GROB G 120 TP-A AIRCRAFT BETA SYSTEM ANALYSIS USING FTA (FAULT TREE ANALYSIS) METHOD

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Abstract

Grob G 120 TP - A beta system aircraft is a system that regulates the size of the angle on the propeller. 42 failures occurred in the beta system from August 2016 to May 2021, resulting in the beta system having to be replaced even before reaching its 2500 flight hour age limit. Using the FTA (Fault Tree Analysis) method, which begins with defining the failure and determining the boundary conditions of the beta system, describing the fault tree model, identifying the minimum cut set from the fault tree, performing a qualitative analysis of the faults tree, and doing a quantitative analysis of the fault tree, it can be seen that the failure that often occurs in the beta system of the Grob G 120 TP-A aircraft is the occurrence of high oil temperature over 84 ℃, the qualitative analysis found 12 causes of failure on the beta system, and based on quantitative analysis obtained probability the occurrence of beta system failure is 0.76363.

Kata Kunci*: Aircraft, Failures, Beta System*

1. Introduction

Airplanes are one type of air transportation mode with complex systems, which, of course, require maintenance to keep the aircraft system in good condition, safe (safe) and airworthy when operated. As it goes the time of use or operation of the aircraft, any system or aircraft components experience a decrease in performance, one of which is experience failure or failure. Failure or failure is the inability of a system or component to perform its proper function with specifications [1]. In general, there are 5 main parts of an airplane, including the fuselage, wing, empennage, engine and landing gear. The engine is one of the most critical parts in an airplane, acting as a propulsion system on an airplane. Grob G 120 TP-A aircraft under the operation of the Indonesian Air Force is a type of aircraft with turboprop engines. The performance of a turboprop engine is inseparable from beta systems section. Without the beta system, the propeller on the plane cannot work so the Grob G 120 TP-A aircraft cannot operate and fly.

Beta system functions as a major regulator small angle on the propeller [2]. Several types of failures occur in beta system causes the beta system to be replaced even before reaching its age limit of 2500 hours of flying. Beta replacement system that is not matched by the availability of sufficient components in the warehouse The 043 Technical Squadron base inventory includes the beta system in critical components. Failure on this beta system will undoubtedly affect the performance from the Grob G 120 TP-A aircraft as a training aircraft from the Indonesian Air Force. Therefore, we need an analysis of the failure of the beta system

so that the beta system for the Grob G 120 TP-A aircraft can be operated with good for its function. Fault Tree Analysis (FTA) is a method used to identify and analyze a system's failure (failure). The Fault Tree Analysis (FTA) method consists of qualitative and quantitative analysis [3]. This qualitative analysis is helpful in knowing the frequent failures occurs in a system, the causes of loss, and corrective actions or prevention so that the failure can be appropriately handled and even not repeated. In the quantitative analysis carried out, probability calculations system or subsystem failure. Qualitative and quantitative analysis in fault tree analysis (FTA) using a boolean algebra approach (boolean algebra approach).

2. Method

The steps taken in analyzing the failure of the beta system of the Grob G 120 TP-A aircraft using the Fault Tree Analysis (FTA) method include [1]

a. Define the failures in the beta system and determine the boundary conditions from the beta system failure data analysis.
b. Depiction of the fault tree model on the beta system using the symbols in the fault tree accompanied by a description of the failure event and its causes. The symbols in the FTA method are shown in Table 2.1, Table 2.2, and Table 2.3.
c. Identify the minimum cut set of the fault tree The minimum cut set is a combination of the slightest component failure, which, if it occurs, can cause a top event to emerge from a system failure.
d. Conduct a qualitative fault tree analysis by identifying failures in the beta system and the causes of failure.
e. Conduct a quantitative fault tree analysis by calculating the probability of failure on the beta system of the Grob G 120 TP-A aircraft using the formula (1).

Table 1. FTA Event Symbol

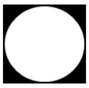
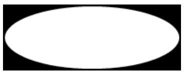
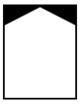
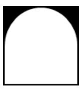
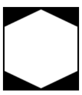
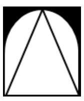
No	Symbol	Description
1.		Basic event
2.		Undeveloped event
3.		Conditioning event
4		External event
5.		Intermediate event

Table 2. FTA Gate Symbol

No.	Symbol	Description
1.		AND Gate
2.		OR Gate
3.		Inhibit Gate
4		Priority AND Gate
5.		Exclusive OR Gate

