

CONCEPTUAL DESING OF THE REGOLITH SIZE SEPARATION DEVICE. D. Pietrusiak¹, P. Moczko¹, J. Wróbel¹ and M. Wilgucki², O. Fryckowski², ¹Wroclaw University of Science and Technology (Lukasiewicza 5, 50-370 Wroclaw, Poland; damian.pietrusiak@pwr.edu.pl), ²Four Point (Jana Długosza 60a, 51-162 Wrocław, Poland).

Introduction: According to the literature, size separation of bulk materials in microgravity conditions is one of the most overlooked issue [1]. Moreover, waterless technologies for any industrial branches, including mineral processing, are strongly desired while progressing climate change. That requirement is one of the main point of United Nations Sustainable Development Goals [2].

The paper presents concept design of centrifugal separator based on the authors invention [3] of the impeller designed for sieving of bulk materials, granulates for operation without additional media like water or air and no external force field e.g. gravity. The design and operational features of the device were addressed in purpose to enable efficient operation in terrestrial areas of water shortages and eventually for extraterrestrial applications where microgravity is expected. In the paper authors present the main principle of operation, conceptual designs and first engineering design of the selected concept.

Principle of operation:

The method of sieving bulk materials in a centrifugal separator consists in the fact that the bulk material is separated on a vibrating impeller, which has the form of a perforated sheet 1 in the shape of a truncated cone and which on the inner side is equipped with a spiral channel 2 forcing a spiral path of movement, in accordance with its geometry, of the separated material which flows along the inner surface of the side face of the sheet 1 (Fig. 1). The material flow and segregation parameters are determined by the angle of inclination of the impeller side face α , the angle of inclination of the spiral channel β , the diameter of the conical impeller, the impeller height, the rotational speed of the impeller assembly with the spiral channel ω and the characteristics of the vibration spectrum of the impeller and the spiral channel assembly, with the last two parameters (rotational speed, vibration spectrum) being controlled in real time.

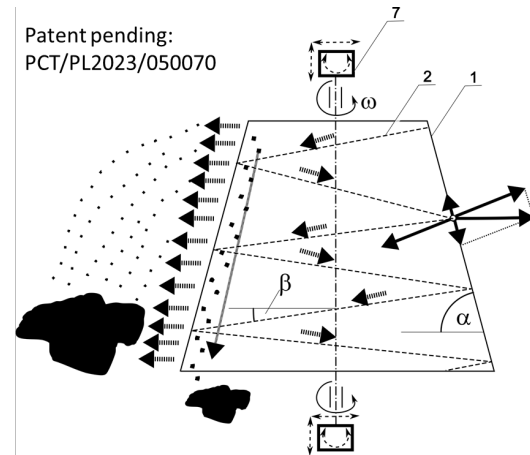


Figure 1. Principle of operation

The design of the impeller generates large enough forces, which result in sieving, so that the presence of a gravity field, the angle of the axis of rotation in the field of gravity or the absence of a gravity field is of secondary importance. Therefore, the position/inclination of the impeller can be arbitrary in relation to the vertical and the position of the impeller should be determined on the basis of the operating parameters of the device and the possible location of other auxiliary devices.

Design development:

The main design parameters determining material flow (α , β , ω) are under numerical investigations with use of the Discrete Element Method analysis (Fig. 2).

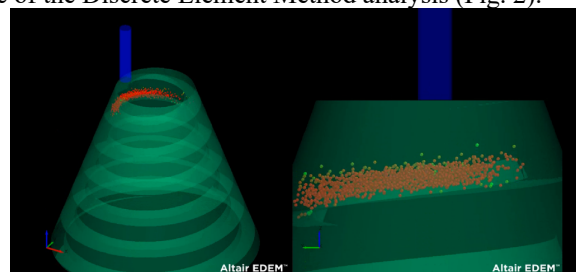


Figure 2. DEM simulation

The conceptual design of the operating device is presented in Figure 3. Favorably, there is set of multiple rotating screens which allows the size separation of a granular material of multiple fractions.

No less importance is the shape of the spiral channel and the size of the perforation holes of the side face

which will be determined in relation to the characteristics of the dry material.

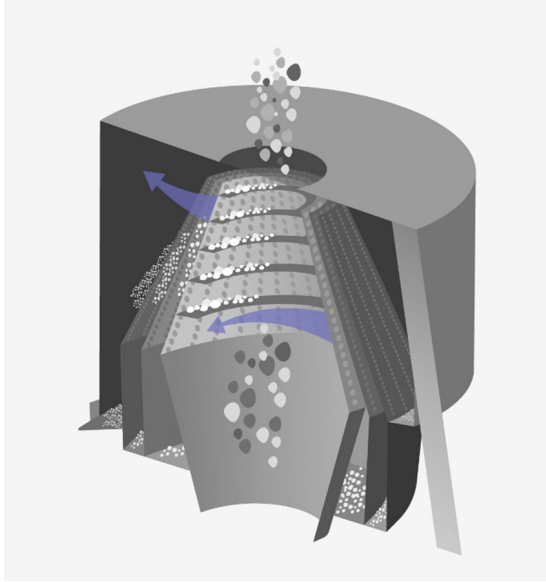


Figure 3. Conceptual visualization of the sieving machine

Conclusions:

The presented design is targeting requirement of the terrestrial and extraterrestrial processing of mineral materials. Water shortages as well as localization of the ores on Earth in the areas of water scarcity put more and more value on the sustainable management of water resources. The extraterrestrial application as a basic requirement forces the operation without transferring media, in no gravity/microgravity and hard conditions. The fundamental idea of operation of the presented solution fits well to those requirement while no media or field(gravity) is required for the operation.

However, as the development of the presented idea is on the conceptual stage, there is still plenty of questions referring to the final output and maintenance which has to be answered.

Nevertheless, in the opinion of authors, the solution has big potential of the application in terrestrial mining what can be treated as the testing and development field for the final extraterrestrial application.

References:

- [1] Rasera et. al. The beneficiation of lunar regolith for space resource utilisation: A review, Planetary and Space Science 186 (2020) 104879
- [2] Sustainable Development Goals, United Nations, 2023
- [3] PCT/PL2023/050070