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Analytical study on the aero dynamical characteristics of a missile at supersonic speed

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Abstract
This article is about the Analytical study of the aerodynamic-shape modeling of missiles at a supersonic speed. This study has been performed to observe the optical aerodynamic module for the missile Co-Related with the optimization Method to create an optimal design. The optimization technique used in this study is the Taguchi design optimization method and it's far supported or demonstrated with the Fit regression approach via generating a regression equation to the problem. The aerodynamic character of diverse sections of the missile such as the forebody radius, the length and the location of the Canards, and the length of the Stabilizer of the air-air model missile at Supersonic Speed (Mach speed of 1.5). This simulation observed the Drag Force, Pressure, and velocity created by the missiles. The DFA is used to convert into a single response system. The optimal design for the Missile consists of 'the radius of the Nose is 0.36m the duration of Front wing or the Canards is 0. 4 m when it places at a distance of 0.2m from the nostril tip and the length Stabilizer wing is 0.5 at this design the missile produces a low amount of drag at the Supersonic Flow').

Keywords: Computational fluid dynamics, missile, fit regression method, taguchi optimization method, desirability function analysis

1. Introduction

The missile is a weapon that is self-propelled or directed by way of remote, manipulate, traditional or nuclear explosive. The incorporation of a strong supply in missiles to provide the desired force for its motion (propulsion), intelligence to go in the appropriate direction (steerage), and effective maneuvering (manipulate) is mainly the technologies of guided missiles. In modern-day, armed force (Such as: Ships, Submarines, Fighting Jets) usage a missile (or) guided missile which is a self–propellant and guided weapon machine, in place of unguided self-propelled munitions, referred to as just a rocket. Missiles have 4 machine additives which concentrated on: guidance, flight machine, engine, and warhead. Missiles are available in different kinds and easily adapted for different functions such as: Surface to Surface Missile and Air-to-Surface missiles (ballistic, cruise, anti-ship, anti-tank, and so forth.), Surface-to-air missiles (anti-aircraft and anti-ballistic), air-to-air missiles, and anti-satellite missiles. The optimization method calls for many iterations which makes computationally high-priced CFD models unappealing to be used in such calculations. A speedy and reliable approach inclusive of the build-up additives method is used to expect overall performance for supersonic missiles quickly and reliably [1, 2, 3]. Keshavarz [4] presented formulations for one-of-a-kind multidisciplinary design optimization (MDO) and MDO formulations are implemented to a sounding missile for you to optimize the overall performance. Three disciplines have been taken into consideration, trajectory, propulsion, and aerodynamics. Sooy and Schmidt [5] presented an observation at aerodynamic predictions, comparisons, and validations of the use of Missile Datcom (97) and aero prediction ninety-eight (AP98) numerical prediction codes. They evaluated the accuracy of every code as compared to experimental wind tunnel observation for an expansion of missile configurations and flight situations. The missile configurations included an axisymmetric body, frame wing tail, and body tail. The consequences of this paper had been used to validate the aerodynamic model used in these observations. The objective of the contemporary paper is to present a fast and dependable method for obtaining supersonic missile aerodynamics by using this approach for locating the most useful supersonic missile form based totally on first-rate performance (i.e., Maximum elevate-over-drag)

Monte Carlo optimization [6, 7] have been used on their parameters for their many appealing features which include robustness, worldwide optimization, and simplicity of implementation. To gain high-quality maneuvering functionality of a larger flight envelope, present-day air-to-air flight condition is turning into increasingly more complex than ever. The big assault attitude and the aero-floor deflection cause severe unsteady flows and nonlinear interference [9]. Therefore, several volumes of aerodynamic records should be provided in the flight manipulation device design, the analysis of flight dynamics, and simulation. Taking the missile as an instance, its aerodynamic pressure is tormented by the multivariate flight dynamic parameters which include the attitude angles, its flight Mach variety, altitude, and actuator reflections [10]. This shall be the established order of an excessive-dimensional aerodynamic database, which satisfies the demands of control machine design and assessment [11] by using wind tunnel (WT) [12] and computational fluid dynamics (CFD) [13], both being costly and time-consuming for missiles [14, 15]. Motivated through keeping off this project, the proper method is to establish aerodynamic models the usage of a positive amount of WT assessments or the use of the CFD software program. Then, the hooked-up fashions are implemented online to predict the aerodynamic force feature of the missile at any flight time. Therefore, the problem of organizing the aerodynamic version for missiles has obtained sizeable interest. Although some methodologies are available for the mathematical modelling of aerodynamics, maximum of them had been advanced primarily based on the linearized aerodynamic force coefficients [16, 17] (or their time derivatives).

1.1 Classification of Missiles

The classification of the missile has a wide range of divisions depending upon their model of launch mode, speed, range, type of propellant, and warheads.

