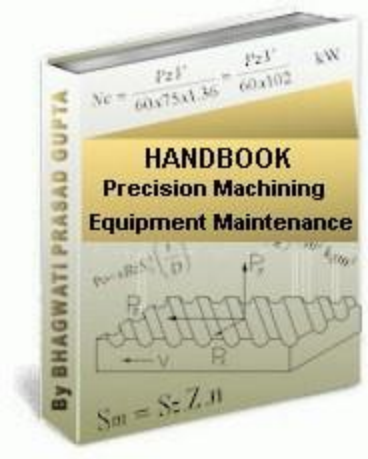
The Machinist Handbook for Precision Machining and Equipment Maintenance.



By Bhagwati Prasad Gupta

Preface:

Today, most countries are heading towards industrial liberalization to compete in the global market. The opening up of the economy has made the market of the developing countries more attractive for international companies. It would mean increased competition. So, the manufacturing companies would like to focus on certain diversification areas, which would enable the introduction of a steady stream of new products to meet the long-term growth and profitability objectives by maximum utilization of existing machine tools and equipment with minimum additional investment. For success on the export front, one will have to show its machining capability to meet international standards of quality, which demand the maintenance of accuracy and other related parameters of the existing machining equipment.

To meet the challenge, each machinist must be trained in precision machining and develop the knowledge of engineers and technologists working on the shop floor. For this, different types of books on machining and machinist handbooks need to be referred to as information required, which is usually not available in machining manuals supplied by the manufacturers, along with the machine tools and equipment. It was, therefore, necessary to compile all such study material and the data as a handy book to enable them to refer to it during the learning process for better results while dealing with machine tools and equipment.

First, different motions required in machine tools for various machining processes have been described. Cutting parameters related to multiple types of material have been tabulated to facilitate the calculation of cutting forces coming onto the cutting tools and the jobs being machined for estimating the required torque and power.

Based on the above data, the type of motor and drive could be selected, and overloading could be prevented. So various kinds of D.C. and A.C. variable speed drives have been described, starting from the conventional Ward Leonard system, thyristor, SCR servo drive to inverter drive, vector control, and brushless drives for controlling the motions of D.C. and A.C. motors including induction, synchronous and brushless type. Different types of speed and feed gearboxes, along with the mode of speed change in steps, have been given for speed regulation.

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Nowadays, step-less variable speed drives are preferred. So, PIV, ball disc drives, and hydraulic stepless drives like Hyvari drives have also been described. Details of different types of planetary gearboxes and cycle drives are given along with the geared motor. Backlash-free gearing arrangement and timing belts are the essential features of CNC machines.

Mechanisms for rapid traverse, reversing, periodic intermittent motion, and rectilinear motion have been given along with precision rack, worm rack-pinion, lead screw, and ball screw arrangements.

Regarding assemblies and systems, the design aspects of spindle units with different types of arrangement of sliding bearings, hydrostatic and air bearings, and rolling bearings have been described. Frame housings, slide-ways, low friction guideways, synthetic linings, hydrostatic and pneumatic guideways, and rolling ways, e.g., Tycho ways and LM guides, have been given in detail. In addition to the conventional friction clutches and rigid couplings, the latest design clutches like toothed clutches, over-running clutches, universal coupling, gear, compression, bellow couplings, safety clutches, and protective devices have been explained in detail.

The chapter on control systems includes the lever and pre-selection of speed and the automatic controls like logic switching, PLC, numerical control, and CNC system. The latest lubrication systems, like centralized automatic lubrication, including metering cartridges and monitoring units, have been described in addition to the conventional manual, splash, and pressurized lubrication devices. In the Hydraulic system, not only the industrial circuit has been touched, but its components, like various types of pumps, valves, actuators, etc., have been given in much detail.

Besides the details of the mechanisms illustrated by more than 175 figures, due care has been taken to indicate the maintenance aspects of all such systems, assemblies, and major components. Mathematical formulae and equations have been provided along with technical data in more than thirty tables, which can be used by designers, application engineers, and maintenance engineers for verification purposes. This has made this book useful not only for students of industrial machines but also for machinists, technologists, and practicing engineers in design, manufacturing, and maintenance.

6.6 INSTALLATION AND MAINTENANCE OF BALL SCREW ASSEMBLY

The nut and bracket structure should be such that the ball screw is not under a twisting load. For that, the parallelism between the ball screw and the linear motion guide should also be maintained. When mounting a ball screw on a machine, care is to be taken that the nut is not separated from the screw. If this is unavoidable, use a sleeve, which is approximately 1 mm smaller than the root diameter of the ball screw, and remove the balls together with the nut without separating them. No balls should fall off, and the return tube is not damaged.

In case standard ball screws are valuable and additional is required for bearing journals and end fittings, the following procedure should be adopted during the machining of the same. Tape up the packed nut at both ends so the nut will not be moved when the shaft is rotated. Ensure that no chips get in. The ball screw should be fixed by the center as far as possible.

6.7 CARE & MAINTENANCE

Properly applied ball screw components change very little during its operating life. As a result, there is no need for adjustment. Here are a few maintenance tips to be followed for the best performance.

a) **Lubrication**: - Machine tool ball screws must be adequately constantly lubricated. Good quality oil P.S. Turbine oil of 38 to 90Cst is recommended, or lithium soap-based grease is preferred. Never use grease that contains graphite. It can build up within the nut and reduce internal clearance.

b) **Dirt protection**: -In an environment that can involve dirt or foreign substances, it is necessary to seal the ball screw with bellows or cover hermetically. A labyrinth seal can protect the nut only if there is no foreign substance or dirt in the surroundings. The easiest way to clean a ball screw is to flush it with clean oil during operation.

c) **Preventive care**: - Common problems and their and their solutions are listed below for better preventive care of ball screws.

i) The cause of jamming is a “Key stoning" effect where one ball enters the return path improperly.

ii) System inaccuracy and non-repeatability may be due to faulty assembly if growling or rambling noise is heard. If there is no noise, the problem may be in loose end bearings on the ball screw or in the control system.

iii) Excessive drive torque may be due to faulty assembling of nut to screw ball nut to the machine to enable it to take its alignment.

iv)If backlash, isolate the cause, whether it is there due to loose end bearings or wear in the nut.

