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Research Article

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Application of Linear Motor in Industry

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Abstract Linear motors work based on electromagnetic induction. They are designed to produce direct translational motion. One advantage of linear motors over indirect translational motion-generating systems using rotary motors is that they produce direct translational motion with high-precision position response. When using linear motors, intermediate mechanical structures such as belt systems and gears are removed. That is a feature that indirect linear motion systems do not have. That makes the system compact and achieves a higher efficiency rate in the same limited space. This paper will analyze the applicability of linear motors in direct translational motion-generating systems used in practice.

Keywords Motion control, Linear Motor, Linear Actuator

1. Introduction

According to [1-4], the basic principle of linear motors was introduced around 1840 by Charles Wheatstone. By the late 1940s, Eric Laithwaite came up with the actual model of working motor and applied in the industrial textile system. Up to now, linear motors have been developed quite completely in hardware design, dynamic quality, and a diverse range of power. Since then, the choice of linear motors in direct motion systems when designing a new system and renovating indirect linear motion systems has become a necessity.

2. Characteristics of a translational drive systems.

To create a translational motion for technology objects, there are two methods: the indirect method and the direct method.

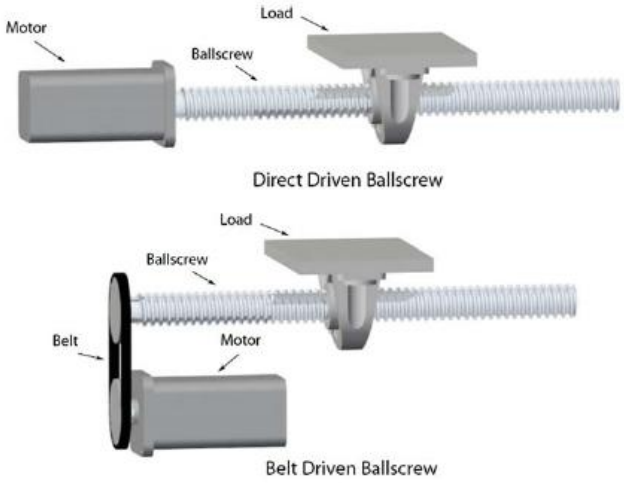

Figure 1: Indirect translational motion is created using belts and screws [5]

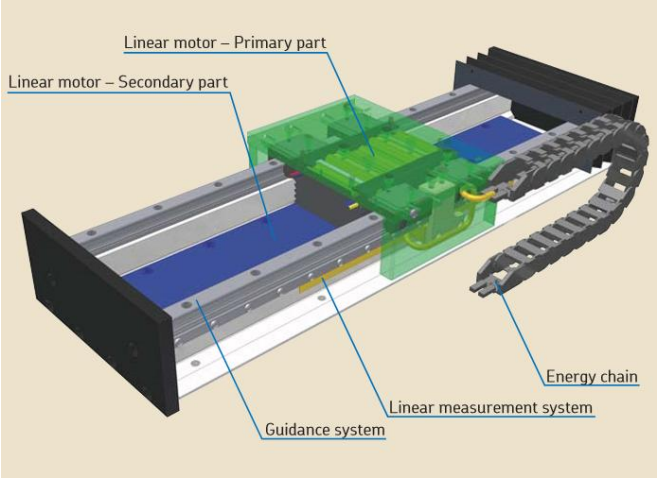

Figure 2: Translational direct motion is created using linear motors [6]

From Figure 1, Figure 2, we have some comments as follows:

The method of creating indirect translational motion: The driving force is a rotary motor. In order to create translational motion for the production structure, it is necessary to use intermediate mechanical elements such as transmission belts, gearboxes, screws, etc. Therefore, it has the following disadvantages: (1) Complex mechanical structure. In the system where intermediate elements exist, the accuracy of the system is low due to the accumulated errors of the elements in the whole system; (2) Low system performance. The kinematic ability of the system is low due to the existence of specific vibrations of intermediate elements; (3) High price, high maintenance costs; (4) Requires a large amount of space.

