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Analysis & Practical Testing of Hexacopter Drone

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Abstract: *Drone is a profoundly bettered inflexibility airplane that has an abecedarian plan and construction. The UAV (Unmanned Upstanding machine) that is employed to lift, convey, note, salvage, and acquire data starting with one spot also onto the following in lower time and without taking several room and price. Drones are codified in the morning in step with their deconstruction, operations, length, and weight. they are also categorized primarily grounded on variables including the wide variety of rotors employed, the position and exposure of the rotors, and the design of the body. With the smallest size possible, the design, aerodynamics, structural weight, and other factors can be altered to alter the loads of colorful drones (monocopter, tricopter, quadcopter, and hexacopter). of a specific drone. The cargo will increase with the adding range of rotors on the price of the size and structural weight of the drone. The structural weight may be reduced with the aid of concluding for any low- weight cloth and converting the design (or indeed size). This dropped weight could be added to the cargo as elevated effectiveness. The feasible cloth will be aluminum still due to the fact carbon fiber has a lighter weight than aluminum, we decided for carbon fiber. originally, we are going to design the shape of a drone with confines after which examine the body, choosing the essential fabric and shape that meets the cargo, power, and stiffness of the demand of the device. also, we will be studying those drone frames using one-of-a-kind software program. also, Computational Fluid Dynamics (CFD) is used to perform a flash evaluation of fleshly variables related to aerodynamic gets in unmanned upstanding auto (UAV). The simulation is used to have a look at whirlpool, stress and turbulence kinetic strength (TKE) with put over- processing. these variables grease the aerodynamic evaluation in upstanding bias. CFD exploration are presently being conducted to ameliorate performance in a huge number of bias conforming of wind turbines, airplane and, as in our case, unmanned upstanding motorcars. It come set up how the aerodynamic gets within the Hexacopter varies in time and that there is an effect when the operation of 4 and two blades in its rotors. in this simulation show the turbulence and variation inside the stress at the shape of the arms, attaining a examine to plump fortune packages that are seeking the reduction of the overpressure and use of the generated turbulence.*

Keywords: Aluminum, Carbon Fiber, Design, Frames, Multirotor, Payload, CFD transient, UAV Blades, TKE, etc.

I. INTRODUCTION

A drone is an unmanned aircraft. Drones are more formally known as unmanned upstanding vehicles (UAVs) or unmanned aircraft systems (UAS). The aircraft may be ever controlled or can fly autonomously through software- controlled flight plans in their bedded systems working in confluence with onboard detectors and GPS. UAVs were initially used for anti-aircraft target practice, intelligence collection, and, more controversially, as weapons platforms, which is when they were most frequently associated with the military in recent history.

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Drones are now also used in a wide range of mercenary places ranging from hunt and deliverance, surveillance, business monitoring, rainfall monitoring and firefighting to particular drones and business drone- grounded photography, as well as videography, husbandry and indeed delivery services. Drones in moment's world have also been an important part of the film assiduity and news journalists are also using them to carry information from inapproachable locales. A typical unmanned aircraft is made of light compound accoutrements to reduce weight and increase maneuverability. This compound material strength allows military drones to voyage at extremely high mound.

Consumer, commercial, and military UAV are all outfitted with cutting-edge technologies including infrared cameras, GPS, and ray. Remote ground control systems (GSC), sometimes known as a ground cockpit, are used to operate drones. An unmanned upstanding vehicle system has two corridors, the drone itself and the control system. The nose of the unmanned upstanding vehicle is where all the detectors and nautical systems are present. Since there is no room for humans, the rest of the body is filled by drone technological systems. The engineering accoutrements used to make the drone are largely complex mixes designed to absorb vibration, which drop the sound produced. These accoutrements are veritably featherlight.

Parts of a Hexacopter

1. **Frame: -** The multiposter's frame basically functions as its body. Depending on the size and design, shape and material can change. A larger frame constantly has further arms than a lower one, and a larger frame is constantly made of carbon fibre, aluminum, or both, whilst a lower one is constantly made of plastic. The periphery of the circle formed by the motor axes is used to determine the multicopter's size. generally, the size is expressed in centimeters. The maximum size of the propellers is determined by its size, thus by using longer arms, larger propellers can be used.

