

الإستهلال

الآية

قال تعالى:

وَأَعِثُوا
لَهُمْ مَا اسْتَطَعْتُمْ مِنْ قُوَّةٍ
وَمِنْ رِبَاطِ الْخَيْلِ تُرْهِبُونَ بِهِ عَدُوَّ اللَّهِ
وَعَدُوَّكُمْ وَأَخْرِينَ مِنْ دُونِهِمْ لَا تَعْلَمُونَهُمُ
اللَّهُ يَعْلَمُهُمْ ۗ وَمَا تُنْفِقُوا مِنْ شَيْءٍ فِي سَبِيلِ اللَّهِ
يُؤْتِ الْيُتْمَ وَأَنْتُمْ لَا تُظْلَمُونَ .

صدق الله العظيم

سورة الأنفال (الآية ٦)

الإهداء

إلى حكمتي وعلمي إلى أدبي وحلمي
إلى من أرضعتني الحب والحنان
إلى من كان دعائها سر نجاحي
إلى كل من في الوجود بعد الله ورسوله أمي الغالية ..

إلى من أحمل اسمه بكل فخر
إلى من سعى وشقى لأنعم بالراحة والهناء
إلى الذي علمني أن أرتقي سلم الحياة بحكمة وصبر
إلى القلب الكبير والدي العزيز

إلى من تذوقت معهم أجمل اللحظات
إلى من سرنا سوياً ونحن نشق الطريق معاً نحو النجاح والإبداع
طلاب الدفعة 13 هندسة الطيران

إلى من مدونا بنور العلم وكلمات من درر
إلى من صاغوا لنا علمهم حروفاً
ومن فكرهم منارة تنير لنا مسيرة العلم والنجاح إلى اساتذتنا ومشرفيننا .

الشكر والعرفان

الحمد والشكر لله رب العالمين حمداً وشكراً يليق
بجلال وجهه وعظيم سلطانه الذي وفقنا لهذا العمل

الشكر الجزيل لمشرفينا الذين لم ييخلوا علينا بوقتهم وجهدهم
وعلمهم .

الدكتور/ طارق حسن السني (اكاديمية الخرطوم للطيران)
الاستاذة / رانيا محمد قرشي (جامعة السودان كلية الهندسة)

شكر خاص لمن الهمنا هذا المشروع وساندنا بعلمه ووقته
الاستاذ: عبد الماجد ادريس/ قسم هندسة الطيران

الشكر ايضا الي قاعدة الشهيد عثمان دقنة الجوية (بورتسودان)
متمثلة في :

العقيد ركن طيار / زيدان خلف حسون
ملازم طيار / مجاهد الامام الحجانا موسى

الشكر لكل من ساعدنا لإنجاز هذا العمل من الاساتذة
والزملاء بقسم هندسة الطيران ...
الشكر لقسم هندسة الطيران بجامعة السودان للعلوم
والتكنولوجيا متمثلاً في:

الدكتور: صخر بابكر ابودرق

المستخلص:

يهدف هذا المشروع إلى تصميم طائرة تدريب عسكرية، وتحليل الدينامية الهوائية لها ودراسة استقراريتها، وتحديد صفات الأداء لضمان أن النموذج المصمم يلبي المتطلبات.

بدأت عملية التصميم مع التقدير الأولي للوزن وحساب معايير الأداء، وتحميل الجناح و نسبة الدفع إلى الوزن. وفقا لذلك تم اختيار مقاطع الجنيحات والتكوين الهيكلي للطائرة وتم رسمهم ببرامج الأوتوكاد والكاتيا. وقد تم اختيار برنامج الداتكوم الرقمي لايجاد بيانات الدينامية الهوائية للطائرة ومشتقات الاستقرار.

اظهرت نتائج تحليل الدينامية الهوائية والاستقرارية والأداء ان الطائره التي تم تصميمها مستقرة ولديها قدرات أداء مقبولة.

