

Brake Pads: Effect of Galvanic Current on the Corrodibility of Friction Materials and Backplates

Marco Bandiera
Brembo S.p.A., R&D Department
Viale Europa 2
Stezzano (BG), 24040
Italy

Arianna Pavesi
Brembo S.p.A., R&D Department
Viale Europa 2
Stezzano (BG), 24040
Italy

Fabio Manzoni
Brembo S.p.A., R&D Department
Viale Europa 2
Stezzano (BG), 24040
Italy

Bozhena Tsyupa
Brembo S.p.A., R&D Department
Viale Europa 2
Stezzano (BG), 24040
Italy

Andrea Bonfanti
Brembo S.p.A., R&D Department
Viale Europa 2
Stezzano (BG), 24040
Italy

Alessandro Mancini
Brembo S.p.A., R&D Department
Viale Europa 2
Stezzano (BG), 24040
Italy

Federico Bertasi
Brembo S.p.A., R&D Department
Viale Europa 2
Stezzano (BG), 24040
Italy

ABSTRACT

The work reports for the first time galvanic current measurements for the friction material – backplate couple. In particular, two configurations including different friction materials and a steel-based backplate are considered. Measurements are performed using Linear Sweep Voltammetry (LSV) and Zero Resistance Ammeter (ZRA) –based techniques and allow to: 1) investigate the interplay between galvanic currents and localized corrosion events at the interface between each investigated friction material and the corresponding backplate; 2) correlate the corrosion potential of stand-alone materials with that of multilayered specimens; and 3) identify friction materials which show a sacrificial anode behavior with respect to the backplate.

Key words: corrosion mechanism, friction material, galvanic coupling, sacrificial anode, brake pad.

© 2022 Association for Materials Protection and Performance (AMPP). All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise) without the prior written permission of AMPP. Positions and opinions advanced in this work are those of the author(s) and not necessarily those of AMPP. Responsibility for the content of the work lies solely with the author(s).

INTRODUCTION

Brake System and Related Corrosion Phenomena

The brake system is a core component of cars, motorbikes, bikes, airplanes etc.. Its main task is to modulate the speed of moving vehicles by converting the kinetic energy into heat.^{1,2} In the case of modern cars or motorbikes, the speed modulation can be performed by using the so-called disc-brake system.^{1,2,3,4,5,6} This generates the braking torque by forcing two brake pads against a disc by the means of a caliper.^{2,3,5,6} In the case of cars, the disc and the caliper are enclosed within each wheel and, as a consequence, can be exposed to corrosion phenomena, mostly related with atmospheric or environmental conditions.^{1,3,7,8}

Brake Pads and Electrochemical Methods

Brake pads are key elements of disc-brake systems for car and motorbike applications.^{2,4} At a first approximation, brake pads are realized by supporting a friction material (FM) onto a steel-based backplate (BP) (See Figure 1A). Nevertheless, a third component named underlayer (UL) is usually comprised between the FM and BP. The UL is necessary for at least the following motivations: a) achieve a certain comfort level during braking (damping of vibration and noise generated by the friction of the FM against the disc); b) guarantee the proper adhesion of the FM to the BP; and c) provide a thermal barrier between the disc and the caliper. For sake of completeness, it is important to mention that a further adhesive layer can be present at the interface between UL and BP. Nevertheless, in the present work the adhesive layer is considered as a part of the UL. Due to their composition, both the FM and UL can be considered as composite materials and typically include abrasives (carbides, oxides), metallic moieties (Fe, Cu, Zn,...), fillers and lubricants.^{9,10,11}

Figure 1A reports the typical configuration of a brake pad in which the friction material and the underlayer are supported onto the backplate. Figure 1B depicts the operating layout of a disc brake system in which two brake pads are forced against the rotor in order to generate a braking torque. In the case of cars, the rotor is mechanically connected to the wheel in order to modulate its rotational speed.