2. **Propellers: -**
   - **Size & Pitch:** Propellers are generally named grounded on their size and pitch by using a four- number. The compass is described by the first two numbers, which are measured in elevation, and the pitch is described by the last two integers. The pitch is described as" the distance a propeller would move in one revolution if it were moving through a soft solid, like a screw through wood."
   - **Material:** Material Carbon fibre, plastic, and wood are frequently used accoutrements for propellers. Although carbon fibre is more precious than plastic and wood, it has benefits similar being lighter, stronger, and having lower vibration.
   - **Number of Blades:** The propeller can have any number of blades, but the most frequent are two, three, or four blades. The properties fluctuate as the number of blades increases; more blades produce a stronger thrust while decreasing efficiency.

3. **Motors:** The most common motor used on a multicopter is brushless Direct Current (DC) motor, this due to a high effectiveness, small size, and low cost.

4. **Electronic Speed Controllers:** An ESC is an electrical circuit that is used to control the speed of the motor. This is done using a palpitation- range Modulation (PWM) signal which the flight regulator circuit sends to the ESC. Grounded on the PWM signal the ESC transfigure the power from a DC battery to a three phase Alternating Current (AC) like signal which control the speed of the motor.

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5. **Batteries:** One of the most generally used batteries for multicopters is the Lithium- ion Polymer (LiPo) battery. Two important parameters when describing batteries are the capacity, measured in ampere hours (Ah), and voltage, measured in volts(V). LiPo batteries are frequently described with an S- number, like 1S, 2S, 3S etc. This relate to how numerous cells connected in series are in the battery. For illustration, a 2S is equal to 2 *3.7 = 7.2 V while a 6S is equal to 6 *3.7 = 22.2V. Easy to flash back is that in a battery connected in series increase the voltage whereas a battery connected in resemblant increase the capacity.

6. **Electronics for Control:** A flight regulator is a small computer on a drone which handle the control of the motors making it suitable to be navigated in air. Different complications of flight regulators live making it all from only being suitable to be manually controlled to having a full- on autopilot making the drone suitable to fly autonomously. A common expression for an alternate computer on board a multicopter which handles other tasks than the flight regulator is a companion computer.
   This computer can run a separate program which sends signals to the flight regulator as means of navigation. The companion computer can make use of different detectors like a camera, a Radio Discovery and Ranging (RADAR) system, spotlighted. to calculate and take opinions on where to navigate to. When the autopilot fails or just simple control of the drone is enough a hand control can be used together with a radio transmitter to manually control the multicopter by transferring control signals to the on- board receiver.

II. LITERATURE REVIEW

[1] M. Hassanalian and A. Abdelkefi, "Bracket, operation and Design Challenge of Drones a Review", Progress in Aerospace Science, April 2017, runnerno.1- 33, have given a new bracket of these drones was first proposed. This bracket includes colourful classes of drones, similar as unmanned air vehicles, micro air vehicles, Nano air vehicles, Pico air vehicles, and smart dust. The maximum wingspan and weight of UAV is 61m and 15000Kg independently while maximum wingspan and weight of Smart Dust is 1 mm and0.005 gm independently. All other types have capacities lying between this range.
The sizing process of drones is generally composed of five-way (1) defining the charge, (2) setting the flight mode grounded on the type, (3) determining the sect shape(planform) and aspect rate, (4) constraint analysis, and (5) weight estimation. They also showed that, the abidance of rotary bodies types of drones is confined due to the needed advanced power for the swimming flight mode. There are numerous challenges in designing these drones when their size and weight are dropped. operations of drones in security surveillance, for foliage and for medical exigency, etc.