The method of creating direct translational motion: In this method, linear motors are used to create an direct translational motion. When using linear motors, the system will overcome the disadvantages of the method of creating indirect translational motion. That is illustrated in the following: (1) Simplified in terms of mechanical structure by eliminating intermediate elements reduces operation maintenance costs; (2) The efficiency of the system is enhanced by eliminating the intermediaries; (3) The kinetic properties of the system are enhanced, due to the elimination of the individual oscillations of the intermediate elements; (4) Increase is upper limit on thrust and acceleration; (5) Less noise during operation, easier maintenance, longer life expectancy. However, linear motors still have a disadvantage. That is, the cooling solution of this type of motor is more complicated than that of a rotating motor.

3. Working principle of linear motor

A linear motor consists of two components: The first component receives the incoming electric current (primary part), the second component is the energy flow given in the mechanical form (secondary part). From this point of view, we can see that, with a linear motor, the linear motion part can be the stator or rotor part of the rotating machine, thereby creating the corresponding linear motor.

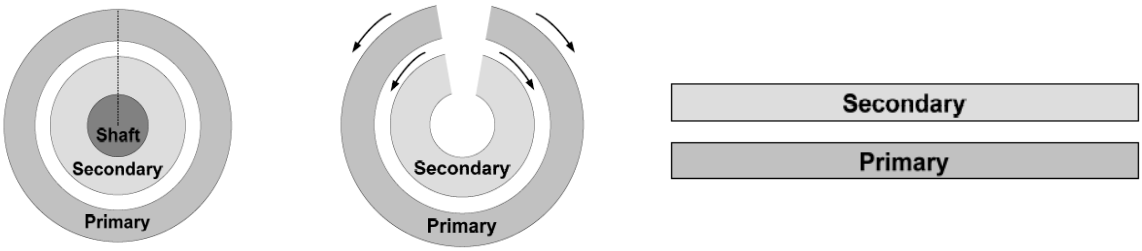

Figure 3: Principle of conversion from the rotary motor to the linear motor [7]

From the basic principle above, linear motors are developed with different structures correspondingly based on the purpose of use. The choice of linear motors depends on their properties and operating principles. We can

create different types of linear motors from actual technological requirements, divided into three main types as follows.

First type: Single-sided.
This motor consists of a primary component (dynamic part), a secondary component (static section).

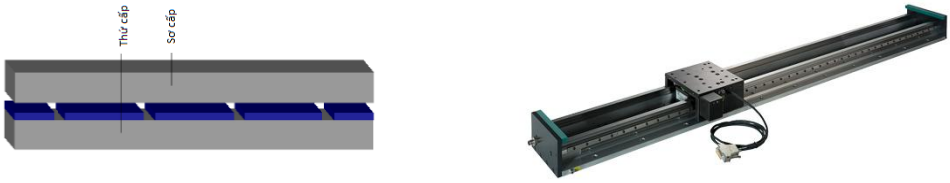

Figure 4: Single-sided linear motor [7,8]

The term stator is often used to refer to the stationary part of an electrical machine. However, in linear motors, the stator is the dynamic part. In this case, the stator is meant to receive power from the power supply. With linear motors, the majority of coil systems are in the dynamic part. The rotor part now acts as the static section, stretching across the entire length of the machine. Examples are the short-circuit loop system of asynchronous linear motors, permanent magnet system of linear excitation linear motors.

