



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 1, January 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com



Review on Design and Battery Optimization Techniques in Electric Vertical Take-Off and Landing Vehicles

Atharva N. Dingore¹, Manas D. Yawalkar², Vishnu R. Nair³, Harshank P. Patil⁴, Prof. S V Shinde⁵,
Prof. K R Pagar⁶, Dr. C D Mohod⁷

B.E. Students, Department of Mechanical Engineering, Guru Gobind Singh College of Engineering and Research
Centre, Nashik, India^{1, 2, 3, 4}

Assistance Professor, Department of Mechanical Engineering, Guru Gobind Singh College of Engineering and
Research Centre, Nashik, India⁵

Assistance Professor, Department of Mechanical Engineering, Guru Gobind Singh College of Engineering and
Research Centre, Nashik, India⁶

Professor, Head of Department of Mechanical Engineering, Guru Gobind Singh College of Engineering and Research
Centre, Nashik, India⁷

ABSTRACT: Fixed wing unmanned aerial vehicles typically have longer running (flight) time than multicopters, but runways are needed. Because it is difficult to expect a wide runway in the city area, the great need is there to develop a vertical takeoff and landing (VTOL) type fixed-wing UAV that does not require any runway. In addition, our goal was to develop a VTOL plane that contains a stable transit flight characteristic. To achieve this goal, we have designed and developed a test plane and the flight parameters have been extensively tested. The developed VTOL plane shows a very smooth transition flight. It is expected that the VTOL UAV will be widely used in the city area in the future for various purposes, such as cargo delivery and emergency medical supply delivery.

KEYWORDS: Unmanned Ariel Vehicles (UAV), Vertical Take-Off and Landing (VTOL), Cargo Delivery.

I. INTRODUCTION

VTOL stands for vertical take-off and landing and, as the name suggests, refers to aircraft that can take off, hover, and land vertically. The best-known example is the helicopter, but the F35B fighter jet can also take-off and land from a standing start off the back of an aircraft carrier. There are two different types of VTOL technology: rotorcraft and powered-lift.

Rotorcraft, or rotary wing aircraft, are those that use lift generated by rotor blades spinning around a central mast, so helicopters, quadcopters and gyrocopters.

Powered-lift vehicles are those that take off and land vertically but perform differently from rotorcraft when in flight. They typically have a more conventional fixed wing plane design. Examples include convertiplanes such as the Bell Boeing V-22 Osprey, which takes off and lands vertically but uses fixed wing lift in normal flight. Vectored thrust planes, such as the Harrier Jump Jet series also used powered-lift by manipulating the thrust from the engine or motor to control the flight of the aircraft. Most powered-lift planes in use today, including the Harrier, V-22 Osprey and the new F-35B, are considered to be V/STOL (vertical and/or short take-off and landing) vehicles. They tend to make a rolling takeoff from a runway when possible as this requires less thrust. This is especially useful for a military plane loaded up with heavy weapons.

The idea of vertical flight has been around for thousands of years, and sketches for a VTOL (helicopter) show up in Leonardo da Vinci's sketch book. Manned VTOL aircraft, in the form of primitive helicopters, first flew in 1907 but



would take until after World War Two to perfect. In the 21st century, unmanned drones are becoming increasingly commonplace. Many of these have VTOL capability, especially the quadcopter type.

An electric vertical takeoff and landing (eVTOL) aircraft uses electric power to hover, take off, and land vertically. This technology came about thanks to major advances in electric propulsion (motors, batteries, electronic controllers) and the growing need for new vehicles for urban air mobility (air taxi). Examples are being developed by companies such as Boeing and Airbus, and by NASA. The concept of eVTOL aircraft emerged in 2011 through the AgustaWestland Project Zero (Italy), the Volo copter VC1 (Germany) and the Opener BlackFly (US).

The VTOL technology is mainly classified based on the nature of requirement such as transport and air strike. The transport class aircraft with VTOL technology are mostly rotorcraft like Helicopters, Gyrodynes, tilt rotors and tilt wings, which use advanced turbo shaft engines. Recent developments in the rotorcraft field is on cyclopyro and heliogyro designs which have always been futuristic and out of grasp since their first prototypes. On the other hand, the attack jets which use VTOL technology primarily contain light weight, efficient turbofans augmented with power lift fans to initiate take off. Electric and hybrid-electric vertical takeoff and landing aircraft, or eVTOLs, are being developed in the quest for fully autonomous personal air vehicles (PAVs).