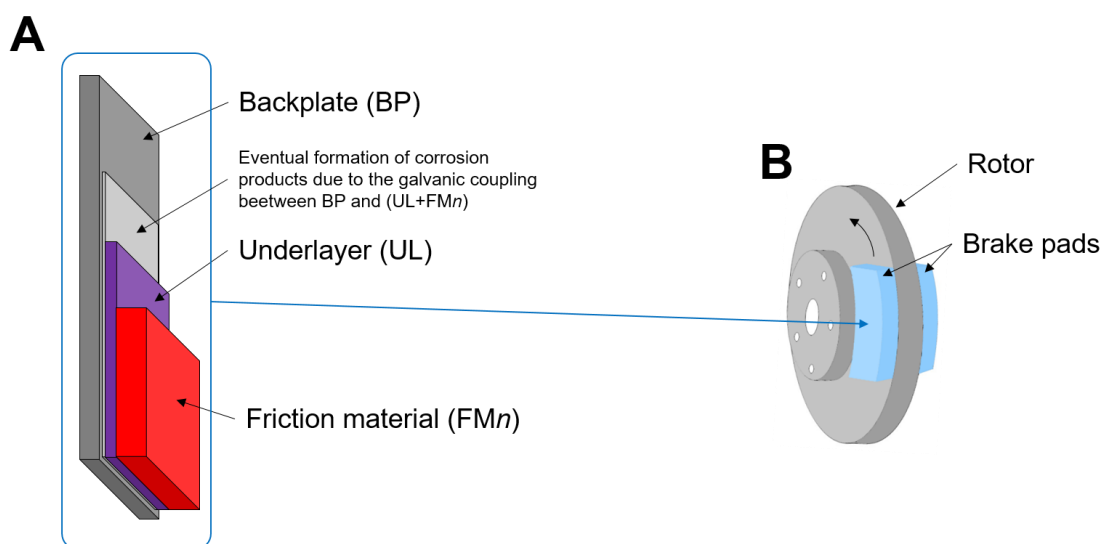


Figure 1: A) Depiction of a brake pad showing a layered structure comprising: backplate (BP), underlayer (UL) and friction material (FMn). The present work investigates two brake pads including different friction materials (FM1 and FM2); B) Schematic picture of a disc brake system in which the brake pads are pushed against a rotor thus generating a braking torque.

The possible exposure of the brake system to corrosive environments (e.g. driving along coastal areas, prolonged parking in wet conditions, raining) can lead to several corrosive events such as the: a) intrinsic corrosion of friction material;¹ b) shear adhesion phenomena (sticking) between disc and brake pads due to the growth of corrosion products at their interface;⁴ c) localized corrosion at the interface between underlayer and steel backplate.¹¹ Referring to the latter event, this is mostly associated to the fact that both FM and UL always show a certain porosity degree and different nobility with respect to the backplate (BP).³ Indeed, once wetted, they could generate a galvanic coupling with the steel-based backplate. It appears thus clear that the formation of corrosion products at the UL/BP interface should be avoided in order to pursue the best adhesion between FM+UL and backplate.

At this regard, the manuscript proposes for the first time galvanic current measurements for the backplate – (FM+UL) couple. In addition, measurements of the BP–FM couple (without UL) allow to highlight the role of the UL in mitigating the galvanic current flow at the BP/FM interface. Measurements of the corrodibility of stand-alone materials, in terms of corrosion current (I_{corr}) and corrosion potential (E_{corr}) are reported as well.

It is important to highlight that, to the best of our knowledge, the manuscript represents the first example of galvanic current measurements applied to the brake pad and will briefly allow to obtain design rules for future braking systems, with a particular reference to the corrosion resistance of the enclosed components.

EXPERIMENTAL PROCEDURE

Materials

The manuscript describes the electrochemical behavior of two different brake pads. Each brake pad: a) includes a different friction material which is labelled as FM n with n equals to 1 or 2 (see Figure 1A); and b) comprises the same underlayer (UL) and steel-based backplate (BP). The two investigated pads and enclosed materials are produced in-house by these authors and are prototypal formulations. The steel BP is a S420MC grade in agreement with EN 10149-2.¹²

As already mentioned, in commercial brake pads the FM, UL and BP are tightly bonded together as schematically depicted in Figure 1A. Consequently, prior to performing the measurements, it is necessary to prepare *ad hoc* specimens. This is performed by: 1) detaching the backplate; and 2) mechanically grinding the pads thus obtaining the four investigated specimens: FM1, FM2, FM1+UL and FM2+UL. In the case of FM n +UL specimens, the thicknesses of UL and FM are equal to 1mm and 5mm respectively.

Composition of the investigated materials

The investigated FM and UL are composite materials. The compositions are summarized in Table 1 in terms of weight percentage of metallic moieties, abrasives, solid lubricants, fillers and rubber. Metallic fibers and powders typically include iron-based components (e.g steels) which are present on a larger extent in the friction materials. Abrasives typically include carbides and/or oxides and are responsible for the generation of the friction force once the pad is pressed against the disc (see Figure 1B). Solid lubricants comprise sulfides and/or graphite-based materials and are necessary in order to stabilize the friction behavior between pad-disc in terms of friction coefficient, reduction of brake noise, friction recovery after repeated brakes and generation of a stable tribo-layer on the disc surface. Rubber is added to the underlayer in order to damp the vibrations generated during braking operations while fillers are necessary in order to guarantee an adequate structural integrity of the brake pad.

From a corrosion resistance point-of-view, it is important to highlight that: a) oxidation reactions are mostly associated with the presence of metallic fibers/powders which are comprised in both FM and UL; b) the