International Journal of Multidisciplinary Research and Development

Volume: 2, Issue: 7, 42-46
July 2015
www.allsubjectjournal.com
e-ISSN: 2349-4182
p-ISSN: 2349-5979
Impact Factor: 3.762

Battal Dogan
Department of Mechanical Engineering, Faculty of Engineering, Kirikkale University, Kirikkale, Turkey

Fatih Turkoglu
Nevşehir Airport, Nevsehir, Turkey

Nur Cekel
Ministry of Transport Maritime Affairs and Communications Ankara, Turkey

Correspondence:
Battal Dogan
Department of Mechanical Engineering, Faculty of Engineering, Kirikkale University, Kirikkale, Turkey

Research on environmental effects within the scope of "green airport project" in nevsehir international airport

Battal Dogan, Fatih Turkoglu, Nur Cekel

Abstract
For the purpose of reducing the negative effects of Airports on environment, "Green Airport Project" has been initiated by Directorate General of Civil Aviation in 06/25/2009. The airports will be called "Green Airport" when the requirements of this project were met. The aim of this study is research of environmental effect on an airport, elimination, reducing and prevention of these effects. This study intends to examine the environmental effect in Nevsehir Kapadokya Airport in the context of "Green Airport Project" with regard to noise, emission and waste management. In addition, a trigeneration system was designed for using energy more efficiently and feasibility of the system was analysed.

Keywords: Energy efficiency, Trigeneration, Green Airport

1. Introduction
In parallel with growing population and industrialization, people can arrive in their destination in shortest time and most comfortably thanks to developing airport. In addition to social and economic benefits of air transport, environmental effects of this sector must be taken into account. The negative environmental effects of airports are noise, emission and wastes. Because it is perceived easily and affects people quickly, noise caused by landing and take-off is most important environmental effect. Aircraft noise occurs mostly during the take-off which consumes the maximum power. The noise occurs during landing, taxi and start the engine. In the occurrence of airport noise, aircraft noise, aircraft engine type, aircraft volume and aerodynamic noise are effective.

2. Materials and Methods
2.1 Noise In Nevsehir Kapadokya Airport
In this study, 41 measurements in total have been made. There are 6 measurement points in Gülşehir town and 20 measurement points in Tuzköy town. The number of measurements in Gülşehir is fewer than ones in Tuzköy, because ILS (instrument landing system) in airport is on the side of Tuzköy, where 1-1 runway is, and landing and take-off directions of aircraft coming from Istanbul are toward 1-1 runway. After 23:00, because there is no flight to Nevşehir Airport, no measurement has been made.

Because there is 1 minute effect on people residence during the take-off and landing, L_{eq} (equivalent noise level measurement) is adjusted to 1 minute. Date, time, take-off and landing status and weather has been recorded in each measurement. Wind directions are designated as North 0^0, East 90^0, South 180^0 and West 270^0. Wind direction display where the winds come from. The wind speed is termed as knot (1 kont=0,514 m/s), height of cloud as feet (1 feet=0,3048 m) cloud rate as 1/8. The results of noise measurement in relation to measurement points are shown Table (1). The measurements exceeding the limits determined by "Assessment and Management Regulations of Noise" shown at Table (2) are in red.

