

Providing a Fuel Calculation and Estimation Model for Air Transport Operations

Mohammad Taghi Partovi^۱

Seyed Abas Mirhoseinimoghadam^۲

Mohammad Reza Mohammadi^۳

۱. Assistant Prof. Operations Research in Department of Science and Technology Studies, AJA Command and Staff University, Tehran, Iran.

۲. MSc in Defense Management, , AJA Command and Staff University, Tehran, Iran

۳. Faculty of Sciences, AJA Command and Staff University, Tehran, Iran

Abstract:

The purpose of this research is to present a fuel calculation and estimation model for air transport operations. For this purpose, the primary data of the C-۱۳۰ aircraft based on the book Dash One Performance was collected to determine the values of independent variables (weight, aircraft speed, altitude, air density, air pressure, wind speed, outside air temperature, engine air temperature) and the variable value dependent (fuel consumption) in different flight modes (landing, cruise, take-off, taxiing). Then, a model based on the MLP neural network was presented to verify and predict the fuel consumption of the aircraft. Then, flight variables were optimized using genetic algorithms. The obtained results indicate that the error value in the proposed algorithm was ۰,۰۰۶۲. By increasing the number of hidden layers, the error value decreased to ۰,۰۰۱۴. Also, the graph of the obtained results indicates a small difference between the results of the algorithm and the real results, which shows the performance of the algorithm. According to the results obtained from the genetic algorithm, it can be said that considering all the independent variables at the same time makes some variables ineffective in terms of fuel consumption, so their coefficients are zero. Also, the coefficients of some variables are negative, which indicates the reverse of fuel consumption and the increase of these coefficients.

key words-Model presentation, fuel estimation, air transport operations, neural network, genetic algorithm

1. INTRODUCTION

The most productive investment in the world is time capital. The point is that time cannot be bought, but it can be used in the best possible way to get the most benefit from it. Today, the range of tools we have for saving time is wide and efficient. Shortening the communication paths and, as a result, communication from one point to another point in the minimum time can prevent its wasting and the loss of this capital. It didn't take long after the construction of the first airplane that the aviation industry activists came to the conclusion that, in addition to using the airplane only for war purposes, the example of passenger transportation and then carrying cargo by this airplane was created and designed for the purpose of carrying cargo and goods (Babaei, ۱۴۰۰). The model for calculating and estimating the fuel in the plane is one of the important models in the aerospace field, which can be used to estimate the amount of fuel needed for the flight of a plane. These models are widely used in the aviation industry as well as in space research. In these models, various parameters such as cargo weight, flight path, weather conditions, etc. are considered to calculate the amount of fuel needed during the flight. Also, predictive models can be used to predict fuel consumption in different conditions and at different stages of flight. In the Air Force, air transport is a type of non-tactical air movement that is carried out to move personnel, preparations, and equipment through the air. In air transportation, all loading facilities and other devices available at air terminals are usually used (Rostami, ۱۳۷۸). Therefore, in today's world, moving cargo and passengers by airplane is a priority. Because the transfer is done with the least amount of time and speed. To carry out air transportation in the shortest time and with the most portable cargo, it is necessary to calculate the amount of fuel in the plane, which requires the investigation of factors affecting fuel consumption so that by calculating these factors, it can be carried on a desired route from the origin to the destination with the largest load. And with the least fuel reserve, this flight route can be done. To calculate the amount of fuel according to the effective factors in fuel consumption and also according to the charts (aircraft performance) of the desired aircraft, there is a need to extract mathematical models. Therefore, in general, the model of calculating and estimating fuel in the plane is one of the important models in the aviation industry, with the help of which the best use of fuel and reduction of fuel costs can be achieved.

۱. PROBLEM STATEMENT

Air transportation refers to the operation of transporting passengers and goods using airplanes. This method of transportation is considered due to its high speed, ability to cover long distances, reduction of travel time, and reduction of transportation costs (Babaei, ۱۴۰۰). Formulas are required for use and calculation. If there is to be a calculation of the optimal amount of fuel in a transport plane, the pilot should calculate the amount of fuel by using the tables included in the flight capability books of each plane, which will be very time-consuming and with low accuracy if it is not available to the air force in today's aviation systems due to the sanctions imposed by the Islamic Republic of Iran. The optimal amount of fuel is calculated by the

computer. Therefore, the Air Force needs mathematical formulas and equations to estimate, estimate, and calculate the optimal amount of fuel. One of the ways to increase the maximum efficiency of air transport is to limit the weight of the aircraft, and one of the ways to reduce the weight of the aircraft is to refuel according to the assigned mission. Calculating the amount of fuel depends on several factors, including altitude, speed, etc., and plays a key role in estimating combat readiness and combat power. The researcher intends to use the existing knowledge and expertise and the guidance of professors to answer the question, "What is the appropriate model for calculating and estimating fuel for air transport operations?"

