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Research Regarding Development of Pesto Gun using Air Multiplier Effect

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Abstract - Considering the rising problem of mosquitos, flies, and pesky insects like fruit fly in the world, the primary goal of this project is to develop a compact hand-held machine-on the principles of mosquito racquet to kill mosquitos by suction. The aim is also to make it lightweight and portable for any teen or elderly to use it comfortably. Also need to make the product alethically pleasing, with soft colors and robust design with good fitments with tolerances. The Pesto gun offers multiple advantages, one of which is that the pest will be sucked, allowing no space for escaping insects, contrary to mosquito rackets. This device can be helpful in situations where rackets fail for some sort of reasons as well as a more efficient investment in comparison with other mosquito repellent techniques Comparative research of several materials that can be employed for manufacture of this product has been done with the help of various resources, and the material that is best suited for production has been chosen. The primary components for this research paper is to discuss conventional methods for mosquito killing and carry out literature review for the same. Then describe the working principle of our innovative technology used in the device PestoGun along with proof of its effectiveness using CFD analysis results for the device and then putting forth the advantages of our technology over conventional ones

Key Words: **mosquito killing, compact and lightweight machine, suction, bladeless mechanism, aesthetic and efficient machine.**

1.INTRODUCTION

1.1 Conventional Techniques used in Mosquito Killing :

1.1.1 Mosquito Racket : It functions by shocking the insect with electricity when it comes into contact, effectively killing it. Integrated rechargeable or disposable batteries power the racket. An on/off switch or button is typically present to regulate the power supply. The racket has an electrically conductive wire mesh or grid. In most cases, the spacing between these wires is tight enough to keep insects from travelling through without touching the grid. A low-voltage electric current travels through the grid's cables when the racket is turned on. The mosquito racket is used to target and strike the flying bug by swinging it in the air. As soon as, the circuit gets completed by mosquito, its body receives an electric shock.

1.1.2 UV Trap : The UV light bulb in the trap emits particular wavelengths of light, mostly UV-A light. Because UV light attracts mosquitoes so strongly, it aids in luring them to the trap. To increase mosquito attractiveness, certain traps may additionally utilise extra attractants like pheromones or carbon dioxide. The mosquitoes may be physically captured or electrocuted upon contact with others' sticky surfaces or electric grids. Normally, when the mosquitoes are captured, they are put into a detachable tray, net, or container. UV mosquito traps are intended to be used outside or in locations with high mosquito activity.

1.2 Literature Review :

[1] Nazaire Aïzoun et. al. Studied the usage of malaria vector sampling for an electronic racket. Collected and studied several species of mosquitos for 14 successive days and verified the efficient use of electronic racket in order to prevent malaria virus.

[2] Pavlovsky et. al. Developed an instrument to grab sandflies present on walls which is identical to racket. Described importance along with the problems for control regarding sandflies. Exact location for places of breeding was also given great importance.

[3] Daniel L. Kline et. al Research activities regarding current developments to analyse traps for mosquitos were conducted.Technologies which make usage of semiochemicals were analysed. To reduce the increasing population of mosquitos these traps are analysed.

[4] Roberto C.A. Thomé et. al. To describe the dynamics of population of mosquitos a numerical model was presented after introducing sterile male mosquitos as a biological control. Research was carried out regarding the application of cost of insecticide

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to provide the optimal control, also for the irradiated mosquitoe's production cost and their delivery along with cost associated with social scenario. By incorporating the Pontryagin's Maximum Principle, optimum control was established.

[5] Hee Il Lee et. al. Used ultraviolet black light traps for measure of mechanical control. Observed that these traps are more effective in capturing mosquitos. Effectiveness of the trap spacing within livestock enclosure was also analysed. Concluded that black light trap is an effective method of control and should be incorporated in existing techniques.

