CORRECTION OF THE MODEL FOR ASSESSING THE EMISSION OF HARMFUL EXHAUST EMISSIONS FROM THE ENGINE OF A SMALL AIRCRAFT DURING THE FLIGHT

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The average daily air traffic in the world in June 2014

190 000 flight operations

It is estimated that 30% is GA
General Aviation – all aircraft except scheduled and military aviation

It is difficult to estimate the number of operated aircraft with piston engines
Fuel consumption in the sector GA in the world in years 2000-2012 with a forecast for 2032

- Avgas
- Jet Fuel

1 kg 100LL – 0.74 g Pb
443 – 516 tons Pb/year

600 000 - 700 000 tons/year

10% 5%
Exhaust emissions tests in pre-flight test

We measure the exhaust gas harmful compounds:

$\text{CO}_2$, $\text{CO}$, $\text{NO}_x$, $\text{HC}$
We measure the compounds harmful exhaust gases during flight.

$h_{\text{fly}} = 1700 \text{ m}$

Steady flight

Descent

Take-off, ascent

Poznan-Lawica

Descent, approach to land, landing

Start-up, Taxing

Cirrus SR20
The result is the measurement of emission of harmful exhaust gases in the flight.
We can not measure the exhaust emissions of an aircraft during the flight.

There is no way to install the analyzer.
We have developed the emission model

\[ m_j = e_j \cdot N_e \cdot t_{fly} \]

where:

- \( m_j \) – mass of the exhaust gas compound \( j \) [g],
- \( e_j \) – specific emission of the exhaust gas compound \( j \) [g/kWh],
- \( N_e \) – effective power resulting from a given load [kW],
- \( t_{fly} \) – flight duration at a given load [h].

\[ t_{fly} = t_{asc} + t_{steady} + t_{land} \ [s] \]

\[ t_{fly} = \frac{h_{fly}}{v_{asc}} + t_{steady} + \frac{h_{fly}}{v_{dsc}} \ [s] \]

\[ t_{steady} = t_{fly} - h_{fly} \left( \frac{1}{v_{asc}} + \frac{1}{v_{dsc}} \right) \ [s] \]
We have developed the model

\[ m_j = \frac{e_j \cdot N_{e_{\text{max}}} \cdot W}{3600} \]

\[ W = \frac{h_{fly}}{v_{asc}} + 0.7 \left( t_{fly} - h_{fly} \cdot \left( \frac{1}{v_{asc}} + \frac{1}{v_{dsc}} \right) \right) + 0.2 \left( \frac{h_{fly}}{v_{dsc}} + t_{op} \right) \]
NO CONFORMITY !!!
Correction of the fuel mixture composition

- **Start-up, taxiing**
- **Take-off, ascent**
- **Steady flight**
- **Descent, approach to land, landing**
- **Taxiing**

![Graph showing emissions over time](image)
**Correction of the model**

\[
m_j = \frac{e_j \cdot N_{e,\text{max}} \cdot k_{T_j}}{3600} \cdot R
\]

\[
R = \left( \frac{h_{\text{lot}}}{v_{\text{wz}}} + 0,7 \left( t_{\text{lot}} - h_{\text{lot}} \left( \frac{1}{v_{\text{wz}}} + \frac{1}{v_{\text{zn}}} \right) + t_\lambda \left( w_\lambda - 1 \right) \right) + 0,2 \left( \frac{h_{\text{lot}}}{v_{\text{zn}}} + t_\text{ol} \right) \right)
\]

<table>
<thead>
<tr>
<th></th>
<th>( k_T )</th>
<th>( w_\lambda )</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>0,31</td>
<td>0,025</td>
</tr>
<tr>
<td>HC</td>
<td>0,60</td>
<td>1</td>
</tr>
<tr>
<td>NO(_x)</td>
<td>1,05</td>
<td>10</td>
</tr>
<tr>
<td>CO(_2)</td>
<td>0,44</td>
<td>1,3</td>
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Conklusion

Good agreement with the measurement model in flight
Thank you for attention!