2. RESEARCH BACKGROUND

In the article (Singh, 2010), 1200 articles were identified and reviewed for their direct relationship with FCO in air transportation. Two hundred and seventy-seven articles were subsequently selected, reviewed, and classified. Each of the 277 selected articles was categorized into four FCO dimensions (aircraft technology and design, air operations and infrastructure, socio-economic measures and policy, and alternative fuels and fuel properties). The paper (Mongeau, 2003) addresses the problem of loading as much cargo as possible on an aircraft while balancing the load to minimize fuel consumption and meet stability/safety requirements. Our formulation method allows solving the problem on a PC within ten minutes with off-the-board integer linear programming software. This method decides which container to load (and in which compartment) and which to put on the floor. The article (Singh, 2014) deals with establishing the basis for fuel efficiency optimization (FCO) in the Indian aviation industry. The purpose of this article is to design a method and develop a five-faceted fuel consumption optimization (FCO) model. Limited research has been conducted to explore the factors affecting FCO in the airline industry. To fill this gap, this study proposes the FCO model and examines the key factors influencing FCO. This study produces results that represent a basis for an optimal fuel economy solution that future researchers can target. In the article (Zhang, 2019), a multi-objective optimization method for airport taxiing based on airport environment and traffic conflicts is proposed. This study aims to achieve a Pareto optimal taxi design in terms of taxiing time, fuel consumption, and pollutant emissions. The article (Salah, 2014) has developed a model of optimal flight paths by taking into account jet noise, fuel consumption, restrictions, and extreme operational restrictions of the aircraft on the route. A two-part approach is obtained as an optimal path. The article (Liu, 2021) to clarify the space of fuel consumption optimization and the effect of emission on the environment under the limitation of special operations of air traffic management in the process of airplane climb, an optimization model of the airplane climb performance parameter has been created considering the environmental impact. Is. The results of this research show that with the change of speed, fuel consumption and temperature increase are different and the performance parameters of the airplane climb are affected by the maximum RTA. Optimizing aircraft flight parameters, can effectively reduce the impact of flight on

the environment and theoretically support the sustainable development of civil aviation.

The article (Yang, 2021) presents a method for spatio-temporal clustering and optimization of aircraft landing and approach routes. The results indicate that the performance indices for two clustering centers based on spatio-temporal distance, compared to two clustering centers based on Euclidean distance, are generally closer to the average performance of the original routes as well as the optimized routes. Spatio-temporal clustering methods may help to discover valuable information where the indicators related to the characteristics reflected in the temporal dimension lie. The article (Salehpour, 2020) proposes a multi-objective optimization method for fuel consumption (including fossil fuel and hydrogen) and emission of polluting gases in a hybrid electric aircraft. The objective of the proposed convex multi-objective model is to minimize the total fuel consumption during the entire flight mission as well as the corresponding fuel cell size. This problem is formulated in the form of mixed integer nonlinear programming using Karosh-Cohen-Tucker optimal conditions and solved by GAMS. The proposed efficient computational problem solution showed that compared to the conventional hybrid-electric aircraft, the optimal fuel cell power can improve the aircraft's performance in terms of fuel consumption and pollutant emissions. The article (Zhang, 2019) explored the effects of stability margin and thrust-specific fuel consumption (TSFC) on BWB design in the framework of multidisciplinary optimization (MDO). This study proves that these two factors have dominant effects on BWB optimization schemes in both aerodynamic shape and weight distribution, which should be considered during the MDO design process. Equilibrium diagram analysis is used to find reasonable static stability margin ranges. It can be concluded that the recommended stability margin for a BWB utility commercial aircraft can be half that of a typical TAW design. The paper (Lovegren, 2011) focuses on the potential performance benefits that can be achieved by improving the cruise speed and altitude profiles of today's flights. The results of this research showed that due to the complete optimization of altitude and speed, a maximum reduction of fuel burning of 3.5% is possible on a cruise. This represents a 2.6 percent system-wide fuel reduction, corresponding to 3.0 billion gallons of jet fuel and 3.2 million tons of CO₂ savings per year. Flights showed more potential to improve speed performance, with approximately 2.4% savings for speed optimization compared to 1.5% for altitude optimization. There are a few barriers to some strategies, such as ladder climbing and lower speeds, which make them attractive in the short term. As obstacles are minimized, increasing runway speed and altitude promises to improve the environmental performance of the aviation industry with relative ease.