[6] Auni Afiqah Khalid et. al. Analysed remote monitoring using real-time data and for that purpose developing an intelligent trap-monitoring system. A mosquito attractant which is emitting carbon dioxide is combined along with an ultraviolet light and a zapper circuit. The project also makes use of IoT technology.

1.3 Approach for Design :

Design of Experiments (DOE) :

Design of experiments (DOE) is a field of applied statistics concerned with the planning, execution, analysis, and interpretation of controlled tests to analyse the factors that influence the value of a parameter or combination of parameters. It is a robust data gathering and analysis tool that may be applied to a wide range of experimental scenarios. It enables the manipulation of many input parameters in order to determine their effect on a desired output (response). DOE can identify crucial interactions that may be missed while experimenting by adjusting numerous inputs at the same time.

Blocking, randomization, and replication are essential ideas in designing an experiment. Blocking allows you to limit randomization when randomizing a factor is impractical or too expensive by conducting all of the trials with one setting of the factor, followed by all of the trials with the other setting. Randomization describes how an experiment's trials are carried out. An unpredictable or uncontrolled variable's impacts are lessened by using a random sequence. Replication is Repeating a whole experimental procedure, down to the setup.

2. EXPERIMENTAL SETUP :

2.1 Concept of Bladeless Fan :

Though it is called as bladeless fan it has a fan or impeller which is hidden in the cylindrical base. Then the air is passed through a circular ring. The total outlet air will get 15 times that of total intake air. Conventional fans have lager blades which cause more noise and also the choppy effect of air. In case of bladeless fans noise is drastically reduced and also the airflow is smooth because of no blades in the circular ring. Along with those benefits air gets multiplied due to Coanda Effect. First-of-all, the air is sucked through the holes in cylindrical base by the impeller run by motor. Then it is forced to flow through the circular ring having air foil cross section and a small opening. The air leaves the small opening with very high velocity and flows sticking to the air foil surface due to Coanda Effect. Due to that a very low-pressure region is created in the centre portion of the circular ring which causes the air behind the fan to get sucked with high velocity which is called as air inducement. Now the flow after leaving the air foil surface have turbulent flow due to high velocity. This causes the air surrounding to it to add up to the air flow which is called as air entrainment. So due to combined effect of the Coanda effect, Air inducement and Air entrainment the outlet air is multiplied to about 15 times that of intake air.

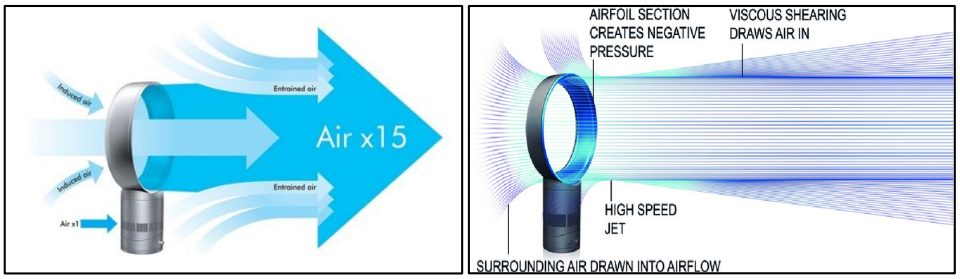

Fig -1: Air Multiplier Effect produced by a Bladeless Fan

2.2 Material :

Acrylonitrile Butadiene Styrene (ABS) Plastic

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- ABS plastic or Acrylonitrile Butadiene Styrene, is an opaque thermoplastic. It is an amorphous polymer composed of three monomers: acrylonitrile, butadiene, and styrene. ABS plastic characteristics' adaptability contributes significantly to its adoption across a wide range of industry sectors.
- Features and Advantages: Butadiene offers strength and hardness, whereas acrylonitrile in ABS plastic provides chemical and thermal stability. The resulting polymer has a lovely, glossy sheen thanks to the styrene. ABS is simple to utilise in 3D printing and injection moulding thanks to its low melting point. The produced plastic can tolerate heavy use and unfavourable environmental circumstances thanks to its high tensile strength, excellent resistance to physical impacts, and chemical corrosion. ABS is simple to mould, sand, and shape, and its glossy surface finish makes it ideal for use with a variety of paints and glues. ABS polymers readily accept colour, enabling completed goods to be dyed in precise hues to adhere to specified project requirements.