The classifications are as follows:

- Based on the Launch of the type the missiles are classified as Surface-to-surface missiles, surface-to-air missiles, surface-to-sea missiles, air-to-air missiles, air-to-surface missiles, and Sea-to-Sea missiles, Sea-to-Surface (coast) Missile, Anti-Tank Missile.
- Based on the range of the missiles are classified into short-range (1000Km or less), medium-range (1000 and 3000km) intermediate-range ballistic missiles (3000-5500km), and intercontinental Ballistic missiles (above 5500km).
- Based on the propulsion system the missile range is classified into Sloid propelled missile, Liquid propelled missile, hybrid propelled missile, Ramjet model, scramjet, and cryogenic propelled missile.
- On the bases of the warhead, a missile is classified as a Conventional warhead missile or a Strategic warhead missile.
- Based on the guidance system the missiles are classified into Wire Guidance, Command Guidance, Terrain Comparison Guidance, Terrestrial Guidance, Inertial Guidance, Beam Rider Guidance, Laser Guidance, Rf, and GPS Reference.

The generally the missile and the rocket consist of the similar design parameters such as the fore body, Mid-section, and the Boattail. The basics design charterstics of the missile define the optimal result.

1.2 Aerodynamics Characteristic of a missile

The missile flows through the air. So, the particles present in the air produces certain amount resistance force to the missile structure. This paper studies aerodynamic forces and moments of the missile which is travelled at supersonic speed. These forces elevate and drag can be categorized into standard types:

- Those due to air friction
- Due to pressure

1.2.1 Fore body

The supersonic aerodynamics of a forebody could be mentioned by way of passing the supersonic drift. The numerous forebody design is given with the aid of conical, hemispherical, and parabolic forebody. For this Study the general aerodynamic body design such as the conical Design for our missile.

1.2.2 Mid-Section

In maximum missile configurations, the mid-segment is cylindrical. This shape is high-quality from the viewpoint of drag, ease of manufacturing, and cargo-wearing functionality. The 0-carry drag ($\alpha=0°$) of a cylindrical frame is resulting from the viscous forces most effective (skin friction). At low angles of assault, a completely small quantity of regular force is developed at the frame, and these outcomes from the "bring-over" from the nostril phase. As an alternative massive angle, some quantity of everyday pressure is evolved because the move-waft drag acts regularly on the body centreline.

1.2.3 Boattail

The tapered portion of the aft segment of the frame is called the boattail. The cause of the boattail is to decrease the drag of a body that has a "squared-off" base. The latter function has a relatively to the big base strain and, therefore, excessive drag values produce due to the big base area. By "boat tailing" the rear portion of the body, the bottom vicinity is reduced, and hence a lower base drag is found. However, the decrease in base drag may be in part nullified by using the boattail drag.

1.2.4 Base Pressure

At supersonic velocities, the base of the body stories a big bad pressure (relative to ambient or loose-movement static strain) resulting in a substantial boom in missile drag. An accurate dedication of this base-strain coefficient is likewise quite worrying since it depends on many parameters, which include boattail angle Mach number, and boattail duration.

2. Design Modelling and Methodology

This goal of the paper is to show the drag pressure on the missile and the way the aerodynamics are tormented in the supersonic flow. The design characteristics of numerous sections of the missile such as the forebody radius, the location of the Front wing, and the Stabilizer, for the air-air version missile at Supersonic Speed. To study the overall performance, we want to present the most desirable shape to a missile design that we try may try to reduce drag pressure and provide a streamlined structure & flow. For the choice of the most excellent Desirable Design, we considered the Taguchi design optimization process for the Creation of the decision matrix and then the observe the parameters such as the Drag, Pressure, Velocity, Temperature and the Acoustic power produced During the Experimentation or the Simulation since the observed is an multi response Criteria for creating a unique response we had used the Desirability Function Analysis. For the DFA the weighted of the individual responses are required from the Entropy method we can able to find out the individual responses for the simulation.

2.1 Aerodynamic Modeling

The universal missile aerodynamic loads are calculated by summing up the aerodynamic traits of the most important components separately (e.g., frame, wing, tail, and so forth…) which includes additives interference factors. The missile's configuration here is composed of an axisymmetric forebody, a cylindrical after body, and two units of in-line cruciform fins. This method is valid for the Mach-wide variety ($1.5 < M \leq 6$).

