AIRCRAFT EMISSIONS AT BOSNIA AND HERZEGOVINA AIRPORTS

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ABSTRACT
Aircraft emissions to total atmospheric emissions due to the last analyses and reports are around 7%. Majority of emissions are released to troposphere and stratosphere and ground-level aircraft emissions at airports area becoming significant due to growing air traffic. Aircraft emissions (CO_2, CO, CH, NO_x, SO_2, vapor…) depend on time spent at each stage of flight such as cruise and landing/take-off (LTO) cycle. In Bosnia and Herzegovina only on Saraejvo Airport exists significant air traffic which is quite seasonal in terms of frequency. Calculation model is based on flight data recorded by BHDCA and emissions calculation are based on Engine Emission Data Bank issued by International Civil Aviation Organization (ICAO). In this work detailed methodology is used and results are relevant to estimate degree of pollution caused by aircraft emissions.

Key words: aircraft emissions, LTO cycle, Bosnia and Herzegovina airports

1. INTRODUCTION

Air transportation is a significant source of air pollution in modern world due to steady increase of number of air operation. Nowdays, exhaust emissions from aircrafts compared to anthropogenic surface emissions is about 7% of all petrol products burned as aviation fuel. Jet fuel isn't just one substance, it's a mixture of different hydrocarbons and special additives. Aircraft emissions vary with the engine type, the engine load and the fuel. Combustion of jet fuel results in CO_2, H_2O, CO, C, NOx, SOx, various non-methane hydrocarbons (NMHC), particles and a great number of organic compounds.

The International Civil Aviation Organization (ICAO) sets standards for world commercial aircraft fleet for both take-off and landing cycles and also for cruise at high altitude. The second one is concerned with ozone depletion in the upper free troposphere and lower stratosphere. Great part of aircraft emissions are released during cruise phase of flight at altitudes higher than 1000 m (out of atmospheric boundary leyer).

The ICAO defines reference emissions LTO cycle (Table 1.) consisting of four operation modes: approach, taxi (taxi-in, taxi-out), take-off and climb (Annex 16) which is used for the calculation and reporting of gaseous emissions. ICAO defined the climbing as the interval between the end of take-off and the moment the plane exits the atmospheric boundary layer (ABL) and approach. ICAO's norms therefore take air traffic emissions into account from the runway reference point to the top of the ABL,

whose height is defined to be 915 m (3000 ft) by default. Time in operating mode and engine thrust setting are used during engines testting for engine certification so ICAO established ICAO Engine Emissions Data Bank for all world commercial aircrafts. Emissions which are controlled for certification of aircraft engines are smoke and gaseous emissions (unburned hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NO*x*)).

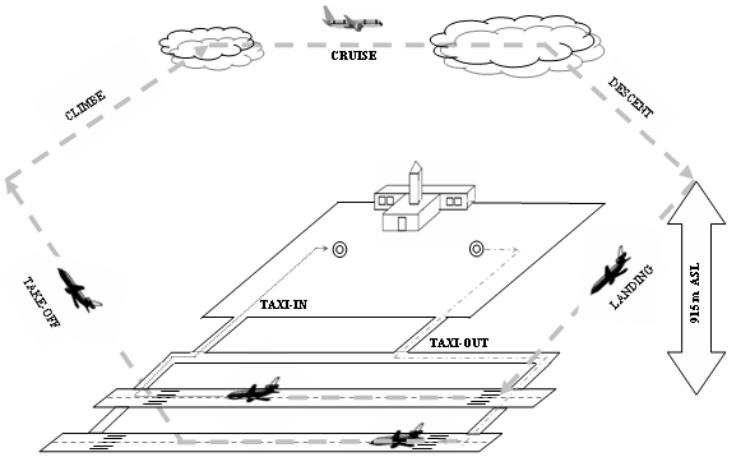

Figure 1. ICAO reference LTO cycle

This work deals with estimating aircraft LTO cycle emissions (CO_2, CH_4, N_2O, NO_x, CO, NVMOC, SO_2) at Bosnia and Herzegovina International airports. The calculation model is based on flight data recorded by BHDCA (Bosnia and Herzegovina Directorate of Civil Aviation) at Sarajevo International airport for 2009. The flight data also includes type and number of aircraft and number of passengers. Air trafic at other Bosnia and Herzegovina International airports (Banjaluka, Tuzla and Mostar) is insignificent so pollution in the vicinity of these airports is minor.