2.3 Construction of Actual Setup :

2.3.1 Iteration 1 :

This is all with the help of initial product concept design sketch. Ordinary PVC pipes of standard diameters 63 mm and 75 mm used concentrically and a Teflon tape outer cover as a spacer between them. Two standard fans of diameters 56 mm each are selected and 2* 9V DC motors are chosen for this setup. To create bladeless fan arrangement, used standard T-joint made of PVC inside which the vertical fan is located. As an extremely important part of the bladeless arrangement that is a slit which designed, and 3D printed at the front end. For testing, used small cotton balls weighing approximately 5mg, which are equivalent in weight as mosquitos.

Reasons of rejecting this iteration:

- The testing was only 10% successful after assembling using these components.
- The motors' speeds were so slow that it became practically impossible to suck air inside it.
- The back end of this PVC model lacked the necessary openings for adequate air passage, leading to suction.
- The fan was installed at a greater distance, causing an obstacle to sucking in air.
- The arrangement for the bladeless was not optimum, and there is significant air loss, making it inefficient.
- The entire assembly became heavier as a consequence of the heavy motors.

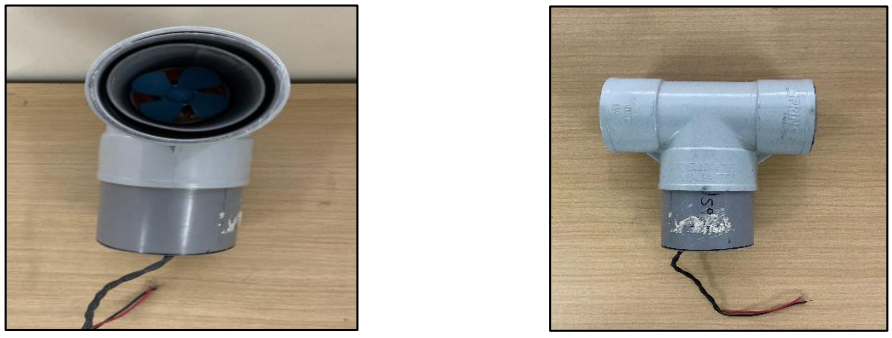

Fig -2: Physical Prototype of Iteration 1

2.3.2 Iteration 2 :

Modifications in Iteration 2 from the flaws of previous iteration:

- First and foremost, replaced the heavy conventional DC motors with 3.7v coreless DC motors typically used in drones. They are lightweight with an extremely high operating speed of up to 50,000 rpm.
- In this variant, two-blade drone propellers are utilized in place of four.
- Both of them help in boosting the total amount of air flow.
- The bladeless setup is improved by reducing the existing model's tail end. As a result, there was a significant decrease in air loss. The handle's pipe diameter is reduced, making it simpler to hold.
- A grill is also designed to accommodate a motor and act as a separator between two PVC pipes. Since the arrangement was 70% successful, we proceeded towards the CAD model.

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Fig -2: Physical Prototype of Iteration 2

2.3.3 Iteration 3 :

- This alteration is only performed in CAD.
- A conical-shaped front-end arrangement is designed in CAD.
- 3D printed this conical-shaped arrangement and tested it using the physical model of iteration 2.
- The suction effect is not considerably improved. As a result, this conical component was discarded.
- Another notable change was the curvature cross section of the bladeless cavity, unlike the previous straight and boxy cross-section. This update will be examined using CFD.