2.1.1 Normal Force Predication

Missile's body can be divided into 3 fundamental components: the forebody (or nostril), the mid-phase, and the aft (or boattail). There are many forebody shapes, but the conical, ogival, and strength series (or hemispherical) shapes are the maximum normally used. They are selected on the idea of blended aerodynamic, guidance, and structural issues. From the go-glide idea formulated by Allen and Perkins, an accurate prediction of the everyday force coefficient of the body is:

$$C_d = 2\alpha + \frac{4C\lambda_{cyl}}{\pi}\alpha^2 \quad --- (1)$$

Where: α is the perspective of attack, λcyl is described as the cylinder fineness ratio (λcyl = L cyl d, missile's cylinder length over missile's diameter, Fig. 1) and C steadily relies upon on the go with-the-flow kind, i.e.

$$c\begin{cases} 1.2 & laminar\ flow \\ 0.3 - 0.4 & Turbulent\ flow \end{cases}$$

Missile floor systems include wing, tail, and canard surfaces. These can be constant or movable (i.e., control surfaces). The floor normal force coefficient is a feature of Mach quantity, the local altitude of attack, aspect ratio, and the floor platform place. CN, which is primarily based at the missile reference area, decreases with increasing supersonic Mach wide variety and will increase with altitude of attack and the wing floor location. The ordinary pressure coefficient spins off for rectangular platform wing finite span with no sweep.

$$C_{N\alpha} = -\frac{4}{\sqrt{M^2-1}}X\left[1 - \frac{1}{2AR\sqrt{M^2-1}}\left(1 - \frac{\gamma M^4 + (M^2-2)^2}{2(M^3-2)^{3/2}}A^{|}\right)\right] \quad --- (2)$$

Where,
M is the Mach range, AR is the thing ratio for the wing or tail and $A^{|}$ is related to thickness to chord ratio (t/c) the missile's general everyday force coefficient after including up all of the additives is:

$$C_N = C_{Nb} + C_{Nw\alpha}(K_w + K_b)_w K_1 \alpha A_w + C_{Nw\alpha}[(K_w + K_b)_t \alpha + (K_w + K_b)_m \sigma]K_2\left(1 - \frac{d\epsilon}{d\alpha}\right)At \quad --- (3)$$

Where,
σ is the tail deflection perspective. $(K_w+K_b)_w$, $(K_w+K_b)_t$, K_2, and k_m are correction elements. K1 is consistently. Aw or (At) are described as the ratio of the wing or (tail) region to the missile's pass phase area. D dε α is the exchange of downwash perspective. The subscripts w and t stand for wing and tail, respectively.

2.1.2 Drag Force Predication

The drag on the missile can be divided into numerous fundamental additives, they are: wave drag because of the presence of shock waves and dependent on the Mach number, viscous drag because of friction, caused drag because of the technology of carrying, base drag due to the wake in the back of the missile, interference drag due to the interaction of diverse waft fields and subsequently roughness drags because of floor roughness. For the conical forebody the wave drag coefficient.

$$C_{Dwc} = \left(0.083 + \frac{0.096}{M^2}\right)5.73\theta^{1.96} \quad --- (4)$$

Where: θ is the half cone angle in radian for parabolic fore body and bodies of close shape the wave drag coefficient

$$C_{Dwp} = C_{Dwc}\frac{0.08(15.5 + M)}{(3 + M)} \quad --- (5)$$

This equation is valid for 1.5 6 ≤ M ≤ and 2.5 λnose ≥, Where λnose nose = L d is called nose fineness ratio The wave drags coefficient of an isolated, rectangular wing or tails of the finite span is

$$C_{Dw} = \frac{K_1(t/c)^2}{\sqrt{M^2-1}}\left[1 - \frac{1}{2AR\sqrt{M^2-1}}\right] \quad --- (6)$$

Where: t c is the thickness to chord ratio and K1 is a constant depending on the type of air foil and the viscous drag coefficient is the main component at supersonic speeds,

$$C_{Df} = \begin{cases} \dfrac{1.328}{\sqrt{R}} & R < 10^6 \\ \dfrac{0.427}{(\log_{10} R - 0.407)^{2.64}} & R > 10^6 \end{cases} \quad ----(7)$$

Where: R is the Reynolds range based totally on the wetted area and the duration of the missile. For massive missiles, turbulent go with the flow may be assumed. The triggered drag coefficient is due to the era of elevate i.e., Depending on the altitude of assault and is approximated via.

$$C_{Df} \stackrel{\text{def}}{=} C_n \propto - - - - - (8)$$

Base drag is a characteristic of both the missile flight circumstance and geometry (i.e., the shape of the missile). The parameters affecting base drag are Reynolds wide variety, Mach number, angle of assault, body's (missile's overall period) fineness ratio (L/d), proximity, and the presence of boat tail or flare. Reynolds variety, angle of assault, body fineness ratio, and fin proximity are regularly omitted due to the fact they may be negligible. And, it is well known the contribution of the base drag to the total drag could be very small. Thus, the base drag coefficient is

$$C_{Db} = 0.3129 e^{-0.38745M} - - - - - (9)$$

Interference drag is experimentally found to be 5% of the total drag force coefficient

$$C_{D\,interference} = 0.05 C_D - - - - - (10)$$

The total drags force coefficient with interference from

$$C_D = 1.05[C_{Dbw} + 4(C_{Dw})_{wing} Aw + 4(C_{Dw})_{tail} At + C_{Df} + C_{Di} - - - - - (11)$$