[2] Mohd Khan, "Quadcopter Flight Dynamics", International Journal of Scientific and Technology Research, Vol. 3, issue.8, August 2014, runnerno.130- 135, concluded that a voltage force is needed for thrust adaptation of the rotors and to perform standard flight operations. The rate of total thrust depending on the angle rate to find thrust of each rotor which is needed for computation of voltage force for needed RPM for each independent rotor.
The result lays the foundation for farther use in control scheme to develop a way to autonomously control the helicopter for flight stability and perfection maneuvering when following a flight path. The procedure on varying the thrust direction of rotors is also illustrated to perform the standard flight operations. It also provides result to handle the Quadcopter with angular perfection by illustrating how the spin of the four rotors should be varied contemporaneously to achieve correct angular exposure along with standard flight operations similar as taking-off, wharf and swimming at an altitude.

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[3] Pan Wei, et.al., "The Design of Hexacopter Frame Grounded on Finite Element Analysis", 3rd International Conference on Mechatronics, Robotics and robotization, 2015, runnerno.1353- 1356, stated the important part of Finite Element Analysis in the Frame design. They showed the comparison between penciled frame and the-frame and how the penciled frame is better than the-frame. It is stated that profile frame has larger space and center of graveness is simple and quick to place. It can support the machine arm and tripod and can have further expansion holes to grease post product upgrades. It takes up little space when folded and is easy to carry whereas-frame's design is simple, good harmony, more flexible and suitable for trick flight, but have limited space and inconvenient for post upgrade.
They have stated, that under bending and twisting cargo, distortion is nearly related to the cross-sectional shape. Stiffness of the solid structure is lower than the concave structure. The torsional stiffness related to unrestricted square section is better than unrestricted indirect sampling. Changing the cross-sectional profile and wall consistence is used substantially to change the stiffness.

[4] S. Subhash, et.al., "CFD Analysis of a Propeller Flow and Cavitation", International Journal of Computer Applications, Vol. 55, issue.16, October 2012, runner. 26- 33, adieu carried CFD analysis of a propeller inflow and cavitation. As trials are veritably precious and time consuming, so they used Fluent6.3 software to get complete computational result for the inflow. Then continuum was chosen as fluid and the parcels of water were assigned to it hence when the operating pressure was lowered below the vapor pressure of girding liquid it stimulates the cavitation. They had answered advance miracle like cavitation of the propeller.
They have represented the performance of the propeller in terms of on-dimensional measure i.e., thrust measure(kit), necklace measure (Ky) and effectiveness and their variation with advanced portions(J). they had also estimated thrust and necklace from the computational results for different rotational speed of the propeller. Then two phases are considered, water and water vapor and showed the performance of the propeller in cavitating and on-cavitating conditions. They have showed development of depressions on propeller blade and comparison between CFD and trials which easily shows that water got vaporized area and this portion of the propeller blade is made to cavitate, therefore it reduces the thrust generated by the propeller and slightly increase the necklace demand. This software can break open water characteristics of propeller with reasonable characteristics.

III. SELECTION OF MOTOR AND PROPELLER & TESTING

- **Size:**
  The name of a motor for multicopters frequently contains a four- number number. This number species the size of the motor in millimeters. An illustration is the T- Motor MN4110 300KV, where 4110 is the number specifying the size.47.4 mm is the periphery of the stator while36.7 mm is the height, so this motor has a stator which is47.4 mm wide and136.7 mm high.

  KV*V=300*24=7200 (1)

- **KV:**
  The KV value is significant when selecting a motor. This is a value that describes the motors gyration relative to the voltage supplied, the Revolutions Per Minute (RPM) per Volt (RPM/ Volt). For illustration, when powering the preliminarily mentioned T- Motor MN4110 300KV with 24V, it would rotate

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Matching a Propeller to a Motor

- **Thrust to Freight Rate:**
  This is a useful guideline when erecting a multicopter. It says that the thrust of all the motors together should be at least twice the weight of the drone. This guideline is used to ensure that the motors always have enough thrust to handlines., situations where it needs to make rapid-fire movements or strong winds. It's calculated by the following formula (Thrust/Weight=Thrust-to-weight ratio)