The article (Gilani, 2020) is done to minimize the fuel consumption of the aircraft in the cruise phase, where the flight is subject to a certain time of arrival for different weights and distances. The approach adopted here uses the sequential quadratic programming algorithm from the MATLAB optimization toolbox, which includes a mathematical model of a jet aircraft based on an aircraft database as a performance evaluator to find out the effect of arrival time constraints on fuel consumption. This

algorithm determines the optimal cruise altitude and speed for minimum fuel consumption if there is no time limit, as well as for different time limits where the flight time decreases with increasing speed and decreasing altitude in most of the investigated cases. This algorithm calculates the optimal speed and altitude according to different flight scenarios with time-of-arrival constraints for minimum fuel consumption, which affects the direct operational cost of the flight. The article (Franco, 2014) has analyzed the effects of average horizontal winds on optimal results, both qualitatively and quantitatively. The effect of initial aircraft weight and a given cruise altitude is also analyzed. Two applications are studied: first, the cost of meeting a given arrival time under incorrect winds, and second, the cost of a flight delay imposed on a nominally optimal route. The optimal results are used to evaluate the optimality of the cruise at constant speed. The results show that the standard Mach constant cruise is very close to optimal. The results are presented for a model of the Boeing 767-300ER. The article (Velásquez-SanMartín, 2021) proposes a mathematical model for the analysis of fuel consumption during an airplane cruise. A closed formula that expresses the changes in aircraft weight over time and thus the fuel flow rate. In addition, a closed-form expression of the main performance parameters of the aircraft is also obtained. We calculated the values of such parameters using Piano-X software and compared them using our mathematical model. The simulation results confirm that the mathematical model provides results very close to reality. The paper (Hu, 2021) focuses on a synthesized ACC controller based on the PnG (Pulse-and-Gliding) strategy to reduce fuel consumption in the vehicle following conditions. A switching logic module is proposed for real-time control. A gear-shifting algorithm and braking logic are added to the control regarding the current condition of the following and the propulsion structure. The simulations are implemented in Matlab/Simulink and the results show that compared to a benchmark controller based on MPC (Model Predictive Control), the synthesized controller can save up to 14.6% in fuel consumption. The article (Kumakshev, 2022) presents the trajectory of a supersonic passenger plane that is optimal in terms of fuel consumption, using the classical method of dynamic planning. The mathematical model of the aircraft is used, which takes into account the maximum ordinary limits imposed on the allowed maneuvers of the aircraft with its design features. The initial and final parts of the route located in areas close to airports with high traffic density are only slightly different for different required flight durations and therefore do not require much accuracy in practical implementation. In the paper (Poll, 2021), a previously published constant Reynolds number model for civil transport aircraft with a turbofan engine is developed to include Reynolds number effects. Provided that the change in temperature with pressure is known, this method can be used for flying in any weather conditions. For a given aircraft traveling in a given atmosphere, there is a pair of Mach numbers and flight levels at which the fuel consumption per unit distance traveled through the air has an absolute minimum. The article (Caers, 2022) optimized flight and design parameters for three objectives: minimum fuel consumption, direct operating costs (DOC), and environmental impact of a passenger jet aircraft by combining several

models (this includes aerodynamics, specific fuel consumption, DOC and has modeled the mass of CO₂ equivalent). In this hybrid model, the importance of each objective is determined by a weighting factor. In addition, the possibility of further optimization of this model by changing the loading of the aircraft wing is analyzed. In the article (Aygun, 2022), off-design modeling of several energetic parameters for turbofan engines was done using a genetic algorithm in the cruise phase. In this context, energetic stability parameters such as exergy efficiency, wasted exergy ratio, energy destruction coefficient, environmental effect coefficient, and energetic stability index were calculated for aircraft engines. The results show that the linear modeling of energetic parameters with a genetic algorithm (GA) increases the accuracy of the model compared to the least squares method (LSM). Exergy efficiency modeling for the turbofan achieves $R = 0,9974$ by LSM while $R = 0,9999$ by GA at an altitude of 11 km. Finally, modeling the energetic criteria for a turbofan engine using parametric flight data can determine the optimal cruise flight conditions in terms of engine performance and environmental stability.

3. RESEARCH METHOD

In this research, with a major focus on the library method, the necessary materials were collected through books, published articles, previous research, and internet sites. Then analytical data was extracted using the Dash One Airplane Performance book and the rest of the data was analyzed based on the components. To identify the relationship between different variables of speed, height, weight of the aircraft, its fuel consumption. The data is extracted by the Plot Digitizer software, and then this data is converted into equations in the Curve Fitting Matlab software, and the formulas collected from the articles are converted into a series of equations. The research community will be all the documents and documents related to the research topic and the statistical community will not be included, while the researcher will use the extracted data in the specialized MATLAB software for simulation. In this research, three categories of variables have been used:

Function variable: fuel estimation model for air transport operations

Macro independent variable: effective factors in calculating the fuel estimate

Independent macro component variable: speed and height

Using studied sources related to the subject, which are both approved by experts and have a practical aspect. The selection of valid and different documents and documents resulting from the conducted research, and the existing documents and documents will have the necessary finality due to being the first category, so there will be validity and reproducibility.