Table 1. The Results of Noise Measurement

No	Tarih-Saat	İniş-Kalkış	Ölçüm Sonucu (Leq) dB(A)	Rüzgar Yönü ve Hızı (knot)	Sıc. ^{0}C	Bulutluluk Yüksekliği ve Oranı	Nem %	Bas. (hPa)
1	01.11.2012 / 10:50	İniş	**42,4**	90^0 – 5	19	4000 ft - 2/8	48	1020
2	01.11.2012 / 12:00	Kalkış	**60,7**	240^0-3	20	4000 ft - 2/8	42	1019
3	01.11.2012 / 15:10	İniş	**54,4**	360^0-2	22	4000 ft - 2/8	37	1018
4	02.11.2012 / 21:40	İniş	**45,2**	120^0-7	11	4000ft - 2/8	8	1018
5	03.11.2012 / 22:05	Kalkış	**59,1**	150^0-4	9	4000 ft - 2/8	7	1021
6	03.11.2012 / 21:00	İniş	**47,9**	110^0-6	11	4000 ft - 2/8	8	1021
7	03.11.2012 / 10:50	İniş	**37,8**	90^0-4	16	4000 ft - 2/8	8	1020
8	03.11.2012 / 11:56	Kalkış	**45,6**	60^0-3	17	4000 ft - 2/8	9	1019
9	05.11.2012 / 12:05	Kalkış	**57,2**	240^0-4	23	4000 ft - 2/8	5	1019
10	05.11.2012 / 21:11	İniş	**52,6**	120^0-10	12	Açık	3	1019
11	06.11.2012 / 11:20	İniş	**47,3**	240^0-3	22	Açık	4	1018
12	06.11.2012 / 11:40	Kalkış	**56,6**	250^0-14	23	Açık	2	1017
13	06.11.2012 / 12:15	Kalkış	**57,7**	240^0-17	23	Açık	1	1017
14	06.11.2012 / 21:00	İniş	**51,3**	130^0-7	10	Açık	3	1019
15	07.11.2012 / 22:03	Kalkış	**45,2**	330^0-3	13	1000 ft - 6/8	46	1016
16	08.11.2012 / 11:00	İniş	**48,0**	240^0-8	16	1000 ft - 7/8	4	1012
17	08.11.2012 / 12:05	Kalkış	**59,1**	270^0-8	14	10000 ft-7/8	2	1012
18	08.11.2012 / 21:05	İniş	**49,0**	Sakin	9	1500 ft - 2/8	8	1014
19	08.11.2012 / 22:30	Kalkış	**60,8**	Sakin	9	2000 ft - 2/8	8	1013
20	10.11.2012 / 20:15	İniş	**63,3**	20^0-24	8	3500 ft - 6/8	84	1013
21	10.11.2012 / 21:35	İniş	**61,7**	20^0-26	8	3500 ft - 6/8	84	1013
22	10.11.2012 / 22:20	Kalkış	**58,5**	20^0-21	7	3500 ft - 6/8	85	1013
23	11.11.2012 / 10:42	İniş	**45,8**	30^0-19	7	2000 ft - 2/8	80	1016
24	11.11.2012 / 11:03	İniş	**50,5**	20^0-20	7	3000 ft - 6/8	78	1016
25	11.11.2012 / 11:57	Kalkış	**49,3**	20^0-20	7	2000 ft- 2/8	78	1016
26	11.11.2012 / 12:05	Kalkış	**52,4**	20^0-2	7	2000 ft - 2/8	78	1016
27	12.11.2012 / 20:45	İniş	**55,3**	220^0-7	10	4000 ft - 3/8	5	1023
28	12.11.2012 / 22:07	Kalkış	**57,2**	340^0-5	10	4000 ft - 3/8	6	1023
29	13.11.2012 / 20:55	İniş	**55,1**	300^0-2	9	3000 ft - 6/8	83	1023
30	13.11.2012 / 22:00	Kalkış	**57,9**	220^0-3	9	3000 ft - 6/8	81	1023
31	14.11.2012 / 12:05	Kalkış	**54,7**	Sakin	12	4000 ft - 4/8	7	1022
32	14.11.2012 / 21:55	Kalkış	**52,3**	Sakin	4	4000 ft - 3/8	3	1023
33	15.11.2012 / 21:05	İniş	**49,2**	Sakin	6	500 ft - 2/8	95	1024
34	16.11.2012 / 12:35	İniş	**47,2**	290^0-3	5	700 ft - 5/8	99	1025
35	18.11.2012 / 12:05	Kalkış	**48,2**	270^0-5	6	700 ft - 5/8	4	1020
36	18.11.2012 / 21:24	İniş	**46,6**	270^0-4	5	300 ft - 5/8	5	1021
37	19.11.2012 / 12:00	Kalkış	**60,4**	240^0-5	4	600 ft - 6/8	93	1022
38	20.11.2012 / 12:05	Kalkış	**59,4**	Sakin	5	1100 ft - 6/8	2	1023
39	20.11.2012 / 14:05	Kalkış	**61,9**	240^0-4	5	1100 ft - 6/8	3	1022
40	23.11.2012 / 11:30	Kalkış	**42,4**	270^0-3	5	Açık	4	1020
41	23.11.2012 / 11:40	Kalkış	**44,1**	270^0-3	5	Açık	4	1020

