THREE-DIMENSIONAL LUNAR REGOLITH BUCKET CONVEYOR - LUREBUCON3D. P. Kulinowski[1] and W. Kuchta[2], [1]AGH University of Krakow, al. Mickiewicza 30, 30-059 Kraków, Poland, piotr.kulinowski@agh.edu.pl, [2]AGH University of Krakow, al. Mickiewicza 30, 30-059 Kraków, Poland, spaceteam@agh.edu.pl

Introduction:

Lunar regolith is a very difficult material to transport. It has completely different properties to materials we have on Earth. This means that transporting it needs special conveyors. These conveyors will protect the regolith from the harsh conditions on Earth and from the regolith itself.

The presentation will present an innovative prototype of the LUREBUCON3D spatial bucket conveyor developed by the Spaceteam AGH scientific club, which will enable effective transport of lunar regolith even over considerable distances. What makes this conveyor so special is that it can be adjusted to move regolith in any direction at any angle. This is a unique concept, not seen in industrial applications on Earth.

Design assumptions:

Conveyors can transport bulk materials in two ways: (1) by transporting them, the transported material does not move relative to the moving elements of the conveyor (belt, plates, buckets) or (2) by moving them along the surface of the chute using structural elements, an external factor or vibrations. Moving regolith along the surface of the trough is associated with the problem of wear of the trough surface due to the abrasiveness of the regolith, with increased energy consumption related to overcoming the friction forces of the transported material on the chute surface and with increased dustiness. Analysis of various types of conveyor design variants showed that it is advisable to look for a solution for transporting lunar regolith with a minimum number of friction nodes and without elastic elements sensitive to extremely low temperatures. The results of the analysis showed that the bucket conveyor can become an interesting alternative to the previously proposed conveyor solutions, and the lack of atmosphere (no wind) on the Moon and low gravity (reducing lifting resistance) additionally add arguments for this solution.

Laboratory tests:

The design of the three-dimensional bucket conveyor was preceded by a series of laboratory tests in a specialist AGH laboratory, the purpose of which was to test the structural components: buckets, the rod and its guidance, as well as to minimize the energy consumption and mass of the device.

In the initial phase of the project, it was necessary to modify known bucket conveyor designs to enable the buckets to be guided horizontally and the direction of movement to be changed at a selected angle. It was decided to use a non-flexible, articulated rod. A standard roller chain was used for the laboratory tests. Laboratory tests showed that this chain has sufficient torsional flexibility for testing the three-dimensional bucket conveyor.

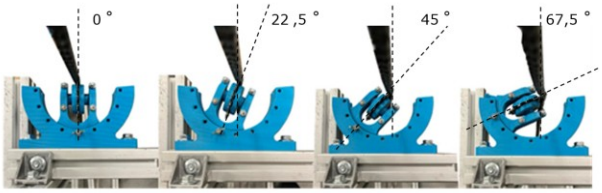

Figure 1. Roller chain torsional flexibility tests.

Another innovative element of the new conveyor design was the rotating bucket. The proposed, articulated design of the bucket holder maintains a vertical position, regardless of the angle of the chain strand.

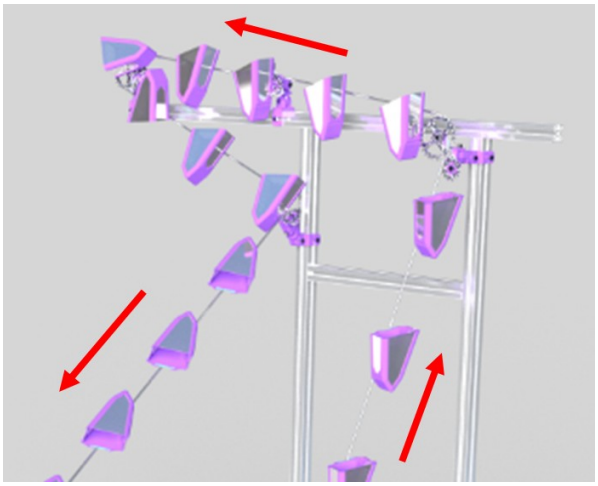

Figure 2. Visualization of bucket positioning on the vertical and horizontal sections.

