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*Air pollution*

# AIRCRAFT ORIGINATED AIR POLLUTION IN THE EXAMPLE OF CORLU AIRPORT

E. TINMAZ[a*], A. OZKAN[a], A. AKPINAR[b]

[a] *Corlu Engineering Faculty, Departman of Environmental Engineering, Trakya University, 59860 Corlu, Tekirdag, Turkey*
[b] *Corlu Airport, Gozen Air Services, 59860 Corlu, Tekirdag, Turkey*

**Abstract.** Nowadays, air transportation is preferred due to shorter time for transport from one place to other. Although it is preferable, air transportation has some disadvantages, i.e. air pollution. In this paper, air pollution which is caused by air craft exhaust emission, changes of emission characteristics according to the type of planes and their impact on environment carried out in example of Corlu airport (TEQ) which is the nearest airport to other Balkan countries. The type of planes coming especially from Uzbekistan, Tajikistan, Kazakhstan and Russia are Antonov, Iliushin, Tupolev, Cessna, etc. Air emission indices of TU 134 coming to TEQ airport, for example, have been determined. For take-off condition the CO value is 2.7 g/kg, $NO_x$ value is 19.1 g/kg, and HC value is 0.12 g/kg. By taking into consideration the emergence action plans and using emission factors, emission values for each type of plane have been determined.

*Keywords*: aircraft, emission index, $NO_x$, $SO_x$.

## AIMS AND BACKGROUND

*Sources and properties of air pollutants.* Air contains natural contaminants such as pollen, fungi spores, salt spray and smoke and dust particles from forest fire and volcanic eruptions. It contains also naturally occuring carbon monoxide (CO) from the breakdown of methane ($CH_4$); hydrocarbons in the form of terpenes from pipe trees; and hydrogen sulphide ($H_2S$) and methane ($CH_4$) from the anaerobic decomposition of organic matter.

The use of fossil fuels for heating and cooling, for transportation, for industry and for energy conversion and incineration of various forms of industrial, municipal and private waste contributes to the air pollution of the atmosphere. So do the handling and processing operations of various industries. The sources of these pollutants are so numerous and varied that they have been categorised into four main groups – mobile transformation (motor vehicles, aircraft, railroads, ships and the handling and/or evaporation of gasoline); stationary combustion (residential, commercial and industrial power and heating, including steam-powered electric power plants); industrial processes (chemical, metallurgical and pulp-paper industries and petroleum refineries), and solid-waste dis-

* For correspondence.

posal (household and commercial refuse, coal refuse and agricultural burning). The activities that accounted for most of the overall air contaminants are shown in Table 1 (Ref. 1).

**Table 1.** Sources of air pollutants[1]

| Sources | Pollutants (in million tonnes per year) | | | | | |
|---|---|---|---|---|---|---|
| | CO | $SO_x$ | HC | $NO_x$ | particulates | total |
| Transportation | 61.1 | 0.9 | 7.8 | 9.1 | 1.4 | 88.3 |
| Fuel combustion from stationary sources (power, heating) | 2.1 | 19.0 | 0.2 | 10.6 | 1.4 | 33.3 |
| Industrial processes | 5.8 | 3.8 | 10.8 | 0.7 | 3.7 | 24.08 |
| Solid waste disposal | 2.2 | 0.0 | 2.4 | 0.2 | 0.9 | 9.7 |
| Miscellaneous (forest fires, agricultural) | 6.2 | 0.0 | 2.4 | 0.2 | 0.9 | 9.7 |
| Total | 85.4 | 23.7 | 21.8 | 20.7 | 7.8 | 159.4 |

*Introduction of TEQ airport.* Corlu airport has been served since 1998. International ICAO code of Corlu airport is LTBU (TEQ). The distance between Corlu town and TEQ airport (22 265 km$^2$) is 15 km and the coordinates of TEQ airport are 41° north and 27° east. The aim for constraction of TEQ airport is to reduce the overburden of Atatürk airport. Aircrafts coming to TEQ airport predominantly are of Russian origin. The types and properties of these air planes are shown in Table 2 (Ref. 2).

**Table 2.** Type and properties of aircrafts coming to TEQ airport[2]

| Type of aircraft | Category | Max.take-off weight (t) | Passenger capacity (persons) |
|---|---|---|---|
| Antonov 12 | cargo | 61 | cargo |
| Antonov 24 | passenger | 22 | 48 |
| Antonov 26 | cargo | 24 | cargo |
| Antonov 28 | passenger | 8 | 15 |
| Antonov 72 | passenger | 17 | 32 |
| Antonov 74 | passenger | 21 | 38 |
| Ilyushin 18 | passenger | 64 | 105 |
| Ilyushin 62M | passenger | 167 | 232 |
| Ilyushin 76 | cargo | 180 | cargo |
| Ilyushin 76TD | cargo | 190 | cargo |
| Ilyushin 86 | passenger | 210 | 316 |
| Ilyushin 96 | cargo | 215 | cargo |
| Tupolev 134 | passenger | 49 | 72 |
| Tupolev 154 | passenger | 100 | 164 |
| B 737-200 | passenger | 60 | 150 |
| A 300 | passenger | 170 | 200 |

