The Analysis Chemical Composition and Microstructure of Bolt Anchor Bushing in Cessna Caravan Type 208B

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Abstract. Bolt Anchor Bushing is a component contained in an aircraft in the form of a cylindrical iron tube in which there is rubber. Bolt Anchor bushing functions as a bearing between moving and immovable components. This is done so that aircraft components can carry out their functions properly and safely. Bolt Anchor Bushing must be sturdy and strong for the shaft elements and the machine to work properly. If the Bolt Anchor bushing does not work properly, it will affect how the component system works. The methods in this research were observation, interviews, quotes with journals, and testing of chemical composition and microstructure. The results of characteristics Bolt Anchor bushing include medium carbon steel with 0.42% Carbon and 93.98% Fe mixture of Nickel 1.91% Ni. Bolt Anchor Bushing has the characteristics of being resilient and corrosion resistant. The results of the microstructure on the outer, middle and inner surface of the bolt anchor bushing consist of ferrite and pearlite phases. The colour of ferrite phase is light and the dark is colour of pearlite phase. The ferrite phase is stable at low temperatures, solubility is limited and can be with Fe3C or cementite. The pearlite phase is in ferrite and Fe3C. In this study, the bushing consisted of Fe-Ni. It has the properties of high hardness, ductility, corrosion resistance and high temperature resistance.

1. Introduction
Bolt Anchor bushing is a machine element that has a loaded shaft so that rotation or alternating movements can take place smoothly and safely. The main function of the Bolt Anchor bushing is as a bearing between movable and immovable components. Bolt Anchor Bushing must have sturdy and strong properties for the shaft elements for the machine to work properly. If the bushing is not working properly, it will affect the entire system components and may not work properly. The brake assembly has bushings (rings) that attach to the arms of the main landing gear. The torque take-up slot is aligned with the torque pin. The torque take-up slot is aligned with the torque pin. Rotational friction occurs so that braking occurs. Main wheel brake assembly is shown in Figure 1, and bolt anchor is shown in description number 19 after Figure 1. Main landing gear instalation is shown in Figure 2.
Figure 1. Main Wheel Brake Assembly
(Source: Cessna Company, 2019)

The description in Figure 1 is as follow:

1. Brake Assy Main Wheel
2. Brake Assy main Wheel
3. Silinder Brake
4. Piston Assy Brake
5. O-Ring
6. Insulator
7. Spring Friction
8. Plate Assy Pressure
9. Lining Brake Organic
10. Lining Brake Metallic
11. Pin Carrier
12. Shim Brake Plate
13. Back Plate Assy
14. Lining Brake Organic
15. Lining Brake Metallic
16. Pin Carrier
17. Bolt
18. Washer
19. Bolt Anchor
20. Washer
21. Nut
22. Torque Plate Assy Brake
23. Torque Plate Assy Brake
24. O-ring
25. Seat Bleeder
26. Screw Bleeder
27. Cap Bleeder

Figure 2. Main Landing Gear Installation
(Source: Cessna Company, 2019)
The description in Figure 2 is as follows:
1. Spring Main Gear Center
2. Trunnion Assy main Gear
3. Cap main landing gear fitting
4. Bolt
5. Washer
6. Shim main Landing gear
7. Barrel Nut
8. Barrel Nut Alt
9. Retainer
10. Race main gear Tunnion
11. Rub strip gear Tunnion
12. Bearing main gear Tunnion
13. Spring main Gear
14. Plug Main Gear String
15. Pin Main Gear
16. Washer
17. Washer
18. Nut

2. Literature Review
Bushings made of SP2515, SCP5050 and SCP50094 tested at 364 ° C have good wear according to the tribometer [1]. Bolt anchor bushing for serving stand braking [2]. Bushings made of platinum-rhodium by hot isostatic pressing, it have environmentally properties and low manufacturing costs [3]. High strength, heat resistant, lightweight, corrosion resistant materials such as titanium, aluminum, composites are very suitable for aircraft materials [4].

