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Failure Analysis of Brake Panel on Automotive Braking System

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Abstract

This paper presents the results of a failure analysis investigation conducted in the braking component of motorcycle. One of the components is the brake panel. This component has been replaced in the non-authorized dealer. After used within 3 months, the brake panels broken during the braking process. The investigation involves several procedures and testing techniques, including: visual observation, chemical composition testing, fractography and hardness testing. Based on the results of the chemical composition testing, the brake panels are made of aluminum alloy (Al-Si) series 4xxx. Fractography was performed in scanning electron microscopy (SEM) and optical microscopy (OM). Vickers hardness machine is used to test the hardness. The result of the observations indicate porosity along the fracture area. The result of the hardness testing shows that the distribution of hardness in different zones is very uniform. Based on the overall analysis, the failure of the brake panel is caused by stress concentration due to the porosity in the solid solutions. The emergence of porosity was suspected an error during the casting process.

Keywords: *brake panel; failure analysis; stress concentration*

1. INTRODUCTION

For safety riding, the brake is a very important component. When a vehicle was running, it takes force to stop. The main factor is a friction force from the brake. When the friction force given on the rotated wheels, the wheel will slow down and finally stop (1). The factor in determining deceleration of the vehicle include the weight of a vehicle, coefficient of friction, pressure distribution on the surface area of braking, and the braking force (2). In order to fulfil this criteria, braking system should be following requirement (3): The brake must be strong enough to decrease vehicle acceleration, the braking system must have simple operational for the driver, and the braking system have to wear resistant properties and good heat resistant properties.

Generally, the type of vehicle brake system is drum brake and disc brake. Mechanical and hydraulic used as the operating system. In recent years, drum brake is widely used on small capacity of motorcycles. The main factor is cheap and simple. Brake which utilizes friction between the material generate heat. It can produce residual stress which is reducing the strength of materials (4). Impact loads and larger braking force can also caused failure of the braking components (5). Furthermore, the friction of kinetic force from wheel vehicles is producing the heat. Hence, overheating on braking components can also be a fracture initiation.

A dispersion casting process is used in brake panel manufacturing. The brake panel slurry is quickly poured to the sand molding and then machined to desired sizes. The most defect of brake panel manufacturing are the occurrence of shrinkage and blowholes at casting process and sand inclusion after machining process (6).

Brake panel is a braking component with double work. Besides as mounting of brake shoe, it also serves to hold all forces during the braking process. Commonly brake panel is made from aluminum alloys. In this case, when the motorcycle through over holes on the road and the rider braking suddenly, the brake panel was fracture. So the braking component not function as usual. To determine the cause of the failure is needed physical and mechanical research. In this study, the cause of failure was analyzed. To obtain the information, some of the methods are used. Description of the failure, metallurgical analysis, and mechanical properties will be discussed.

2. METHOD

Methods used to determine the occurrence of failured component are macro and micro observation, chemical composition, and testing of mechanical properties (7). Failure analysis of braking panel system of motorcycle are presented. Figure 1 shows the brake system component of a motorcycle. Brake panel/backplate is a failured component. This component has been repaired. After used in 3 months, the brake panel is fractured during braking process. From the result of the observation using digital camera, the obtained shape and fracture location as shown in Figure 2.

Figure 1. Braking system

Figure 2. Broken component

3. Results and Discussion

3.1 Material composition

Generally, aluminium alloys are used as automotive parts. They have good mechanical properties and corrosion resistant, from the chemical test a aluminium alloy with Si alloying less than 13% is Aluminium alloy 4XXX series (8). The chemical composition of aluminium alloys series 4XXX (Al-Si) used as brake panel are listed in Table 1.

Table 1. Chemical composition of brake panel

Element	Composition (%)
Al	83,89
Si	11,4
Zn	2,76
Fe	1,20
Mn	0,408
Cu	0,120
Cr	0,0837
Sn	0,0510
Ti	0,0108
Pb	< 0,030
Ca	0,0042
V	< 0,0100

3.2 Fractographs

The results of the observation on the fracture surface are shown in Figure 3. and Figure 4. Scanning electron microscopy (SEM) and optical microscope (OM) methods are used to visualize the fracture surface. Based on the result of the observations in the figure 3.a, it can be seen the initial cracks on the surface of test specimen. The crack propagates with big dimensions. These cracks propagate continues in line with the change of the force. Moreover, observations along fracture lines indicate porosity, as shown in Figure 3.a and 3.b. In Figure 3.a, the dimension of blowholes are large. On the other hand the observation result shows that void surface is more smooth, a smoother surface is indicated cause gas trapped in the casting process (9). As the consequence of these void, stress amplification increase at that section (10). It can increase fracture probability at void section.