II. LITERATURE REVIEW

In the present chapter, the contribution made by different researchers and authors in the field of eVTOL technology were enlisted in short. It includes the methods, mathematical modelling, softwares, different input parameters as well as their output results. The literature is based on VTOL and UAV Propellant technology, implementation types; finally, the summary of literature reviewed is added.

[1] Mohamed Nadir Boukoberinea, Zhibin Zhou Aug 29, 2019: The interest in electric unmanned aerial vehicles (UAVs) had rapidly grown in recent years. The reason was that UAVs had abilities to perform some difficult or dangerous tasks, with high mobility, safety, and low cost. It should be noted that UAVs had revolutionized many public services which includes real time monitoring, search and rescue, wildlife surveys, delivery services, wireless coverage, and precision agriculture. To increase endurance and achieve good performance, UAVs generally used a hybrid power supply system architecture. A hybrid power architecture may combine several power sources such as fuel cell, battery, solar cells, and supercapacitor. The choice of a suitable power source hybridization architecture with an optimal energy management system was, therefore crucial that enabled an efficient operation of advanced UAVs. In the context of battery-powered UAV platforms, that had included new technologies such as swapping laser-beam inflight recharging and tethering. This paper proposed a comprehensive and critical state of the art review on power supply configurations and energy management systems that found out gaps to provide insights and recommendations for future research.

[2] Yukai Chen Oct 2018: The market of small drones had recently increased due to their use in many fields of application. The most popular drones were multirotor, in particular quadcopters. That was usually supplied with batteries of limited capacity, and for this reason their total flight time was also limited. As a consequence of the non-linear characteristics of batteries, estimation of the real flight time became an issue, since most battery models did not include all the non-idealises. Consequently, applications such as delivery service, search and rescue, surveillance had not been accomplished correctly because of inaccurate energy estimations. This paper has described a battery-aware model for an accurate analysis of the drone energy consumption; this model has been then applied to a scenario of drone delivery. Results showed an accuracy greater of about 16% with respect to the traditional estimated model.

[3] M Ashari, Muhammad Rivai Aug 31. 2018: This research proposed the calculation of energy used in modern drip irrigation systems with water pumps drone by Brushless DC motors. The drip irrigation system was highly efficient in the use of water and electricity with higher quality crops. This system required a flow of water with a certain pressure so that water dropped into the plant had a constant discharge. Pressurized water source was generated from two methods, namely overhead water tank and direct water pump. In the overhead water tank method, the amount of water pressure and energy required to provide the water depended on the amount of water discharged and the height of the tank positioned. In the direct water pump method, the amount of water pressure and electrical energy required depended on the speed of the pump rotation and the amount of water discharged. In this study, the direct water pump system was controlled by PI method which made the water pressure more stabled. The simulation result indicated that irrigation system with overhead water tank required higher energy than the



direct water pump. The direct water pump method required simple infrastructure which had operated at all required water pressure.

[4] Kadir Sabanci Jan 24, 2020: In this study, Artificial Neural Networks, Extreme Machine Learning and Support Vector Machine (SVM) was used to estimate power consumption of Brushless DC motor in Unmanned Aerial Vehicle (UAV). Durably 3648 Brushless DC motor of UAV was modelled with the Finite Element Analysis software. Then it was simulated with Ansys-Rmxprt according to pulse degree, speed and battery voltage of the UAV. The training times and Mean Absolute Percentage Errors (MAPE) of the Artificial Intelligence Techniques (AITs) was calculated for motor input power estimation. The best result among the implemented AITs was achieved with the MAPE of 0.269% by the SVM model. Then the graphical user interface (GUI) was developed to easily obtain information about how efficient the battery could be used, and the flight time of UAVs. Thanks to the proposed GUI software, the input power of the motor had been estimated via input parameters without the long-time consumed simulations.

[5] SunhoJee, Hyunchn Cho Sep, 2018: Currently, many companies had succeeded in logistics delivery experiments that utilized drone and reported it. When a drone was used commercially, long-term flight was an important performance that a drone should have. However, unlike vehicles operated on the ground, drone was a vehicle that continued to consume energy when maintaining the current altitude or moving to the destination. Therefore, the drones flew for a long time as the capacity of the battery was large, but the batteries with large capacity was restricted by heavy weight and it acted as a limited factor in a commercial use. To address this issue, we attempted to compare how far we could fly than forward flight based on the flight pattern with the same energy consumption conditioned. In this paper, the comparison of energy consumption was performed in three flight pattern, forward flight without altitude change and forward flight with altitude change, by computer simulation and it showed the increased flight distance when the quadrotor flew with altitude changes from high altitude to low altitude.