Root the fuselage using rivet bolts with a finite element system to the installation process [5]. The joints on the fuselage consist of 2023-T3 aluminum alloy and the excellent bonding is 5x higher than the pure joint [6]. Copper alloy bushings having a high power capacity for deformation are used in aircraft engines [7]. Multi-axial axial compressor in modern aircraft engines and high heads [8]. Testing the bolt anchor bushing hardness using experimental theory and methods [9]. Rob bushing has difficulty controlling the dimensional accuracy of the material [10]. Bushing made of zirconium ceramic [11]. The finite element method and Catia program are very useful for connecting lugs to aircraft [12]. The MD 80 aircraft shows poor results because effect PH on the corrosion rate [13]. Method of energy dissipation in nail joints in plane structures by replacing parts of the hysteresis loop joint [14]. Bushing power is increased by reprocessing with billet extrusion. The effect of increasing the friction coefficient on the extrusion speed and billet heat will increase the billet breakdown and extrusion speed [15].

Ti6A14V titanium alloys are used in the aviation industry but there are drawbacks that titanium is difficult to cut but lightweight and highly corrosion resistant [16]. Research on aircraft maintenance must be carried out regularly and periodically so that safety is guaranteed [17]. Aluminum alloy 6061-T6 is suitable for aircraft bushings [18]. Bushing with a smooth surface quality consisting of Inconel Ti-6Al-4V material has high tool wear properties and is suitable for aircraft materials [19]. AlSi304 and Ti6Al4V and Inconel 718 materials are especially suitable for landing gear materials and brake systems because they have high wear resistance [20]. The brake lining characteristic of the Cessna 208B is a medium carbon steel alloy with 95.9% Fe and 0.33% C with a chromium alloy [21].

3. Method
3.1 Location: Polytechnic Manufacturing of Ceper, Klaten, Central Java.
3.2 **Material**: Bolt Anchor Bushing of Cessna Caravan 208B as in **Figure 3**.

![Figure 3. Bolt Anchor Bushing](image)

3.3 **Instrument**: Microscope optic for microstructure testing as in **Figure 4 (a)** and Optic Electron Spectroscopy as in **Figure 4 (b)**, polishing machine in **Figure 4 (c)**, and grinding machine in **Figure 4 (d)**.

![Figure 4.](image)

3.4 **Method**:

3.4.1. **Test the chemical composition**

The following steps for testing the composition are as follows: cleaning the specimen surface; placing the specimen on the test object; melt the test object; capturing light color; and record the chemical composition results.

3.4.2. **Microstructure test**

Prepare specimen, turn on machine in microstructure test, check in the magnifying lens; activate the microscope; scan an image at the desired magnification.

4. **Results and Discuss**

4.1 **Results of Chemical Composition**

The results of the characteristics of the Bolt anchor bushing in Cessna Caravan Type 208B as in Table 1 and the chemical element composition as in **Figure 5**.
Figure 5. Chemical Composition Testing

Table 1. Chemical Composition

| Element | Chemical composition (%) |
|---------|--------------------------|
| C       | 0.42994                  |
| Si      | 1.4876                   |
| Mn      | 0.71905                  |
| P       | 0.01894                  |
| S       | 0.00715                  |
| Cr      | 0.77823                  |
| Mo      | 0.43010                  |
| Ni      | 1.9188                   |
| Al      | 0.04225                  |
| Co      | 0.01971                  |
| Cu      | 0.04487                  |
| Nb      | 0.01975                  |
| Ti      | 0.01773                  |
| V       | 0.07847                  |
| W       | 0                        |
| Pb      | 0.0678                   |
| Fe      | 93.98243%                |

(Source: Polman Ceper, Klaten, Jawa Tengah)

The function of element in bolt anchor bushing in Cessna caravan Type 208B:

a. Iron (Fe)
   Iron is the dominant element in the bolt anchor bushing. The iron element contained in the bolt anchor bushing formation is 93.98243%.

b. Nickel (Ni)
   Ni has tough properties and is resistant to corrosion (rust), is heat resistant up to 1200°C but does not have high hardness. The bolt anchor bushing material in this study contained 1.9188% nickel elements.

c. Silicon (Si)
   This bolt anchor bushing material contains 1.4876% silicon, which is ductile and heat resistant.

d. Chromium (Cr)
   This element is used as a protective and friction resistant steel surface. This Cr is shiny, hard, brittle, and corrosion resistant. The chromium contained in this bolt anchor bushing material is 0.77823%.

e. Manganese (Mn)
   This bushing material containing 0.71905% manganese has crack resistance.
f. Molybdenum (Mo)

Molybdenum contained in the bolt anchor bushing material is 0.43010% which has friction and heat resistance properties.

g. Carbon (C)

Carbon function in friction resistant steel. Contains 0.492% Carbon.