According to Assessment and Management Regulations of Noise, maximum noise level emitted by airports cannot exceed the limit levels shown at Table (2). Looking at the results by considering the limit levels, which are $L_{daylight}$ = 65 dBA, $L_{evening}$= 60 dBA and L_{night}=55 dBA, shown at Table (2), only number 19,20 and 21. Measurements are over the limit levels. In the course of measurement of number 20,21 the humidity at 84%, the wind speed from take-off point through measurement points at about 24-26 knot have impact on the result. Measurement number 2,13,14,22,40 and 41 in Gülşehir don't exceed the limit level. In addition the noise level during the take-off is higher the one during the landing.

Table 2. Airport Environmental Noise Limit Levels

Regions	**Small Airports (under 50.000 take-off/landing per year)**			**Big Airports (over 50.000 take-off/landing per year)**		
	$L_{daylight}$ (dBA)	**$L_{evening}$ (dBA)**	**L_{night} (dBA)**	**$L_{daylight}$ (dBA)**	**$L_{evening}$ (dBA)**	**L_{night} (dBA)**
Education, culture, healt centres and summer camp places.	63	58	53	65	60	55
Regions where the houses are plentiful	65	60	55	68	63	58
Regions where the stores are plentiful	67	62	57	72	67	62
Industrial regions	70	65	60	75	70	65

2.2 Emission Caused By Aircrafts

The aircrafts, the main emission source in Airports, consume a derivative of gas oil called Jet A1.With the combustion of 1 kg fuel, nearly 3,15 kg CO_2, 1,24 H_2O and 0,6 SO_2 resulted from lead arise [5]. In aircraft engine, 350 lt of fuel produces about 1 ton CO_2. There are two main emission problem caused by aircraft. First, in order to have high consumption efficiency with little power for manoeuvre on the ground, the consumption of high amount of fuel is needed. Therefore the great amount of non-consumed hydro-carbon occurs. The amount of hydro-carbon must be reduced. Second emission problem is that, during the take-off, climbing and flight, nitrogen oxide emitted by aircrafts [6]. The stage except straight flight is called landing and take-off (LTO)

2.2.1 IPCC Method in Determination of Aircraft Emission

The Intergovernmental Panel on Climate Change (IPCC) was founded in 1988 by World Meteorological Organization and United Nations Environmental Programme in order to evaluate the risks of climate change caused by human activities. IPCC proposes two kinds of Tier method in determination of aircraft emission. Method Tier 1 is based on the multiplication of mean emission factor with total fuel consumption. In method Tier 2, fuel used in the process of LTO and amounts of emission given are estimated with the help of LTO statistics for each type of aircraft [7]. Table (3) includes some kind of aircrafts and emission factors for each phase of LTO.

Table 3. Samples of LTO Emission Factors for Some Aircraft Types [6,8]

	LTO Emission Factor (kg/LTO)							LTO Fuel Consumption Kg/LTO
Aircraft Type	**CO_2**	**CH_4**	**N_2O**	**NO_X**	**CO**	**NMVOC**	**SO_2**	
A300	5450	0,12	0,2	25,86	14,8	1,12	1,72	1720
A310	4760	0,63	0,2	19,46	28,3	5,67	1,51	1510
A319	2310	0,06	0,1	8,73	6,35	0,54	0,73	730
A320	2440	0,06	0,1	9,01	6,19	0,51	0,77	770
A321	3020	0,14	0,1	16,72	7,55	1,27	0,96	960
A330-200/300	7050	0,13	0,2	35,57	16,2	1,15	2,23	2230
A340-200	5890	0,42	0,2	28,31	26,19	3,78	1,86	1860
A340-400	6380	0,39	0,2	34,81	25,23	3,51	2,02	2020
A340-500/600	10660	0,01	0,3	64,45	15,31	0,13	3,37	3370

The formula used in this method are described below.