Abstract:

This project is aimed to design a military training aircraft, and perform aerodynamic and stability analysis. On other hand, the performance qualities are determined to ensure that the designed model satisfies the requirements.

The design process began with first weight estimation and calculation of performance parameters, wing loading and thrust to weight ratio; accordingly the airfoils sections and airplane geometrical configuration were selected and drawn by AutoCAD and CATIA programs. Digital DATCOM program was chosen to find aerodynamic data and stability derivatives.

Results of aerodynamic, stability and performance analyses show that the designed aircraft is stable with acceptable performance capabilities.

Table of Contents

الاستهلال	II
Dedication	III
Acknowledgement	IV
المستخلص	V
Abstract	VI
Table of Contents	VII
List of Tables	XI
List of Figures	XII
List of Symbols	XV
Abbreviations.....	XVIII

Chapter One: Introduction and Literature Review

1.1 Introduction	2
1.2 Motivation	3
1.3 Objectives	3
1.4 Methodology	3
1.4.2 Analytical Method	3
1.4.2 Applied and Computational Methods.....	4
1.5 Gantt Chart	4
1.6 Thesis Outline	5
1.7 Literature Review	5
1.7.1 Training Phases	5
1.7.2 Historical Background for Similar Design	7
1.7.3 Similar Approaches.....	11

Chapter Two: Conceptual Design Procedure

2.1 Mission Specification	15
2.1.1 Mission Requirements.....	15
2.1.2 Mission Profile	15
2.2 Weight Estimation	16
2.2.1 Fuel Weight Estimate	17
2.2.2 Empty Weight Estimate	17
2.3 Wing Loading	18
2.3.1 Stall Speed Wing Loading	19

2.3.2 Takeoff Wing Loading	19
2.3.3 Landing Wing Loading	20
2.3.4 Cruise Range Wing Loading.....	20
2.3.5 Loiter Endurance Wing Loading	20
2.4 Thrust To Weight Ratio	21
2.5 Geometry Configuration And Layout	21
2.5.1 Airfoil Selection	21
2.5.2 Wing Configuration	22
2.5.3 Tail Configuration	23
2.5.4 Fuselage Sizing	24
2.6 V– N Diagram	25
2.6.1 V – N Diagram without Gust Effect	26
2.6.2 Gust V – N Diagram	27
2.6.3 Combined V – N Diagram	28
2.7 Weight of Components	28
2.7.1 Structures Group	29
2.7.2 Propulsion Group.....	29
2.7.3 Equipment Group.....	29
2.7.4 Wing Weight.....	30
2.7.5 Horizontal Tail Weight.....	30
2.7.6 Vertical Tail Weight.....	30
2.7.7 Fuselage Weight.....	30
2.7.8 Main Landing Gear Weight.....	30
2.7.9 Nose Landing Gear Weight.....	31
2.7.10 Engine Section Weight.....	31
2.7.11 Instrument Weight.....	31
2.8 Center Of Gravity.....	31

Chapter Three: Performance and Stability Analysis

3.1 Performance Analysis.....	34
3.1.1 Aerodynamic and Geometric Data	34
3.1.2 Thrust at Steady Level Flight	34
3.1.3 Velocity at Steady Level Flight	35
3.1.4 Thrust To Weight Ratio In Level Flight	35
3.1.5 Velocity at Minimum Thrust Required	35

3.1.6 Maximum Velocity	35
3.1.7 Range	36
3.1.8 Endurance	36
3.1.9 Rate of Climb	36
3.1.10 Level Turn Flight	37
3.2 Stability Analysis	38
3.2.1 Longitudinal Stability.....	38
3.2.2 Lateral Stability.....	38
3.2.3 Directional Stability.....	39

