LINEAR MOTORS

Since linear motors do not have any gear unit it is more simple converting motion in electrical drives. Combined with magnet floating technology an absolutely contact-less and so a wear resistant passenger traffic or non-abrasive transport of goods is possible. Using this technology usually should enable high speed. So Transrapid uses a combination of synchronous linear drive and electromagnetic floating. Linear direct drives combined with magnet floating technology are also useful for non-abrasive and exact transport of persons and goods in fields as transportation technology, construction technology and machine tool design. Suitable combinations of driving, carrying and leading open new perspectives for drive technology.

Technology of linear motors

In the following function, design, characteristic features, advantages and disadvantages are demonstrated shortly. In principle solutions based on all electrical types of machines are possible unrolling stator and rotor into the plane

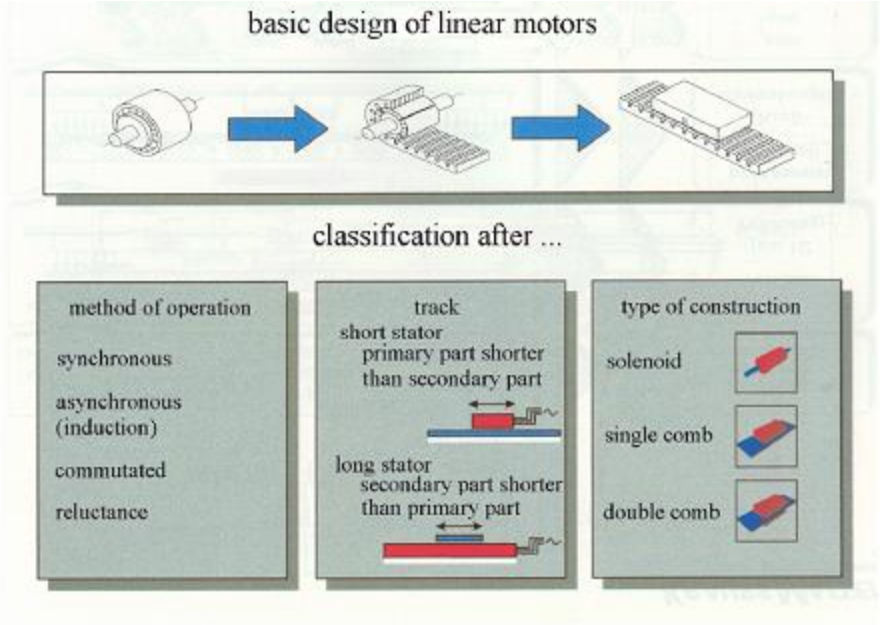

Fig. 251: linear motors, design overview (source: KRAUSSMAFFEI)

Linear motor then corresponds to an unrolled induction motor with short circuit rotor or to permanent-magnet synchronous motor. DC machines with brushes or switched reluctance machines are used more rarely. Depending on fields of usage linear motors are constructed as solenoid, single-comb or double-comb versions in short stator or long stator implementation. It is an advantage of long stator implementations that no power has to be transmitted to passive, moved secondary part, while short stator implementations need the drive energy to be transmitted to the moved active part. For that reason an inductive power transmission has to be used to design a contact-less system. In contrast to rotating machines in single-comb versions the normal force between stator and rotor must be compensated by suitable leading systems or double-comb versions must be used instead. This normal force usually is one order of magnitude above

feed force. In three-phase windings of synchronous or induction machines a moving field is generated instead of three-phase field. This moving field moves at synchronous speed.

$$v_1 = \tau_p \cdot 2 \cdot f_1$$

As in three-phase machines force is generated by voltage induction in the squirrel-cage rotor of the induction machine or by interaction with permanent-magnet field of the synchronous machine.

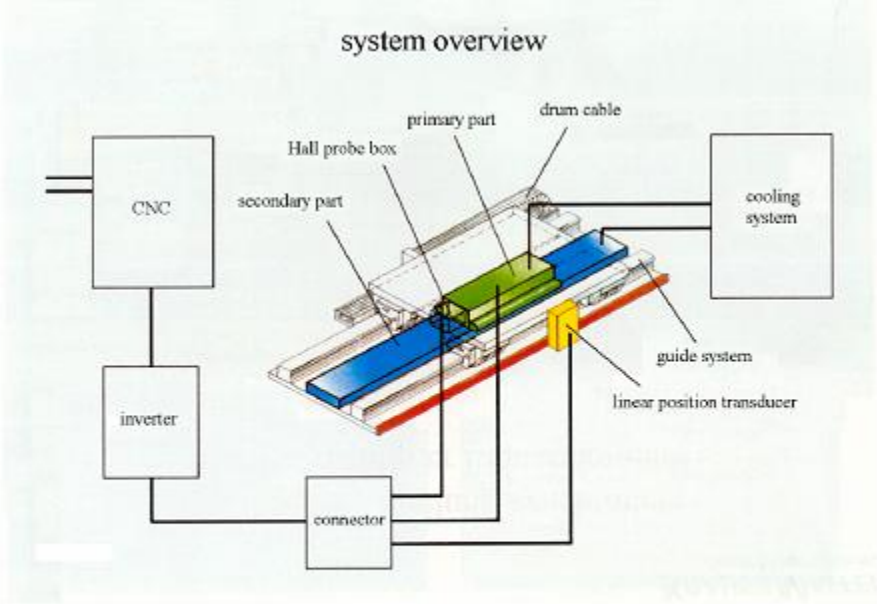

Fig. 252: linear drive, system overview (source: KRAUSSMAFFEI)

