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DESIGN OF MECHANICAL MINI-VARIABLE SPEED DRIVE WITH APPLICATION AT TRANSPORT SYSTEMS

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***Abstract*—** This paper is presented a construction of variable-speed drive used for the transport systems, requirement for the changing of tact of lines in working, in function of workpieces sizes. The construction news of variable-speed drive is that fitting of revolution speed is done by the forced alter of intermediary ball, locating between two symmetrical flanges versus of shaft leading by spatial cam, which is acting by the worm and worm gear system.

***Keywords*—**Adjustment, Transport system, Mini-variable speed drive

I. INTRODUCTION

THE product design represents an important part from the production process, which requires the following [1]-[17]:

1) Determining the processes to be used,
2) Development of operation flow charts,
3) Production layouts,
4) Setup charts and machine tool layouts,
5) Equipment selection and sequence,
6) Material handling details,
7) Tooling needs,
8) Inspection plans for Quality Assurance and Quality Control, etc.

The utilities of layout can be design in accordance with the function or process, where the process-oriented plant layout is commonly used. This arrangement means groups together all similar functions, as milling, turning, grinding, due to an economical arrangement with less capital, achieves higher machining utilization, and easy to automate. Basic guidelines for an effective enterprise layout include [14], [15]:

a) A planned material flow patterns,
b) Minimal backtracking,
c) Minimal work-in-process,
d) Few built-in-flexibility,
e) Maximum ratio of processing time to overall time,
f) Minimal travel distances for material handling,
g) Optimal quality practice,
h) Smooth and adequate materials flow,
i) Good housekeeping,
j) Access to maintenance.

In side of the assembly lines at feeding, carrying and unloading of workpieces are used the handling systems. The transport system is encompasses from a mechanical moving system of workpieces, the lifting installation for up and down load, and electrical system. One's of moving system representing the electrical motor with an engaged device. The carrying of workpieces with different sizes and dimensions supposed to alter the tact line. This is realized with the electronic and mechanical variable-speed drives [18].

There are multiple types of material handling system used in manufacturing, such as:

i. Roller conveyors,
ii. Rail-guided transporters,
iii. Automated guided-vehicles (AGVs),
iv. Elevated tracks,
v. Forklift trucks,
vi. Robot,
vii. Other mechanical, electrical or hydraulic devices.

In the last years, automated material handling systems are widely used by automated guided vehicle systems and automated storage and retrieval systems [14], [17].

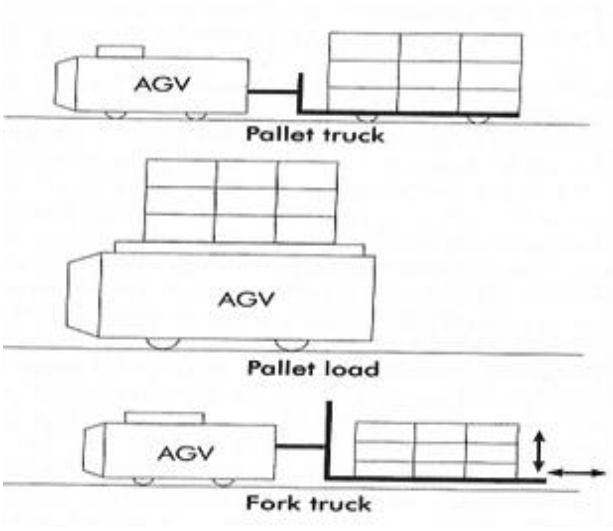

Fig. 1. Load transfer modes with AGVs [14]

The automated guided vehicle systems are divided in:

1. Train,

2. Forklift,
3. Unit load, and
4. Assembly.

These systems used for guidance fixed bar codes, radio frequency, magnetic stripe, voice recognition, and machine vision [11]-[15].

This paper is presented a simple and cheap construction of mechanical variable-speed drive with a ball and pressured disks. The constructive news of this device is that the out revolution fitting is done by forced locating of ball which is working between two opposed symmetrical wheel disks of enter-exit shaft by a inner spatial cam acting by worm and worm gear system.

II. THEORETICAL ASPECTS

The transport systems can be realized into versatile constructive types, in function of moving workpieces types, addressing precision, and moving speed.

A transport system could be simple or versatile, locating inside or external technological system with intermittent or continuous operating [14]-[19].

The way driven (direction) by a transport system could be linear, circular and aggregated.