In this research, 99 data in different flight modes (landing, cruise, take-off, taxiing) were extracted from the graphs, which were predicted using MLP neural network for more data in the number of 300 data. This was done to increase the accuracy of the results in the next step. The obtained data was defined functionally through regression and an equation was created to determine the amount of fuel consumed based on the extracted variables. In the next section, the variable values were

optimized. For this purpose, by using the genetic algorithm in MATLAB software, the amount of fuel consumed in different flight modes was optimized and the optimal value of the variables was obtained for different modes.

4. CASE STUDY

In this research, the C-130 plane is considered as a case study. The Lockheed C-130 Hercules (in English: Lockheed C-130 Hercules) is a military transport or logistics aircraft with 4 turboprop engines that was built by Lockheed in 1954 and is now manufactured by Lockheed Martin. This plane can use all kinds of runways for flight and landing. In addition to military transport, the C-130 Hercules can perform various missions, including airborne transport, search and rescue, scientific research support, weather reconnaissance, aerial refueling, maritime patrol, and aerial firefighting. The C-130 has long been the primary tactical transport aircraft for many militaries around the world, and more than 40 variants of the C-130 Hercules are in service in more than 70 countries. A highly armed model of this aircraft called the Lockheed AC-130 Specter/Spooky has been developed with heavy firepower for offensive missions. During its years of service, this aircraft has participated in numerous military assistance operations for the United States Army. As of 2010, more than 2,000 aircraft have been built, which has the longest continuous production period among all military aircraft. In 2007, this aircraft became the fifth military aircraft after English Electric Canberra, Boeing B-52 Stratofortress, Tupolev-90, and Boeing KC-130 Stratotanker, which reached its 50th year of continuous military service in its main user country, the United States of America. The United States of America entered the Korean War in a situation where all its military transport aircraft such as C-47, C-47, C-119 (Flying Boxcar), and C-124 (Constellation) had piston engines and their designs belonged to World War II; Therefore, February 2, 1951, the United States Air Force tendered the design of a military transport aircraft with the following specifications:

Carrying capacity of about 17140 kg of freight

The possibility of flying from the desert runway

Flying at high speed from low altitude

Long operating range

The C-130 is considered one of the most successful military aircraft in history, which has been in production since the early 1950s and has been used in countless military, civilian, and humanitarian operations. This aircraft, of which about 2,300 aircraft were built until 2009, has the longest continuous production period among all military aircraft. In 2007, this aircraft became the fifth military aircraft (after the English Electric Canberra, B-52, Tupolev Tu-90, and Boeing Cassi-13) to reach its 50th year of continuous military service in its main user country (USA)



Figure 1: C-130 aircraft

5. Research findings

Results of primary data collection

In this research, primary data has been collected through the extraction of numerical values from the available graphs in the field of C-130 aircraft performance. Table 1 shows the relationship between the variables according to the diagrams of this plane.

Table 1. The relationship obtained between the variables according to the graphs

Variable	Fuel consumption	Engine outlet air temperature	air pressure	wind speed	density	Engine intake air temperature	Aircraft weight
Increasing the weight of the aircraft	Increase	-	-	-	-	-	-
Increasing the speed of the plane	Increase	-	-	-	-	-	-
Increasing the height of the aircraft	Decrease	-	Decrease	Increase	Decrease	Decrease	<i>unknown</i>
Increase in air density	Increase	Increase	Increase	Increase	-	Increase	<i>Decrease</i>
Increase in air pressure	Increase	Increase	-	Decrease	Increase	Increase	<i>Decrease</i>

6. PREDICTION MODEL

In the current research, 99 data have been collected, which are defined in the form of three columns. The first two columns show the coordinates of the X and y points.