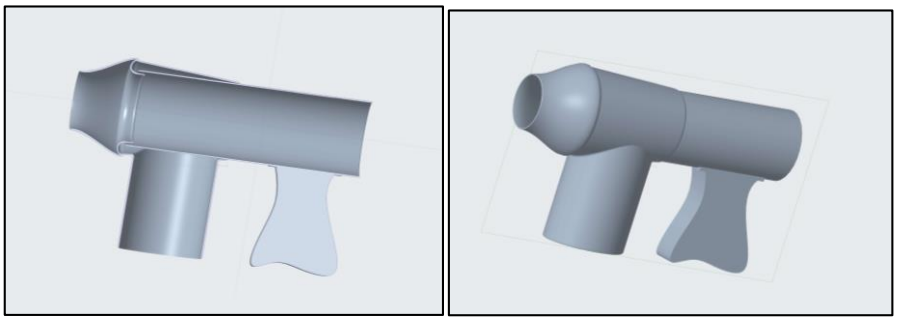

Fig -3: Iteration 3 performed in CAD

2.3.4 Iteration 4 :

- Two separate parts for the fan and the electronic components are integrated together for a better aesthetic appearance.
- Furthermore, 3* 4 volts rechargeable batteries will be used in series combination to build a 12 volts battery pack of 0.5 Ah which will operate two 3.7 volts fans and a mosquito killing mesh that consumes up to 4 volts to convert it into 4000 volts approximately. This rechargeable battery pack will be equipped with an USB type-C charging port.

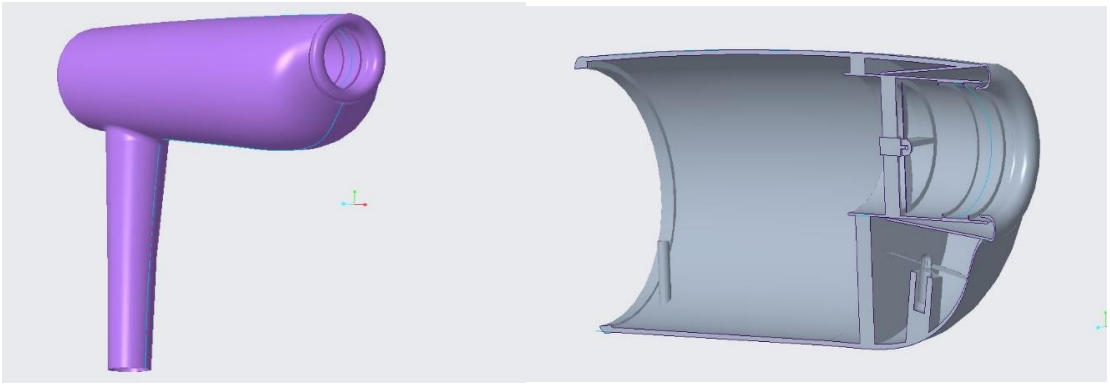

Fig -4: Iteration 4 performed in CAD

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RESULTS :

Computational Fluid Dynamics (CFD) analysis is performed to check out the effectiveness of improvements in the design iteration by iteration. Boundary conditions and important parameters used are as follows :

1) Diameter of Fan (D) = 55 mm.
2) Rated RPM (N) = 48000 rpm
3) Advancement Ratio (J) = 0.3
4) Inlet Velocity (V_i) = 13.2 m/s …….. (Formula : $V_i = J*N*D$)