The version additionally accounts for corrections and interference factors along with fin body interference, correction for taper ratio, correction for boundary layer effect, correction for the not remote wing, the impact of go with the flow stagnation, wing tail interference (correction for stagnation), and correction for downwash and interference elements for a tail movable place.

2.2 Taguchi Design Optimization method

The Taguchi method includes lowering the adjustments in a course through a robust design of experiments. The typical nature of the method is to achieve a maximum exceptional product at a low cost to the producer. The Taguchi approach is introduced by Dr. Genichi Taguchi of Japan who conserved the variation. Taguchi developed a technique for designing experiments to research how extraordinary parameters will fluctuate suggest and variance of a method performance function that describes how nicely the technique is operating. The experimental layout suggested via Taguchi entails the use of orthogonal arrays to prepare the parameters affecting the manner and the degrees at which they have to be varied. Instead of getting to test all possible combos like the factorial layout, the Taguchi technique checks pairs of combos. This allows for the gathering of the necessary facts to decide which elements most affect product quality with a minimum amount of experimentation, hence saving time and sources. The Taguchi approach is high-quality used whilst there may be an intermediate wide variety of variables (3 to 50), few interactions between variables, and while only some variables make contributions extensively. Genichi Taguchi used a loss characteristic: it is a distinction among experimental values and goal values that is again transformed into the S/N ratio which is defined as the ratio of mean to conventional deviation. Taguchi used the time sign and noise which represent desired values of the response, Taguchi has divided the S/N ratio into specifically the medium-the-excellent, lower-the-quality, and higher-the-best. In this experiment, the characteristic which is the drag force the lower the fine to beautify the efficiency of the automobile speed. The following equation was used to calculate the S/N ratio which had been acquired below Table3 the Taguchi evaluation is achieved via the usage of the Minitab Software device and the suggested plot, mean of S/N ratio plots to gain the nice result Signal to noise ratio

In this experiment, we considered 4 factors and the 3 levels of variation the table is as follows.

Table 1: The Factor and their Level Considered for the Design of the Decision Matrix for the Simulation.

Levels	Rn (m)	FWL1 (m)	RWL (m)	FWP (m)
Level- 1	0.12	0.02	0.04	0.01
Level- 2	0.24	0.03	0.05	0.15
Level- 3	0.36	0.04	0.06	0.20

2.3 Formulation of Decision Matrix for the Study

Based on the Decision Matrix we had used the Minitab to create a DOE method. The formulation of the decision matrix is used to obtain the optimal solution for the considered design. In this study, we considered observing the optimal aerodynamic characteristics of various sections of the missile as the forebody radius, the position of the Front wing, and the length of the Stabilizer, for the air-air model missile at Supersonic Speed.

Table 2: The Decision Matrix which is obtained for performing the Simulation and Observe the charters tics of the Missile at a Mach Speed of 1.5

S/No	Rn (m)	FWL (m)	FWP (m)	RWL (m)
1	0.12	0.02	0.01	0.04
2	0.12	0.03	0.015	0.05
3	0.12	0.04	0.02	0.06
4	0.24	0.02	0.015	0.06
5	0.24	0.03	0.02	0.04
6	0.24	0.04	0.01	0.05
7	0.36	0.02	0.02	0.05
8	0.36	0.03	0.01	0.06
9	0.36	0.04	0.015	0.04

2.4 Optimization method used for Observing and validating the Result

2.4.1 Entropy Method

The Entropy method is used to determine the Weight of factors when the data of the decision matrix is known it was proposed by C.E. SHAMNON in 1948. It was an Objective type of weighting method. The Entropy method consists of 4 steps as follows.

Step 1: Determine the Decision matrix with factor values

Step 2: In this step, the normalization of the matrix will be performed by the formula

$$Pij = \mathbf{Xij} / \sum_{i=0}^{m} \mathbf{Xij} ----(12)$$

Step 3: Computation of the Entropy measure of project outcome using the following Equation

$$Ej = -\mathbf{K} \sum_{i=1}^{m} \mathbf{Pij} * \mathbf{Ln}(\mathbf{Pij}) ----(13)$$

Where the Value of the K is 1/Ln (M)

Step 4: Determination of the Weights with the following Equation.

$$Wj = \mathbf{1} - \mathbf{Ej} / \sum_{j=1}^{n} (\mathbf{1} - \mathbf{Ej}) ----- (14)$$

2.4.2 Desirability Function Analysis Process

The DFA was introduced by Harringfor in 1965, the DFA is used for the simultaneous DE optimization of Multiple Responses. The objective technique is to normalize the value index into a common scale of [0, 1] for any variation, with help of a geometric mean-optimize the overall metric. Transformation of each estimated response into unit less utility.