Also, the remaining three columns show the measured signal values. According to the rules of the neural network, to implement the network, 70% of the total data should be defined as training data for the network, which in this research is 70 cases, and 30% of the total data should be defined as test data for the network, which is in 30 cases in this research. At this stage, the data has been modeled with different neural networks, including a single layer and a multilayer, as well as different transfer and learning functions and different numbers of neurons in the middle layers. The number of neurons in the middle layer of the perceptron network has a great effect on the performance of these networks. The optimal number of neurons is selected based on the lowest mean squared error for modeling the neural network. All records are divided into three validation and experimental training sets. The number of records in the training set is 70% and in each of the other two sets, 10% of the total records have been selected. It should be noted that the most suitable parameters have been identified in each run by changing the model parameters and according to the accuracy of the system output prediction. The structure of the implemented neural network is a four-layer MLP network. For example, by changing the network architecture and repeatedly implementing different networks, the best architecture was obtained with Tansig transfer functions in the hidden layers and Purelin in the output layer. Also, the Trailm function was recognized as the most appropriate learning function. The proposed neural network for data has a multi-layered architecture. The number of hidden layers is two layers, and the number of neurons in the first layer is 20 and in the second layer is 20. The output layer contains one neuron and its activation function is purelin. The architecture of the neural network model has been used. The performance of the network was measured with MSE SE and R indices. In Figure 3, neural network training is presented for the entire data. The horizontal axis shows the number of training repetitions and the vertical axis shows the training error. This diagram shows how the neural network error trend has decreased based on the validation and test training data. It is the distance between the system estimates and the actual outputs that are calculated for each error training period and displayed on the vertical axis. The best performance of validation is the point where the error of the validation and testing data is at a minimum. In this research, this point is automatically placed in a section that does not overfit and underfit, and the three separate parts of the data are together in one point, Be fixed minimum in terms of error. The first point of the best validation is considered in the 4th training Cruise. The optimal point was also obtained based on the process of reducing errors and between the error intervals, that there was no over-fitting and under-fitting, and the average squared error for all three parts of the training data, validation, and test were gone through the same process.

Table ۲. Predictive neural network model settings

quantity	changeable
۲۹	Number of output layers
۲۰	Number of hidden layers
۲	Classification of hidden layers
Tansig, Tansig,pourelin	Decision function
Traingdx,learnngdm	learning function
Mse	Error function
۰,۱۰۰	Learning coefficient
۳۰۰۰	Epoch number
۱۰۰۰	Maximum number of operations
۱e-۵	Target coefficient
۰,۸	Momentum training coefficient

۲. EVALUATION OF THE PREDICTION MODEL

To evaluate the obtained model, we first divide the data into two categories, training, and testing, create the model using the training data, and then test the obtained results on the testing data, then calculate the accuracy of the model. Of Cruise, The implementation of some algorithms requires that the data be divided into three categories: training, validation, and testing. Finally, an algorithm whose validation result is better than other algorithms is identified. To evaluate the methods of predicting the difference between the actual value and the predicted value from the mean square error index, the square root of the error, the Pearson correlation coefficient (r), and the coefficient of determination (R) have been used.

* Mean Square Error Index (MSE): It is necessary to keep the values of this index as low as possible to increase the accuracy of forecasting methods.

*Index of the square root of the error (RMSE): if the value of this index is less than ۰,۱, the algorithm in question is favorable.

*Pearson's correlation coefficient index (r): the value of the correlation coefficient is between ۱ and +۱ and the positive and negative signs indicate a positive or negative correlation of the variables. If there is a strong positive correlation between the actual value and the predicted value, r is close to +۱ and if there is a strong negative correlation between them, the value of r will be close to ۱. If there is a weak correlation between the variables or there is no linear correlation between the variables, r will be close to zero.

*Coefficient of determination index: The value of the coefficient of determination is between zero and one, and the closer it is to one, it indicates the better fit of the data by the model. The value grows with the increase of the model, and it is necessary to influence the number of observations and the number of features in the model (Filmsuser, ۲۰۰۸). The accuracy of the algorithms is compared with each other in the MATLAB environment.

The first simulation output is according to Figure 3, in which the number of output layers, the number of hidden layers, the classification of hidden layers, and the number of inputs and outputs are shown.

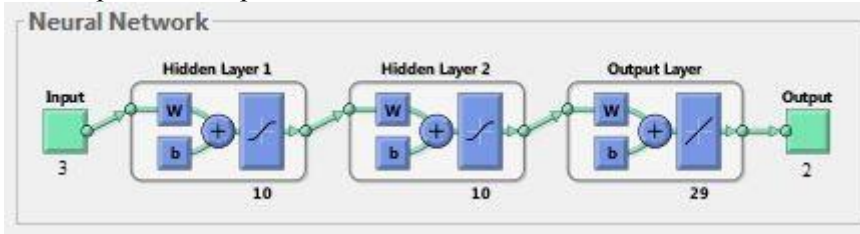


Figure 3. Neural network model used

The second output of the algorithm after its execution is according to Figure 4, according to which the algorithm has provided the required output calculations after 100 epochs and in 3 seconds. Also, according to the image below, the test and training data are superimposed on each other. The reason for this inference is that the validation value is greater than zero. Also, the obtained target coefficient is 0.021.

