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Hazards in the Polish Civil Aviation resulting from engines failures

Abstract: Published by the Civil Aviation Authority in May 2017, the State Safety Programme 2017-2020 in the appendix A presents "Events Data - 2016". Detailed description of the hazard arising from the technical condition of aircraft limits to the general presentation of the events in terms of SCF-NP (System Component Failure Non Powerplant) and SCF-PP (System Component Failure Powerplant). The analysis of these events performed in the Institute of Aviation (aviation events reports are collected in the European Coordination Center for Accident and Incident Reporting System database - ECCAIRS) has shown that the general aviation and commercial aviation (CAT) should be treated separately. Especially events caused by the powerplants failures must be considered separately for piston, turbofan, turboshaft, turboprop types and also their each installation has to be taken into account. Events caused by the technical condition of aircraft, especially engines, are the most common cause of accidents in general aviation. The aim of the article is to improve risk awareness and, ultimately, reduce the number of the aviation events associated with exploitation of the piston engines. Particularly significant impact on reducing the number of accidents in general aviation can be achieved by the implementation of modern technical solutions to control the technical condition of the engines and reduce their operating costs, while operators are fully aware of the risks resulting from the possibility of extending engine time on wing. In conclusion: reversing the dangerous trend of piston engine failures causing aviation safety hazards requires, above all, changes in the way these engines are operated.

Keywords: Civil Aviation; Engines failures

Introduction

Published by the Civil Aviation Authority in May 2017, the National Security Plan 2017-2020 in Appendix A presents "Data on events - 2016". A detailed description of the hazard resulting from the technical condition of aircraft limits to the general presentation of aviation events in SCF-NP categories (System Component Failure Non-Powerplant) and SCF-PP (System Component Failure Powerplant). The analyzes of these events carried out at the Institute of Aviation (reported aviation events are collected in the ECCAIRS database for the Accident and Incident Reporting System) indicate that a contractual type of aviation should be treated separately (general and commercial aviation). Especially, events caused by the failure of aircraft propulsion units must be considered separately with the division into the type of power unit (piston, turboprop, turbine helicopter, jet turbine), including individual installations in accordance with ATA-100. Works related to the statistical and technical analysis of aviation events have been conducted for several years at the Institute of Aviation, and their results are presented in articles [2], [3], [4], [5], [9], [10]. Events caused by the technical condition of the aircraft, and in particular, engines are the most common cause of accidents in general aviation.

The aim of the activity, as well as the purpose of this publication, is to improve the risk awareness and ultimately reduce the number of aviation events associated with the use of engines. The implementation of modern technical solutions enabling the technical condition of used engines and lowering the costs of their operation while maintaining full awareness of the risk resulting from the possibility of extending the engine's service can have a particularly significant impact on reducing the number of accidents in general aviation. The method of operation of air piston engines developed by the Institute according to the technical condition [8] meets these needs.

Airline events caused by engines - in statistical terms

The ECCAIRS database is based on reports of aviation incidents by various airline services. It is very extensive and currently contains about 7000 events occurring in air traffic in 2008 ÷ 2016. Aircraft propulsion engines from 2008 to the end of 2016 were the cause of the following number:

a. Turbine helicopter engines – 122
b. Turboprop engines – 101
c. Turbine jet engines – 124
d. Piston engines – 207

As the number of aircraft participating in the air traffic was changing at that time, in order to objectify the analysis of the data, coefficients were introduced referring to the number of events caused by engine failures to the number of registered aircraft. This is not the most precise method for determining the intensity of incidence of disability. However, as long as the total airplanes of general aviation aircraft are not known, objective comparisons will only be possible in relation to the number of registered aircraft. The article uses the coefficients K1000 described in formulas 1.1 and 1.2 as follows:

$$K_{1000s(\text{indeks dla silnika})} = \frac{LZ}{LSP} \cdot 1000 \qquad (1.1)$$

where:
LZ – number of aviation events caused by specific engine type defects.
LSP – number of aircraft driven by a specific type of engine..
while,

$$K_{1000a(\text{indeks dla silnika})} = \frac{LA}{LSP} \cdot 1000 \qquad (1.2)$$