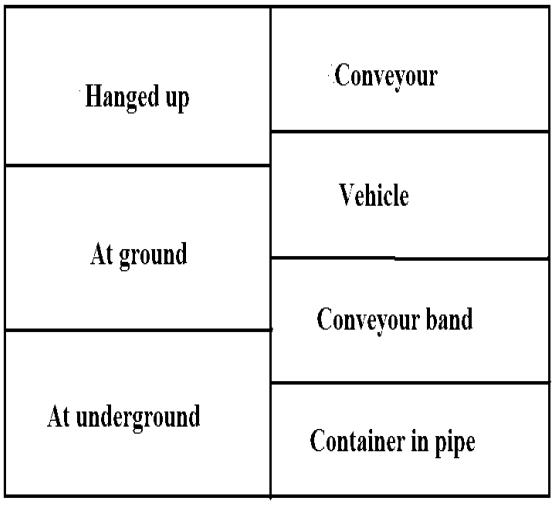

Fig. 2. Types of transport systems

In industry sectors, can be found many transport systems (Fig. 2), with have a variety weight of flexibility (Fig. 3).

The transport systems with circular or linear trajectory could be with intermittent or continuous operating time. The average way driven by a transport system has calculated with formula [15], [17], [18]:

$$D = \sum_{i=1}^{i} d_i \,/\, l \tag{1}$$

Where:

- d_i is the drive size doing by transport system for driving to address-*i*,
- l is number of transport operations that are possible to have done.

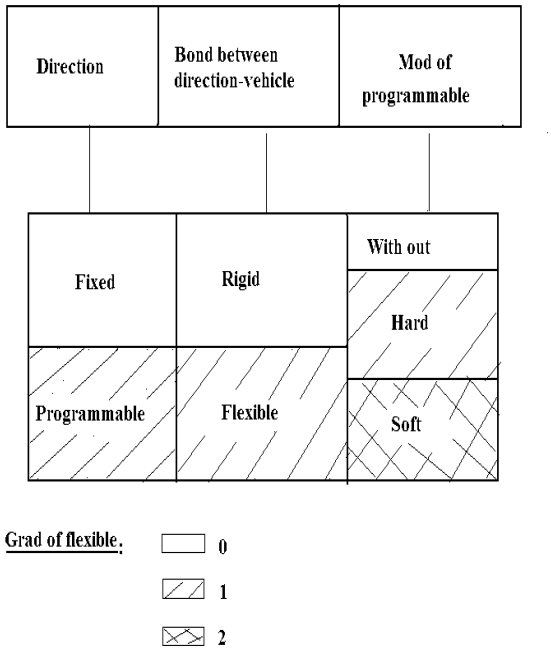

Fig. 3. Types of flexibility

The transport systems could be stationary or mobile systems [10]-[18].

a. Inside of transport systems could be found the devices such as: worm and worm gear, nut-screw with balls, gear-rack, speed reducer gears and variable-speed drives.
b. By the kinematics analysis of speed reducers and variable-speed drives could be emphasize;
c. the speed reducer gears had computation of revolution series after geometric progressive;
d. for to achieved a real run speeds is required that revolution speeds of exit shaft n_1, n_2, n_3, n_{i-1}, n_i, to form a geometrical progressive, as:

$$n_i = \varphi^{i-1} \cdot n_1 \tag{2}$$

Where the ratio of geometric progressive is:

$$\varphi^{i-1} = \sqrt[i-1]{\frac{n_i}{n_1}} \tag{3}$$

I. - At transport systems with adjustment devices in steeps of revolution speed appears a losing speed:

$$\Delta v_{max} = 1 - \frac{1}{\varphi} \tag{4}$$

II. - At transport systems with continue variable drive the losing speed is avoided by that the difference between two consecutive revolution speeds is very little:

$$\lim_{\Delta n \to 0} \frac{n_{i+1}}{n_i} = \lim_{\Delta n \to 0} \frac{n_i + \Delta n}{n_i} = 1 \quad (5)$$

III. - At variable-speed drives with ratio φ = 1 and Δv_{max} = 0, the gear ratio has a linear variation.

Inside of continuous variable-speed drives, the transmission of flux forces is done by the friction.

A new constructive solution of variable-speed drive, with a ball and adjustment revolution speed by the cam with a parabola shape would be present more in next.

III. MINI VARIABLE_SPEED DRIVES FOR TRANSPORT SYSTEMS

The function principle of variable-speed drive with a ball is supposed to locating this ball between two symmetrical wheel disks.

At this variable-speed drive, the gear ratio is done by altering the contact radius disks with ball, and the wheel disks having a special shape, which is ensured a uniform speed for all contact points.

The gear ratio-*i* is [17], [18]:

$$i_{1,2} = \frac{n_1}{n_2} = \frac{\rho_2}{\varepsilon_e \cdot \rho_1} \quad (6)$$

Where:

- ε_e is a specific slipping, and
- ρ_1, ρ_2 are the curvature radius, which they are determined in contact points.

In Fig. 4 is showing the new construction of variable-speed drive with a ball. The variable-speed drive has the following elements:

1. *Casing,*
2. *Enter shaft,*
3. *Intermediary element (ball),*
4. *Cam,*
5. *Exit shaft,*
6. *Compensation ring,*
7. *Screw,*
8. *Screw,*
9. *Cover casing,*
10. *Worm,*
11. *Ball bearing,*
12. *Revolution sleeve,*
13. *Ball bearing,*
14. *Pressure ring,*
15. *Disk spring,*
16. *Ball bearing,*
17. *Cover,*
18. *Screw,*
19. Revolution sleeve.