Chapter Four: Results and Discussion

4.1 Result and Discussion	42
4.1.1 Wight Estimation	42
4.1.2 Wing Loading.....	43
4.1.3 Thrust to Weight Ratio.....	44
4.1.4 Geometry Configuration and Layout.....	44
4.1.5 V-N Diagram	48
4.1.6 Weight of Components	51
4.1.7 Center Of Gravity	52
4.2 Aerodynamics.....	53
4.2.1 Lift	53
4.2.2 Drag	55
4.3 Performance	56
4.3.1 Thrust Required.....	56
4.3.2 Maximum Velocity.....	57
4.3.3 The Power Required.....	58
4.3.4 Rate of Climb.....	59
4.3.5 Range.....	59
4.3.6 Endurance.....	59
4.3.7 Minimum Turn Radius.....	60
4.3.8 Maximum Turn Radius.....	60
4.3.9 Landing Distance.....	60
4.4 Stability	61
4.4.1 Longitudinal Static Stability	61
4.4.2 Directional Static Stability	62
4.5 Model Fabrication.....	62

Chapter Five: Conclusion and Recommendations	
5.1 Conclusion	67
5.2 Recommendations	67
References	69
Appendices	71
Appendix A: DATCOM Input file.....	72
Appendix B: DATCOM Output Excel Sheet.....	75

List of Tables

Table (2-1): Mission Requirements	15
Table (2-2): Mission Profile Segments	42
Table (4-1): Fuel Weight	43
Table (4-2): Total Takeoff Gross Weight	43
Table (4-3): Wing Loading	44
Table (4-4): Wing/Tail Parameters	38
Table (4-5): Fuselage Parameters	47
Table (4-6): Parameter of V-N Maneuver Diagram.....	48
Table (4-7): Parameter of V-N Gust Diagram	49
Table (4-8): Max. And Min. Combined Load Factor.....	51
Table (4-9): Weight of Components	51
Table (4-10): Center Of Gravity	52
Table (4-11): Thrust Required	53
Table (4-12): DATCOM Results.....	61

List of Figures

Figure (1-1): Project Gantt chart	5
Figure (1-2): Top, Front and Side View For K-8 Military Trainer Aircraft.....	9
Figure (1-3): Top, Front and Side View for L-39 Military Trainer Aircraft.....	10
Figure (1-4): Top, Front And Side View For MB-339 Military Trainer Aircraft	11
Figure (2-1): Mission Profile	15
Figure (2-2): Takeoff Distance Estimation	19
Figure (2-3): NACA 64A-114 Airfoil Geometry	22
Figure (2-4): NACA 64A-114 Airfoil Geometry.....	22
Figure (2-5): Fuselage Dimension Historical Data.....	24
Figure (2-6): Fuselage Body Dimention.....	25
Figure (2-7): V-N Diagram without Gust Effect	26
Figure (2-8): The Geometry of an Upward Gust.....	27
Figure (2-9): A Typical Gust V-N Diagram	27
Figure (2-10): A Typical Combined V-N Diagram for an Aircraft	28
Figure (3-1): Airplane in Level Turn.....	37
Figure (4-1): (a) Wing by Using CATIA, (b) Wing By Using AutoCAD...45	
Figure (4-2): (a) Horizontal Tail by Using CATIA, (b) Horizontal Tail by Using AutoCAD	46

Figure (4-3): (a) Vertical Tail by Using CATIA, (b) Vertical Tail by Using AutoCAD	46
Figure (4-4): (a) Fuselage by Using CATIA, (b) Fuselage by Using AutoCAD.....	47
Figure (4-5): Full Layout of the Proposed Aircraft.....	48
Figure (4-6): Maneuver V-N Diagram.....	49
Figure (4-7): Gust V-N Diagram	50
Figure (4-8): Combined V-N Diagram.....	50
Figure (4-9): Lift Coefficient Due To Angle Of Attack	53
Figure (4-10): Lift Change Due To Ground Effect.....	54
Figure (4-11): Basic Drag Coefficient.....	55
Figure (4-12): Drag Due To Ground Effect.....	56
Figure (4-13): Thrust Required Diagram.....	57
Figure (4-14): Thrust Required and Thrust Available Diagram.....	58
Figure (4-15): Power Required Diagram	58
Figure (4-16): Rate of Climb	59
Figure (4-17): Minimum Turn Radius	60
Figure (4-18): Minimum Turn Radius	61
Figure (4-19): Fuselage, Wing, Horizontal and Vertical Tail Cross Section.....	63