[6] Viacheslav Balobanov, Tuukka Verho, 24 October 2020: The scratch resistance of polymers is important for numerous applications, as scratching can lead to degradation of surface properties and also represents an elementary process in abrasive wear. However, scratching of polymers is a complex process involving several modes of deformation, and theoretical understanding of it is incomplete. Numerical modelling is a potentially useful means towards a clearer picture of the scratching process, but the central role of tip-substrate contact and highly localized large deformations makes finite element analysis (FEA) challenging. Here, they took further the numerical approach by investigating a highly ductile semi-crystalline polymer by FEA and taking the inherent rate dependency of polymers into account by using an elasto-viscoplastic material model. Two γ -Al₂O₃ and f-Al₂O₃ HDPE nanocomposites, which have shown themselves to be suitable for tribological applications, were studied. There discussed the effect of nanofillers on the scratch behaviour and highlighted the significance of recovery properties, which still pose a challenge to numerical modelling

[7] Dhinesh S.K., Megalingam, 22 April 2020: In recent years, additive manufacturing process has found various applications in many industrial as well as commercial sectors. ABS and PLA are the most commonly used filaments in 3D printing. Although both of them provide high quality materials in their own ways, their resistance to stresses is not of industrial standards. 3D printed materials are always considered to be fragile and required to be given care. So, in order to present with a new filament material which can withstand higher stresses as compared to the conventional filaments, blends of PLA and ABS were produced in various compositions (20% ABS and 80% PLA; 50% ABS and 50% PLA; 80% ABS and 20% PLA) and they were tested for their resistance against tensile and flexural loads. Specimens with the above compositions were printed in accordance with ASTM geometry considering the ASTM standards. The UTS data for various combinations were established. The UTS data were then cross-indexed with the result of the flexural test. Results were compared to the properties of normal ABS and PLA and observed that the blend materials outperformed pure ABS and PLA by a marginal amount. Thus, implementation of this filament material in 3D printing applications ensured products with higher resistance to stresses.

[8] P.Sukwisute, A.Sakulkalavek-30 August 2017: This work aimed to investigate the effect of sputtering power on the hardness and wear resistance of chromium nitride (CrN) thin films deposited on the acrylonitrile butadiene styrene (ABS) substrates. These coatings were performed by a reactive DC magnetron sputtering technique. The values of sputtering power were adjusted in the range of 125-200 W. The total pressure (Pt), nitrogen partial



pressure (PN₂), and sputtering time were kept constant at 4×10⁻³ mbar, 30%, and 120 min, respectively. The surface roughness of the thin films was characterized by atomic force microscopy (AFM). The crystalline structure of these CrN thin films was studied using X-ray diffraction (XRD). The hardness and Young's modulus of the CrN coated ABS samples were analyzed by a nanoindentation hardness test. Wear resistance tests under ambient air condition at room temperature were carried out by pin-on-disc method. The wear scars of the samples were determined by scanning electron microscope (SEM). The results showed that the hardness values were varied from 6.65 to 9.58 GPa. Young's modulus of the samples was changed from 30.87 to 44.25 GPa. The CrN coating deposited on the ABS substrate at 175 W exhibited the highest hardness of 9.58 GPa which value is as high as that of steel. This indicated its potential and promising applications as hard coating layers for ABS plastic parts.

III. MATERIAL SELECTION

The Publication by Viacheslav Balobanov, Tuukka Verho⁶ explicates about one of crucial properties that a polymer should possess that is resistance towards scratches on the surface of the polymers. This property of polymer being scratch resistance is vital for numerous applications, as scratching can lead to degradation of surface properties and also represents an elementary process in abrasive wear. Further studies shown that two γ -Al₂O₃ and f-Al₂O₃ HDPE nanocomposites were found to be suitable for tribological applications such as in UAVs and VTOLs. They used modelling and experimentation processes to learn more about the scratch resistance behaviour of HDPE. In addition to this, they empirically investigated the result of nanoparticle fillers on the scratch properties. The nanoparticles fillers had only a slight effect on the scratch behaviour, but they did perceive an increase in the elastic penetration in the case of gamma alumina filler (up to 12%, depending on the scratch velocity and loading), attributable to a decrease in the elastic modulus. In spite of this that did not have any effect on the friction behaviour: the friction coefficients for neat HDPE (0.32 ± 0.05) and gamma alumina composite (0.31 ± 0.06) were close to each other. They also discovered that the friction coefficient for fumed alumina composite is 0.35 ± 0.04, and the dissimilarity can be enlightened by a larger quantity of dissipative (plastic and viscoelastic) distortion.