- **Thrust:**
  The following tables, show the speciation of the former mentioned motors. This tables are handed by the manufacturer. The thrust depends on which propeller and what voltage is handed. As seen in the tables, the T- Motor MN4110 300KV have a maximum thrust of 3224 gram. The total thrust is calculated by multiplying the thrust with the number of motors. If a hexacopter was handed with the six T- Motor MN4110 300KV it would give a maximum total thrust of

  $$6*3.224=19.344Kg \qquad (2)$$

We must next select a motor and propeller that has the highest efficiency you can find for that operating point. Another way to say this is that you need to optimize the specific thrust of your hexacopter motors. Just remember that a "good" value for specific thrust is relative because ideal specific thrust varies with both hexacopter mass and propeller diameter. The key to optimization based on specific thrust is get the highest specific thrust you can for your given hexacopter mass. Adjust the propeller and motor selection as necessary to do so.

Table No. 3.1: Thrust Table of T-Motor MN4110 300KV.

Type	Propeller	Throttle	Voltage (v)	Thrust (g)	Torque (N*m)	Current (A)	RPM	Power (W)	Efficiency (g/W)
MN4110 KV 300	P18*6.1"	40	23.76	850	0.18	2.79	2744	66	12.82
		50	23.65	1225	0.26	4.78	3262	113	10.85
		60	23.54	1566	0.33	6.98	3686	157	9.53
		70	23.48	1965	0.41	9.95	4118	234	8.41
		80	23.41	2364	0.49	13.38	4509	313	7.55
		90	23.29	2776	0.58	17.38	4855	405	6.86
		100	23.18	3224	0.68	23.10	5261	535	6.02

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Practical Testing of Motor on Thrust and Temperature Checking Unit

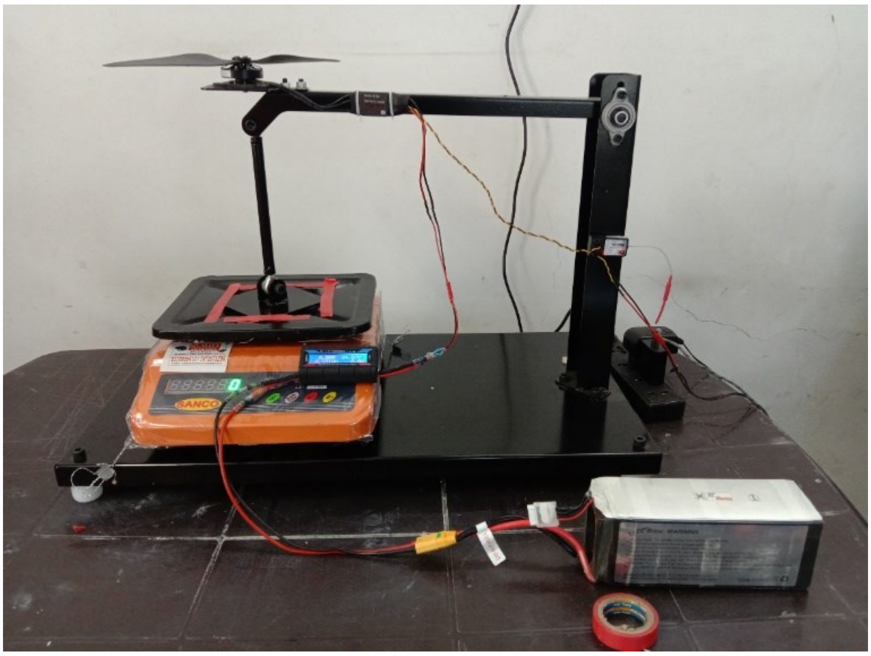

Figure No. 3.1: Testing of Motor

Test 1: Testing of Motor at 65% Throttle

Testing of the motors was done on the Motor Test Bench designed by us in Solid work. This test was done to check the compatibility of the motors with the ESC (Electronic Speed Controller) and to check the performance of the motors at different throttle inputs. This test also helps us to determine whether there are any heating issues with the motors when operated continuously for more than 60 minutes.

The motor mounted on the test bench was allowed to run at 65% throttle continuously until the battery drains out. With every 15 minutes readings of current, voltage, thrust produced, and temperature of the motor was noted down by us.