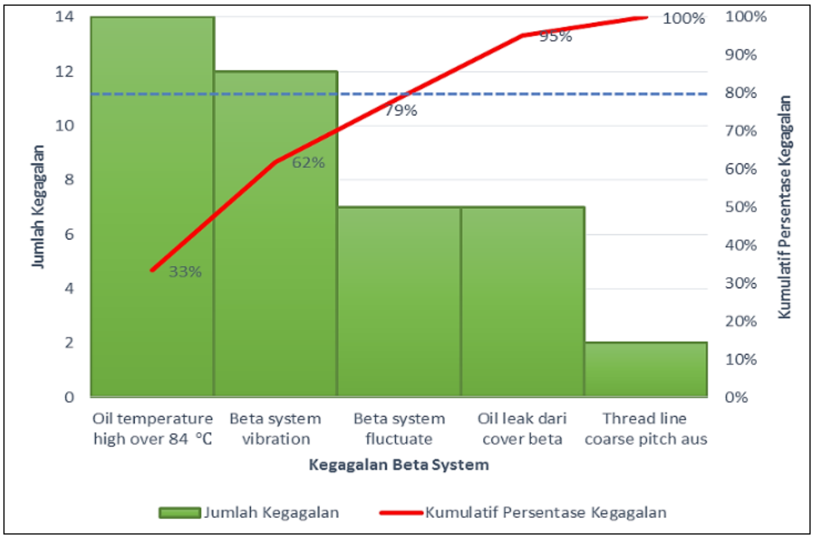


Figure 1. Pareto Diagram

Table 3. Transfer Symbol

No	Symbol	Description
1.		Transfer In
2.		Transfer Out

Principle System

A beta system is a system that manages at least the flow of oil that enters the propeller piston, which in this case, helps adjust the size of the propeller angle. The beta system is located on the rear of the accessories gearbox and is forwarded through the reduction gearbox that enters the propeller hub. The beta system itself is installed in the drive shaft of the G 120 TP-A grob aircraft engine [4]. Beta system failure data on 24 Grob G 120 aircraft TP-A from August 2016 to May 2021 in the 043 Technical Squadron is presented in a Pareto diagram, shown in Figure 2.1.1 below.

Pareto charts are a combination of bar and line charts representing a particular data set. Pareto diagrams help identify and classify defects or other factors that occur most often or are essential in a data set. Pareto diagrams usually use the 80/20 rule, which means that 80% of an output or event result is caused by at least 20% of the input or cause of the event. The 80/20 Pareto principle was developed by Joseph M. Juran in 1937 [5].

Through the Pareto diagram of the beta system failure data, Figure 1 shows that the failure that often occurs in the beta system of the Grob G 120 TP-A aircraft is a high oil temperature of over 84 °C, which occurred 14 times. Other failures in the form of beta system vibration occurred 12 times, beta system fluctuated, oil leak from cover beta occurred 7 times, and thread line coarse pitch wear occurred 2 times from 2016 to 2021. Overall, during this period, The Grob G 120 TP-A failed 42 times. Based on the Pareto 80/20 rule, it can be seen that 33% of beta system failures occur due to high oil temperatures over 84 °C and 29% occur due to beta system vibrations.

3. Finding and Discussion

The failures that occurred in the beta system of the Grob G 120 TP-A aircraft during the research data period from August 2016 – May 2021 were high oil temperature over 84 °C, beta system vibration, beta system fluctuation, oil leak from the cover beta system, and thread line worn coarse pitch. The first step in determining the minimum cut set is e.g., each logic gate and event or events, an example shown as follows:

T is the top event or primary failure
A and D are intermediate events
B is the fundamental event (primary event)
C is a conditioning event

And suppose:
T : Beta System Failure
A1 : Oil Temperature High Over 84 °C
A2 : Beta System Fluctuate
A3 : Beta System Vibration
A4 : Oil Leak from Cover Beta System
A5 : Thread Line Coarse Pitch Worn
B1 : Bulb Oil Temperature Sensor US (Unserviceable)
B2 : Oil circulation is not smooth
B3 : There is a bubble in the inverted shuttle valve
B4 : The tachometer of the N2 generator is dirty
B5 : Tachometer generator N2 US (Unserviceable)
B6 : The constant speed propeller setting does not match the AMM
B7 : Error from manufacture
B8 : Propeller rotation is not constant
B9 : Beta valve oil port is oval in shape
B10 : The seal on the beta cover is torn
B11 : The seal on the beta cover is loose
B12 : Installation of constant speed bolts is forced when tightening
C1 : Distance 28.5 – 29.5 mm
C2 : Size < 12.9 mm
C3 : Limitation > 0.2 mm
C4 : Does not match or fit the thread (thread)
D1 : The constant speed propeller setting is not correct
D2 : The size of the bushing does not match
D3 : The movement of the beta pin is unstable

The examples are then placed accordingly on fault tree, which is shown in Figure 2 below.

