ANALYSIS OF TURBOPROP ENGINES TEST RESULTS AND A PROPOSAL TO IMPROVE THE RELIABILITY

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Summary. This paper deals with a success of aircraft engines during their tests and it searches ways how to improve conditions. The conditions improving is always very desirable and benefit activity. The paper also deals with a data collection, their detailed statistical analysis and it deals with an implementation of the gained conclusions into the experience too. These conclusions must be checked and it must be found out if they are suitable for the experience. There is a small comparison between an old and a new type of an engine pennant at the end of the paper. Results of the comparison are quite interesting.

Keywords: statistical analysis, data collection, turboprop engine, model, general overhaul, success

1. INTRODUCTION

The reason why we write about this topic is that we and readers will learn about principles of aircraft engines and we will use our theoretical knowledge in the experience. A solution of this problem, which is mentioned in the paper, is one of our main tasks in terms of our workload. An interconnection of a theoretical and practical dealing with the problem increases our skills.

An engine resources exploitation for increasingly longer period of time or aging of an engine results in an exploitation of an imaginary power source of the engine. This shows the increased number of engines not-passing throw engine tests. This is an undesirable condition. The not-passing engine means that the engine does not fulfil the conditions of the design directive.

2. PROCESS OF THE DATA ANALYSIS

An engine type classification for the statistics

It is important to have an appropriate set of data, if we want to have a right and informative statistical analysis. The set of data has to be sorted by the engine type. Each type differs by the engine power or by the scanned temperature, for example. The X type of the data and its derivatives have the biggest quotient of the set of the data. The derivatives X-2 and X-3 are inappropriate for us. Both derivatives have different limits for the generator RPM and for the temperatures between turbines (T4) for a given engine power. Our research are going to work only with the engines X and X-1. [1]

Now, the set of the data can be filter or sort by several aspects. The main aspects are the two types of rear wall of the compressor, the outside pennant. We have four researched areas because of this. Now, we must define control elements for the analysis. The elements are the switchboard of the generator turbine (SGT), the switchboard of the free turbine (SFT) and the backlash V 3/1. Adjustments of these control elements have a direct influence to the engine parameters. We can specifically influence the parameters because of this. [2]

The next step is the statistical analysis of the sorted data. It explores interactions between researched components and the parameters. We have to authenticate a previously described condition and eventually, we have to describe differences between present and previous conditions.

3. THE BASIC STATISTICS OF THE ENGINES TESTS

Now, we are summarizing some basic statistics of the engines tests and we are also analysing the targeted statistical research in some ways. This analysis is important for more accurate description of the physical situation.

3.1 A success of the engines during tests

It represents a ratio between engines with right results and engines with some kind of a defect that affect the engine power or the reliability. These statistics are recorded from the beginning of the year 2011. There is a success of each month in the Figure 1. There is a limit that could be good to reach too.

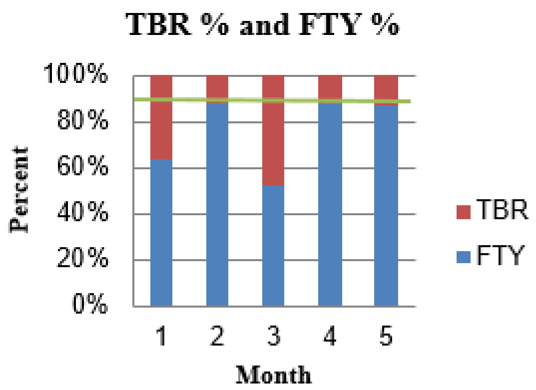

Figure 1 Monthly FTY progress; TBR – a bad test, FTY – a good test

We have better summary about a difficulty of an engines assembly in each month, if we display the number of the defects and the number of the engines in the figure. The Figure 2 shows various fluctuations between months too.

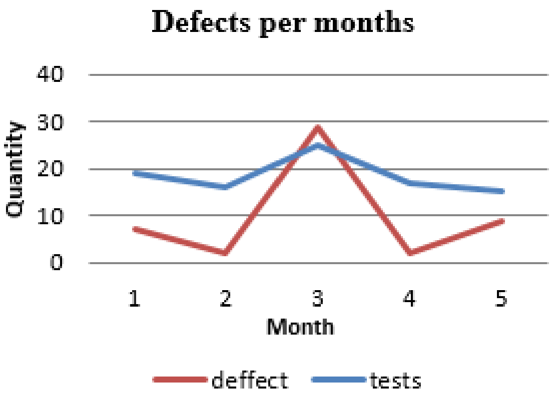

Figure 2 An illustration of the defects trend development

It is obvious from this figure that the number of the engines and the number of the defects are related. The Figure 3 confirm this statement.