## AIRPORT ORIGINATED AIR POLLUTION

*Effect of aircraft movement on air pollution.* There is an important relationship between aircraft movement and air pollution, although this relationship is different according to the type of aircraft. In Turky, most of the airtraffic is caused by jets which are subsonic. The flight level of these aircrafts, generally, is between 25 000-60 000 ft. The main emissions of aircrafts are CO, $CO_2$, $NO_x$, $SO_x$, NMVOC, unburned hydrocarbons, etc. Water vapour forms ice clouds behind the aircraft. These clouds reflect the radiation coming from sun and so the radiation ratio reaching the earth is reduced. Consequence of this event, and it is by no means exaggerating to say that aircraft originated air pollution is a reason for global warming[3].

Aircraft engines burn fuel and producing emissions. The impact of these emissions give rise to concerns both at ground level and at the global level, where the principle concern is aviation's contribution to climate change.

In the nearest vicinity of airports, concerns focus on the potential health and environment effects of emissions such as nitrogen oxides ($NO_x$) and particulates. Also at ground level, but more widely spread, there are concerns that aircraft engine emissions such as $NO_x$ may contribute to acid rain.

Pollutant formation in combustion, regulated aircraft emissions during landing/take-off, and currently unregulated cruise emissions are covered in some depth[4]. The principal points briefly described here, with somewhat greater details given to more recent findings about soot and particulate emissions.

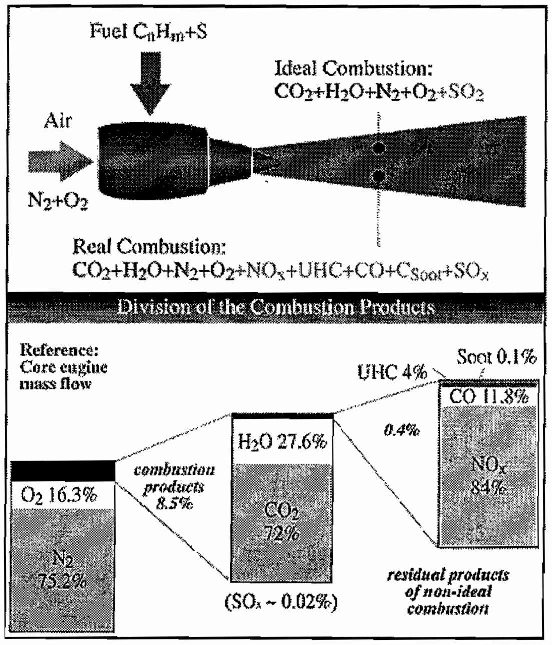


**Fig. 1.** Scheme of ideal combustion products (top) and all existing combustion products[4]

Under ideal conditions, combustion of kerosene-type fuels produces carbon dioxide ($CO_2$) and water vapor ($H_2O$), the proportions of which depend on the specific fuel carbon to hydrogen ratio. Figure 1 shows the ideal and "real" combustion processes and also illustrates the scale of the combustion products by showing that at cruise conditions they constitute only about 8.5% of total mass flow emerging from the engine. Of these combustion products only a very small volume (about 0.4%) of residual products arises from non-ideal combustion processes (soot, HC, and CO) and the oxidation of nitrogen ($NO_x$)[4].

There are numerous reasons for differences in aircraft emissions – vehicle type, aircraft type, flight conditions (Table 4) (Ref. 4).

**Table 3.** Improvements in emissions levels of GE CF6-50E2 engine[4]

| Emission | Applicable ICAO standard | Levels for original production engine | Levels for "low emissions" production engine |
|---|---|---|---|
| Smoke (SN) | 18.8 | 6.5 | 12.5 |
| HC (g kN-1) | 19.6 | 57.8 | 3.4 |
| CO (g kN-1) | 118 | 97.3 | 29.8 |
| $NO_x$ (g kN-1) | 100 | 58.2 | 51.6 |

The type of plane coming from, especially, Uzbekistan, Tajikistan, Kazakhstan and Russia are Antonov, Iliushin, Tupolev, Cessna, etc. Emission indices for these different aircrafts, coming to TEQ Airport, in respect with aircraft type and flight conditions are given in Table 4.

These different flight conditions mentioned above according to ICAO data are shown in Fig. 2.