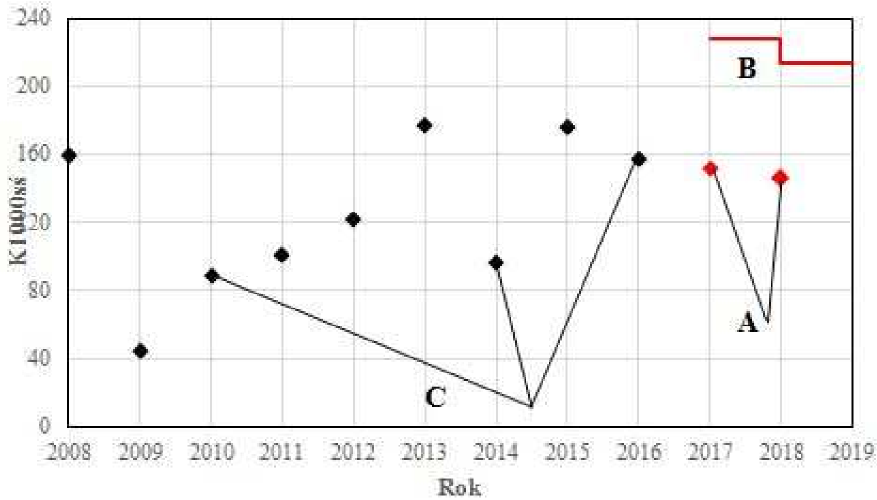
where:
LA – number of emergency landings, interrupted flights and takeoffs caused by faults of a particular type of engine.

Engine indexes:
ś – turbine helicopters,
tś – turboprop,
o – turbine jet,
t – piston.

The forecasted average and maximum values of coefficients for individual types of aircraft engines were determined in accordance with the methodology described in [4] and [5].

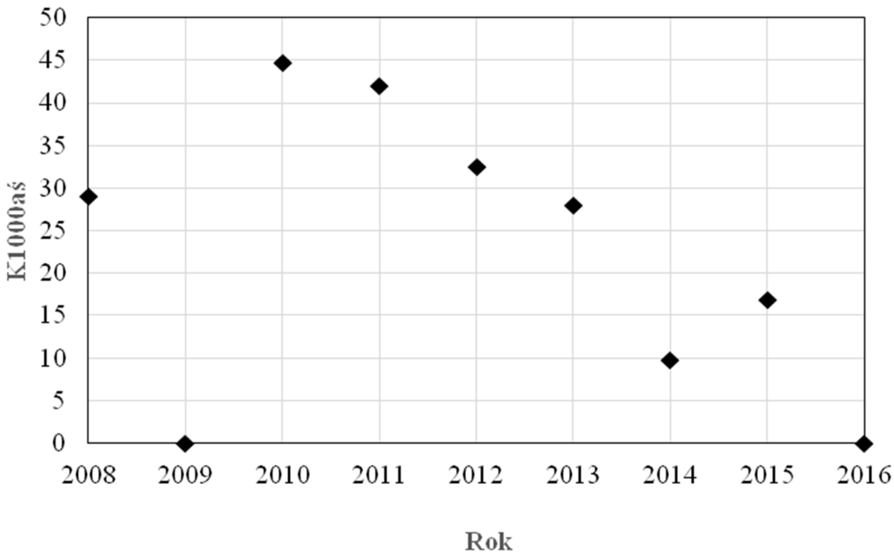
Turbine helicopter engines

In Figure **1**. values of K1000 are calculated for all reported aviation events caused by helicopter turbine propulsion engines. The red color indicates the projected average values of this coefficient for 2017 and 2018. The continuous red line determines the forecasted maximum values in years 2017÷2018 and 2018÷2019.