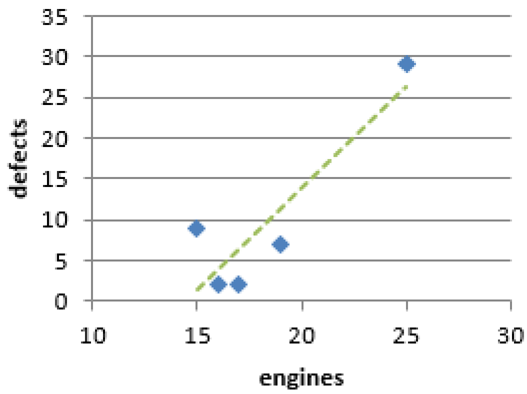

Figure 3 The dependency of the number of the defects on the number of the assembled engines

The Figure 3 shows that with increasing number of the engines the number of potential defects is increasing too. The number of values is quite small so a correlation between the tests and the engines is 88.7 % in this set. In this case, we can say that this is a strong dependence. Further points adding confirms or disproves this dependence. The next logical step is to do a linear regression. It is displayed in the Graph 3 (a green dashed line). If we put the numbers into the equation of the regression, we find out that it is possible to produce even 14 engines per month without the defects identified during the tests. Then, the number of the defects grows up. If we produce 20 engines per month, 13 defects that influence the engine quality can be found out. If we increase the number of the produced engines per month twice (40 engines), the number of the possible defects will increase almost five times (63 defects per month).

3.2 A success of the tests by a general overhaul order

A success that is sorted by general overhauls can suggest ways which we should follow.

Mostly, the ways are changing or keeping the components during the general overhaul (GO). If we have a right analysis, we can enhance the engines status and decrease costs for repeating the tests. The set of the data of which we come out is from the beginning of the year 2009 till half of the year 2011 (13th June 2011). The values mentioned in the Table 1 could be different, if we divided them by years. But it is pointless for this work.

Table 1 The success of the tests for each general overhaul

GO	success
1. GO	77,05 %
2. GO	67,74 %
3. GO	66,67 %
4. GO	78,69 %
5. GO	83,33 %

It is obvious from the Table 1 that the success of the tests after an engines maintenance decreases during the first GO. It means that every fourth engine have to repeat the tests due to some reasons. The number of the engines with the defects is even worse at the second and the third GO. Every third engine does not pass throw the tests. It is bewildering that the fourth and chiefly the fifth GO have much bigger success than the second and the third GO have. This is due to a service live of remaining worn components. The service live is over and these components must be changed during the fourth and the fifth GO. It is possible that the physical condition of the engine is almost the same as a new engine after the fifth GO. [3]

It is also interesting to compare the occurring defects that occur during the tests. There are pie charts in the Figure 4. The charts show which defects occur during the tests.

