

Linear Motion Guideways – A Recent Technology for Higher Accuracy and Precision Motion of Machine Tool

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Abstract - The Guideway is one of the important elements of machine tool. The main function of the guideway is to make sure that the cutting tool or machine tool operative element moves along predetermined path. The Linear Motion Guideways provide a smooth and linear motion in machine tools, due to which higher accuracy and precision can be obtained. The paper deals with the study of Linear Motion Guideways, its structure, Advantages and Applications in various machine tools where precision is of great importance.

Keywords: Linear Motion Guideways, Construction, Advantages, Applications.

I. INTRODUCTION

Linear Motion Guideways (LM Guideways) also known as Linear Motion bearings have a mechanism to bear the load and to guide their linear motion simultaneously[1]. A linear guideway allows a type of linear motion that utilizes rolling elements such as balls or rollers. By using recirculating elements between rail and block, a linear guideway can achieve high precision linear motion. Compared to traditional slide, the coefficient of friction is 1/50[2].

1.1 Types of Linear Motion Bearings[1]

A) Sliding contact linear motion bearings

This type is the oldest, simplest, least expensive way, and it still has wide range of applications. In general all sliding contact bearings have greater friction coefficient than other types described hereunder, and because of this, they are considered to be inferior to these guides for precise positioning applications. With lubricant forcibly maintained between two relatively moving objects, a relative speed helps to pull in lubricant, and thereby, a thin film is formed.

B) Rolling element linear motion bearings

This type decreases friction utilizing rolling contact via rolling elements (balls, rollers, etc.) that are placed between two relatively moving objects. There are many specialized manufacturers and each manufacturer provides wide variety of products. Because of its superiority over the sliding contact linear motion bearings as described hereunder and because of its availability, this type has won the position as an essential component for the equipment that requires highly accurate positioning operation.

C) Hydrostatic or aerostatic linear motion bearings

When extremely accurate and quiet operation must be attained, a guide without mechanical contact between its elements is often chosen. With pressurized fluid forcibly supplied between two relatively moving objects, one of them is kept floating by the fluid. Depending upon the fluid in use, it is classified in aerostatic and hydrostatic linear motion bearings. Although this type of guides is very advantageous for particular purposes, it is usually costly, difficult in manufacturing, and requires expensive auxiliary apparatus. Yet, this type is sometimes used for ultra-precision machines.

D) Magnetic linear motion bearings

By means of magnetic force, either repelling or attracting, one of the two relatively moving objects is kept afloat. Use of electromagnet makes it costly and ineffective in energy consumption. This type has very limited applications.

II STRUCTURE OF LINEAR MOTION GUIDEWAY

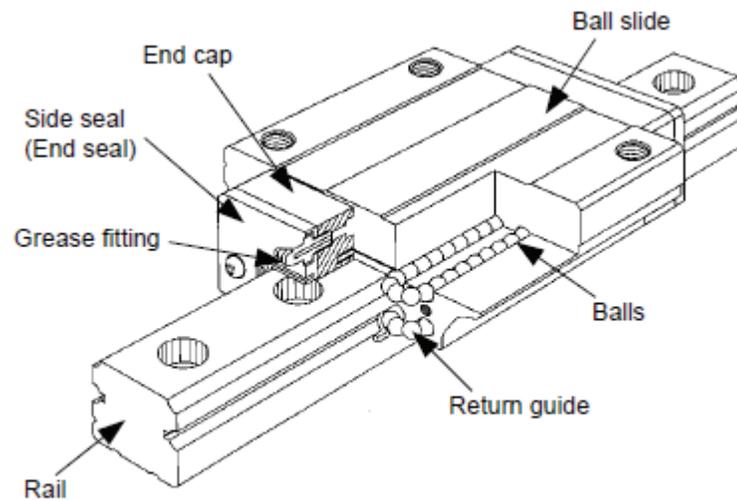


Fig. 1 Structure of LM Guideway[1]

The linear guides consist of a mechanism in which steel balls are circulated infinitely to enable an infinite stroke of ball slides theoretically. Balls roll along the ball groove formed on a rail and a ball slide and there, they are scooped at the point A by the tip of an end cap. There, they are forced to change their circulating direction by a return guide of the end cap and guided to a circulating hole provided inside of the ball slide. The balls continue to pass through the hole to the other end of the ball slide and, further, go through the circulation circuit to the tip of the end cap of the other side and then, return to the ball grooves of rail and ball slide. Thus, the balls repeat their endless circulation motion.