Figure (4-20): Wing, Horizontal and Vertical Section From Foam without
Cover63

Figure (4-21): All Section of Model with Foam without Cover.....64

Figure (4-22): Front, Top, Side and Hind View of Model with Foam and
without Cover.....64

Figure (4-23): Full Model with Foam Sticker Cover.....65

Figure (4-24): The Front, Side and Top View Of Model with Sticker.....65

List of symbols:

AR	Aspect Ratio
a	Speed of Sound
B_H	Horizontal Tail Span
b_w	Wing Span
C	Specific Fuel Consumption
\bar{C}	Mean Aerodynamic Chord
C_{HT}	Horizontal Tail Volume Coefficient
C_{VT}	Vertical Tail Volume Coefficient
C_{root}	Root Chord
C_{tip}	Tip Chord
CD_o	Zero Lift Drag
Cd	Drag Coefficient
CL_{max}	Maximum Lift Coefficient
Cl	Lift Coefficient
D_f	Fuselage Diameter
E	Endurance
e	Span Efficiency
F_W	Fuselage Width at Horizontal Tail Intersection
g	Gravity
H_T	Horizontal Tail Height above Fuselage
H_V	Vertical Tail Height above Fuselage

K_G	Coefficient of Load Factor
K_{vs}	Variable Sweep Content
L_*	Moment Arm
L_f	Fuselage Length
L_{rear}	Rear Fuselage Length
$L_{cockpit}$	Cockpit Length
$\frac{L}{D}$	Lift To Drag Ratio
M_{max}	Maximum Mach number
m	Mass
M_G	Aircraft Mass Ratio
n	Load Factor
N_Z	Ultimate Load Factor
N_L	Ultimate Landing Load Factor
N_{En}	Number of Engine
P_R	Power Required
P_A	Power Available
q	Dynamic Pressure
R	Range
R_{min}	Minimum Turn Radius
$\frac{R}{c}$	Rate of Climb
S_w	Wing Area
S_{HT}	Horizontal Tail Area

S_{VT}	Vertical Tail Area
$S_{landing}$	Landing Distance
T_R	Thrust Required
T_A	Thrust Available
$\frac{T}{W}$	Thrust To Weight Ratio
$\frac{T}{W}$	Thrust To Weight Ratio
V	Cruse Speed
V_{stall}	Stall Speed
$V_{approach}$	Approach Speed
V_{Si}	Stall Speed For Negative Load Factor
V_{Ge}	Gust Equivalent Speed
V_E	Aircraft Equivalent Speed
V_{max}	Maximum Velocity
V_{TRmin}	Velocity at Minimum Thrust Require
W_o	Maximum Takeoff Weight
W_{crew}	Crew Weight
W_e	Empty Weight
W_f	Fuel Weight
$\frac{W}{S}$	Wing Loading
W_{Wing}	Wing Weight
W_{Dg}	Design Gross Weight

$W_{H.T}$	Horizontal Tail Weight
$W_{V.T}$	Vertical Tail Weight
W_{Fuse}	Weight of Fuselage
$W_{Main L.G}$	Weight of Main Landing Gear
W_L	Landing Design Gross Weight
$W_{Nose L.G}$	Weight of Nose Landing Gear
$W_{Eng.Section}$	Weight of Engine Section
W_{Inst}	Weight of Instrument
\bar{Y}	Distance Location of Mean Aerodynamic Chord
σ	Density ratio
ρ	Air Density
Λ	Sweep Angle
θ_{rear}	Rear Fuselage Angle
$\theta_{cockpit}$	Cockpit Angle
γ	Climb Angle
Λ	Wing Sweep At 25% Mac

Abbreviations:

CFD	Computational Fluid Dynamic
CG	Center of Gravity
TOP	Takeoff Parameter