1. Current and forecast values of K1000sś, A - forecasted mean value of the coefficient for 2017 and 2018, B - forecasted maximum values of the coefficient for 2017 ÷ 2018 and 2018 ÷ 2019, C - actual current values of the coefficient

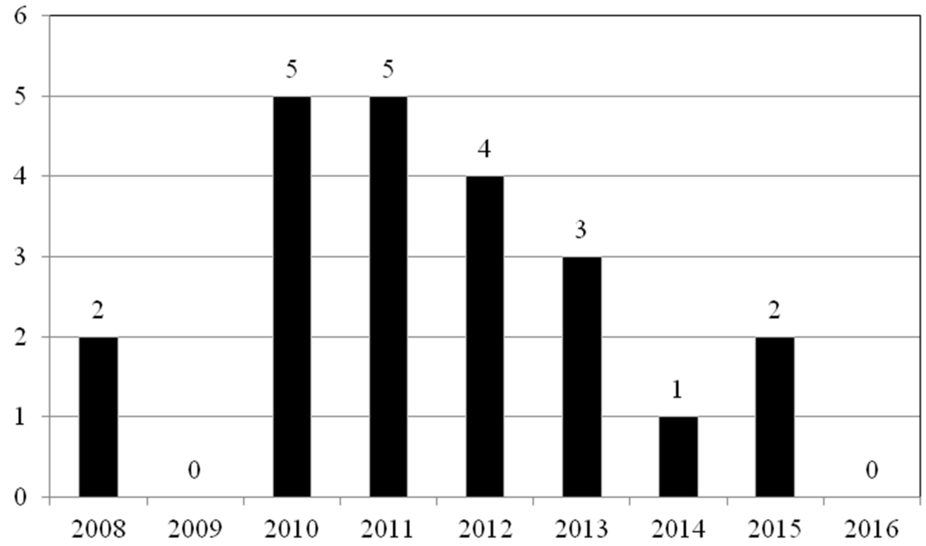
However, the factor K1000aa of the number of serious events ended with an emergency landing, interrupted flight or take-off is shown in Fig. **2**.



2. Change in the K1000aś factor in years 2008÷2016

There is a systematic decrease in the coefficient determining the level of dangerous situations caused by failures of helicopter turbine engines.

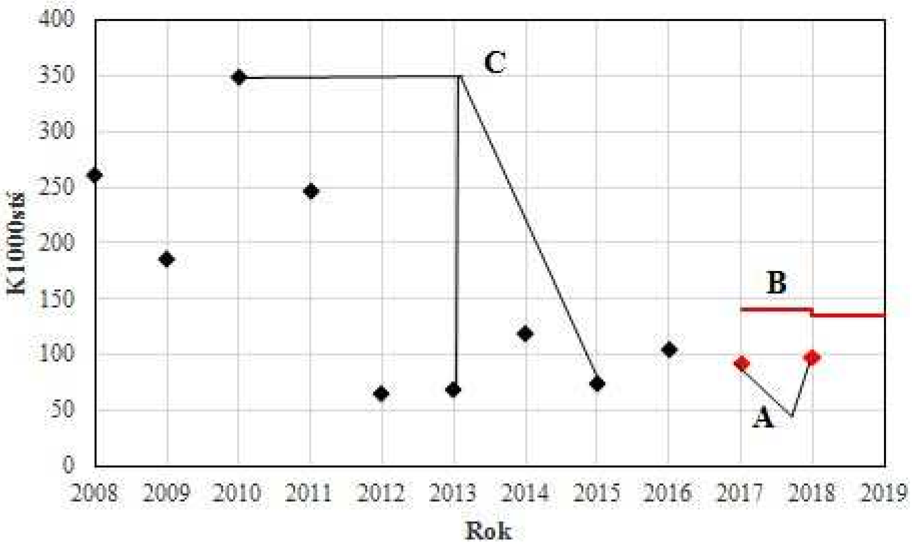
Figure **3** presents in absolute numbers the aviation events ended with an emergency landing, interrupted flight or take-off of helicopters powered by a turbine engine.