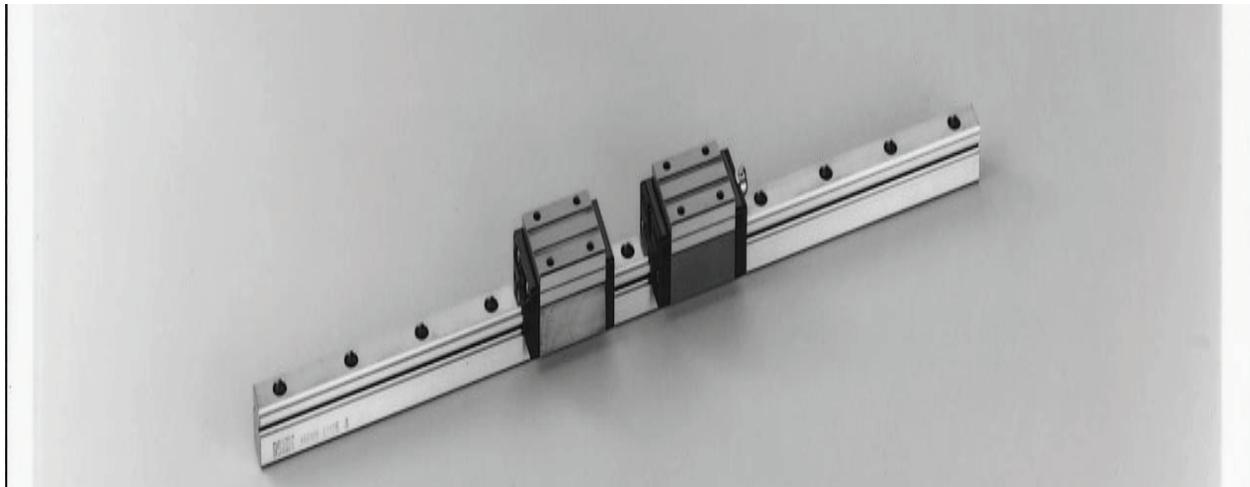


Fig. 2 LM Guideway with two Blocks[3]

2.1 ADVANTAGES OF LINEAR MOTION GUIDEWAYS

Following are the advantages of LM Guideways[2] due to which their demand for high precision work is increasing:

1. High Positional Accuracy

When a load is driven by a LM guideway, the frictional contact between load and bed desk is rolling contact. The coefficient of friction is only 1/50 of traditional contact.

2. Long Life with high motion Accuracy

With a traditional slide, errors in accuracy are caused by the counter flow of oil film. Insufficient lubrication causes wear between the contact surfaces. In contrast, rolling contact has little wear, therefore machines can achieve a long life with motion accuracy.

3. High speed motion is possible with low driving force

LM Guideways have little frictional resistance, only a small force is required to move a load.

4. Equal loading capacity in all directions

LM Guideways can take the load in either vertical or horizontal directions.

5. Easy Installation

Installing a Linear Guideway is quite easy. Grinding or Milling the machine surface, following the recommended installation procedure, and tightening the bolts to the required torque can achieve highly accurate linear motion.

6. Easy Lubrication

7. Interchangeability

Function	Rolling guide	Sliding guide
Friction	<ul style="list-style-type: none"> • Friction coefficient: 0.01 and lower • Difference between static and dynamic friction is small. • Change by speed is slight. 	<ul style="list-style-type: none"> • Friction is great • Static and dynamic friction vary greatly.
Positioning accuracy	<ul style="list-style-type: none"> • Lost motion is slight. • Stick-slip is slight. • Easy to sub-micron positioning 	<ul style="list-style-type: none"> • Lost motion is great. • Stick-slip at low speed is great. • Difficult to achieve sub-micron positioning
Life	<ul style="list-style-type: none"> • Easy to estimate life 	<ul style="list-style-type: none"> • Difficult to estimate life
Static rigidity	<ul style="list-style-type: none"> • Generally high • No play because of preload • Easy-to estimate rigidity 	<ul style="list-style-type: none"> • Rigidity is great against load from a single direction. • There is mechanical play. • Difficult to estimate rigidity
Speed	<ul style="list-style-type: none"> • Wide range of use from low to high speed. 	<ul style="list-style-type: none"> • Unsuitable for extremely low and high speed
Maintenance, reliability	<ul style="list-style-type: none"> • Long life through simple maintenance 	<ul style="list-style-type: none"> • Precision is lost greatly by deteriorated guide surface.

