

shipyard or great railroad shops, the system consisted either of a central boiler plant transmitting steam to engines located in various parts of the manufacturing area or, in some instances, of a number of boiler plants with large engines adjacent and smaller ones at considerable distances.

The disadvantages of long lines of shafting were realized long before electricity offered a way out of the difficulty. Unless the greatest care be used in keeping the shafting in alignment and the journals well oiled, the power wasted in the friction of bearings and belts becomes a very large percentage of the total power received from the prime mover. This friction loss is continuous even when, as is often the case in large shops, a single particular tool, like a large boring mill, has to run when all the rest of the shop is shut down.

The decided advantages of the application of motors to machine tools in industrial work has been thoroughly exemplified in machine shop practice to-day. The conditions under which machine tools operate are so varied that it is impossible to make any general statement covering all of the possible operating conditions, but some of the individual conditions are always important, as for instance—the character of the work machined, kind of material cut, shape of the cutting tool, quality of tool steel, method of treating tool steel. All of these should be taken into account to intelligently fit a motor to any machine tool.

Broadly speaking, machine tools may be divided into two classes, first, those with direct rotary motion of work or cutter, and second, those with a reciprocating motion, either of work or cutter. Under the first classification come lathes, boring mills, milling machines, drill presses, and so forth. The second class includes planers, shapers, slotters, and machines of a similar character.

The factors which have had more to do with the recent impetus given to the study of rapid production than any others are the high speed steels and the variable speed electric motors. These agents have not only brought about conditions entirely new to the manufacturing fraternity at large, but their influence has extended further, having induced a complete study of manufacturing conditions, involving not only the rapid production of work, but also improved methods of handling work between operations.

It is to be noted here that whatever the class of machine tool, the variable speed motor generally offers decided advantages in the way of rapid and economical production. With the old method of speed variation, by means of cone pulleys or nests of gears, only large increments in speed are obtainable. This invariably means that tools cannot be worked up to their limit of productive capacity. With the new high speed steels requiring a greater pull-