By using the top down approach, it is obtained;
T = A1 + A2 + A3 + A4 + A5
T = (B1 + B2 + B3) + (B4 + B5 + D1) + (D2 + D3 + B9) + (B10 + B11) + (C4 B12)
T = B1 + B2 + B3 + B4 + B5 + (C1 B6) + (C2 B7) + (C3 B8) + B9 + B10 + B11 + (C4 B12)

So, the minimum cut set of the fault tree beta system obtained through an example is 12 of which are {B1}, {B2}, {B3}, {B4}, {B5}, {C1, B6}, {C2, B7}, {C3, B8}, {B9}, {B10}, {B11}, and {C4, B12}.

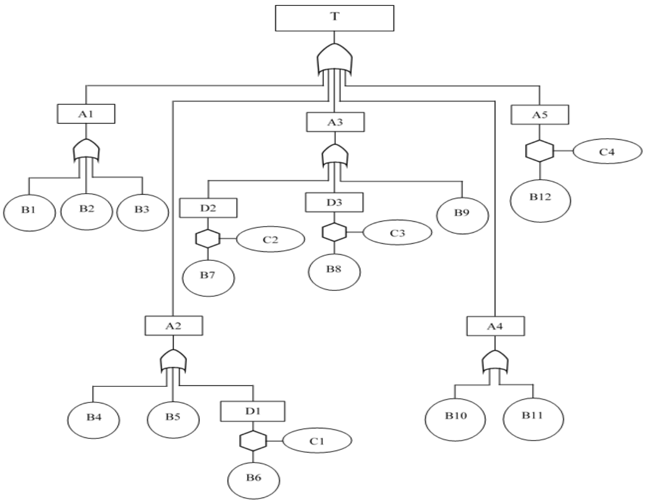


Figure 2. FTA Diagram of Beta System Fault

The results of a qualitative analysis on the beta system of the Grob G 120 TP-A aircraft by defining a minimum cut set, obtained 12 causes of the top event failure of the beta system. The cause of the top event failure of the beta system,
among others, are:

1) US Bulb oil temperature sensor (Unserviceable)
2) Oil circulation is not smooth
3) There is a bubble in the inverted shuttle valve
4) The tachometer of the N2 generator is dirty
5) US N2 generator tachometer (Unserviceable)
6) The constant speed propeller setting does not match AMM (distance 28.5 – 29.5mm)
7) Manufacturing error in bushing size less than 12.9 mm
8) Unconstant propeller rotation causes the beta pin to fail comply with the 0.2 mm limitation
9) Beta valve oil port is oval in shape
10) Seal on torn beta cover
11) Seal on the beta cover is loose
12) Installation of constant speed bolts that do not match the forced thread when tightening

The sum of the probabilities of each cut set yields the probability of the top event occurring. The probability of each cut set or basic event can be formulated [1].

$$P = \frac{\text{Number of 1 basic event}}{\text{Total basic event}} \tag{1}$$

The probability calculation of each cut set is shown in Table 4.
Calculation of the probability of failure of the top event through quantitative analysis is:
T = B1 + B2 + B3 + B4 + B5 + (C1 B6) + (C2 B7) + (C3 B8) + B9 + B10 + B11 + (C4 B12)
T = 0,07143 + 0,14286 + 0,11905 + 0,09524 + 0,04762 + 0,00057 + 0,00227 + 0,02041 + 0,09524 + 0,04762 + 0,11905 + 0,00227
T = 0,76363
So, the probability of failure on the beta system of the Grob G 120 TP-A aircraft is 0.76363 or the failure percentage is 76.363%.

Table 4. Probability calculation

Cause of Failure	**Sym**	**Number of Event**	**Probabilitas cut set**
Bulb oil temperature sensor US (Unserviceable)	B1	3	0,07143
Oil circulation is not smooth	B2	6	0,14286
Indicated Bubble on inverted shuttle valve	B3	5	0,11905
Tachometer generator N2 dirty	B4	4	0,09524
Tachometer generator N2 US (Unserviceable)	B5	2	0,04762
Setting constant speed propeller not proper AMM (distance 28,5 – 29, 5 mm)	{C1 B6}	1	0,00057
bushing size less than 12,9 mm	{C2 B7}	2	0,00227
Propeller rotation found not contant	{C3 B8}	6	0,02041
Beta valve oil port not oval	B9	4	0,09524
Seal cover beta found split	B10	2	0,04762
Seal pada cover beta loose	B11	5	0,11905
Bolt installed not proper	{C4 B12}	2	0,00227

4. Conclusion

Through data processing failures that occurred in the beta version the Grob G 120 TP-A aircraft system, it can be concluded that :

a. The failure that often occurs in the Grob G 120 TP-A aircraft's beta system is high oil temperature of over 84 °C.
b. Based on the FTA (Fault Tree Analysis) qualitative analysis obtained 12 the cause of the top event failure of the Grob G 120 aircraft beta system TP-A.
c. Based on the quantitative analysis of the FTA (Fault Tree Analysis), a value has obtained the possibility of a beta system failure of the Grob G 120 TP-A aircraft, that is equal to 0.76363.

References

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