LTO emission= Number of LTO X emission factor of LTO(1)

2.2.2. In Nevşehir Kapadokya Airport, Determination of Aircraft CO_2 Emission by IPCC Method

With the IPCC Tier 2 method, for the determination of aircrafts emission in Kapadokya Airport, between 2007-2011 years types of aircrafts and the number of flights of these aircrafts has been employed [9]. In airport the result calculated for CO_2 emission are shown below.

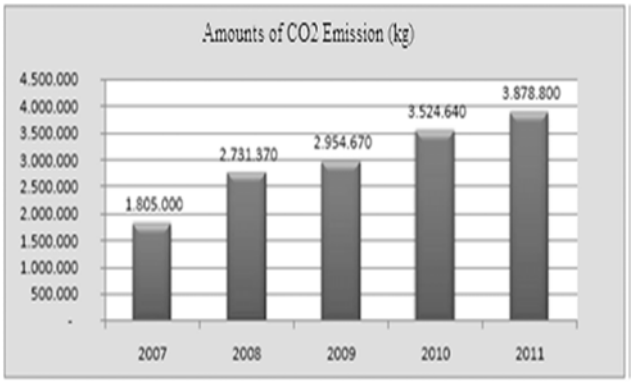

Fig. 1. CO_2 Emissions between 22007-2011 years.

Airport management can take operational measures for the reduction of aircraft emission. One of the operational measures is the planning of landing and take-off time. The most gas emission of aircrafts arises during the take-off for 0,7 minutes, climbing for 2,2 minutes and taxi for 2,6 minutes. A study of prediction of exhaust emission levels in the process of LTO at airport in Turkey, shows that in 2001, 7614,34 to 8338,79 ton exhaust emission is estimated to be produced per year. And when LTO time is decreased approximately 25%, the total amount of emission is decreased between 33% and 31%. When taxi time is decreased 2 minutes, the amount of emission is decreased 6% [5]. With the operational measures are taken, in Nevşehir Airport, it's estimated that emission caused by aircrafts may decline in great amount.

2.3 Waste Management In Airport

In airports, in winters, the use of organic chemicals in order to clean the runways, taxi paths and aprons from ice and snow, washing of aircrafts and other vehicle, supplying of oil and fuel, leaks during aircraft maintenance, cleaning of parking area, using fertilizer on green areas caused by environmental and water resources pollutions [10].

Waste Reduction Measures in Airports

1. For the purpose of the reduction of waste and to follow the latest knowledge and technologies closely, airport staff must get educations.
2. If necessary, to revise the existing system efficiently, if that is not impossible, to change the existing system with higher efficiency systems.
3. All resources must be used more efficiently in line with the Sustainable Management and Energy Efficiency policies adopted by the airport. Measures should be taken to prevent the waste of resources. The protection of resources must be taken care at highest level.
4. While products are bought, long-lived productions should be preferred.
5. Importance should be given to the appropriate packaging of stocked products and store in appropriate circumstances, in order to no degradation, spillage and damaging of products.
6. Working on separate collection of wastes in source must be conducted carefully. The decomposition of reusable and recyclable wastes must be provided from the wastes to be disposed.

2.4 Designing of Trigeneration System At Airport

The most important energy consumption sources at airport are heating, cooling and electricity energy. In order to use energy most efficiently, where consumption is available, trigeneration system must be established. For example, if we set up this system in Nevsehir Airport, the needed heat capacity of system is below;

190.000 kg fuel-oil 4 is consumed a year in order to heat the airport. When the mean calorific value for fuel-oil 4 is taken as 10100 kcal/h, the heat necessity a year is;

190.000 kg x 10100 kcal/kg =1.919.000.000 kcal.

Assuming that heating system works 10 hours per day and for about 6 months, operating time of system is;

6 months x 30 days x 10 hours = 1.800 hours

The needed heat capacity per hour is;

1.919.000.000 kcal / 1.800 hours = 1.066.111 kcal/h

Flow chart of system is below.