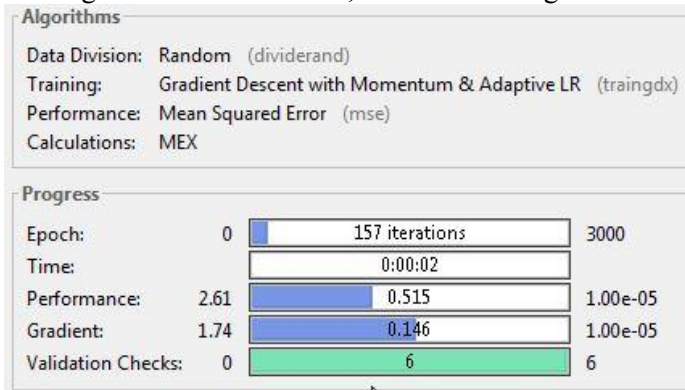


Figure 4. Time and Epoch

Figure 5 shows the learning status of the algorithm. According to this diagram, the algorithm has considered the value of the objective function to be zero.

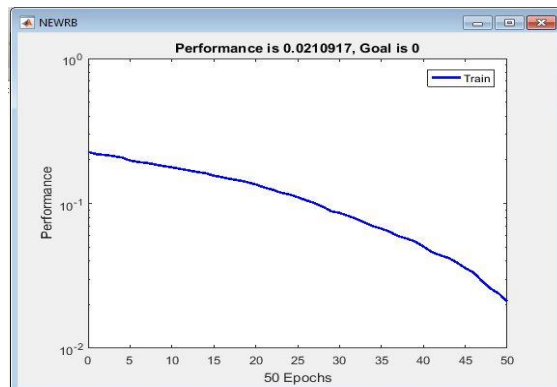


Figure 5. Algorithm training chart

Figure 9 shows the closeness of the results obtained on the best values and training values, and it can be concluded that the training of the algorithm has been done well.

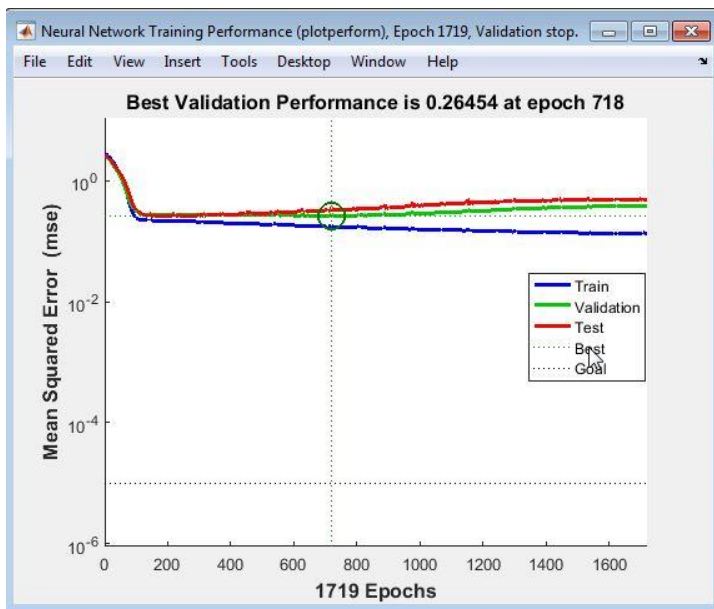


Figure 9: Training and testing diagram of prediction model

In this research, the error measurement function of the MSE type was considered. However, the amount of error in constant conditions changes by increasing and decreasing the number of layers, which, in this research, different states have been evaluated, and the results are shown in Table 3.

Table 3: MSE error of prediction model in different modes

Classification of hidden layers	Number of hidden layers	Number of output layers	MSE	Row
2	20	29	0.0062	0,1
2	30	30	0.0050	0,2
2	40	35	0.0038	0,3
2	50	40	0.0045	0,4
5	55	45	0.0029	0,5
10	60	50	0.0029	0,6

Due to the low MSE values obtained and also the appropriate correlation coefficient between the model output and the target output, neural networks can model the data optimally. In Figure 10, information such as MSE, RMSE, error histogram,

regression, mean, and standard deviation are divided into total data, test data, training data, and evaluation data.