The research and analysis process of additive manufacturing was done by Dhinesh S.K., Megalingam⁷ in which they explained about the most common materials used as filaments which are ABS and PLA. They also stated that both the materials are high quality materials in their own ways but their resistance to stresses is not met up to the industrial standards. Hence, they conducted a study to check the 3D printed ABS- PLA blend with different proportions. They carried out tensile and flexural tests and from the results the following conclusions were attained that PLA is found out to be superior when Ultimate Tensile Strength (UTS) is the primary factor under consideration when compared to ABS. When tensile stress tests were conducted PLA seemed to show impressive results, and when a greater amount of PLA (80%) is added with minimum amount of ABS (20%), the mixture showed better results. The 50–50 mixture on the other hand has shown maximum flexural strength when matched to the other specimens. The outcomes from the flexural tests determined that the 50–50 composition of ABS-PLA materials used as alternate layers are possessing better strength than the distinct polymers.

P. Sukwisute, A. Sakulalavek⁸ in the research work intended to scrutinize the effects on the hardness and wear resistance by depositing a thin film of CrN (chromium nitride) on the substrates of acrylonitrile butadiene styrene (ABS). The coating processes were completed by a reactive DC magnetron sputtering technique. The range of the values of sputtering power were kept between 125-200 W. The total pressure (Pt), nitrogen partial pressure (PN₂), and sputtering time were kept constant at 4×10⁻³ mbar, 30%, and 120 min, correspondingly. Moreover, it was discovered that sputtering power has the impact on the crystal orientation, crystal size, hardness, young's modulus and wear resistance of the coatings. The hardness of the coatings varies from 6.65 to 9.58 GPa. Young's modulus of the coating varies from 30.87 to 44.25 GPa. The CrN coating deposited on the ABS substrate at 175 W shows the largest hardness which was 9.58 GPa which is nearly equivalent to steel. This leads to the highest wear resistance of the ABS surface.

IV. DESIGN AND BATTERY OPTIMIZATION TECHNIQUES

Power supply & energy management techniques, power source hybridization architecture with an optimal energy management system in order to optimize the battery consumption were enlightened by Mohamed Nadir, Boukoberinea, Zhibin Zhou¹ in their review publication on UAV energy management. In this review they explained about several techniques and strategies like power supply hybridization in which the power sources to the UAV might be provided by combining numerous sources such as fuel cell, battery, solar cells, and supercapacitor, etc. Furthermore, they proposed

a distinctive technique known as swapping which is applied to recharge the UAV's depleted batteries during an on-going mission. Hot swapping is a particular technique in which an exhausted battery is replaced by a completely charged one, keeping the UAV powered on. Further it can join its hotspot and be operative. Moreover, they discussed various strategies and practises to optimize battery consumption.

Yukai Chen²embraced about the battery consumption by taking into consideration different working conditions of a quadcopter since the utility of unmanned aerial vehicles(UAVs) or drones have increased in numerous application provinces, for instance monitoring, mapping, delivery, etc. This paper demonstrated a model describing non-linear characteristics of the battery which is one of the crucial aspects in order to estimate the real state-of-charge of the battery. He conducted a simulation for diverse delivery assignments at different distances, payloads and horizontal speed. The results were partially achieved for estimation of the real battery performance and overall flight time.

The research on the energy consumption of a brushless DC motor used in modern day drones and UAVs was conducted by M Ashari, Muhammad Rivai³ and Kadir Sabanci⁴in the research publications. Where M Ashari and Muhammad Rivai³ considered an additional factor which is energy consumption when used with drip irrigation apparatus equipped to a water pump drone. While Kadir Sabanci⁴ took into consideration the effect of varying loads of brushless DC motor on energy consumption while vertically taking-off, landing, hovering and horizontal movement of the drone as well as the speed range of motor. Furthermore, using a FEA (Finite Element Analysis) software two-dimensional modelling of the external rotor BLDC motor was performed. Simulation studies were conducted in which the DC battery voltage, pulse width, and speed range of the motor were changed with certain limits and 3000 data of the input power values were attained with the parametric solvent. AITs were determined by trial-and-error method. MAPE error values were determined for ANN, ELM, SVM as 0.389%, 1.258% and 0.269%, respectively. It was determined that a highly effective input power estimation could be obtained with the SVM model. Hence, by implementing the AIT method the power level of the batteries can be calculated using BLDC motor modelled with FEA software.