Table 1. Comparative characteristics of Rolling and Sliding Guideway[3]

2.2 APPLICATIONS OF LM GUIDEWAYS

Following are few Applications of LM Guideways:

1. Used in CNC machining Centre

Fig. shows a CNC machining centre in which Linear Motion Guideways are been used for getting high accuracy & Precision Motion.

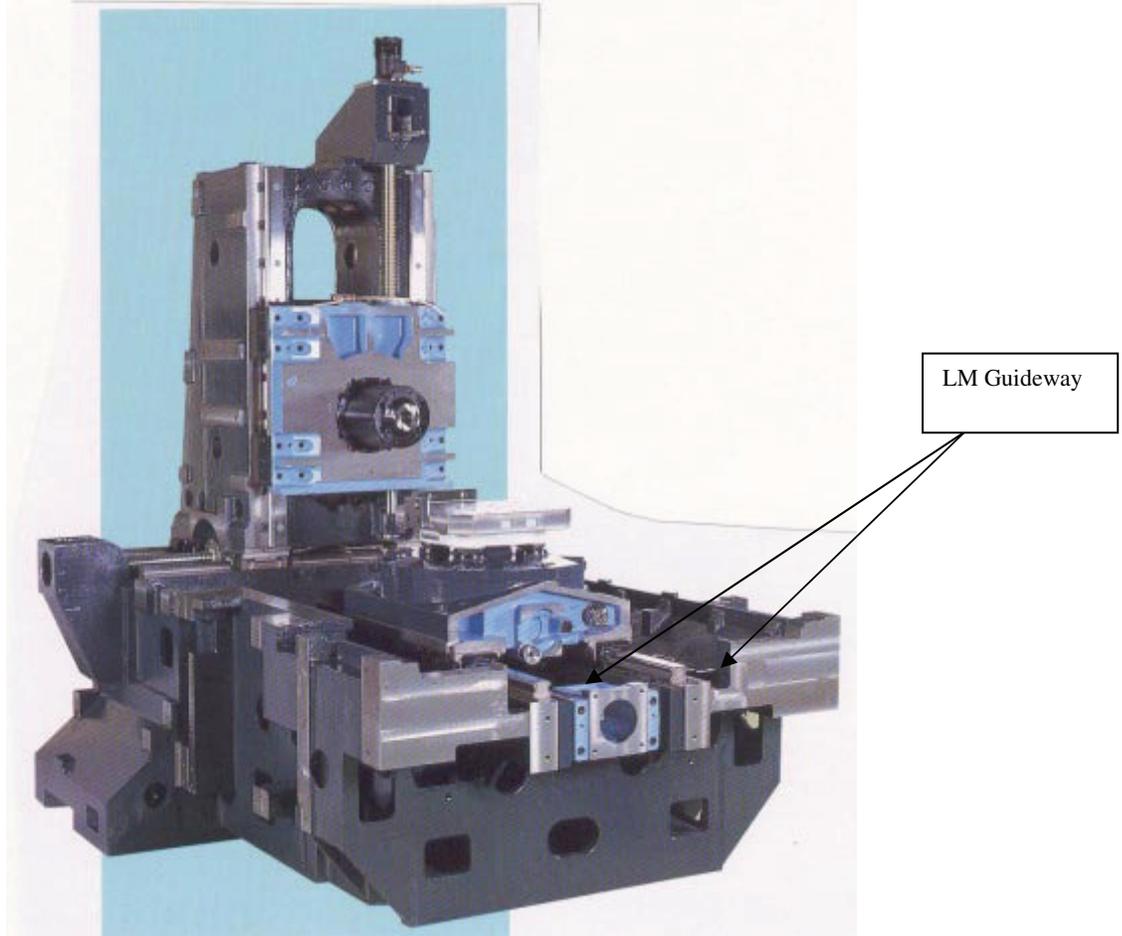


Fig.3 CNC Machining Centre

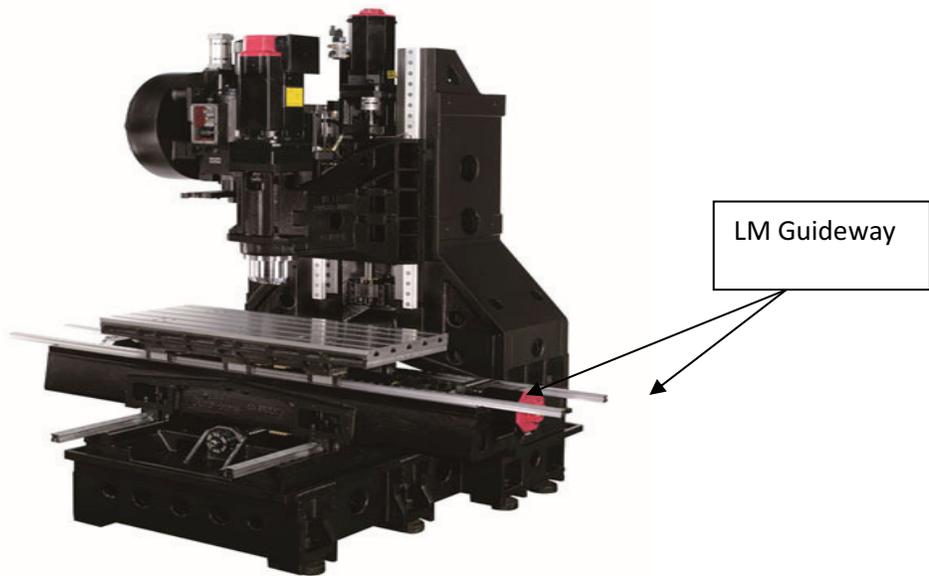


Fig.4 Vertical Machining Centre (VMC)

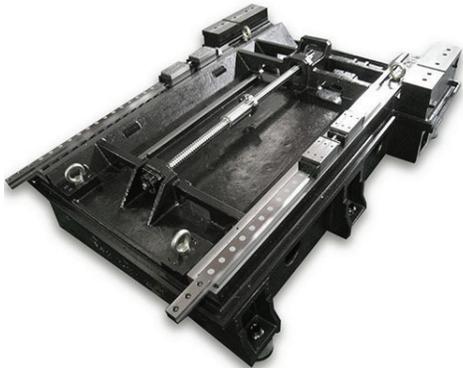


Fig. 5 Base of VMC showing LM Guideway

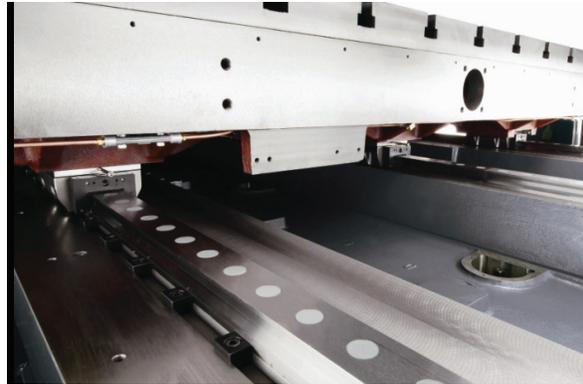


Fig. 6 CNC Machine tool with LM Guideway

2. The application of the linear guideways is very extensive, such as automation equipment, heavy-duty carry equipment, heavy-cut machining tool, CNC grinding machine,
3. large-scale planning machine and machining center with the demand of high rigidity and heavy load.
4. Injection Moulding Machine.
5. CNC Lathe.
6. Industrial Robots
7. Semiconductor Machines- PCB Driller
8. Other Machines- Measuring Machine, Transporting Machine, Welding Machine, Medical equipments, Test equipments etc[4].
9. It can also be used in Aluminium Extrusion Press[7].

Various Manufacturing Catalogues are available for selection of LM Guideway for a particular Machine tool. Following are few of the Manufacturers of LM Guideways:

NSK Ltd.

HIWIN Linear Motion Products & Technology

ABBA LINEAR TECH Co. Ltd

Precision Bearing House

AUTOMATION COMPONENTS.....Components in Motion Linear Guideways

AMT Linearways

According to Manufacturers Catalogue the LM Guideway can be selected by following their selection procedure as mentioned in the particular catalogue.

III. CONCLUSION

The paper discusses about the Linear Motion Guideway, a high accuracy & precision motion is obtained. It has various advantages like Easy Lubrication, installation, interchangeability, long life with high motion accuracy, high positional accuracy etc. The structure of Linear Motion Guideway (LM Guideway) that consists of Guide Rail, Guide Block, Balls, End cap, End seal. LM Guideways are used on various machine tools such as CNC Machining Centre, CNC Lathe, Industrial robots, Semiconductor machines, other machines like Measuring machine, Transporting machine, welding machine etc. Also few Manufacturers of LM Guideways are mentioned.

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