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Linear Motors for Industrial Automation Applications

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Abstract
Linear machines rarely achieve the performance expected from their rotary equivalents in terms of power factor or efficiency. However, in several applications, this reduction in performance is more than compensated for by convenience and robustness. This paper will analyze the applicability of linear motors in direct translational motion-generating systems used in Industrial Automation Applications.

Keywords: Linear Motion, Linear Motor, Motion Control

1. Introduction

Linear induction motors are little more than a "cut open and rolled flat" version of rotary AC induction motors [1-10]. Today's linear motion applications are more demanding than ever before. More exact positioning, longer life, less maintenance, fewer moving parts. Motion control companies strive to meet and exceed these requirements through continual technological advancement. Advancements in linear encoder technology also allow for higher-speed operation. Today's linear encoders and other devices can meet this challenge, are less noise-susceptible, and cost less. Commutation is done electronically either by Hall-effect sensors or sinusoidal [11]. Hall-effect sensors located within the forcer are activated by the magnets on the rail. Sine commutation is accomplished using the linear encoder signals back to the controller. A common technique is using the Hall-effect initially and then switching to sinusoidal commutation. The force generated by the same size motor is more significant than brush motor technology due to improved magnet materials.

2. Industrial Applications of Linear Motor Applications

Linear induction motors consist of a moving primary (rotor in traditional rotary induction motors) that contains the motor coils and a stationary secondary (stator in standard rotary induction motors). These motors primarily include a three-phase winding, which carries the current supplied by the AC synchronous or AC vector drive. As current flows in the primary windings, it is induced to flow in the secondary windings. The interaction of the electromagnetic fields produced by the currents in the primary and secondary windings generates linear force to propel the primary.

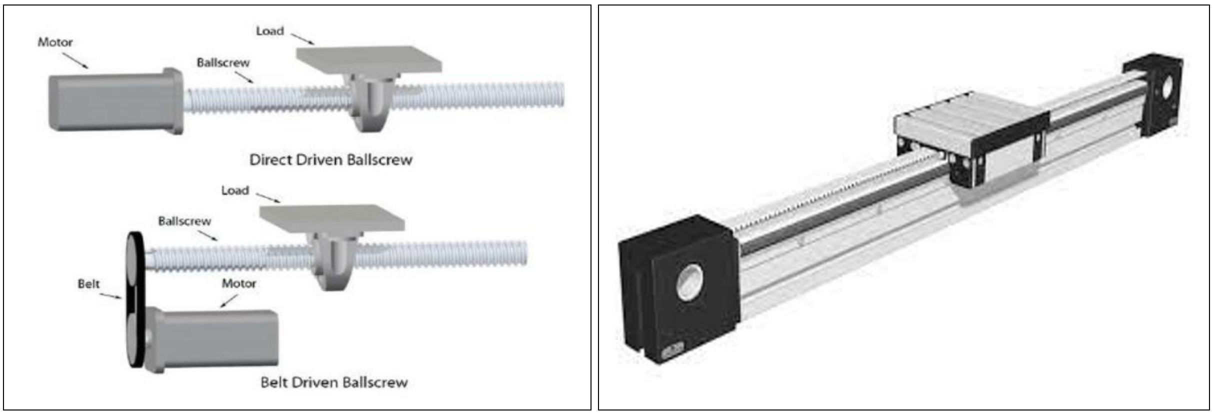


Fig 1: Characteristics of a linear motion system

In Fig.1, We can see that using linear motors makes the system compact and achieves a higher efficiency in the same limited space. Linear motors have now been used in practice in all power ranges. In the high-power range, they are in the transmission mechanism used in transport vehicles such as trains and metro. In the medium and low power range, they are applied in automatic control of CNC digital machine tools, robot arm control, lifting machines, and flexible production systems with high requirements of position accuracy, high speed, and fast impact. In the low power range, they are used in equipment such as printers, laser cutters used in surgery, etc.

Electrical linear motors produce direct linear motion without rotary components. The motor driving the system can be controlled to provide the desired velocity, acceleration, torque, and position to yield optimal performance.

Fig 2: Korea's maglev train launches in Incheon [12]

