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OPERATION CHARACTERISTICS AND TESTING PARAMETERS OF TRANSPORT CHANNELS

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Abstract: *Today's advanced, automated serving systems must operate efficiently in a dynamically changing environment, where modern methods and procedures can be applied during the realization of handling processes. To be able to apply various optimization methods and simulation software with appropriate efficiency during the planning and operation of material handling devices, it is necessary to explore the parameters of the technical devices to take the individual characteristics into account. In this article, the next step of previously started research is presented, in which the variants of conveyor belts and the most important operating characteristics are explored.*

Key words: *transport channels, advanced planning methods, machine parameters*

1. INTRODUCTION

Today's modern, automated service systems must operate effectively in a dynamically changing environment, where modern methods and procedures can be applied during the design and operation of the handling processes. Of these, optimization methods and simulation software are the most frequently used tools in logistics, which are very effective, but usually serve to properly map processes, and therefore are less able to consider the characteristics of technical devices (e.g. material handling machines). To be able to use them with sufficient efficiency during the design and operation of material handling devices, it is necessary to explore the parameters of the technical devices, which can help us to take the individual characteristics into account and enable to set them accurately.

In this article, previously started research [1] will be continued, which serves for the accurate modelling of material handling equipment, primarily for simulation tests of handling systems. On the following pages, the variants of transport channels and their most important operating characteristics are explored.

2. VARIATIONS AND CHARACTERISTICS OF TRANSPORT CHANNELS

The simplest implementation of material handling tasks can be done with the help of transport channels [2], which can move various goods even without a driving force (for example gravity chute). For movement, the goods are placed on a transport channel, which, in accordance with the applied transport principle (e.g. the movement of the conveyor belt), brings them to the end (or a given point) of a given track, where they can be removed (e.g. dropped). transport channels can be distinguished primarily based on the applied drive method and the implementation of the power transfer (Fig. 1).

The most important advantages of transport channels are the simple movement process and the complex track design options. The disadvantages include the fixed loading and unloading points and the rigid structural design.

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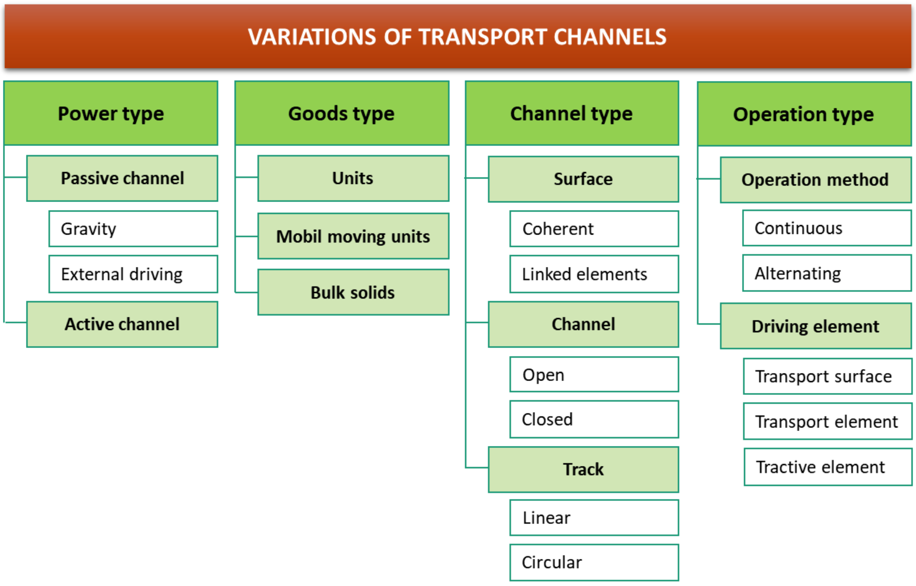

Figure 1. Variations of transport channels [3]

2.1. Characteristics of gravity conveyors

In the case of gravity conveyors (Fig. 2), the goods move on a fixed surface or channel placed on a slope due to the force of gravity, for which an appropriate level difference must always be ensured. The goods moved can be piece goods (e.g. chute), transport units (e.g. rail track), or bulk materials (e.g. slide). The straight or curved track can be a simple metal channel, usually with a side wall, a row of rollers placed on a slope without a drive, or an inclined rail or pair of rails. Their main advantage is simple, low-energy operation.

a) Spiral slide, source: [4] *b) Feeder chute, source: [5]*

Figure 2. Gravity conveyors

The most important operating characteristics of gravity conveyors:

- moving goods between two points (uploading and unloading point)
- external loader equipment (or manual loading),
- level difference between the starting and the end points,
- simple operation and maintenance,
- uncontrollable flow characteristics,
- continuous goods movement,
- simple, automatic unloading (fall from the channel), etc.

2.2. Characteristics of externally powered conveyors

Externally powered conveyors (Fig. 3) are generally passive tracks, surfaces, or channels on which an external force independent of the track performs the movement [6]. For movement, we can use manual force (e.g. on roller conveyor), high-pressure air (in pneumatic transport), pusher elements (e.g. in screw conveyor), etc. The most important operating characteristics of externally powered conveyors are:

- in generally moving goods between two points (except pneumatic conveyors)
- uploading realized by external machines or manually (pneumatic conveyors can upload automatically),
- in generally use linear transport lines (pneumatic conveyors can contain curved sections),
- transport lines can be horizontal, vertical or tilted,
- simple operation and maintenance,
- simply controllable flow characteristics,
- continuous goods movement,
- simple, automatic unloading, etc.

a) Screw conveyor, source: [7]

b) Pneumatic conveyor system, source: [8]

