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# Failure and sensitivity analysis of a reconfigurable vibrating screen using finite element analysis

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ABSTRACT

In mineral processing industries vibrating screens operate under high structural loading and continuous vibrations. In this regard, this may result in high strain rates, which may often lead to structural failure or damage to the screen. In order to lessen the possibility of failure occurring, theories and techniques for analyzing machine structures are investigated and applied to perform a sensitivity study of a newly developed vibrating screen. Structural strength and stability of a vibrating screen is essential to insure that failure doesn't occur during production. In this paper a finite element analysis (FEA) on a reconfigurable vibrating screen (RVS) is carried out to determine whether the structure will perform as desired under extreme working conditions at the different configurations of 305 mm × 610 mm, 305 mm × 1220 mm and 610 mm × 1220 mm. This process is aimed at eliminating unplanned shutdowns and minimizes maintenance cost of the equipment. Each component of a screen structure is analyzed separately, stress and displacement parameters are determined based on dynamic analysis. In addition, a modal analysis was carried out for the first three (3) modes at frequency f of 18.756 Hz, 32.676 Hz and 39.619 Hz respectively. The results from the analysis showed weak points on the side plates of screen structure. Further improvements were incorporated to effectively optimize the RVS structure after undergoing an industrial investigation of similar machines.

## 1. Introduction

Ability to diminish the occurrence of a vibrating screen structural failure under various loading scenarios requires a great deal of attention during the analysis phase. Vibrating screen is known as mineral beneficiation equipment used in mineral processing industries mainly for separation of many precious export commodities. RVS is newly improved screening equipment aimed at increasing productivity while achieving high processing efficiency [1]. Generally in mining industries vibrating screen structures experiences continuous structural failures due to the extreme conditions they operate under. According to study conducted by Steyn [2], "due to the operating conditions of the vibrating screens, the stresses in the components need to be minimal in order to achieve an acceptable fatigue life" Hou et al. [3] further highlighted that in order to improve the efficiency of the screen the structural strength and the longevity of the vibrating screen should be analyzed. Design of machines is a challenging task if the dynamic loading acting on the screen structure is not fully recognized, which includes evaluation of stress distributions [4]. FEA is considered as the most essential and effective method of optimizing the mass and most importantly the structural strength of the screen. There are different types FEA which currently exists are: static analysis, modal analysis, harmonic analysis, transient dynamic analysis, spectrum analysis, buckling analysis and explicit dynamic analysis. For the scope of this paper dynamic analysis is used to predict the stresses acting on the screen structure, since it is able to calculate the effect of steady loading conditions on the screen structure, at the

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same time ignoring the inertia $I$ and damping effects $\zeta$ caused by time varying loads. The next section of this article, presents the working principles of the proposed reconfigurable vibrating screen, related works on similar machines and the methodology used to carry-out the FEA simulations.

## 2. Industrial investigation

In this paper, a case study of company XYZ was used to investigate the failures associated with conventional vibrating screens. These machines are often used in this company for segregation of mineral concentrates acquired from runoff mine with that particular quarry. Unfortunately the machines suffered successive number of failures which resulted in high number of stoppages, resulting in huge economic losses. In addition to this, fluctuation in mineral concentrates demand forced the company to acquire new machines to supplement the existing machines in order to meet up with the demand, thus also influenced their annual operating cost negatively. To investigate this further, a heuristic approach was adopted and is discussed in the section of this paper.

### *2.1. Heuristic approach*

Table 3 depicts the results of the failure modes of different components of vibrating screen used in company XYZ. A visual inspection approach was used to determine the percentage of failure (%) and the cumulative percentage of failures for each sub-components of the vibrating screen for a period of 6 years. The following formulae were used:

$$\gamma = \frac{i}{n} \times 100 \tag{1}$$

Where γ the cumulative percentages of failure for each component is, $i$ is the cumulative frequency and $n$ is the number of failure recorded over the period of 6 years. To analyse the failure mechanism of structures, it is generally essential to identify the operating condition under which the structure failed. The findings from the industrial investigation using heuristic approach showed that 19 screen panels failed on the machine which resulted in downtime. Overloading of material during screen was observed as one of the contributors to screen panel failure as shown in Fig. 1a–c. From these findings, the type of measures required to avert the above mentioned failures needs to be put in place. To familiarize with these measures, a literature review presented in the next section of this paper was conducted and mainly focused on the engineering tools required in solving failure and sensitivity studies using relevant case studies in this field.

Ultimate failure due to stress exceeding material strength, instability (buckling) due to load combination and time dependent


**Fig. 1.** Industrial investigation of vibrating screens failure.