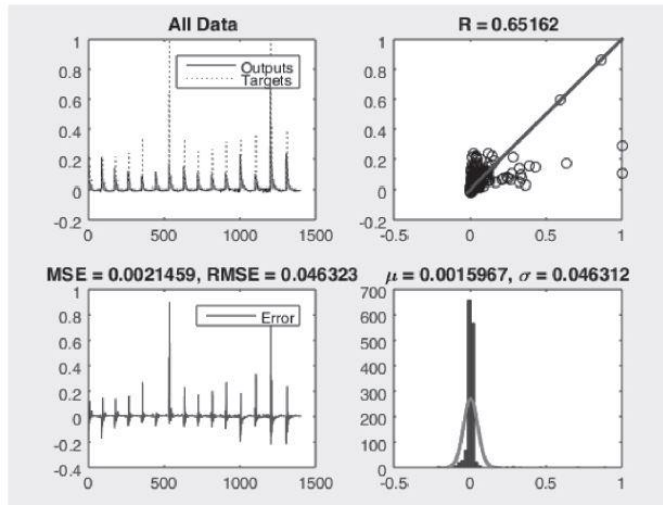


Figure 7. Regression output data of the prediction model

In each of the above figures, the lower right graph shows the output of the estimation system compared to the normal distribution. The difference between the error values and the middle point of the graph shows the distance between the error and zero. The closer the error distribution diagram is to the normal distribution diagram, it indicates that the error number is closer to zero and the system is more accurate in estimating the values. The upper right diagram is the regression diagram of the model between the system outputs and the actual outputs. The correlation coefficient R shows. How much of the neural network output variation is explained by the actual (target) output? The closer the value of this coefficient is to one, the more correlation there is between the model outputs and the target outputs. In complete correlation, it is R . The top left graph shows the estimation of the system and the real data related to the validation data. The bottom left graph shows the MSE and RMSE, and it shows the process of increase and decrease in error during the Cruise, training, validation, and testing. Also, Figure 9 shows the difference in the obtained results. According to this diagram, it can be said that the results of the algorithm match the results of the real values.

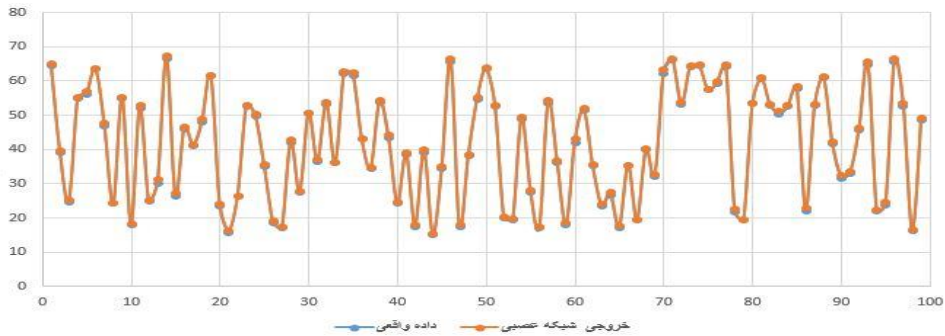


Figure ۷. The difference between actual and predicted values with the model

۸. DERIVATION OF EQ

In this section, the performance of the aircraft is explained in ξ parts. Taxiing, take-off, cruise and landing. Up to this section, the data required to determine the mathematical equation between the independent variables (engine outlet air temperature, engine inlet air temperature, wind speed, air pressure, aircraft weight (pounds), air density, aircraft altitude, aircraft speed) and the dependent variable (aircraft fuel consumption). In this research, the equations were extracted using the Curve Fitting MATLAB software, the results of which are shown in Table ξ .

Table ξ . is the table of coefficients of each variable obtained in the equation

	Airplane speed	Aircraft height	air density	Aircraft weight (lbs)	air pressure	wind speed	Outside air temperature	Engine air temperature	Constant
Landing	۸,۶۸۰۵ ۷۰-۱۸	۲,۱۲۵۵ ۸۰-۱۷	.	۰,۰۰۶۷ ۸۵۵۷۹	۶,۴۸۹۶ ۸۰-۲۱	.	- ۴,۱۰۵۶ ۱۰-۲۰	.	- ۱,۱۵۸۹ ۵۰-۱۶
Cruise	۰,۸۴۵۰ ۷۵۶۱۶	.	- ۰,۵۲۵۹ ۱۵۲۸۹	۰,۰۱۶۰ ۹۰۲۱۳	۰,۲۴۵۰ ۴۰۵۷۷	- ۷,۸۹۴۳ ۲۰۷۲	۰,۰۴۴۲ ۲۴۹۴۹	- ۱۱۱۲,۳ ۰۰۹۱۸	۲۸۸۸۸ ۲,۷۶۵۸
take off	- ۲۰,۳۹۸ ۹۵۶۵۳	- ۲۸۰,۸۲ ۴۱۵۱۲	۸۵,۰۸۸ ۵۰۳۴۸	- ۰,۳۵۵۹ ۸۰۹۱۸	۰,۰۴۸۳ ۲۴۱۲۱	۸۰۷,۸۸ ۲۴۴۲۱	۰,۰۶۷۴ ۹۰۷۸۹	.	۹۲۳۵,۰ ۴۷۱۳۲
take taxi	- ۰,۴۵۵۹ ۴۶۷۱۹	۱۹۵,۲۶ ۷۸۳۶۱	.	.	.	.	.	۵,۶۸۱۱ ۱۵۸۳۷	- ۱۹۳۰,۴ ۵۲۴۱۳

9. OPTIMIZATION

In this part of the research, the optimization of independent variables is discussed to optimize the value of the dependent variable. It should be noted that a genetic algorithm is used in this section to optimize the variables. In this research, a genetic algorithm was used in MATLAB software for optimization. The settings of this algorithm in the current research were done in such a way that the values of chromosome coefficient, initial population, and mutation rate are equal to 0.1, 100, and 0.01 respectively. The graph in Figure 4 shows the convergence of the best value of the objective function. Also, Table 5 shows the optimal values of the variables in different flight modes.