3. Number of emergency landings, interrupted flights and helicopter launches caused by engine failures in years 2008÷2016

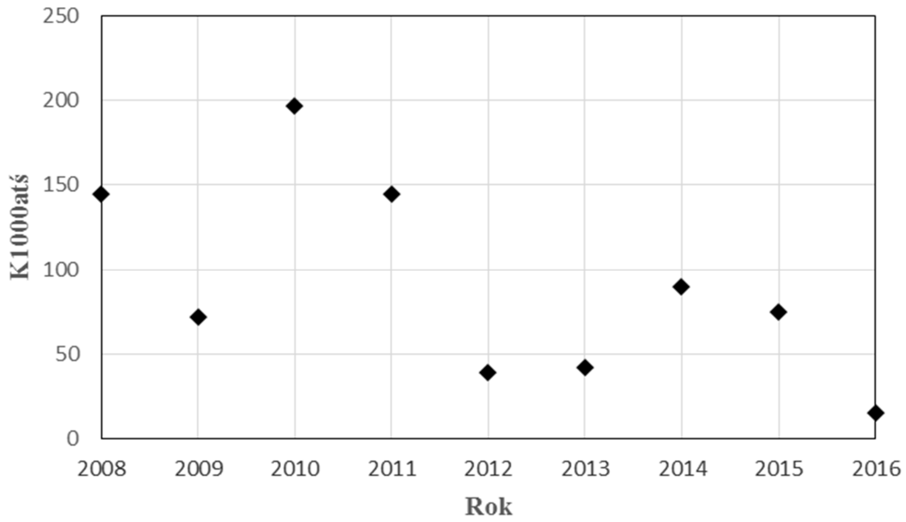
Turboprop engines

Figure **4.** presents identical parameters as Fig.1. so that for turboprop engine.



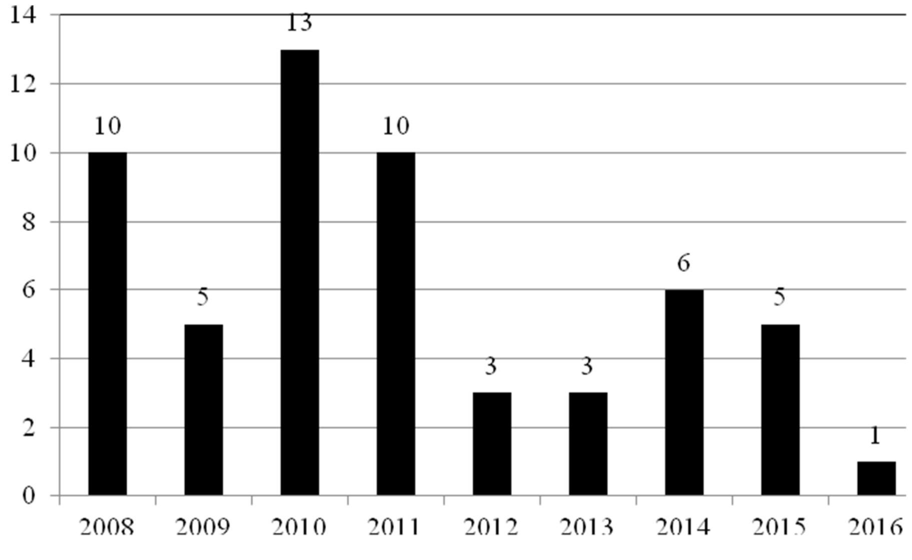
4. The current and forecast values of the K1000stś coefficient (as shown in Fig. 1.)

The probable cause of a significant decrease in 2012 and subsequent years of the aviation events factor caused by defects of turboprop engines in comparison to previous years was the replacement of the fleet, and thus the type of engine of one from air operators. Figure **5**. shows the change in the value of the coefficient $K_{1000atś}$.