In addition to ensuring the stability of the three-dimensional transfer, the bucket design enables efficient unloading of the regolith.

Bucket loading has become a significant problem. Laboratory tests have shown that the self-loading process does not guarantee uniform loading of the buckets and causes excessive increase in chain stress, vibrations and instability on the guide sets.

Figure 3. The process of self-loading of buckets.

An interesting, innovative solution is the rod-scraper pulsating feeder, developed during the TOLRECON project. It enables the initial separation of regolith on a spiral-drum sifter and its dosing into buckets while ensuring dust mitigation..

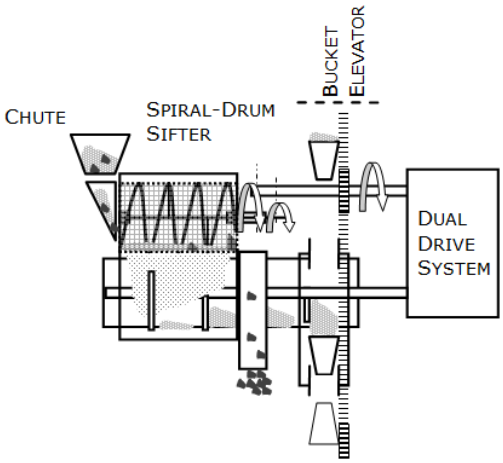

Figure 4. The rod-scraper pulsating feeder.

Results and Discussion:

In accordance with the design assumptions, a three-dimensional bucket conveyor was constructed, upon which functionality and energy consumption tests were conducted. The energy consumption of transport systems is defined by the energy consumption index, which is measured as the amount of energy used to transport 1 kg of material over a distance of 1 m: $w_e = N/(Q*L)$ [W·s / (kg·m)], where Q – mass flow, capacity [kg/s], N – required drive power [W], L – length of the transportation path [m].

The test results showed that the energy consumption index we was the lowest when the buckets were fully loaded. However, at low cable speeds, the energy consumption increased due to the resistance of the roller chain.

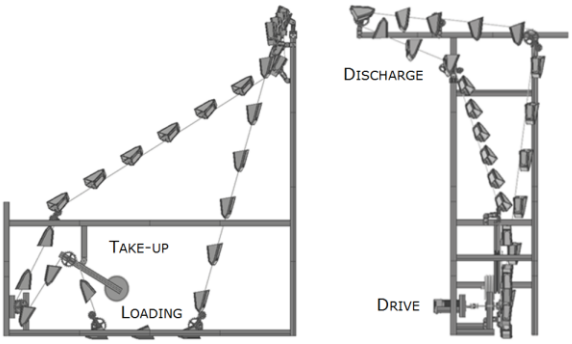

Figure 5. Visualization of the laboratory model of a three-dimensional bucket conveyor.

Summary:

The assessment of the conveyor efficiency was conducted using energy consumption and structure mass indicators, i.e. the energy consumed and the mass of the device related to the obtained system efficiency. The technical parameters of the LUREBUCON3D device are such that it can be regarded as having the potential for use in the transport of icy regolith from the bottom of a lunar crater.

Key features of the LUREBUCON3D conveyor:

- capable of vertical, diagonal and horizontal transport,
- simple design, enabling the use of other devices to guide the route, e.g. a silo,
- potential for long-distance transport (several hundred meters),
- flexible drive location,
- low energy consumption index and minimal abrasive wear due to the limitation of friction nodes to supports changing the direction of the movement of the chain,
- necessity to design a special string/chain, enabling operation in extreme lunar conditions,
- necessity to make dedicated string/chain guiding systems.

References:

[1] Kulinowski P. (2023) *Prototype of a Conveyor System for the Transport of Lunar Regolith* Springer Nature (Springer Aerospace Technology)

[2] Kuchta W. (2024) *Prototype of a single-chain bucket conveyor with variable route geometry for lunar regolith transport* - unpublished diploma work AGH University