Steps involved in the Process

Step 1: Calculation of the Desirability Index

For the larger the best value:

$$d_i = \frac{y_j - y_{min}}{y_{max} - y_{min}} --- (15)$$

For the smaller the best value:

$$d_i = \frac{y_j - y_{max}}{y_{min} - y_{max}} --- (16)$$

Step 2: Compute the Composite desirable individual by using the formula:

$$d_G = \sqrt[w]{d_1^{\,w} + d_2^{\,w} + d_3^{\,w} + d_4^{\,w} \ldots\ldots + d_n^{\,w}} --- (17)$$

Step 3: Determine the optimal level for the combination by using the Taguchi method by plotting the means and signal-to-noise ratio Graph.

Step 4: Determine the Optimal design for the Decision matrix through the Minitab Taguchi DOE method.

2.5 Design Parameters and Simulation Process

The Design is a general design that is considered as follows

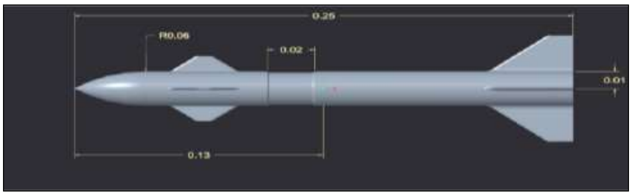

Fig 1: The Design of the missile Considered for the paper aerodynamic analysis on missile design Published in the Journal October 2020 edition of IJSDR Volume 5 Issue 10

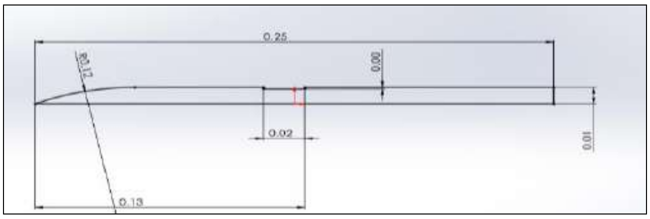

Fig 2: The 2d-sketch of the body of the missile design in solidworks-2021 software

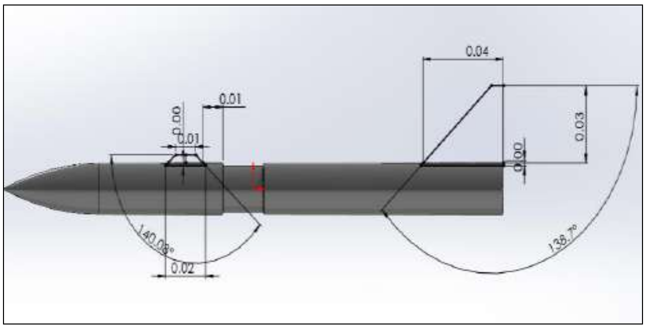

Fig 3: The 2d-sketch of the wing of the missile design in solidworks-2021 software

Figure 1a represents the 3D model considered and is utilized for simulation purposes. It is a general design of a missile and the dimensions can be observed in the figure. Figure 2 represents the 2D sketch of the missile body excluding the fins of the missile. Figure 3 represents the 2D sketch of the front fins and the back fins of the missile.

For the Simulation the values are considered as follows:

- Total cells: 159042.
- Fluid cells: 159042.
- Fluid cells contacting solids 5995.

The Domine boundary is created as follows

Positive X-axis: 1.5 M, Negative X-axis: -0.25 m, Positive Y-axis: 0.2 M, Negative Y-axis: -0.2 M, Positive Z-axis: 0.2 M, Negative Z-axis: -0.2 m, All the walls of the missile bodies are considered to be the Real walls, the design and the simulation of the Missile are performed in the Solid works Software.