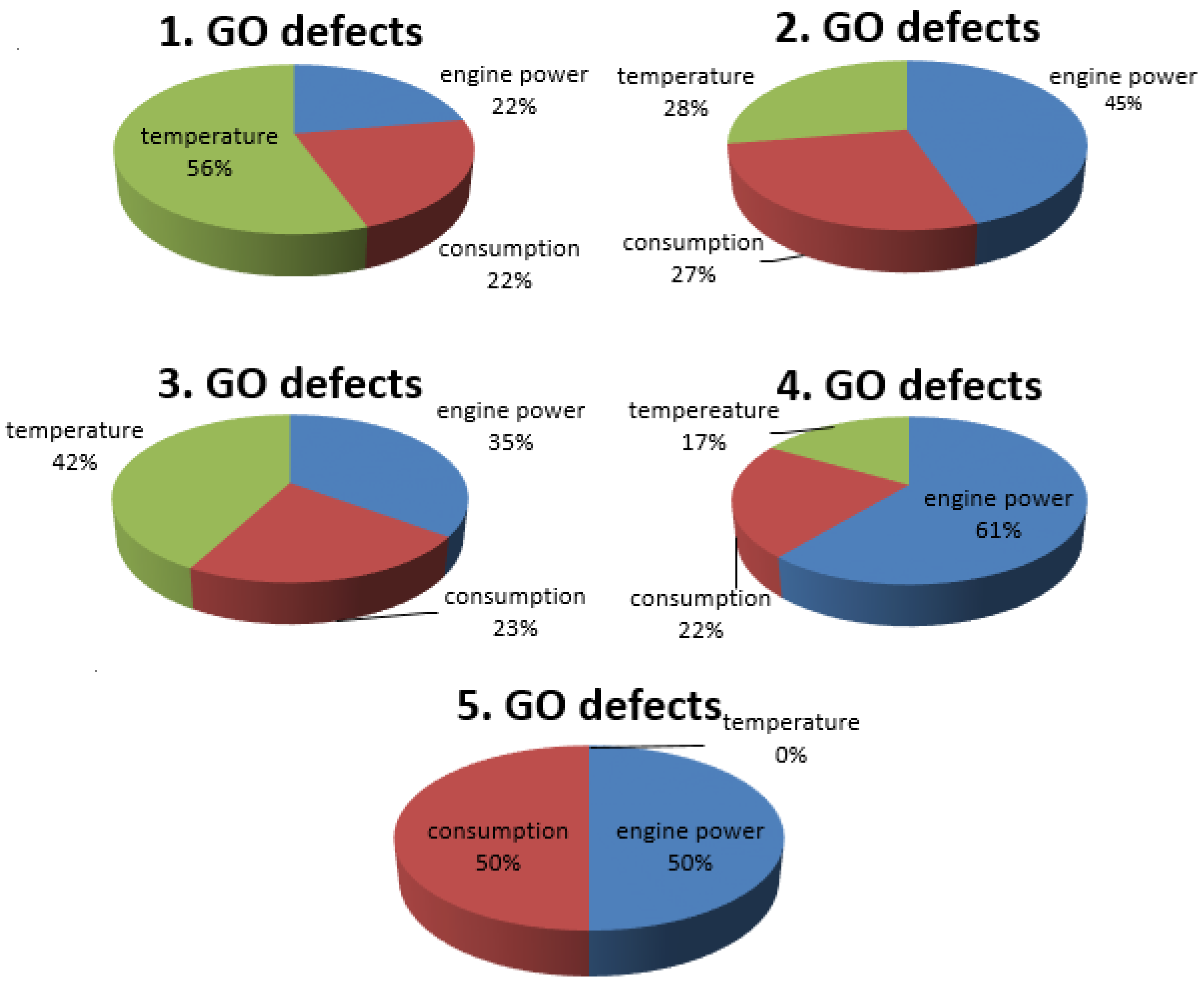

Figure 4 The percentages of the defects of each GO

The first and the third GO have the problems with the temperature while the second and the fourth have the problems with the engine power. The problems with consumption are constant and they are not getting better or worse during each GO. The fifth pie chart is misleading. This is because there are few GOs with only two defects in the set of the data until now. The number of defects will probably grow. The figure 4 shows pie charts with percentage of each type of the defect calculated from the total number of the defects found out during the tests. These charts do not take into account the number of the defects from each test. It means that the engine can have more than one insufficient parameters during one test. These charts represent a quotient of the insufficient parameters and thus they represent the most frequent reason of repeating the test too.

4. COMPARISON OF TEORETICAL AND PRACTICAL REACTIONS OF THE ENGINE GENERATOR RPM

It was very difficult to make a frequency histogram from the gained data. We created two more sets of data because of this. These another sets show how the engine works with every change that have been done. The values of the changes have been theoretically recalculated and they have been compared with real changes. These new sets of the data was used for making two frequency histograms. These histograms show the frequencies of reactions to the changes. There is an evaluation of the reactions in the Table 2 listed below.

Table 2 Review of the engine reactions

bigger reaction	1
right reaction	2
lower reaction	3
no reaction	4
reverse reaction	5

The histograms made from values listed in the Table 2 are in the next two figures. The Figure 5 shows the reactions of the engine with an old type of the outside pennant.