Second type: Double-sided
Typically, the primary part is the Stator component that is symmetrically arranged

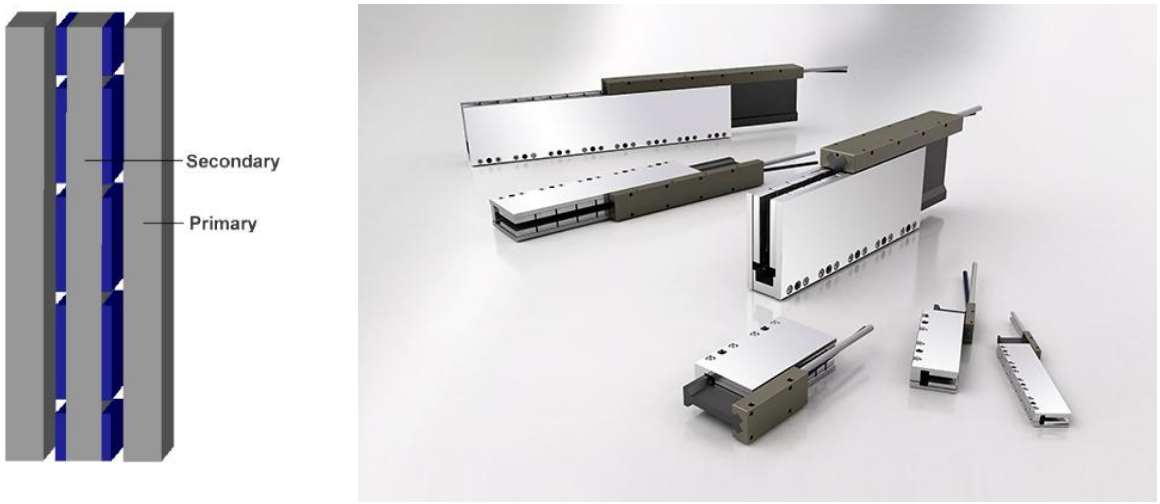

Figure 5: Double-sided linear motor [7, 9]

Third type: Tubular linear motor
Originating from the idea of rolling a Single-sided linear motor with a single sliding surface around a straight shaft, the result is a tubular motor.

Figure 6: Tubular linear motor [7, 10]

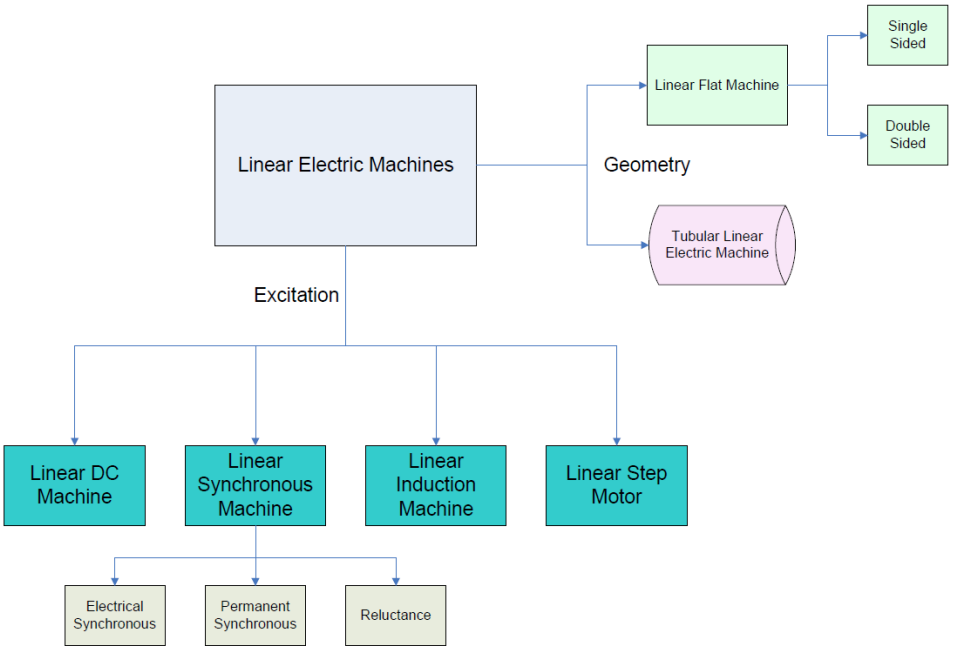

Figure 7: Classify linear motors according to working principle and geometric structure [11]

4. Application of Linear Motors

Linear motors have now been used in practice in all power ranges. In the high power range, they are present in the transmission mechanism used in transport vehicles such as trains, metro. In the medium and low power range, they are applied in automatic control of CNC digital machine tools, robot arm control, lifting machines, controlling flexible production systems with high requirements of position accuracy, high speed, and fast impact. In the low power range, they are used in types of equipment such as printers, laser cutters used in surgery, etc.