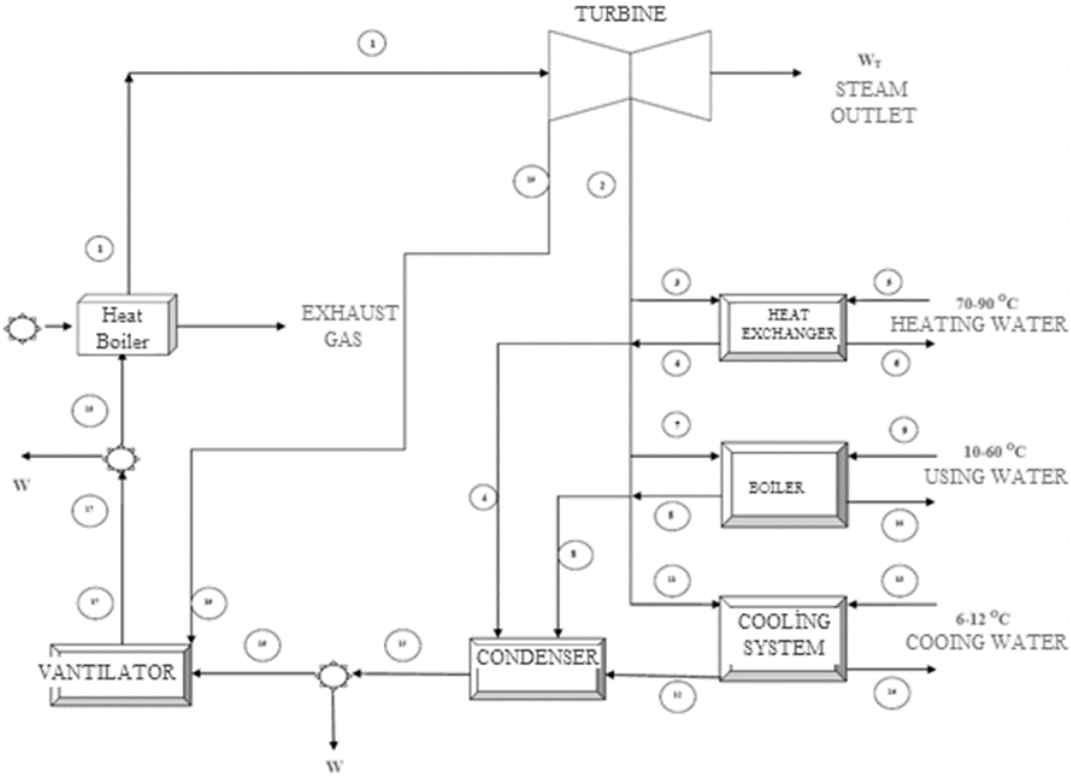

Fig. 2. Trigeneration system flow chart

Thermodynamic values are identified for all of flow points. The total energy of control volume doesn't change in open system. In open systems, the entering energy as heat, work and mass flow in to control volume must be equal released energy from the control system. The law of conservation of energy is below;

$$\dot{Q} - \dot{W} = \sum \dot{m}_{ç}\, \dot{\theta}_{ç} - \sum \dot{m}_{g}\, \dot{\theta}_{g} \qquad (2)$$

θ is total energy of the unit mass of the fluid including flow work. If we show entering and exiting status 1 and 2, if we take into account no change mass flow, kinetics energy, potential energy, the equation of conservation of energy is;

$\dot{Q} = \dot{m}\,(h_2\text{-}h_1)$ [11] (3)

If the thermodynamic values calculated for each points by using this conservation equation and thermodynamic steam charts; the following table is obtained.

Table 4. Thermodynamics values of all of point in trigeneration system

Akım No	1	2	3	4	5	6	7	8	9	10
$\dot{m}$(kg/h)	3362,82	3180,42	2365	2365	55	55	222,7	222,7	2066	2066
P (bar)	35	14	8	8	5	5	8	8	5	5
T (^{O}C)	325	170,7	170,4	170,4	70	90	170,4	170,4	10	60
h (kJ/kg)	3043,1	2705,06	2667,5	719,09	293,45	377,37	2667,5	719,09	42,51	251,58
s (kJ/kgK)	6,5588	6,6616	6,6596	2,0416	0,9549	1,1926	6,6596	2,0416	0,151	0,831