It was observed that the battery drains out completely after 60 minutes. As the charge of the battery goes on decreasing gradually the current & voltage also drops down. Due to the drop in current & voltage the thrust produced by the motors also drops slightly. The temperature of the motors was observed to be increased with time because of the continuous operation of the motor. The below table shows the readings of the test conducted:

Table No. 3.2: Result Table of the Test 1

Sr. No.	Time (min)	Current (A)	Voltage (V)	Thrust (g)	Temperature (^{0}F)
1	0	8.34	23.77	1668	86
2	15	7.84	23.06	1600	90
3	30	7.48	22.57	1544	92
4	45	7.40	22.12	1520	95
5	60	7.32	21.85	1500	101

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Test 2: Testing of Motor with Throttle Gradually Increasing

This test was conducted with 25% throttle input to the motor at the start which was gradually increased 100%. After every 20 minutes readings of the current, voltage, thrust produced, & temperature was noted down after which the throttle % was increased by 25%. This process was continued till the throttle input reaches 100%.

This test was helpful to understand whether the motor produces the required amount of thrust at different throttle inputs. The below table shows the observations of the test 2:

Table No. 3.3: Result Table of Test 2

Sr. No.	Time (min)	Throttle (in Percentage)	Ampere (A)	Voltage (V)	Thrust (g)	Temperature (^{0}F)
1		0	0	23.98	0	80
2	0	25	1.02	23.97	421	81
3	20	50	4.9	23.67	1244	86
4	40	75	10.1	23.10	2120	94
5	60	100	20.4	22.55	3021	110

IV. ANALYSIS OF HEXACOPTER DRONE

1. Meshing

In Computational Fluid Dynamics (CFD), meshing refers to the process of dividing the domain containing the fluid flow into small, interconnected cells or elements. This grid-like structure allows for the numerical approximation of the governing equations of fluid flow. The quality of the mesh plays a crucial role in CFD simulations, as it affects the accuracy and convergence of the solution. The mesh should be appropriately refined in regions of interest and near complex geometries to capture the flow features accurately. Different types of meshes, such as structured or unstructured grids, can be used based on the complexity of the flow problem and the desired level of accuracy.

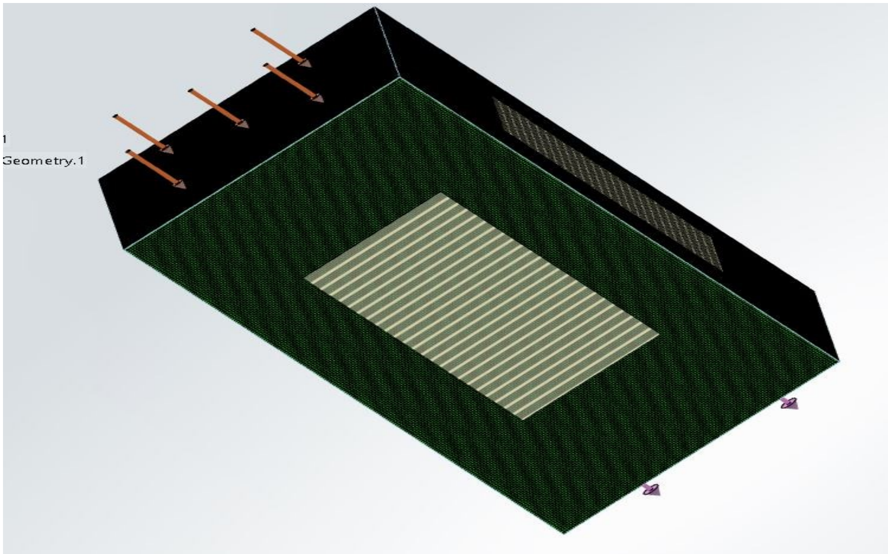

Figure No. 4.1: Meshing of Domain

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2. Boundary Conditions

In computational fluid dynamics (CFD), the boundary conditions of a domain refer to the prescribed values or constraints applied at the boundaries of the computational domain. These conditions help define the behavior of the fluid flow within the domain. Boundary conditions can include specifying the velocity, pressure, temperature, or concentration at the boundary surfaces, as well as imposing constraints such as symmetry or periodicity. Properly defining boundary conditions is crucial as they directly influence the accuracy and reliability of the CFD simulation, ensuring that the flow behavior is realistic and representative of the physical system being studied.