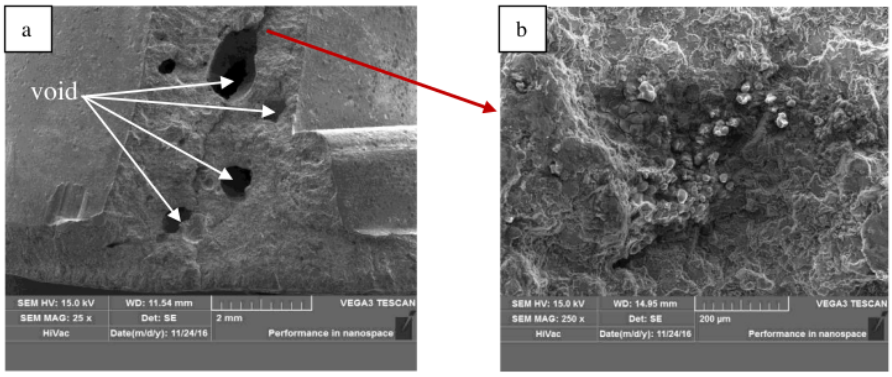

Figure 3. (a) SEM image of void. (b) Oxide inclusions

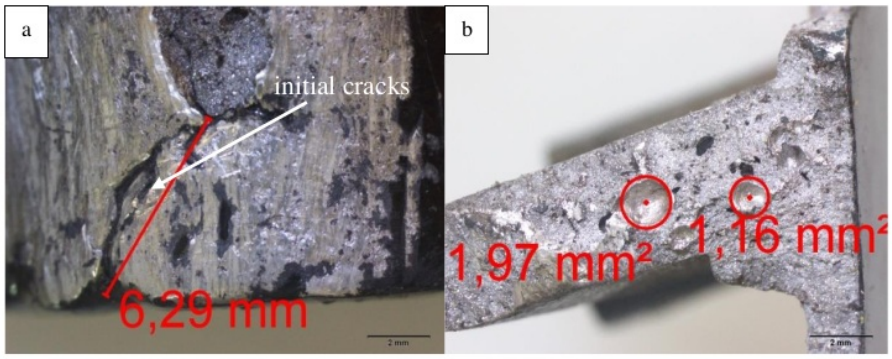

Figure 4. (a) Crack propagation. (b) Dimension of void

Porosity, occur in almost all aluminium alloy castings, can decrease their mechanical properties (11) and increase fatigue live (12). The occurrence of porosity is due to two main aspects, (i) the shrinkage of casting slurry during the solidification; (ii) the solubility of gasses (13), (14). Hydrogen is the main gas of porosity agent in aluminium casting as hydrogen is highly soluble gas (15), (16).

One of the objectives of good casting product is avoiding porosity in a casting product. This can be achieved by melt degassing. In aluminium cast slurry, the amount of hydrogen can reach 0.3–0.5 cm^3/100 g, while the industrial standard requires the concentration of hydrogen before casting close to 0.1 cm^3/100 g (17). The control of hydrogen is of major concern in foundries, to control porosity result from trapped gas, several methods are used, either separately or in combination, such as blowing nitrogen or argon into the melt (16), (18), (19), re-melting (20), and rotating impeler degassing (21).

Observations on the fracture surface shows that the fracture occurred between grain boundaries. Fracture surface is rough and brittle with a dark color may indicate that fracture is intergranular fracture types (10).

3.3 Hardness Testing

In this study, vickers hardness testing is used to determine the distribution of hardness value areas near the fault and areas far away from the fracture. Testing is done according to the standard ASTM E92 (22). Indentation performed at 5 times with a load of 100 gf for 10 seconds. The test results obtained hardness values are not much different. This means that the distribution of hardness in both these areas is very uniform. The average value of hardness fracture area is 110.6 HVN. This value is relatively higher when compared to areas far away from the fault in value by 109.46 HVN.

4. CONCLUSIONS

The cause of the failure on motorcycle brake panel has been investigated. Based on the results of the investigation on the brake panel, the failure is caused by stress concentration. Stress concentration is caused by void. The emergence of the void caused by the inability of the fluid of aluminium alloy to form a solid during the casting process. To reduce the occurrence of void in the component, nitrogen gasses can be sprayed during the casting process. So that the trapped oxygen can come out of the casting liquid and minimize the voids, then the strength of the component can be maximized. The casting process can change from disperssion casting to squeeze casting to repair imperfection of casting product.

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