Akım No	11	12	13	14	15	16	17	18	19
$\dot{m}$(kg/h)	776,12	776,12	90107	90107	3362,82	3362,82	3545,22	3362,82	182,4
P (bar)	8	8	5	5	8	14	14	35	14
T (^{O}C)	170,4	170,4	12	6	170,4	170,4	195,04	195,04	220
h (kJ/kg)	2667,5	719,09	50,89	25,72	719,09	720,09	829,97	833,47	2855,5
s (kJ/kgK)	6,6596	2,0416	0,1804	0,0091	2,04016	2,04026	2,28035	2,28068	6,6062

If the total energy amount of the heat boiler is calculated according to 1 and 18 flow value;

$\dot{Q}= \dot{m}(h_1 - h_{18})$ =3362,82 (3043,1-833,47)

$\dot{Q}$= 7430588 kJ/h . $\frac{1\ kcal}{4{,}1868\ kJ}$ = 1774765 kcal =2.064 kW

If the amount of the needed fuel is calculated according to capacity of heat boiler;

The Liquefied natural gas (LNG) will be used in system. The calorific value of LNG is 9155 kcal/m^3. The amount of consumed LNG in year is calculated is below;

$$B_y = \frac{\dot{Q}_k . Z_g . Z_y}{2 . H_u . \eta_k} \qquad (4)$$

$B_y = \frac{1774765\ kcal x 10 saat x 360\ gün}{2x9155\ kcal/m^3 x 0{,}90}$ = 387.715 m^3/year

The consumption costs of the electric, heating and generator systems energies mean 926.000.-TL in year. The LNG consumption cost of trigeneration system in year is mean 582.000.-TL. If the trigenerator system is established in Airport, 344,000.-TL is saved in year. The establish costs of the system that is 4.300.000.-TL is saved in 12 year. Because of the life of system is 25 year, 4.400.000.-TL is saved in 13 year.

3. Conclusions

In a world whose population increases rapidly, with the consumption of energy sources unconsciously by people, the end of sources and environmental problems has been faced. The most important environmental problems are air, water, soil and noise pollution. In airport that is the each sources of environmental problems affect the entire world, the reduction and elimination of air, water, soil and noise pollution must be taken importance. As a result of the importance, the environmentally friendly airports occur thanks to "Green Airport Project". In this study, Nevsehir Airport selected as a model, will contribute the environment socially and economically.

4. References

1. ürültü Azaltım Önlemleri El Kitabı,Çevre ve Orman Bakanlığı,2008
2. Çapa,E. Trabzon Havaalanı Uçak Hareketlerinin Yakın Yerleşim Birimleri Üzerindeki Çevresel Etkileri,Yüksek Lisans Tezi,2008
3. Şahin, G.Y., Trabzon Havalimanı Gürültüsü ve İnsan Üzerindeki Etkileri, Yüksek Lisans Tezi,2007
4. Powers, O. J. Aircraft Noise Generation and Control, Noise Around Airports, Noise Pullition, Saenz, A. L. And Stephens, W. B., John Willey and Sons Ltd., 1986.
5. Karakoç H.,Altuntaş Ö., Türkiye'deki Bazı Hava Alanlarında İç Hat Uçuşları İçin Uçak Seçiminde Çevresel Etkilerin Göz Önünde Bulundurulmasının İncelenmesi,Havacılık ve Uzay Teknolojileri Dergisi, Ocak 2011,Cilt 5, Sayı 1
6. Çağatan,K.,İstanbul Atatürk Havalimanı İçin Uçak Emisyonlarının Belirlenmesi ve Çevresel Etkileri, Yüksek Lisans Tezi,2011
7. Rypdal,K., Aircraft Emission, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC Publication
8. IPCC Guidelines for National Greenhouse Gas Inventories, The Reference Manual (Volume 3), 1996
9. DHMİ İstatistik Yıllığı 2007,2008,2009,2010,2011
10. Korul,V.,Havaalanı Çevre Yönetim Sistemi, Anadolu Üniversitesi Sosyal Bilimler Dergisi,2003
11. Haberdar F., Bir İlaç Firmasında Trijenerasyon Sistemi Kurulmasının Termodinamik Analizi, Yüksek Lisans Tezi, 2009