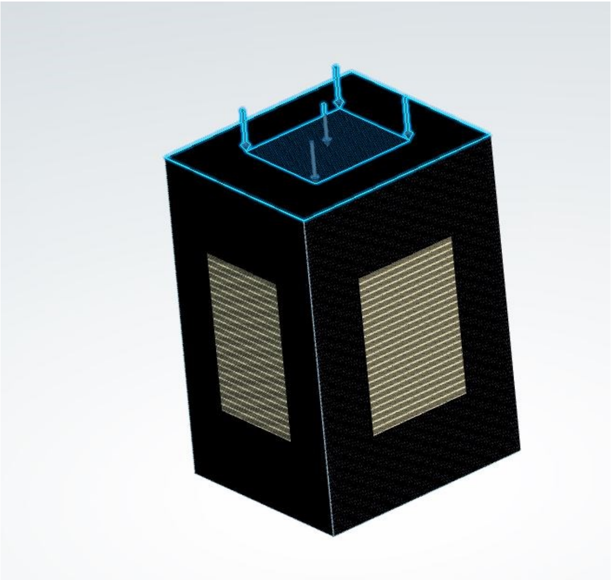

Figure No. 4.2: Direction Inlet of Air in Domain

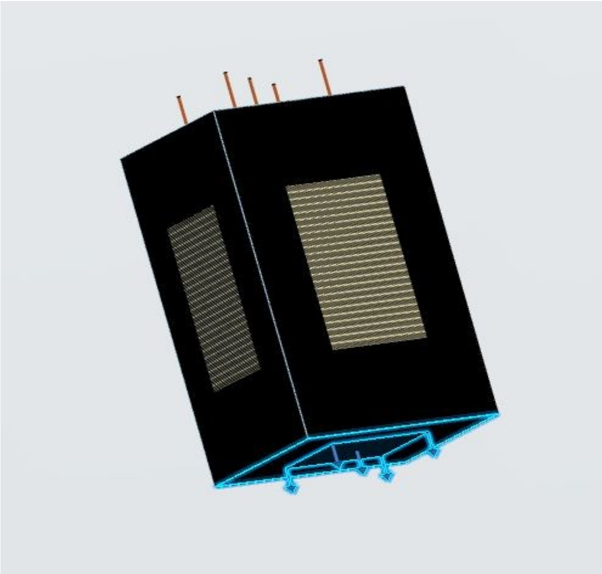

Figure No. 4.3: Directi**on of Outlet of Air in Domain**

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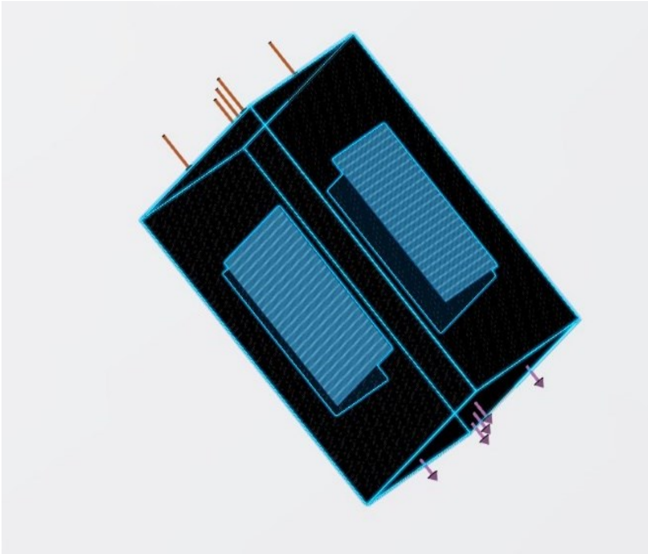

Figure No. 4.4: Wall of The Domain

3. CFD Analysis

CFD analysis of a pressure gauge involves using computational fluid dynamics (CFD) techniques to simulate the flow of fluid around the gauge. By creating a numerical model of the gauge and its surrounding domain, the CFD analysis predicts the pressure distribution on the gauge's surface, providing insights into the fluid behavior and its impact on the gauge's performance. On the other hand, the velocity line analysis focuses on visualizing the flow velocities of air within the domain using CFD simulations. It helps to identify areas of high and low velocities, flow patterns, and potential turbulence zones, allowing for a comprehensive understanding of the fluid dynamics and aiding in design optimization or troubleshooting.