5. Change in the K1000atś coefficient in years 2008÷2016

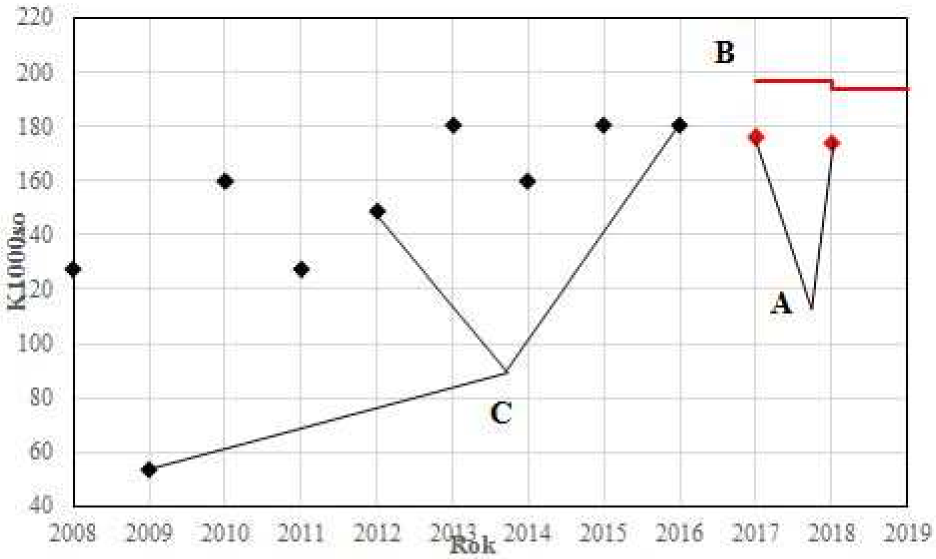
However, the absolute number of serious events caused by turboprop engines is shown in Fig. **6.**



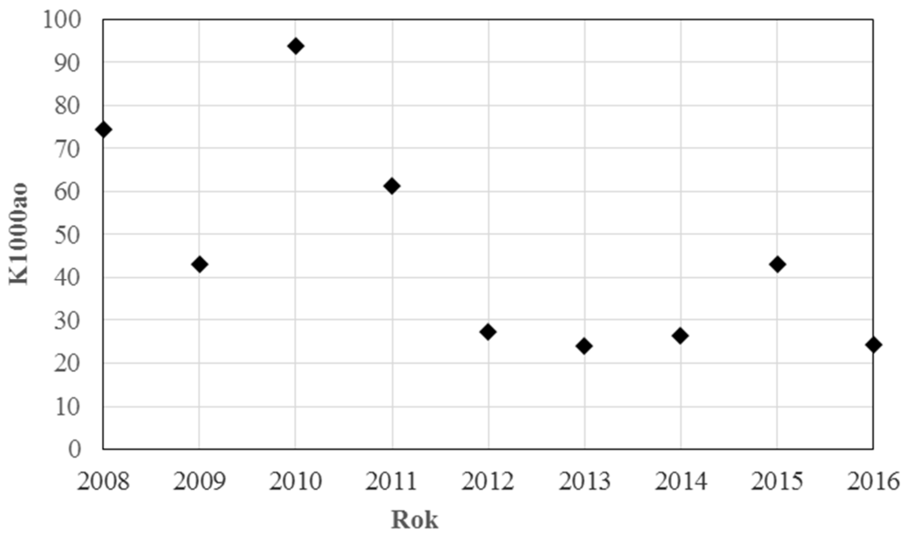
6. Number of emergency landings, interrupted flights and takeoffs of turboprop aircraft caused by engine defects in the years 2008÷2016

Turbine jet engines

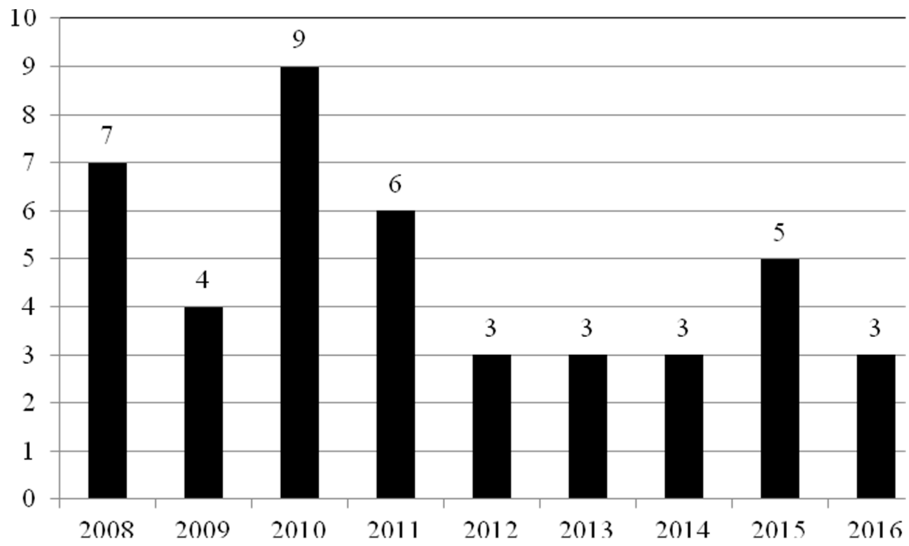
The considered factors for turbine jet engines, both for all aviation occurrences (Fig. **7**.) And the second (Fig. **8**.) For emergency situations, remain constant since 2012. This is also confirmed by the number of these events presented in Fig. **9**.