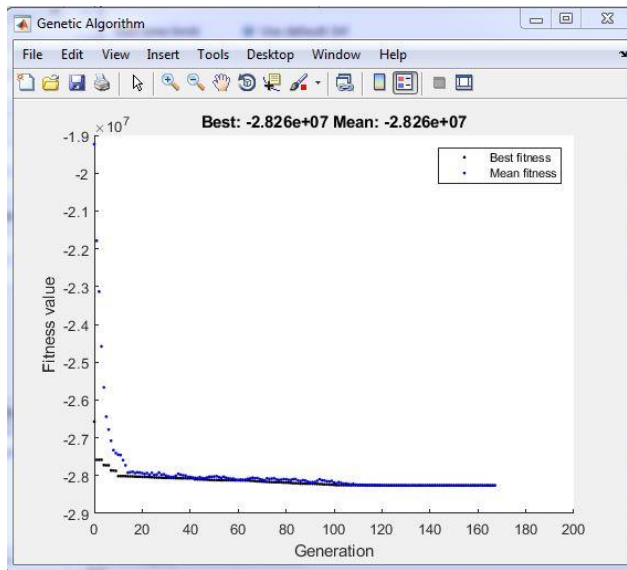


Figure 4. The diagram of the best value of the objective function (F)

Table 5. optimization results

	Airplane speed	Aircraft height	air density	Aircraft weight (lbs)	air pressure	wind speed	Outside air temperature	Engine air temperature
Landing	26.	1575	.	146924	2.32	.	19	.
Cruise	26.	.	53,91374	1.095	116.7	525,5513	2.	665
take off	28.	50.	1.317	1.000	1146	32,3619	.	1.2
take a taxi	11	.	.	.	.	.	14	655

10. CONCLUSION

Considering the importance of fuel consumption in air transportation, it is important to determine the amount of fuel consumption and the best flight mode. Therefore, in current research, the use of neural network algorithms and genetic algorithms has been suggested. For this purpose, 99 data were collected. Then, according to the neural network process, 23 of the total data was defined as training data for the network, which is 66 cases in this research, and 13 of the total data was defined as test data for the network, which in this research is in 33 cases. Then the algorithm settings in the form of the number of output layers 29, the number of hidden layers 30, the classification of hidden layers 3, the decision function Tansig, Tansig, purely, the training function Traingdx, learned, the error function me, the learning coefficient 1.0 and 0.1, the number of epochs 3000, The maximum number of operations was 1000, the target coefficient was 0.1, and the momentum training coefficient was 0.8. The obtained results indicate that the error value in the proposed algorithm was 0.0062. By increasing the number of hidden layers, the error value decreased to 0.0014. Also, the graph of the obtained results indicates a small difference between the results of the algorithm and the real results, which shows the performance of the algorithm. Also, according to the results obtained from the genetic algorithm, it can be said that in considering the performance of the aircraft in 4 modes, taxiing, take-off, cruise, and landing, And independent variables (engine outlet air temperature, engine inlet air temperature, wind speed, air pressure, aircraft weight (pounds), air density, aircraft altitude, aircraft speed) and dependent variable (aircraft fuel consumption), it can be said that in Considering all the independent variables at the same time has made some variables ineffective in the amount of fuel consumption, so that their coefficients are zero. Also, the coefficients of some variables are negative, which indicates the reverse of fuel consumption and the increase of these coefficients.

According to the obtained results as well as the research conducted in this field, it is suggested that by combining the genetic algorithm in the desired neural network, the error rate is lower than the obtained results. It is also suggested to investigate other effective factors such as fuel type, engine type and other factors that have not been discussed in this research. Calculation of fuel consumption of other aircraft should be investigated. According to the proposed formula presented above: it is suggested that the Vice-Chancellor of Nahaja, by providing instructions, asks the flight battalions to use this formula instead of manual calculation. It is also suggested that Nahaja training vice-chancellor plans a training cruise for all 130 th-130 pilots based on the use of this new method. Also, commanders of Nahaja transportation bases should put this cruise on the agenda for all pilots and ask T-130 pilots to use this formula in the annual tests based on the evaluation of the base unit. And finally, it is suggested that the War Institute of the Command and Staff University use this formula in the war game system. It should be noted that the lack of access to additional information about military aircraft and the lack of access to military aircraft software due to the existence of sanctions are also limitations of the current research in the area of up-to-date information on the C-130 aircraft.

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