A review of selected control surfaces for aircraft performance improves

Mohammad Hossein Moghimi Esfandabadi[1], Kamyab Karbasishargh[1], sajedeh azizi goodarzi[1], Mohammad Hassan Djavareshkian[1*] and Ali esmaeili

[1] *Department of Mechanical Engineering, Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran*

*javareshkian@um.ac.ir

Abstract— Unmanned aerial vehicles (UAVs) offer benefits like increased efficiency, broader accessibility, and reduced costs compared to manned aircraft. However, they face challenges like flight stability and performance issues, especially at high angles of attack. This article reviews different wing control surfaces and modifications used on UAVs to improve flight characteristics. Specifically, it describes elevons, split drag rudders, spoiler slot deflectors, and all moving wing tips. These controls aim to enhance control authority, manoeuvrability, drag modulation, lift augmentation, and stability through means like asymmetric deflection and boundary layer control. The review indicates that while integrated controls like elevons simplify designs, discrete control systems also have advantages. Continued research and development of UAV control mechanisms will further improve their capabilities.

Keyword: UAV, Control surfaces, Wing, Performance, Stability

1. INTRODUCTION

Unmanned aircraft, or in other words, drones, are a type of aircraft that can fly without the need for human pilots. These drones or aircraft are capable of autonomous navigation and carrying out specific missions in the air by utilizing intelligent processors, sensors, and accessing GPS information and weather data [1]. Unmanned aircraft are considered a significant innovation in the aerospace and aviation industry from a technological standpoint. These technological marvels provide capabilities for guidance, data collection, mapping, enhancing security, and conducting scientific research in various fields [2]. One of the best advantages of unmanned aircraft is their high performance and accuracy. This allows them to efficiently and effectively carry out various tasks [3]. In addition, due to the lack of need for a pilot, the use of unmanned aircraft significantly reduces maintenance and operational costs [4]. Many companies and organizations are currently developing and using unmanned aerial vehicles, and the future of this technology seems very clear and promising in various fields. With the continued advancement of technology and the utilization of artificial intelligence and the Internet of Things, unmanned aerial vehicles can play a significant role in today's world and also in the future [1]. Some of the major applications of unmanned aircraft include:

1- Environmental protection: Unmanned aircraft can help in environmental monitoring and surveillance missions by detecting air and water pollution, identifying fires, observing natural changes, and identifying animals and plants in difficult areas.

2- Border security and military systems: These aircraft are used alongside soldiers and security forces for border control, intelligent detection of suspicious boats and aircraft, monitoring natural resources, and identifying restricted areas.

3- Smart agriculture: Unmanned aircraft have numerous applications in smart agriculture. By analysing aerial images and using intelligent algorithms, they can identify irrigation needs, types and quantities of nutrients in the soil, and propose optimal plans for efficient agricultural production.

With the advancement of aerodynamics, various methods are employed to improve the control performance of aircraft. In the early 1990s, the United States launched the Innovative Control Effectors Program, aimed at developing and researching control systems for unmanned aircraft. This program was divided into two phases. In this study, analytical and conceptual investigations were carried out on control effectors, including conventional ones such as flaps, ailerons, leading-edge flaps, and some other effectors like split drag rudder flaps and all moving wing tips were examined [5].

2. COMMONLY USED CONTROL SURFACES IN AIRCRAFT

In Elevons combine pitch (elevator) and roll (aileron) control functions through tail surfaces that deflect symmetrically or differentially [6,7]. This simplifies designs while retaining control. Split drag rudders consist of two independently deflecting rear rudder sections. By generating differential drag on each side, they provide precise yaw and auxiliary pitch control [8,9]. Spoiler slot deflectors feature deployable raised spoilers on wing surfaces with narrow gaps that reenergize boundary layer flows. This increases useable lift, stability near stall margins, and control [10,11]. All moving wing tips utilize dedicated actuators that enable adjusting each tip independently. By redistributing lift and drag or countering gusts, they enhance control authority, agility, efficiency, and gust response. While integrated controls like elevons offer weight and design benefits, discrete control systems have advantages as well. Furthermore, combinations of multiple control effectors can optimize overall flight performance.

CONCLUSION

In summary, UAV development continues to advance through innovations in wing and control surface designs. Challenges around flight dynamics, efficiency, and versatility persist, especially at high angles of attack. Ongoing research on mechanisms ranging from integrated elevons to differential split rudders and drag modulating spoiler slot deflectors aims to push performance boundaries further. UAV control system design involves navigating tradeoffs, but a multifaceted approach can potentially maximize benefits. Continued testing, analysis, and improvements to such technologies will enable superior unmanned aerial systems.

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