Bolt author Bushing is a component contained in an airplane in the form of a cylindrical iron tube in which there is rubber. The bolt author bushing functions as a cushion between moving and immovable components so that the functions of the aircraft components can carry out their functions properly and safely. The results of the chemical composition in the Bolt author bushing include medium carbon steel with 0.42% Carbon and 93.98% Fe, a mixture of Nickel 1.91% Ni. Bolt anchor bushing has the characteristics of ductility and corrosion resistance. The microstructure results on the outer, middle and inner surfaces of the bushings consisting of ferrite and pearlite. The light is colour of ferrite phase and the dark is colour of pearlite. The ferrite phase is stable at low temperatures, solubility is limited and can be with Fe₃C or cementite. The pearlite phase is in ferrite and Fe₃C. In this study, the bolt anchor bushing consisted of Fe-Ni. This bolt author bushing has the properties of high hardness, high ductility, corrosion resistance, and resistance to high temperatures.

4.2 Results of Microstructure

Three images of microstructure results on the Cessna Caravan 208B bolt anchor bushing, the outer, middle, and inner surfaces have ferrite and perlite phases. The light is colour of ferrite phase and the dark is colour of pearlite. It as in Figure 6. Microstructure 100x magnification; Microstructure 50x magnification as in Figure 7 and Microstructure 200x magnification as in Figure 8.

![Figure 6](Source: Polman Ceper, Klaten)

![Figure 7](Source: Polman Ceper, Klaten)
This corresponds to the carbon content of the material which is 0.42994%, so the element is classified as medium carbon steel. In addition to the carbon element, there is also the largest element, namely the element iron (Fe) 93.98243%, where the iron element has good hardness and good ductility. Silicon (Si) 0.14876%, where the silicon content has elastic properties and has high ductility, besides silicon, it also adds hardness and sharpness to steel. In addition to the silicon element there is also an element of manganese (Mn) 0.71095%, the content of manganese has properties that are resistant to friction and pressure resistance (impact load).

Nickel (Ni) 1.9188%, nickel has properties that are ductile and resistant to chemicals to deal with serious corrosion (rust) but does not have high hardness, nickel is an element that is mixed into steel to overcome damage at high temperatures. Molybdenum (Mo) 0.43010%, has heat resistance properties making it suitable for hot tool steel, the maximum mixing limit of this element is 7% and also serves to neutralize the hardness of tungsten. Molybdenum is an additional element of maximum steel ductility. Chromium (Cr) 0.77823%, this element is used as a protective and friction resistant steel surface. Steel is shiny, hard and brittle and resistant to corrosion. Perlite in medium carbon steel is a mixture of ferrite and cementite. Perlite is an alloy of ferrite and cementite. Perlite has high hardness when the iron element is high. Perlite is shiny, ferrite is light in color, and cementite is dark in color. High carbon steel is an alloy of perlite and cementite while mild carbon steel is a blend of perlite and ferrite.

5. Conclusion

Bolt author bushing is a component contained in an airplane in the form of a cylindrical iron tube in which there is rubber. The bolt author bushing functions as a cushion between moving and immovable components so that the functions of the aircraft components can carry out their functions properly and safely. The results of the chemical composition in the Bolt author bushing include medium carbon steel with 0.42% Carbon and 93.98% Fe, a mixture of Nickel 1.91% Ni. Bushing has the characteristics of ductility and corrosion resistance. The microstructure results on the outer, middle and inner surfaces of the bushings consisting of ferrite and perlite. The ferrite phase is light in color and the pearlite phase is dark. The ferrite phase is stable at low temperatures, solubility is limited and it can be with Fe3C or cementite. The pearlite phase is in ferrite and Fe3C. In this study, the bushing consisted of Fe-Ni. This bolt author bushing has the properties of high hardness, high ductility, corrosion resistance, and resistance to high temperatures.

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References

[1] Chen, S., Yin, N., Yu, Q., and Zhang, Z. 2019. A novel tribometer for investigating bushing wear. Wear, 430, pp.263-271.
[2] Tuan, C. Y., and Dass, W., C. 2016. Expedient airfield runway repair using folded fibreglass mat. International Journal of Pavement Engineering. 174, pp. 283-299.
[3] Caretto, F., Laera, A. M., Di Nuzzo, F., Iovino, R., Di Benedetto, F., Pesce, E., ... and Tapfer, L. 2016. Molybdenum disilicide-silicon nitride bushing nozzles tailor-made for basalt fibers production. Ceramics International, 42(10), pp. 11844-11850.