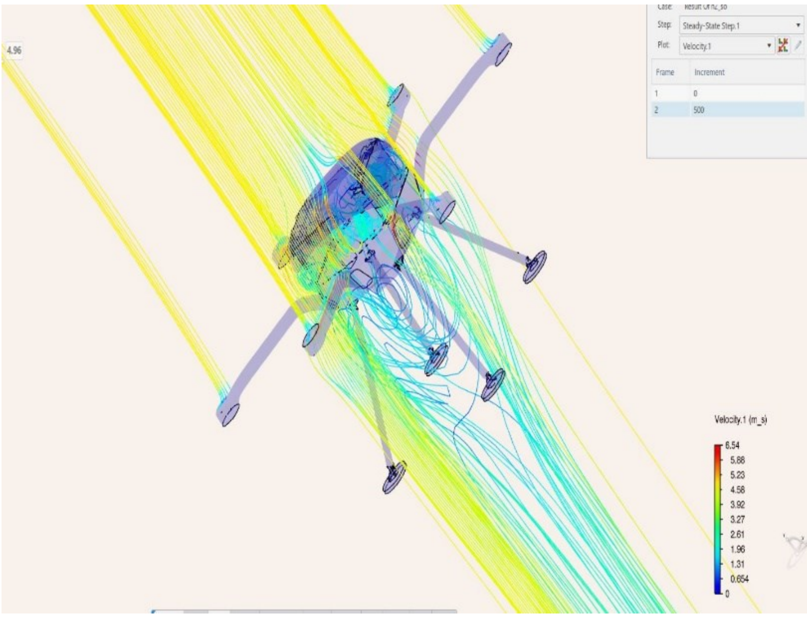

Figure No. 4.5: Velocity Lines

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V. RESULT OF ANALYSIS of HEXACOPTER DRONE

The results of a CFD (Computational Fluid Dynamics) analysis of a pressure gauge and velocity line of air in the domain can provide valuable insights into the behavior of airflow and pressure distribution. The pressure gauge readings obtained from the CFD analysis can indicate the variations in pressure at different locations within the domain, allowing engineers to identify regions of high or low pressure. This information is crucial in understanding the flow characteristics and potential areas of concern in terms of pressure differentials. Additionally, the velocity line of air obtained from the analysis illustrates the airflow patterns and velocities throughout the domain. By visualizing the velocity distribution, engineers can assess factors like flow separation, recirculation zones, and areas of high or low velocity. These insights help in optimizing the design, identifying potential issues, and ensuring efficient and safe operation of the system.

Velocity	Drag(N)	Drag (Kg)	C_D
5	1.3	0.13	0.62885
10	5.429	0.5	0.65654
20	23.38	2.3	0.70685
25	35.69	3.5	0.69057
30	50.8571	5.085	0.68337

VI. CONCLUSION

CFD analysis of hexacopter drone was conducted and studied. Then the design of the hexacopter drone and the meshing of hexacopter with delicacy play a crucial part. The validated mesh is chosen and an aerodynamic analysis is done. CFD simulations and wind lair trials served as styles to estimate the design quality of the UAV, vindicating that all the design conditions were achieved. Above observation gives an idea about the design and analysis of a Hexacopter Drone, hence the FEA analysis and CFD analysis of assembly has been done and is proved as safe, since no distortion exceeds the given safety values. Design of Hexacopter has explained colorful aspects and parameters of analysis using SIMULIA SIMULATION and ANSYS workbench software; this result will help in better optimization of the Hexacopter in future.

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