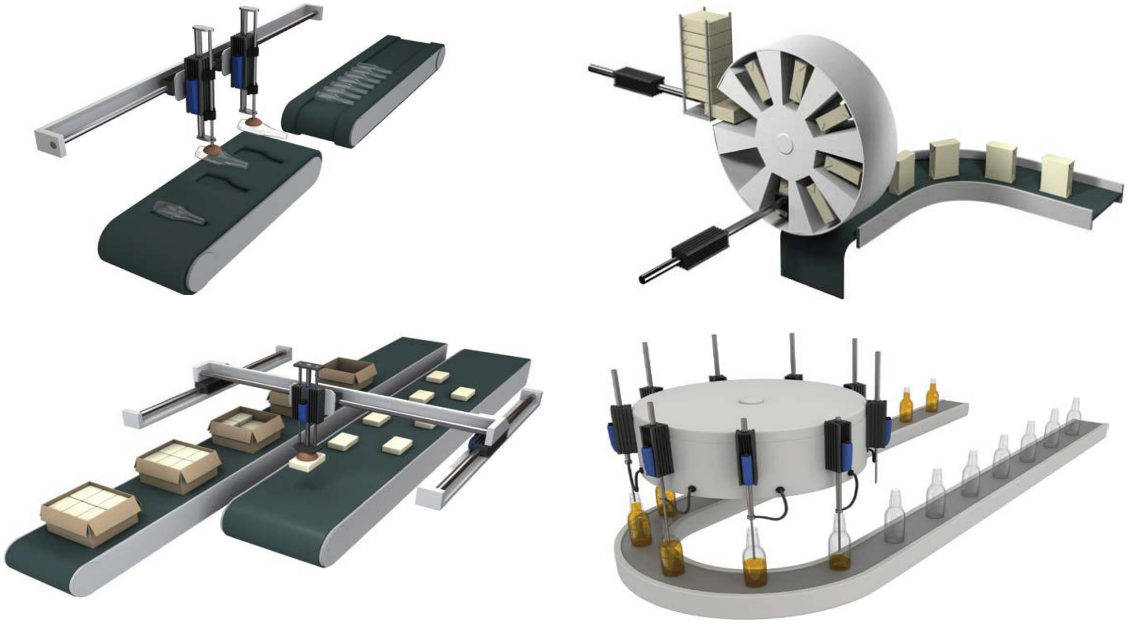

Figure 8: Application of linear motors in packaging technology [12]