3. Result

The Simulation for each model in the Decision matrix has been performed for the observation the result of the Simulation is as follows

Table 3: The Simulation result observed for the result of the decision matrix

Eno.	Drag	Pressure (Pa)		Temperature (K)		Velocity (m/s)		Acoustic		Viscosity	
	Force (N)	Min	Max	Min	Max	Min	Max	Power (W/m^3)	Power Level (dB)	Dynamic (Pa*s)	Turbulent (Pa*s)
1	39.1442	38875	259573	282.57	430.4	0	547.6	1.28E+06	181.071	2.42E-05	0.033145
2	34.3074	55065	230010	264.8	422.7	0	567.8	1.28E+06	181.084	2.39E-05	0.037255
3	30.039	51823	197736	263.61	423.8	0	569.5	3.92E+06	185.934	2.39E-05	0.036564
4	31.3713	50285	207019	258.91	423.7	0	577.7	2.34E+06	183.683	2.39E-05	0.036136
5	29.5247	50572	197456	259.95	423.7	0	576.1	4.11E+06	186.14	2.39E-05	0.036938
6	32.7808	51984	209076	263.02	422.7	0	570.5	2.51E+06	183.998	2.39E-05	0.037098
7	29.10766	49884	200323	262.3	423.6	0	571.8	4.05E+06	186.077	2.39E-05	0.035626
8	31.0753	49096	206889	260.75	422.8	0	574.5	6.32E+06	188.007	2.39E-05	0.037484
9	30.341	52664	210640	261.62	423.8	0	573.2	1.56E+06	181.925	2.40E-05	0.037797

The Counter Picture of the Simulation of the one experiment is as follow

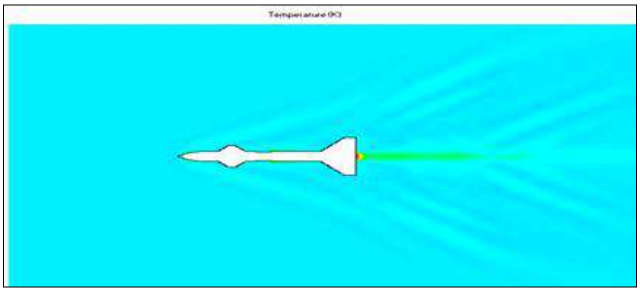

Fig 4: The Simulated temperature counter of the number 5

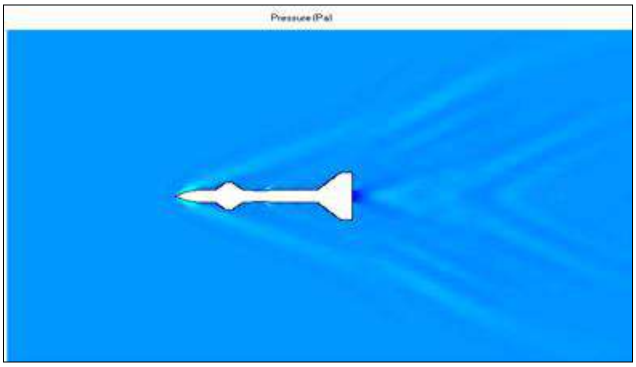

Fig 5: The Simulated pressure counter of the number 5

4.1 Determination of the weights for the factor using the entropy method

Step 1: the Decision matrix for the following experiment is determined in table 6 the same matrix is considered in this entropy method also for the study we had only considered only Drag, pressure, and velocity,

Table 4: The Decision matrix for the entropy method

Experiment	Drag	Pressure	Velocity
1	39.1442	259573	547.552
2	34.3074	230010	567.769
3	30.039	197736	569.485
4	31.3713	207019	577.687
5	29.5247	197456	576.118
6	32.7808	209076	570.475
7	29.10766	200323	571.795
8	31.0753	206889	574.527
9	30.341	210640	573.152
Sum	453.5176	5396081	10521.72

Step 2: The normalized matrix (From the Equation 12) of the decision matrix is

Table 5: The Normalized Matrix for the Entropy Method

Experiment	Drag	Pressure	Velocity
1	-0.21145	-0.14597	-0.15382
2	-0.1953	-0.1345	-0.15754
3	-0.1798	-0.12116	-0.15785
4	-0.18477	-0.12509	-0.15934
5	-0.17784	-0.12104	-0.15906
6	-0.1899	-0.12595	-0.15803
7	-0.17625	-0.12227	-0.15827
8	-0.18368	-0.12504	-0.15877
9	-0.18094	-0.1266	-0.15852
Sum	-1.67992	-1.14763	-1.4212

M=9, That Implies, K=0.45512

Step 3: the Entropy measure (From the Equation 13 & 14) of project outcome is as follows

Table 6: The Entropy Measure for the Normalized Matrix (Table- 5)

1-Ej	0.235437	0.477693	0.353183
Wj	0.220796	0.447986	0.331218

The weight (W_j) for the response factors the weights for the system have been obtained the result of the simulation are as follow:

Drag = 0.220796

Pressure = 0.447986

Velocity = 0.331218

4.2 Determination of the Single response for the Multi-response System using DFA method

Step 1: Calculation of the Desirability Index

Table 7: The Calculation of the Desirability Index Matrix for the Decision Matrix (Table-4) obtained from the Equation 15 and 16

Experiment	Drag	Pressure	Velocity
1	0	0	1
2	0.481919	0.475924465	0.329119
3	0.907205	0.995492377	0.272175
4	0.77446	0.846048586	0
5	0.958448	1	0.052066
6	0.634023	0.812933657	0.239323
7	1	0.953845163	0.19552
8	0.803952	0.848141411	0.104861
9	0.877115	0.787755365	0.150489
Wj	0.220796	0.447985871	0.331218

Step 2: Compute the Composite desirable individual.