Figure 3. Externally powered conveyors

2.3. Characteristics of powered transport channels

Powered transport channels (Fig. 4) consist of a moving conveyor surface or conveyor elements that move the goods placed on it at a speed corresponding to the conveying capacity of the channel. The conveyor can be linear (e.g. conveyor belt) or rotating (e.g. turntable), and the movement can be continuous (e.g. roller conveyor) or alternating (e.g. vibratory conveyor). The most important features of powered transport channels are:

- moving goods between two or more points,
- external loader equipment, or manual loading,
- linear or complex lines,
- in generally horizontal lines, but slopes or rising sections also can be applied,
- limited goods types (roller conveyors can only move piece goods, etc.),
- simple operation and maintenance,
- simply controllable flow characteristics (by the driving force),
- continuous goods movement,
- simple, automatic unloading, etc.

a) Rotary table, source: [9] *b) Vibration conveyors, source: [10]*

Figure 4. Powered transport channels

4. SPECIFIC TESTING PARAMETERS OF TRANSPORT CHANNELS

From the perspective of operational modelling, transport channels are the easiest material handling equipment to test, as they can generally be easily defined and tested with the characteristic dimensions of the track (conveying surface, cross-section, length, number of straight and curved sections, etc.) and drive parameters (velocities, accelerations, etc.).

In advanced industrial and service systems, we most often encounter roller conveyors and various types of conveyor belts (Fig. 5) [11]. Conveyor belts are continuous-operating conveyors for the transport and loading of piece goods and bulk materials, in which the products are moving on an endless conveyor surface embedded in a given linear track, which can be coherent surfaces (rubber, textile, steel fabric, composite belt, etc.) or interconnected elements (connected, fitted, overlapped, etc.) [14]. Roller conveyors are continuous-operating conveyors in which the products are moved by rolling elements embedded in a given linear track. We speak of gravity roller conveyor transport if the goods move on a free-running row of rollers placed at a given slope angle. In the case of driven roller conveyors, the goods are moved along the track by the coercive force exerted by the rotating rollers [15].

The transport channel, as a movement solution, allows for a fundamentally similar handling solution even in the case of completely different structural designs. In the case of the two devices above (conveyor belt and roller conveyor), for example, we can consider similar application environments and transport characteristics.

a) Belt conveyors, source: [12] *b) Roller conveyors, source: [13]*

Figure 5. Transport channel systems

Material handling equipment has various properties, which are primarily determined by the structural design and fundamentally influence their applicability [16]. The most important properties of conveyors are the following:

- drive mode characteristics (roller movement, moving surface, passive surface, etc.),
- structural properties (track line, track sections, conveyor surface characteristics, etc.)
- operating properties (automatic goods movement, continuous operation, automatic delivery, etc.)
- system properties (fittings, transfers, performances, etc.), etc.

The most important differences between the characteristics of transport channel types arise primarily due to the functional structure, while the greatest similarities arise from the operational nature (Table I).

In the case of transport channels, the handling processes can be defined simply (e.g. by specifying the route) [17], but during operation analysis, the effect of certain parameters can be influenced by many factors, e.g. changes in product characteristics, changes in transport speed, changes in track characteristics, etc.

When testing handling systems (e.g. simulation), different conveyor paths are usually considered by changing only a few basic parameters (speed, geometry, etc.), which can lead to inaccurate test results and does not allow for detailed comparison of individual types [18].

Changes in product characteristics (e.g. width) in some cases also require changing the width of the path, which can be a significant cost factor, but can also significantly increase the space requirement in complex routes.

Transport speed is often used as a variable parameter, but in some variants (e.g. roller conveyors) this can cause goods stability problems (goods may tip over on an ascending section), which is not considered.

It is common for track characteristics to be modified during tests, which is not preceded by a usability test, so it is possible that the version that performs better in comparison is not feasible in practice or can only be used with significant modifications.

Among other things, by precisely defining and customizing the above characteristics, more effective comparisons and evaluations are possible, but this requires further research to define the characteristics of transport channels.

Table I.

Comparison of significant parameters of different transport channels.

Parameters	*Chute*	*Roller conveyor*	*Belt conveyor*	*Rotary table*	*Vibration conveyor*	*Pneumatic conveyor*	*Screw conveyor*
1. Operations							
transport	x	x	x	-	x	x	x
loading/feeding	(x)	(x)	(x)	x	-	-	(x)
storing	-	x	x	-	-	-	-
2. Goods							
bulk solids	x	-	x	-	x	x	x
piece goods	x	x	x	x	-	-	-
loading units	-	x	-	-	-	-	-
3. Structure							
channel	*open*	*open*	*open*	*open*	*open*	*closed*	*closed*
driving method	*grav.*	*driv.*	*driv.*	*driv.*	*driv.*	*ext.*	*ext.*
4. Track							
upload/unload points	*2*	*more*	*more*	*2*	*2*	*more*	*2*
fitting	-	x	x	-	-	-	-
line	*simp.*	*comp.*	*comp.*	*simp.*	*simp.*	*comp.*	*simp.*
4. Line sections							
horizontal	-	x	x	x	x	x	x
slope	x	x	x	-	-	x	x
vertical	x	-	-	-	-	x	x

5. CONCLUSIONS

Today's modern, automated handling systems must operate efficiently in a dynamically changing environment, where we can apply effective methods and procedures during the design and operation of the handling processes. To be able to apply various optimization methods and simulation software with appropriate efficiency during the design and operation of material handling devices, it is necessary to explore those parameters of the technical devices, with which we can accurately set and adjust the individual characteristics.

This article presents the next step of previously started research, where in addition to the general description and overview, the parameters of the different versions were defined, which play the most important role during the various system tests.

In the continuation of the research, those parameter values will be uncovered by examining the explored characteristics, which allow for more effective comparisons and evaluations.

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