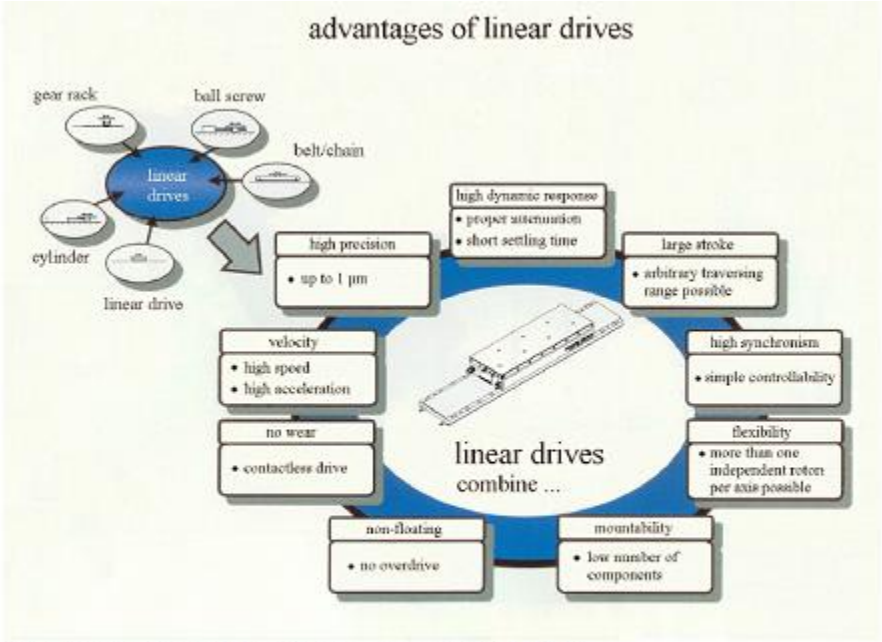

Fig. 253: advantages of linear drives (source: KRAUSSMAFFEI)

Three-phase machine supply is made field-oriented by frequency converters to achieve high dynamic behavior. For that induction machines need flux model and speed sensor, but synchronous machines just need a position sensor. For positioning jobs high dynamic servo drives with cascade control consisting of position control with lower-level speed and current control loop are used. This control structure is usual in rotating machines. Depending on the place the position measurement is installed a distinction is made between direct and indirect position control. Since many movements in production and transportation systems are translatory, linear drives are useful in these fields. In such motors linear movements are generated directly, so that gear units such as

spindle/bolt, gear rack/pinion, belt/chain systems are unnecessary. As a result from that rubbing, elasticity and play are dropped, which is positive for servo drives with high positioning precision and dynamic. In opposition to that there are disadvantages such as lower feed forces, no self-catch and higher costs.

Industrial application opportunities

Two different opportunities to implement linear drives are shown at the following pictures

Fig. 254: induction linear motor (NSK-RHP)

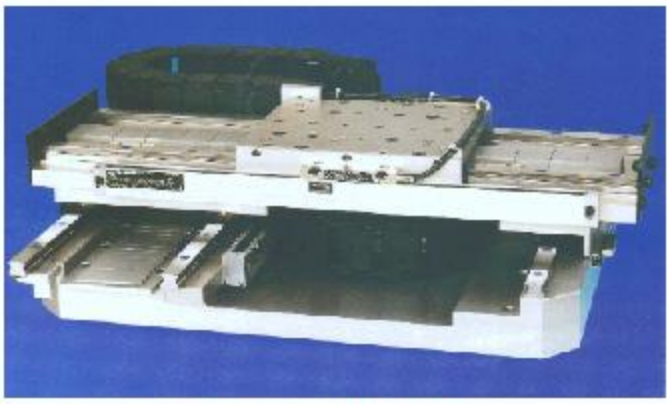

Fig. 255: synchronous linear motor (SKF)

Most promising application fields of linear drives for industrial applications:

machine tools: machining center, skimming, grinding, milling, cutting, blanking and high speed machines.

automation: handling systems, wafer handling, packing machines, pick-and-place

machines, packaging machines, automatic tester, printing technology

general mechanical engineering: laser machining, bonder for semiconductor industry,

printed board machining, measurement machines, paper, plastic, wood, glass machining.