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Empirical, analytical and numerical approaches to failure analysis of a frictional power transmission composite roller

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ABSTRACT

The current study investigated the impact of different parameters on the failure of a frictional power transmission mechanism composed of a steel tyre and a two-layer composite rotating roller. Empirical, analytical and finite element methods were employed to study the mechanism. As for the empirical approach, a few rollers were made with different materials for the outer layer of the composite driver roller in order to examine the probable causes of the failure. In addition, thermography was conducted to find the increase in the temperature due to the working conditions. Analytical formulations were also employed so, as to understand the correlation between stress distribution and deformation regime in the contacting parts. Moreover, through relating the analytical to the empirical data, a homogenous representative cylinder was defined as equivalent to the composite cylinder. In order to reveal the details of stress and deformation distribution inside the roller parts, numerical analysis was performed employing finite element method. The results of such modeling helped us understand the relationship between the tuneable parameters and output results. Furthermore, by relating FEM results to the empirical data, probable causes of the failures were explained. According to the interpretation of the results and the data obtained via the introduced approaches, a few suggestions were presented as applicable in designing proper two-layer composite rollers.

1. Introduction

Magnetic separation method is a basic direct approach used in extracting iron from ore. For this purpose, in the magnetite processing plant, milled ore is passed through magnetic separators. However, some portions of the iron that are hard to be extracted by magnetic separation method are sent to the hematite factory to be extracted by other separation methods such as centrifugal and flotation techniques. In these processes, a certain amount of water should be added to iron ore powder; the obtained slurry is then sent to cyclones or flotation tanks for separation. The smaller the particles of iron ore inside the slurry, the higher the extraction efficiency (iron enrichment) will be. On the other hand, due to the moisture and the gravity pressure of the piled materials, the iron ore powder might become agglomerated forming tight lumps. The lumps must therefore, be primarily grounded and then fed as homogeneous slurry to the mentioned process equipment. Accordingly, a washing drum machine is used as depicted in Fig. 1 [1]. This equipment operates as follows: lumps of mineral ore and water are charged into a huge rotating cylinder. Due to the rotation, the lump material is washed and homogeneous slurry finally exits the other end of the cylinder providing suitable input for the rest of the production line. Pertaining to the device structure and geometry, the main cylinder that is called drum has a diameter about 3360 mm and its total weight is

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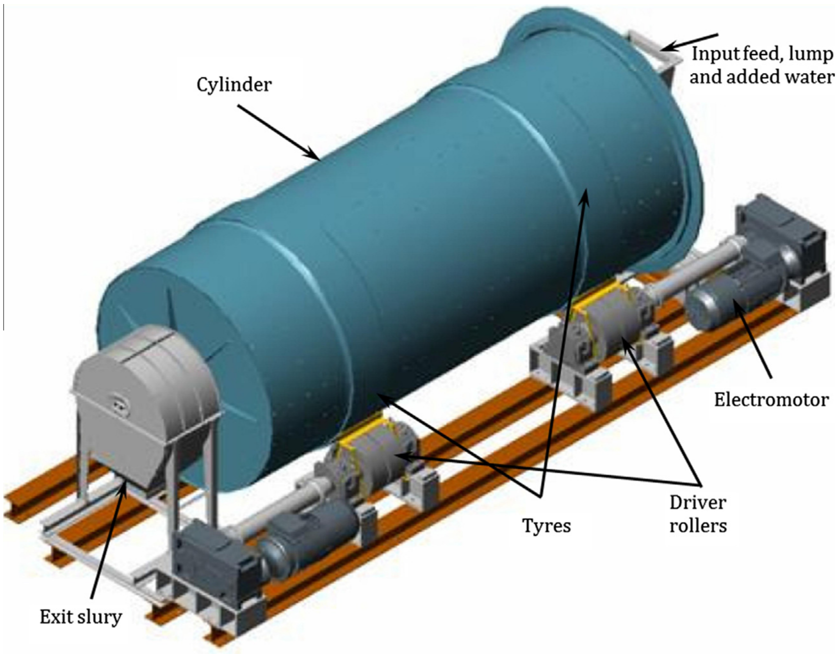

Fig. 1. Washing drum schematic and sub-units.

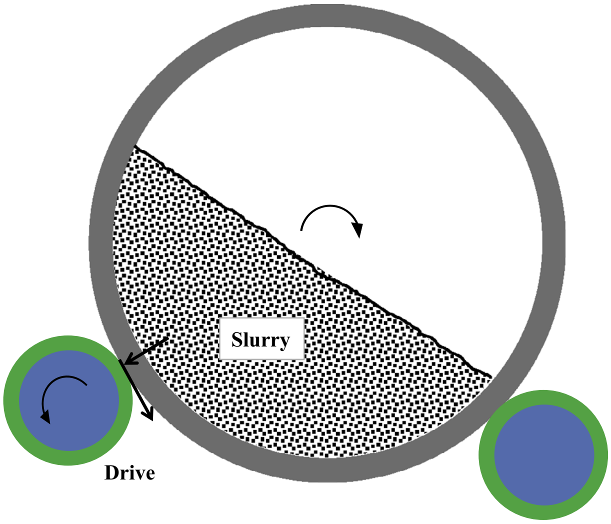

Fig. 2. Schematic of cross section of the washing drum and loading condition on the drive roller.

estimated about 240 kN. As shown in Fig. 1, the drum is mounted on four rollers with diameters of about 850 mm and 320-mm widths. These four rollers act as the supports of the cylinder. The frictional power transmission allows the two rollers to be idler and the others to be drivers coupled with two electro motors. As depicted in Fig. 2, the torque required to rotate the drum is provided by the friction force between the drum's tyres and driver rollers.

1.1. Problem description

As it was already mentioned, due to the contact force between the rollers and tyres (Fig. 2) a complex stress condition is induced in the components [2]. Moreover, contaminations, small particles and powdered minerals suspended in the environment around the machine can come onto the interface between the rollers and tyres, increasing the possibility of failure in the components. Stress distribution (especially contact stress) in the components is the main reason for the failure. The stress can cause tribological defects on the surfaces of the components such as pitting and scuffing [3]. Moreover, the stress at the interface of the outer and inner layers of the composite rollers can cause delamination failure as a type of peeling [4–7].