The power consumption of drones and UAVs according to their assorted flight patterns was done by Sunho Jee, Hyunchn Cho⁵ in their publication. Using simulation, they calculated the distinct values of power consumption of moving upward, downward, forward and hovering. By scrutinizing the results obtained in the simulation it can be attained that the power consumption of downward is lower than hovering and the power consumption of upward and forward are higher than hovering. The result shows that $P_{downward} < P_{hovering} < P_{forward} < P_{upward}$. It was also found that even if the altitude is different the power consumption for hovering is same for a drone or UAV because of its characteristics.

V. METHODOLOGY

Selection of Appropriate Material

- Using ABS or HDPE for Drone Body

Design of Structural and Aerodynamic elements

- Using CREO and Ansys cfx solver

Testing and Analysis of the Initial Design

- Using Matlab and Ansys linear dynamic solver

Searching for Optimal Communication System between Drone and RC

- Between Radio or GPS system

Manufacturing Prototype and Testing Control Systems

- Using low cost alternatives

Finalizing the Concept and lift off!

- Final manufacturing of the product using 3D printer

Final Implementation and Testing

- Testing the drone to its maximum capacity along with decided delivery load



VI. CONCLUSION

Hybridization of the UAVs was covered by Mohamed Nadir¹. They also provided ways of optimizing the batteries by combining different power sources and using new technologies for efficient recharging of batteries.

Market survey of small drones and real flight time calculations were done by Yukai Chen². They provided results of their optimized battery consumption model and showed 16% increase in efficiency of a quadcopter.

Use of Brushless DC motors for irrigation process was discussed by M Ashari³. They concluded that Brushless DC motors are more cost efficient and are able to work in rigorous environmental conditions. They also state the use of these motors in UAVs for delivery and military applications.

Kadir Sabanci⁴ conducted Finite Element Analysis of a Brushless DC motor powered UAV and how much it affects the battery consumption of the drone. Methods like Mean Absolute Percentage Errors (MAPE) of the Artificial Intelligence Techniques (AITs) were used for calculating the results.

Sunho Jee⁵ stated a certain flight pattern in their research which would help in forward flight of a VTOL UAV. This helps in logistics and transportation of heavy cargo and decreases the battery consumption during its flight.

HPDE is a great option for a scratch resistant material in high pressure, it was stated by Viacheslav Balobanov⁶. But there are some issues during the simulation and analysis of the material model.

We have reviewed several research papers and studies consisting of research, development, design methodology, fields of engineering related to VTOL and UAV technology.

REFERENCES

- [1] Mohamed Nadir Boukoberinea, Zhibin Zhou, Mohamed Benbouzida, c: aUniversity of Brest, UMR CNRS 60 IRDL, 29238 Brest, France, bSENYncr'ea Ouest, UMR CNRS 6027 IRDL, 29200 Brest, France, cShanghai Maritime University, 201306 Shanghai, China.
- [2] Yukai Chen Donkyu Baek Alberto Bocca Alberto Macii Enrico Macii Massimo Poncino: Department of Control and Computer Engineering, Politecnico di Torino, Torino, Italy.
- [3] Suwito, M Ashari, Muhammad Rivai, Muh. Anis Mus: Department of Electrical Engineering, Institute Teknologi Sepuluh Nopember, Surabaya, Indonesia.
- [4] Kadir Sabanci: Department of Electrical Electronics Engineering, Engineering Faculty, Karamanoglu Mehmetbey University, 70100 Karaman, Turkey.
- [5] Sunho Jee*, Hyunchan Cho*: School of Electrical, Electronics and Communication Engineering, KOREATECH.
- [6] Osama Jamal Al-zoghy, Osama Ibrahim Khalil, Abanoub Monir reda: October 6th University, Egypt
- [7] <https://www.sciencedirect.com/science/article/pii/S1270963821005459>
- [8] <http://www.diva-portal.org/smash/get/diva2:126844/FULLTEXT01.pdf>



Impact Factor:
7.569



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details