2. ESTIMATION OF AIRCRAFT EMISSIONS

Air pollutant emission estimation coulld be obtained by the following equation:

$$AE_{p,i} = EF_{p,i} \times LTO_i \quad ...(1)$$

where

p	air pollutant
i	aircraft type (Boeing 737, Airbus 320, ATR72...)
$EF_{p,i}$	emissions of air pollutant *p* from aircraft type *i* for time period *T*
LTO_i	number of LTO cycle for aircraft *i* for time period *T*

Fuel flow and pollution emission rates and times in each operation mode (Table 1.) of the LTO cycle vary which depend on the aircraft type, meteorological conditions and operational considerations at the airport.

Table 1. Distribution of time in LTO cycle

LTO Mode Phase	Time in operating mode minutes	Time in operating mode at SJJ airport minutes	Throttle setting	Mode percentage
Take-off	0,7	0,7	100%	3%
Climb	2,2	2,2	85%	9%
Approach	4	4	30%	16%
Taxi/ground idle	26	18	7%	72%
TOTAL	32,9	24,9		

Table 2. Aircraft LTO emissions at Sarajevo airport in 2009

		LTO EMISSSIONS FACTORS/AIRCRAFT (KG/LTO/AIRCRAFT)							
AIRCRAFT	FL/YE	CO_2	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	LTO fuel consupm. (kg/LTO)
FOKKER 100	1394	2390	0,14	0,1	5,75	13,84	1,29	0,76	760
BAE 146	980	1800	0,14	0,1	4,07	11,18	1,27	0,57	570
CRJ-200	694	1060	0,06	0,03	2,27	6,7	0,56	0,33	330
B 737-800	668	2780	0,07	0,1	12,3	7,07	0,65	0,88	880
B 737-400	518	2480	0,08	0,1	7,19	13,03	0,75	0,78	780
A 319	488	2310	0,06	0,1	8,73	6,35	0,54	0,73	730
MD-83	99	3180	0,19	0,1	11,97	6,46	1,69	1,01	1010
A320	50	2440	0,06	0,1	9,01	6,19	0,51	0,77	770
B 737-500	27	2480	0,08	0,1	7,19	13,03	0,75	0,78	780
DHC8-400	2084	640	0	0,02	1,51	2,24	0	0,2	200
ATR72	2929	620	0,03	0,02	1,82	2,33	0,26	0,2	200
TOTAL	9931	13753780	603,32	543,48	40087,82	62263,84	5492,32	4357,33	7010

Compared to ICAO reference LTO cycle, taxi time at Sarajevo airport is shorter due to extent of Sarajevo airport and air traffic frequency. That means pollution emissions at taxi operating mode at Sarajevo airport is lower around 25% which gives differnt distribution per operating mode. Presented flight data recorded by BHDCA does not include some military and general aviation flights so calculated annual pollutant quantities for 2009 (Table 2.) could be considered realistic.

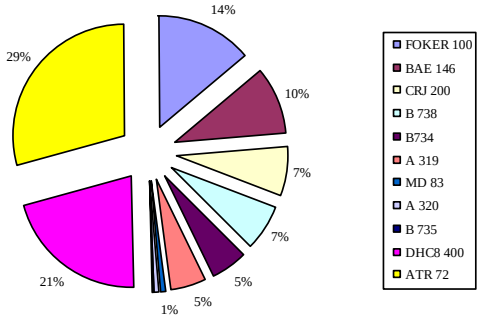

Figure 2. Distribution of aircraft types at Sarajevo airport

Distribution of aircrafts flown to Sarajevo airport (Figure 2.) shows that almost 50% of all flights are performed by turboprop aircrafts ATR72 and DHC8-400. These aircrafts have lower fuel consumption per LTO cycle which cause also lower pollutant emissions. Expected annual rise of air traffic about 20% will cause arrival of bigger aircrafts and consequntly more emissions.

3. CONCLUSION

The estimation of exhaust gas emissions (CO_2, CH_4, N_2O, NO_x, CO, NVMOC, SO_2) of aircraft LTO cycles at Bosnia and Herzegovina airports is presented only for Sarajevo airport due to insignificent air traffic at other airports. Lower duration of taxi mode in comparassion with standard ICAO LTO cycle may cause slight varation of pollution emissions during ground operation.

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