Table 8: The dg values of the experiment obtained from the equation 17

Experiment	1	2	3	4	5	6	7	8	9
Dg	1	1.312354	1.379734	1.232661	1.332593	1.345973	1.368242	1.330567	1.339636
Rank	9	7	1	8	5	3	2	6	4

The optimal design based on the DFA is experiment 8 but the simulation is not Dg is not valid but the verifications required to obtain the optimal simulation must be valid by Taguchi optimization.

4.3 Determination of the Optimum result for the Experiment using Taguchi Design Optimization Method

Step 1: Determine the optimal level for the combination by using the Taguchi method. The Taguchi analysis is performed for the simulation and the result is as follows.

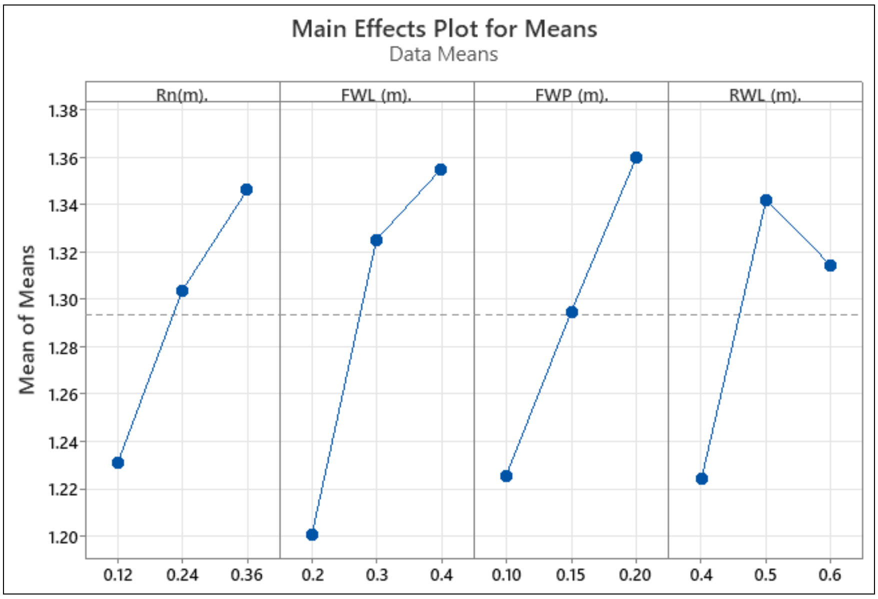

Fig 6: The Mean of Means vs. the models or the level obtained in the Taguchi optimization method for the simulation by using the d_G Values which are single response for a multi-responses system.

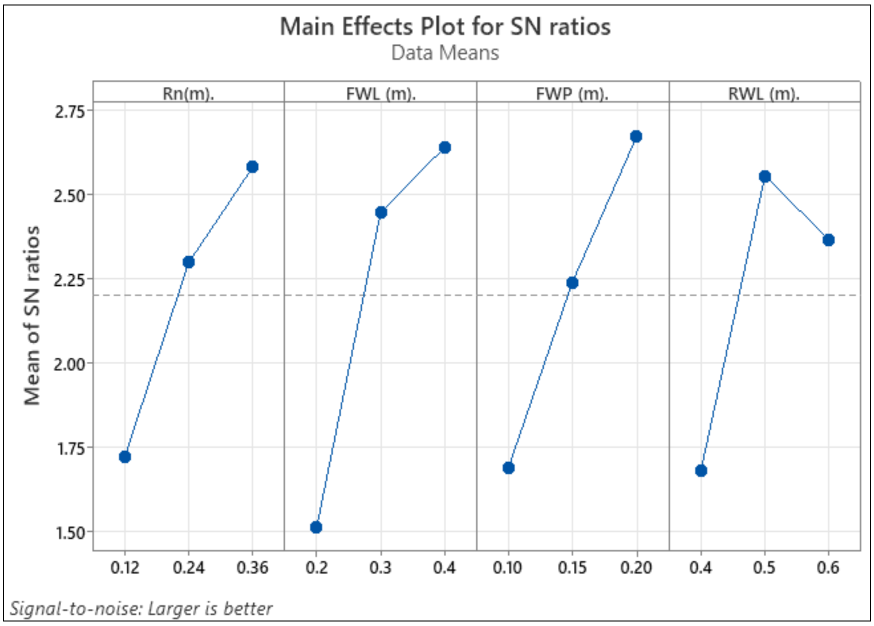

Fig 7: The Signal to Noise vs the models or the level obtained in the Taguchi optimization method for the simulation by using the d_G Values which are single response for a multi-responses system they consider the Larger the better model.

