



## Hydrostatic Leadscrew in compare to linear motor and ballscrew



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### 關鍵詞

- 液靜壓導螺桿 hydrostatic leadscrew
- 滾珠導螺桿 ballscrew
- 線性馬達 linear motor

### 摘要

本文針對德國 Hyprostatic 公司所研發的液靜壓導螺桿的物理特性與機械性能如剛性、加速性能、進給力、進給速度、功率、發熱量與冷卻等基本特性有詳細技術說明。文中亦針對液靜壓導螺桿與傳統滾珠導螺桿及線性馬達在性能、價格與應用作出比較說明；此外，對液靜壓導螺桿與傳統滾珠導螺桿及線性馬達三種傳動元件，在垂直軸與一般水平軸導軌系統之設計選擇上之差異與優點有具參考價值的技術分析。

*Well known problems of ballscrews led to the development of synchronous linear motor and wear free hydrostatic leadscrews of HYPROSTATIK Schönfeld GmbH. We introduce the hydrostatic leadscrew and compare it with the linear motor drive and ballscrews.*

While a part of the user of linear motors get disillusioned or disappointed after the first enthusiasm, hundreds of hydrostatic leadscrews are used for up to 7 years round the clock with highest precision and 100% reliability.

#### The hydrostatic leadscrew

As a ballscrew, the hydrostatic leadscrew transfers the rotation of a servomotor in a linear move. The hydrostatic nut flies on a hydrostatic oil film and is absolutely wear free. The thickness of the oil film is kept constant, independent of the load and speed by the oil flow controlled by the new PM-flow controller. The play free hydrostatic nut is extreme stiff and has a very low, load independent friction. At speed around 0, e.g. at positioning, the friction is too low to measure. There



is no drive torque step at move reverse. So the positioning precision and the smallest move and the slowest speed only depend on the measuring system and the control. Hydrostatic lead screws working like a shock absorber with excellent damping against vibrations of the machining. The hydrostatic leadscrew work absolute silent and make no vibrations like usual at using ballscrews. Hydrostatic leadscrews have no limit of acceleration. Very slow move or short move oscillating with high frequency can be done even under very high load. The hydrostatic leadscrew is available with rotating spindle as standard or rotating nut in size 40 to 160mm for max. axial forces between 10 and 500 kN, speed up to 120 m/min, up to length of 5 meter in different pitches and with spindle ends according customers demand. Hydrostatic leadscrews can be bearing in hydrostatic bearings and are completed by hydrostatic linear guides.

#### Physical basics

Electric energy can be transferred effectively in mechanic energy by relative low forces and high speed. Usually linear axes are made with high rpm rotating motors with leadscrew to get slow precise linear speed with high feed forces. With high quality parts, the slide can be moved very sensitive with low forces.

The linear motor leaves this principle of gear reduction. To get this large direct forces, extreme strong magnet fields must be initiated, which is only possible to with very high electric current and/or coils with large inductivity. A magnetic field behave like a mass. To change linear force of the linear motor needs a change of the magnetic field, which takes time. So the linear motor needs time to react on a sudden external force or even to keep position, even if high voltages are used to change the magnetic field.

This problem is much less at servo drives of leadscrews, cause the magnetic fields and the current trough the coils of the motor is multiple less than at the linear

motor.

#### Stiffness at static and dynamic load

The stiffness of the linear motor results in only by the position control of the drive together with the needed linear scale position measuring system. Without the position control, the stiffness is zero!

Against static load the stiffness of the linear motor is endless, because it compensates the errors. But this is the same with hydrostatic leadscrew, if a linear scale is used for position control.

The dynamic stiffness of the linear motor is low cause of the time delay by position measuring, reaction time of the control and built up of the magnetic field.

Linear motor producer tell that dynamic stiffness of about 30N/μm at 100kg slide weight up to 120 N/μm at 600 kg slide weight are possible, without any information to the frequencies.

By the very low damping in moving direction, there is a danger of resonance at dynamic load. The stiffness of the complete hydrostatic leadscrew with size 50, with working thread length of 400mm, is about 350 to 400 N/μm, in both side fixture or with larger size multiple higher. The stiffness of the smallest nut to the screw and the hydrostatic leadscrew bearing is higher than 1500N/μm. Together with the high damping and the higher total mass, the oscillation move and dynamic position errors of the hydrostatic leadscrew by vibrating cutting forces are extremely reduced.

Also oscillating move caused by external forces gets down much quicker using a extremely damped hydrostatic leadscrew instead of a linear motor.

#### Acceleration features

At hydrostatic leadscrew and linear motor there are no acceleration limits by the parts. Max. acceleration is limited by the moving masses and max. feed forces. The life of the hydrostatic leadscrew is independent of the max. acceleration. The servo motor needs to



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