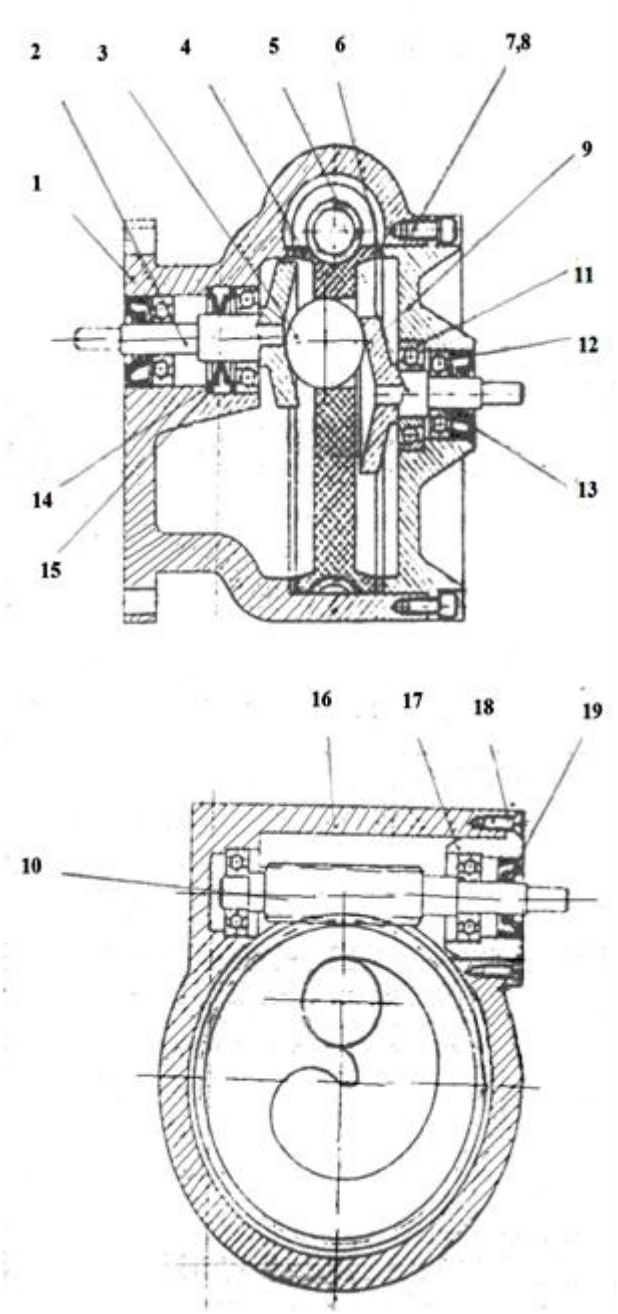

Fig. 4. The variable-speed drive with a ball

The location of ball -*3*, it's realized by the cam – *4*, rotating the worm gear, by the action of worm – *10*.

The revolution of mini variable-speed drives variation after a quadratic equation form:

$$y = C_0 + C_{1x} + C_{2x} \quad (7)$$

, and the law of variation is shown in Fig. 5.

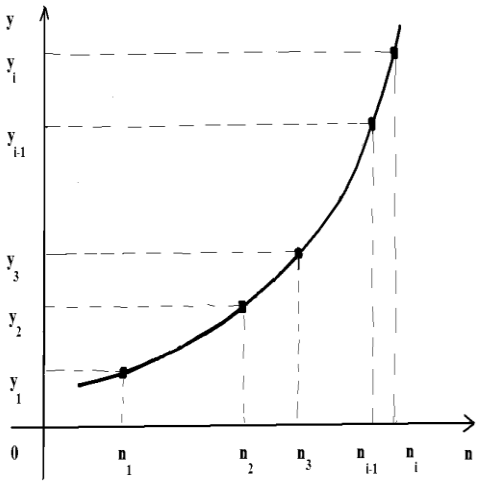

Fig. 5. The analytic diagram of revolutions

Analyzing the diagram from Fig. 5, can be observed its linearity character for all the revolutions speeds of mini-variable spindle speeds drive, which means that the system emphasis a good working on entirely range.

IV. CONCLUSION

This paper has presented a construction of mechanical mini-variable speed drive with a ball and pressure disks with application in transport systems.

The significant conclusions of this paper that can be done are the followings:

A. The variable speed drives used in construction of transport systems had the goal to achieve a useful speed, reduced energetic consumes, due to a low cost of maintenance.

B. This mini variable-speed drive represents an original construction, which has a little size with simple constructive elements, and low cost of fabrication.

C. The novel of this device is that the out revolution fitting is done by forced locating of ball which is working between two opposed symmetrical wheel disks of enter-exit shaft by a inner spatial cam acting by worm and worm gear system.

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