The Result indicates in Figure 2 that the optimal design for the Missile at the Supersonic Flow if the layout consists of 'the radius of the Nose is 0.36m the duration of Front wing or the Canards is 0. 4 m when it places at a distance of 0.2m from the nostril tip and the length Stabilizer wing is 0.5 at this design the missile produces a low amount of drag at the Supersonic Flow.

4.4 Performing the Regression analysis method

The regression analysis is performed to obtain the regression equation is generated is as follows Dg-0=0.518 + 0.481 Rn(m). + 0.774 FWL (m). + 1.347 FWP (m). + 0.451 RWL (m).

The simulation of the residual plot for Dg is plotted.

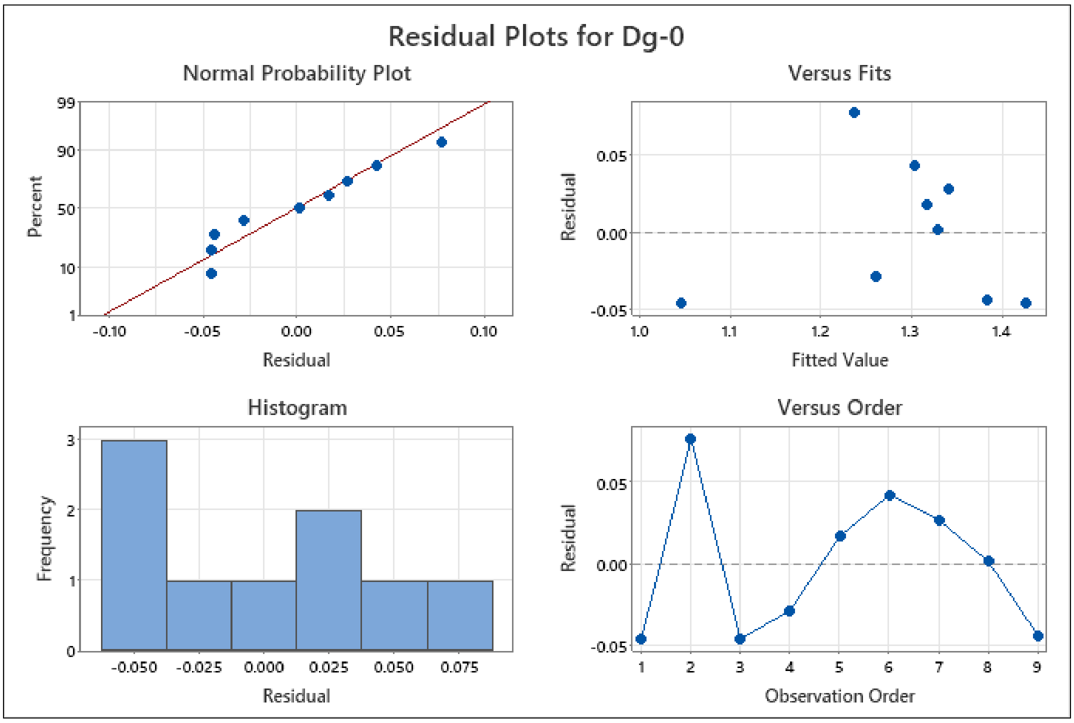

Fig 8: Represents the Plot between the Residual plot, fitted value, residual and observation data plot the residual plot the all the points are very linear to or correlated to the line

5. Conclusions

This Study concluded that

The optimal design for the Missile at the Supersonic Flow if the layout consists of 'the radius of the Nose is 0.36m the duration of Front wing or the Canards is 0. 4 m when it places at a distance of 0.2 m from the nostril tip and the length Stabilizer wing is 0.5 at this design the missile produces a low amount of drag at the Supersonic Flow

The weight of the response for the simulation which is obtained by the Entropy method is as follows Drag-22.0796%, Pressure -44.7986%, and the Velocity–33.12218%". Using the DFA method and the TAGUCHI design optimization method the Design parameters are validated.

The Linear regression analysis is performed and created a Regression equation which is for to estimate the dG the normalized value of the DFA method the equation is "Dg-0 =0.518 + 0.481 Rn(m). + 0.774 FWL (m). + 1.347 FWP (m). + 0.451 RWL (m)." The Linear regression analysis produces 96.5% of the R-sq the optimal case.

The residual plot of the analysis is produced in Figure 3

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