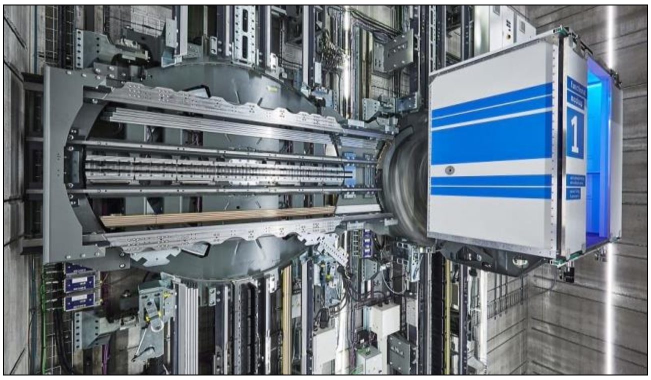
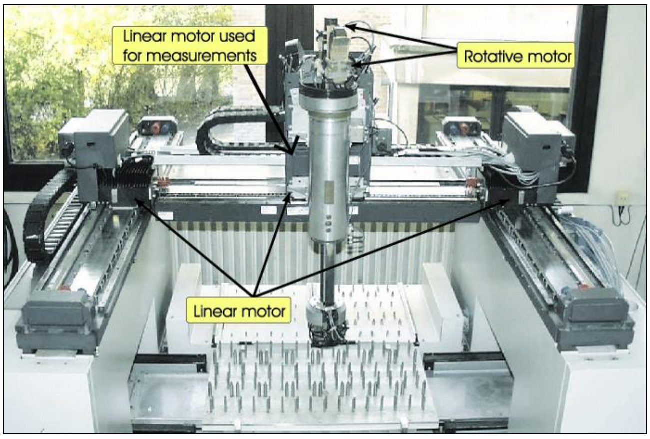
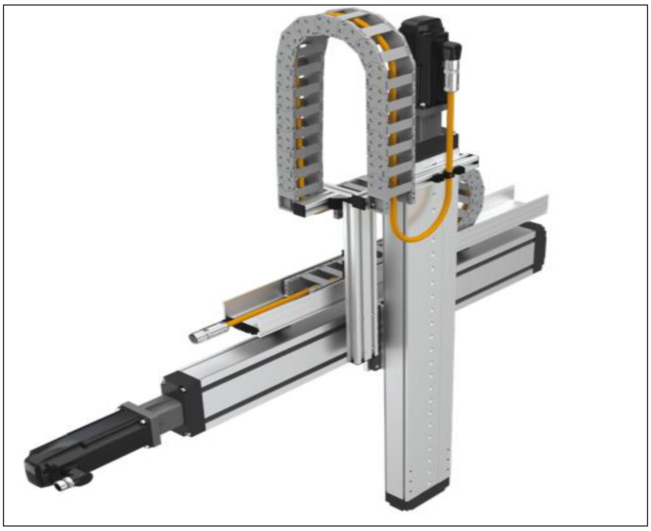


Fig 3: ThyssenKrupp's linear motor elevator capable of traveling sideways [13]



a.)

b.)



c.)

Fig 4: Application of linear motors in CNC machines

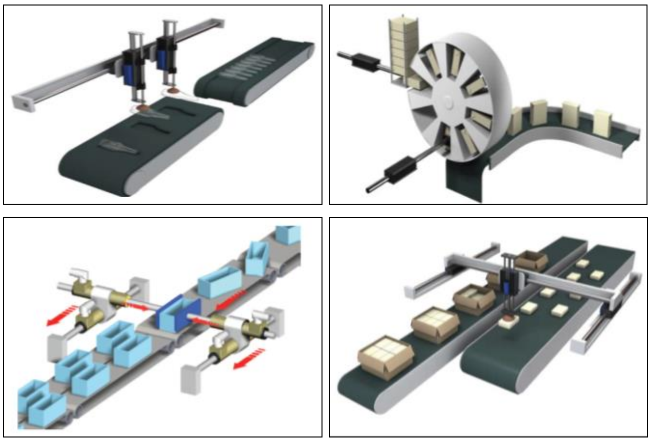


Fig 5: Application of linear motors in packaging technology [12]

Some typical linear motion applications are illustrated in Fig 2 to Fig 5. The system designer often specifies linear motion technologies when manufacturing processes require high precision, high-speed repeatability, and flexibility for CNC, robotics, and material handling applications. A basic linear

motion system integrates a power component, such as a motor, a thrust mechanism, an actuator, and a guidance infrastructure, such as a rail.
The linear motion can be selected and sized quickly and easily, thanks to predefined axis combinations. Each multi-axis system is also available as a Smart Function Kit for handling or dispensing. Preinstalled software then allows even quicker commissioning and intuitive programming. This significantly reduces the engineering time.

3. Conclusion

This analysis of Linear motor applications in motion systems has been described in this work. Linear actuators are essential for automated motion control of pick-and-place applications, industrial-grade machinery, and consumer-grade equipment. The most important factors to consider when sizing, selecting, installing, and operating a linear system are the loads and moments, speed, acceleration, required accuracy, and rigidity. Accuracy is how closely the system moves compared to a commanded position. Rigidity is essential because the system must be stiff or rigid enough to prevent deformation or unintentional movement. Typically, linear motors exhibit the best accuracy but have higher initial costs. Overall, linear motors are the best choice if you are pursuing both acceleration and accuracy in one single system, which is hard to find in other systems.

4. Author Contributions

Huong T.V. Nguyen devised the project's main conceptual ideas and wrote the manuscript. Quang H. Nguyen contributed to identifying appropriate structures to express ideas. All authors have read and agreed to the published version of the manuscript.

5. Acknowledgement

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