7. Current and forecast values of the coefficient K_{1000so},(markings as in Fig. 1.)



8. Change in the value of the coefficient K_{1000ao} in years 2008÷2016

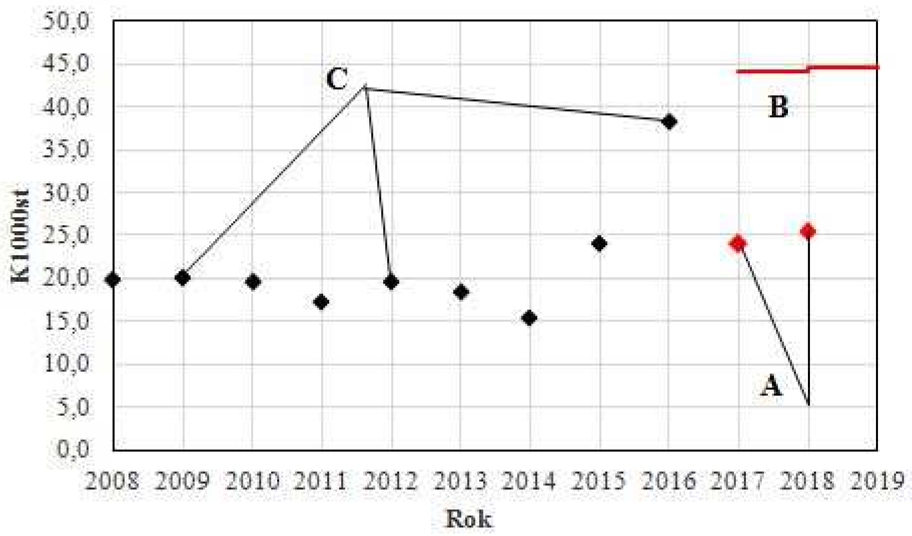


9. Number of emergency landings, interrupted flights and take-offs of jet aircraft caused by engine defects in years 2008÷2016

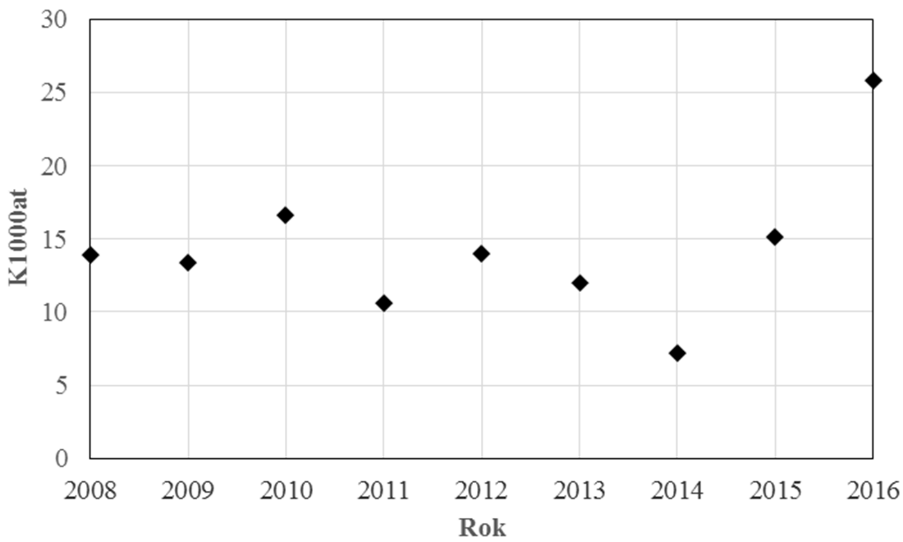
The above-described coefficients of reported events caused by aircraft engines related to almost 100% of two-engine aircraft. Failure of one engine does not cause a dangerous situation yet, and the technique of landing with one working engine is described in the airplane flight instructions. The number of emergency landings interrupted flights and take-offs is very small. High values of coefficients result from a small number of operated aircraft and characterized by a significant intensity of flying. From the analyzes carried out so far in [2] and [6], it follows that the failures of helicopter turbine engines, turboprop engines and jet turbines operated in the national aviation do not pose a risk to the safety of flying.