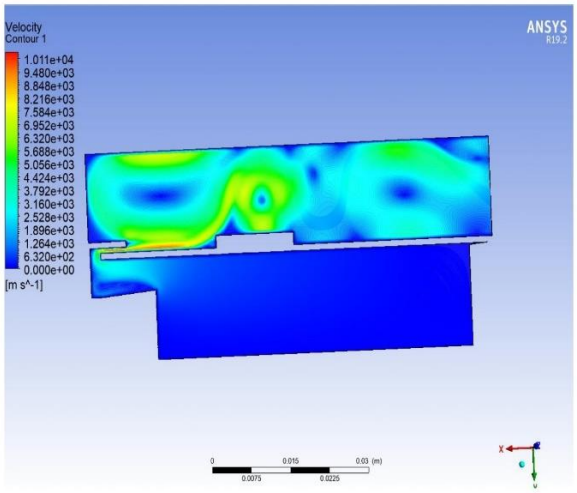

Fig -5: Overall Velocity Profile – Iteration 1

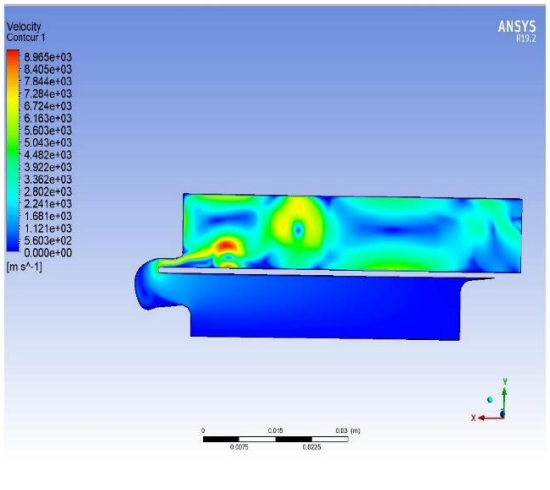

Fig -6: Overall Velocity Profile – Iteration 2

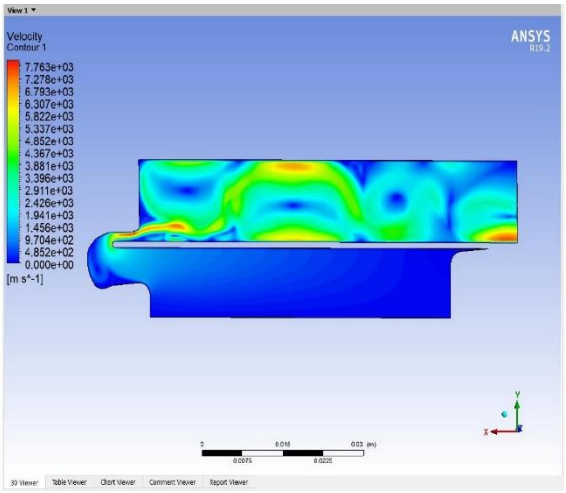

Fig -7: Overall Velocity Profile – Final Iteration

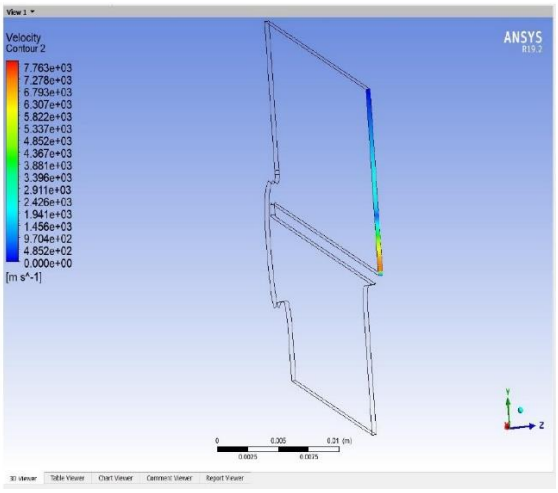

Fig -8: Outlet Velocity Profile – Final Iteration

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CONCLUSION :

In the development of Pesto Gun, two iterations are created manually in the form of prototypes and two iterations in CAD. Performed experiments and CFD analysis on these iterations. From the results obtained from experiments and CFD it is concluded that the development of this project is successful. Also, the material chosen for the product is appropriate. Used Design of Expeiments (DOE) method in the development. One regular suction fan supplemented by a bladeless fan arrangement has created a huge amount of suction due to air multiplier effect which will effectively suck the mosquito in. Also, any teen or elderly person can use it comfortably and easily. From the performance obtained for this product it can also be concluded that this product will be a stepping stone for the future technologies for mosquito killing.

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