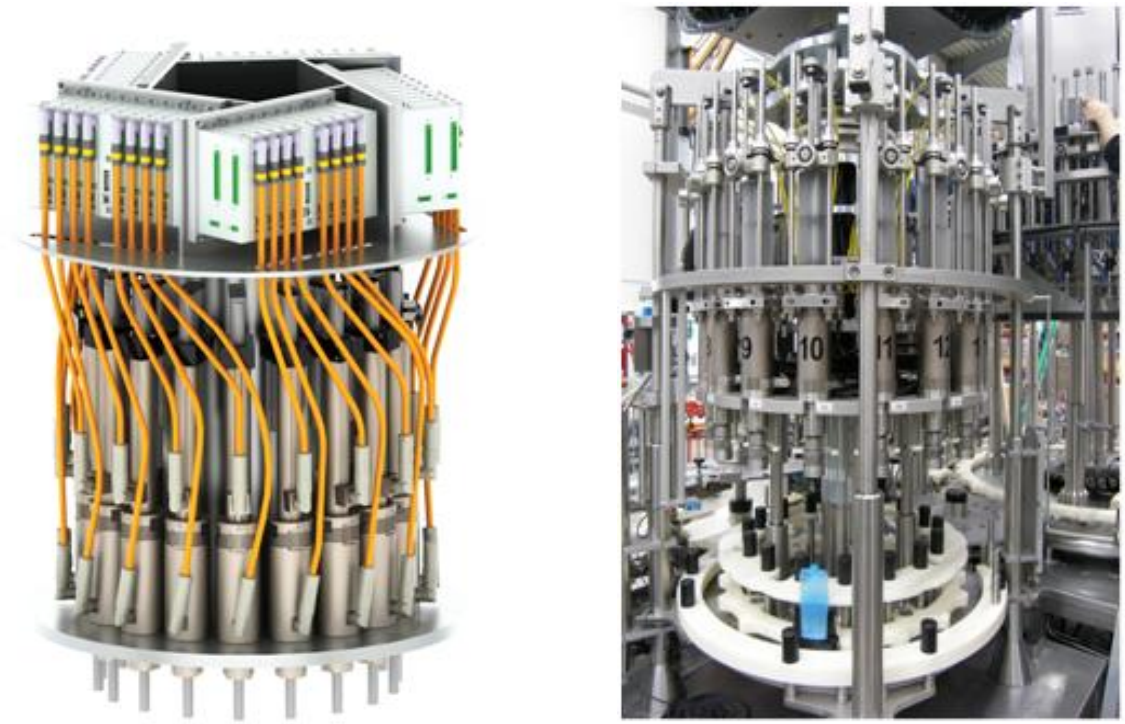

Figure 9: Application of linear motors in flexible conveyor belts and automatic corkscrews [10] (Photo: Rossmann)

Figure 10: Application of linear motors in CNC machines, hexapod robots [10]

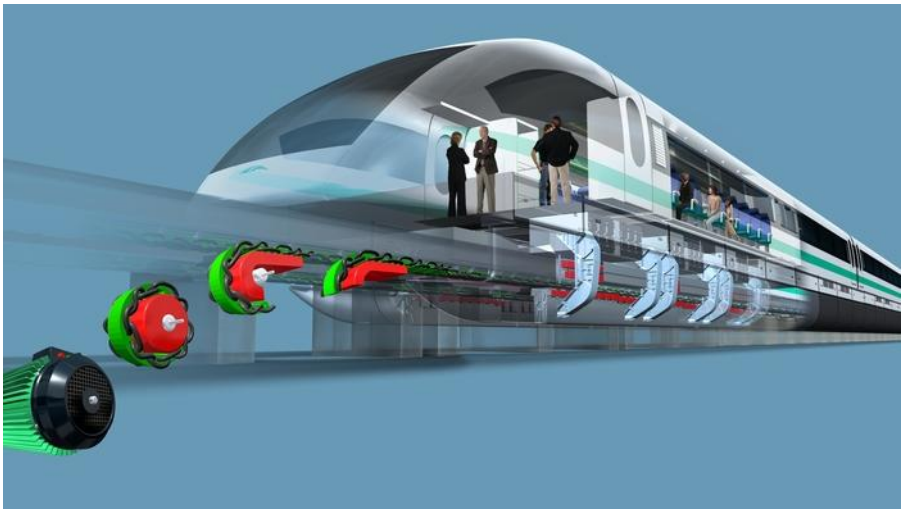

Figure 11: Magnetic train developed from the working principle of linear motor [13]

It is noticeable that linear motors when manufactured as modules, Fig. 8 - Fig. 11, will easily combine quickly to form a multi-axis motion system. The chain intervention, as well as customizing the technological process, will become more straightforward when the motors are connected to the central control system. That is the most visible evidence of the participation of linear motors in the technological process in high-automation lines.

5. Conclusion

At present, linear motors have developed quite entirely in terms of hardware in all power ranges. Another factor to consider is the accuracy of the position of the systems when using linear motors. That is a problem involving speed, acceleration, response time, and stopping accuracy. Therefore, together with hardware devices, the task of designing controllers for linear motors is an urgent requirement. The next research direction is to build control algorithms for this technology object.

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