Air piston engines

The situation regarding piston air engines is different. The authors of the article would like to draw the attention of the reader to the fact that the coefficients and numbers presented below do not apply to engines built on motor gliders, motorboats, motoparalots and ultralight aircraft. It should also be emphasized that in national aviation about 95% of registered piston aircraft are powered by one engine. Figures **10** and **11** they present a picture of a significant increase in the factors discussed in the article.

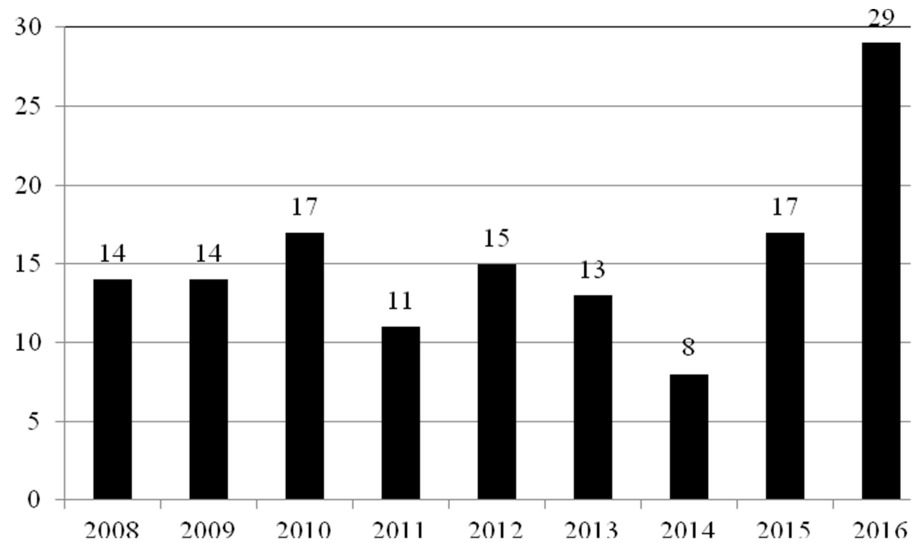


10. Current and forecast values of the coefficient K_{1000st},(markings as in Fig.1.)



11. Change in the K_{1000at} coefficient in years 2008÷2016

This is also confirmed by more than threefold increase in the number of emergency situations caused by the failure of piston engines, shown in Figure **12**. It should be mentioned that the number of registered aircraft has not changed significantly - 1107 in 2014, 1123 in 2015 and 1124 in 2016.



12. The number of emergency landings, interrupted flights and take-offs of aircraft powered by piston engines caused by engine failures in the years 2008÷2016

Detailed analysis of the situation related to the malfunctions of aircraft piston engines operated in our country, and presented in [2] and [6], do not leave any doubts that these engines pose a threat to the safety of domestic aviation.

Summary

The reversal of the dangerous growth trend of the failure of reciprocating engines that poses a threat to aviation safety requires, above all, a change in the way in which these engines operate. According to the authors, a new engine operation system should be introduced, described in [8], indicated in the introduction to the article.

The Civil Aviation Office, accepting the conclusions presented from the conducted analyzes, admits the possibility of operating selected types of reciprocating engines in accordance with the method presented in [8], but its use is not an obligatory activity.

The implementation of a commercial offer beneficial to the user may result in the improvement of awareness of the risk of engine operation and, as a result, a reduction in the number of aviation incidents related to their use.

Source materials

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