8.4 SLIDE WAYS OF MACHINE TOOLS

The tool or the job travels in a straight line or a circle together with the units on which the tool or job is mounted. Ways are provided to guide the unit's travel. Slideways and antifriction ways are used. The principal characteristics of the ways are given below.

1. Accuracy of the travel
2. Durability
3. Rigidity.

Types of Sideways for Rectilinear Motion

Slideways may be encompassing type (with the apex upward) or encompassing type (with the apex downward), as shown in Fig. 8.2. The former retains lubricants more poorly than the latter type. That is why encompassed types are generally used for a low traverse of a middle or a table. The advantages are that the encompassed type is easy to manufacture and has no tendency to accumulate. The type is easy to manufacture, and it does not tend to collect dirt and chips, so it is unnecessary to provide a shield or other protective devices. Encompassing slideways are employed in M/c, with units traversing at higher speeds because they can retain lubricants in large quantities**.**

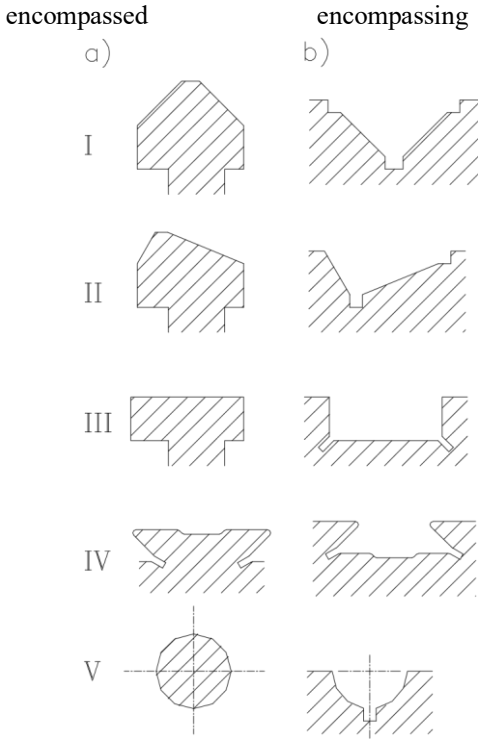

Fig. 8.2 Principal types of slideways

(i) **V ways**

V ways are difficult to manufacture but are capable of self-adjustment. Clearance is automatically eliminated under the action of load. 'V' ways are symmetrical as the load is directed vertically by the weight of the traveling unit and are more suitable for higher speeds, such as planners and grinding M/c. A deeper 'V' with a slight apex angle is preferred for precision machine tools with less loading.

Chapter 9: LOW FRICTION SLIDEWAYS

9.1 INTRODUCTION

Conventional guideway materials such as cast iron to steel, cast iron to cast iron, etc., cause stick-slip motion at low velocity because of their negative friction characteristics; while seeking the solution, it is concluded that-

. 1) stick-slip is eliminated when the friction velocity characteristics have a positive slope.

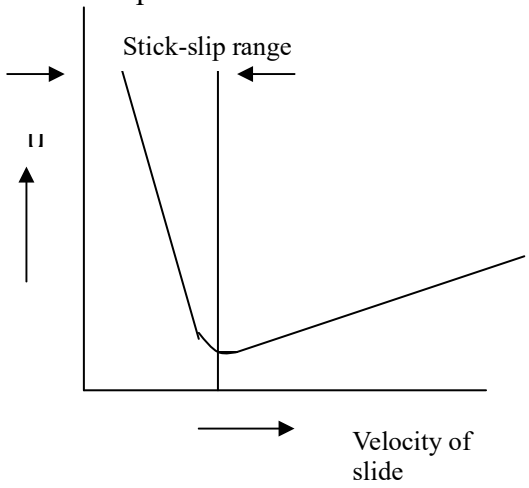

Fig.9.1 Diagram for velocity-friction relationship

2) When the difference between the kinetic and static friction is slight, the elastic energy stored in the driving system will also be small, and hence stick slip will be minimized.

Several methods are being followed in the guideways system to achieve these characteristics.

9.2 NON-METALLIC SLIDEWAY LININGS

As the friction coefficient is higher between cast iron – cast iron and between cast iron –steel pairs, it was thought to apply synthetic lining on one of the slide pairs. Plastic like nylon and Perspex on cast iron gives a frictional pair better than cast iron – cast iron pair even though their friction velocity characteristics curve has a negative slope. This is because plastic has anticorrosive and conformability properties. Plastics like phenolics and epoxies give positive slope friction velocity characteristics in a fair range of velocities. The former has that in a low-velocity regime, and the latter in a high-velocity regime (1.5-2 m/min). PTFE (Polytetrafluoroethylene) has a positive slope friction velocity characteristic at all the operating velocities encountered in a machine tool. PTFE has a lamellar structure that goes from chain-to-chain branching. This gives essential attributes to the plastic, such as

i) Anti-sticking tendency
ii) Thermal stability
iii) Non solubility and lowest dry coefficient of friction
iv) Slideway does not wear in contact with PTFE.