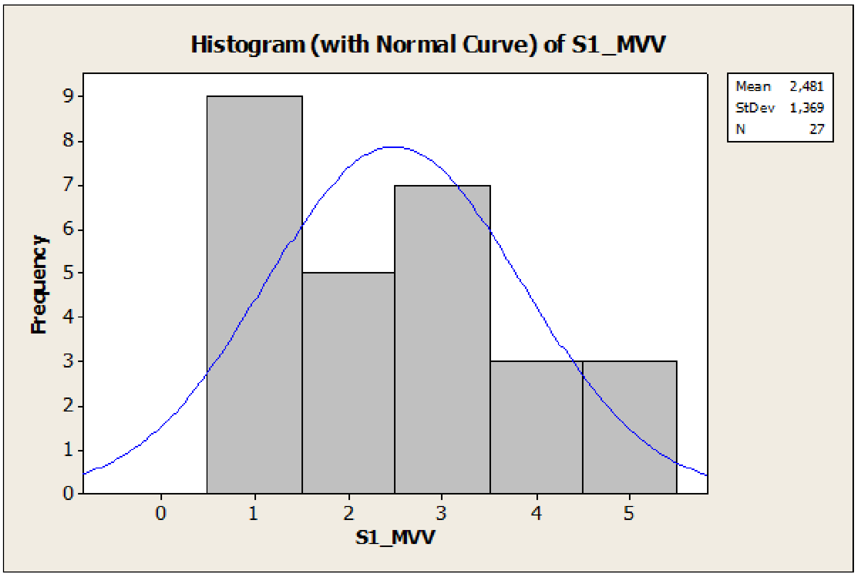

Figure 5 The frequency histogram of the reactions of the engine generator RPM with the old type of the pennant

The Figure 6 shows the most frequent reactions for the engines with a new type of the outside pennant.

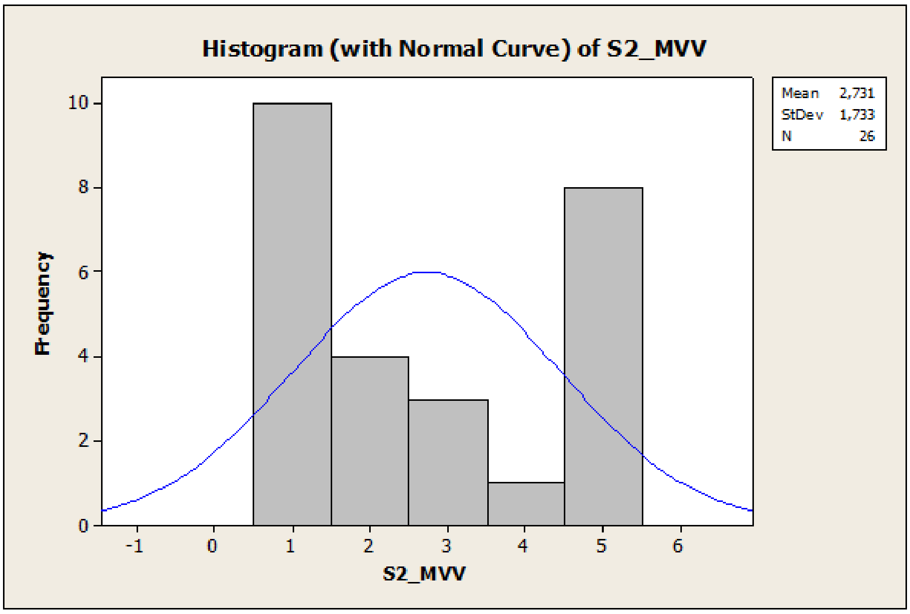

Figure 6 The frequency histogram of the reactions of the engine generator RPM with the new type of the pennant

An ideal condition is represented by column No 2. It is obvious from the histograms that the engines with the old type of the pennant react better and more appropriately than the engines with the new type of the pennant. But it does not mean that the new type of the pennant is worse than the old one. The done changes have been made only by using the same theoretical assumption. So it is very likely that there are different rules of the changes for each pennant. These rules probably make a different results, if we use the same theory for both. But it is necessary to eliminate a specific behaviour of the engine (column No 5) at both pennant. [4]

5. CONCLUSION

The most important benefit of this paper was a start-up of the collecting of the data. This data are used as a base for a configuration of the engines and for a back analysis, if the engine does not fulfil conditions of the test. An importance of this step takes shape with increasing time. It is because the data collection for the analysis is still running.

It is important to ensure the strict partition of the data for next statistical analysis. Inaccuracies in the data distribution or a usage of the same data distribution for a dealing with different problems cause an error interpretation of the observed facts.

4. LITERATURE LIST

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