reference:

[1] C. Das, R. Gupta, S. Halder, A. Datta, R. Ganguly, Film wise Condensation from Humid Air on a Vertical Super hydrophilic Surface: Explicit Roles of the Humidity Ratio Difference and the Degree of Subcooling, ASME J. Heat Transfer, Paper No: HT-20-1609, 143(6): 061601, June 2021.https://doi.org/10.1115/1.4050412

[2] Wang, C., & Li, S. (2018). A review of fog detection methods. Atmospheric Research, 204, 56-68.

[3] Winker, D. M., & Osborn, M. T. (1990). Remote sensing of clouds and aerosols from GLAS: Global algorithms and validation strategies. In Laser Radar V (Vol. 1311, pp. 130-141). International Society for Optics and Photonics.

[4] Ko, J., Vieira, M., Cho, H., & Kim, H. (2020). A Review of Optical Techniques for Visibility Measurement. Sensors, 20(18), 5267.