[4] Ilg, J., Müller, T., and Kuhn, S. 2017. Dry Machining of Multilayer Composite Materials in Aircraft Construction. Lightweight Design worldwide, 10(6), pp. 42-47.

[5] Chernykh, E. V., Zaidès, C. A., and Kudryavtsev, A. A. 2019. Peculiarities of making bolt and rivet connections with interference when assembling the aircraft MS-21. In IOP Conference Series: Materials Science and Engineering, 632(1), p. 012090.

[6] Pitta, S., de la Mora Carles, V., Roure, F., Crespo, D., and Rojas, J. I. 2018. On the static strength of aluminium and carbon fibre aircraft lap joint repairs. Composite Structures, 201, pp. 276-290.

[7] SHU, C., Fan, W., Wang, Z., and Zhang, J. 2015. Study on Optimization of Plastic Forming Process for Copper Alloy Rod Bushing. Hot Working Technology, 09.

[8] Boyko, L., and Dyomin, A. 2018. Numerical study of flows in axial compressors of aircraft gas-turbine engines. Восточно-Европейский журнал передовых технологий, 4(8), pp. 40-49.

[9] Lu, S., Zhang, B., Wang, Z., and Hu, X. 2017. Experimental Study on Influence of Spinning Forming Process Parameters on Quality and Performance of Connecting Rod Bushing. Hot Working Technology, 03.

[10] Lv, W., Fan, W. X., Wang, Y., and Li, J. H. 2016. Dimensional accuracy analysis of spinning process of connecting rob bushing. Journal of Plasticity Engineering, 03.

[11] Alisin, V. V., and Roshchin, M. N. 2019. Research of Friction Type Bearing with Zirconium Ceramics Bushing. In 2019 International Multi-Conference on Industrial Engineering and Modern Technologies (FarEastCon) (pp. 1-4).

[12] Phadnis, P., Anilkumar, G., and Madhusudhan, T. 2015. Review on fatigue and damage tolerance evaluation of aircraft lug-joint. International Research Journal of Engineering and Technology (IRJET), 502.

[13] Suhartaya, N. U. C., and Rochmadi, R. 2020. The effect of pH upon corrosion rate of aircraft component type MD 80 on fuselage part. In IOP Conference Series: Materials Science and Engineering, 732(1), p. 012089.

[14] Tachi, T., Machida, S., Okada, T., and Suzuki, S. 2017. Simple Energy Dissipation Model of Riveted Lap Joint in Aircraft Structure. Transactions of The Japan Society for Aeronautical and Space Sciences, 60(6), pp. 341-346.

[15] Wenxin, F., Cuncun, C., Hualong, Y., and Wenbo, Y. 2016. Simulation analysis on damage of connecting rod bushing in warm extrusion based on finite element. Forging & Stamping Technology, 08.

[16] Li, L., Xue, H., and Wu, P. 2018. Experimental study on the axis line deflection of Ti6A14V titanium alloy in gun-drilling process. In IOP Conference Series: Materials Science and Engineering, 301(1), pp. 012012.

[17] Nathanael, D., Tsagkas, V., and Marmaras, N. 2016. Trade-offs among factors shaping operators decision-making: the case of aircraft maintenance technicians. Cognition, Technology & Work, 18(4), pp. 807-820.

[18] Phadnis, P., Anilkumar, G., and Madhusudhan, T. 2015. Review on fatigue and damage tolerance evaluation of aircraft lug-joint. International Research Journal of Engineering and Technology (IRJET), 502.

[19] Dehghan, S., and Baharudin, B. T. 2019. Friction drilling of difficult-to-machine materials: workpiece microstructural alterations and tool wear. Metals, 9(9), pp. 945.

[20] Dehghan, S., Ismail, M. I. S., Ariffin, M. K. A., and Baharudin, B. T. H. T. 2019. Measurement and analysis of thrust force and torque in friction drilling of difficult-to-machine materials. The International Journal of Advanced Manufacturing Technology, 105(7), pp. 2749-2769.

[21] Suroso, I. 2020. Characteristics of Brake Lining Cessna Caravan Type 208B. In IOP Conference Series: Materials Science and Engineering, 722(1), p. 012027.