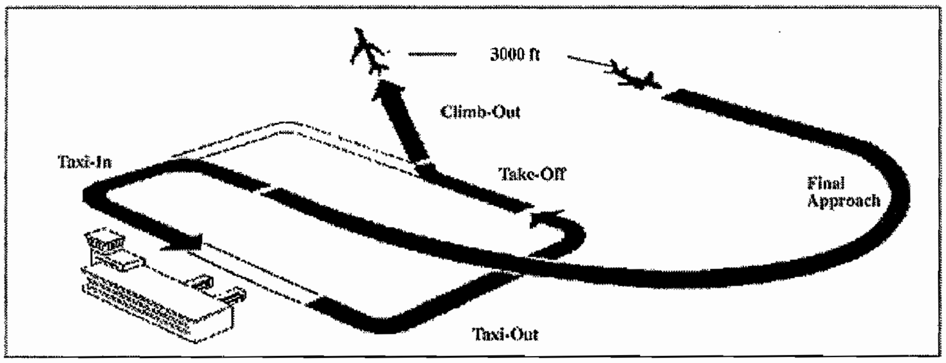


**Fig. 2.** The ICAO landing and take-off cycle (LTO)[4]

*Control of aircraft originated air pollution.* The first legal regulation about control of emission of aircraft exhaust gases was made by USA Environmental Protection Agency (EPA) in 1970 and emissions of CO, HC, $NO_x$ were restricted in circulation of take-off landing[6]. The first international restriction for some of the gaseous pollutants was published in Annex 16, volume 2 (Civil Avaition Convention) in 1981, by the International Civil Avaition Organization[7]. To secure the emission standards which is mentioned in this convention, it is stipulated that subsonic jets should be certificated in respect of smoke, unburned HC, CO and $NO_x$. To be certificated, motors must be tested.

**Table 4**. Emission indices of various type of aircrafts (g pollutant / kg fuel )[5]

| Type of aircraft | Take-off condition | | | Climb-out condition | | | Approach condition | | | Idle condition | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | $NO_x$ | HC | CO | $NO_x$ | HC | CO | $NO_x$ | HC | CO | $NO_x$ |
| TU 134 | 0.12 | 2.7 | 19.1 | 0.14 | 3.2 | 16.3 | 1.5 | 14.5 | 7.0 | 43.6 | 60.3 | 3.6 |
| TU 154 M | 0.12 | 0.35 | 37 | 0.12 | 0.4 | 31.5 | 0.2 | 0.9 | 11.8 | 0.3 | 6.9 | 5.8 |
| TU 154 A | 2.0 | 5.0 | 13.9 | 2.0 | 6.0 | 12.9 | 2.6 | 13.0 | 5.4 | 32.0 | 64.0 | 2.7 |
| IL 76 | 0.7 | 2.2 | 16.5 | 0.8 | 2.8 | 13.5 | 2.7 | 15.4 | 6.3 | 13.3 | 62.4 | 3.3 |
| IL 62 | 0.3 | 2.8 | 16.3 | 0.4 | 3.7 | 12.6 | 1.2 | 11.8 | 5.1 | 10.5 | 54 | 2.7 |
| IL 96 | 0.4 | 3.0 | 14.5 | 0.5 | 3.6 | 11.6 | 1.9 | 18.2 | 5.1 | 12.7 | 77.7 | 2.9 |
| IL 86 | 0.5 | 3.9 | 12.8 | 0.6 | 4.2 | 12.1 | 1.2 | 9.3 | 5.1 | 52 | 54.4 | 2.7 |

The new limits relate to nitrogen oxides ($NO_x$). Emissions of $NO_x$ from aircraft engines have a direct impact on air quality, particularly in the vicinity of airports, and they contribute to the production of ozone, which is a greenhouse gas.

ICAO engine emission standards were first established in 1980 in Annex 16 to the Convention on International Civil Aviation. In 1993, the original limits for $NO_x$ were reduced by 20%, on an earlier recommendation by CAEP. The new limits represent a further reduction by an average of about 16% and will be applicable to new engine designs after 2003.

Annex 16 Convention's new arranged and additional form, without any change, was accepted in Turkey, in June 24,1993. In addition to this, to prevent air pollution, Air Quality Protection Regularity has been in force since November 2, 1986.

## CONCLUCIONS

Several important conclusions can be drawn from the present assessment of combustion technology in relation to emissions production and control.

- Research and development programs over the past 25 years have provided a basis for vastly improved combustion systems for modern aircraft engines. Current combustion systems achieve virtually 100% energy conversion efficiency at virtually all power settings. Better fuel/air mixing processes, linear cooling techniques, and materials have contributed to this progress. The levels of unburned products, such as CO and HC, from engines are now very low, and visible smoke levels are now under control.
- Reductions in $CO_2$ depend primarily on engine cycle, not on the combustor. The role of the combustor is to ensure that the demands of the more fuel-efficient cycle (low $CO_2$) are met without compromising engine performance.
- The more fuel-efficient engines, with their high bypass ratios, introduced in the 1970s and 1980s reduced $CO_2$, HC, and CO emissions but increased $NO_x$. Although technological improvements have constrained the rise in $NO_x$, it has become clear that more substantial reductions require more radical solutions (with associated risks and penalties).
- Technology that has reduced $NO_x$ emissions at high power, near the ground, also reduces $NO_x$ at high altitude, though not necessarily by the same amount.
- Current research goals are to achieve $NO_x$ levels of 50% of current standards in 5 to 10 years. Work is also in progress to achieve $NO_x$ levels 50–70% below current $NO_x$ standards using more advanced, staged combustors.
- Although there has been a marked improvement in the measurement and assessment of trace species and aerosols emerging from engines, knowledge about their formation – hence our ability to control them – is extremely limited.

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