Introduction to Machine Maintenance and Installation
What is the place of Maintenance Professionals in Industry?

- Maintenance Planner
- Sales Engineer
- Maintenance Engineer
- Technique Manager
• Which industries require the service of maintenance professionals?
• All manufacturing industries:
  ✓ Metal industries
  ✓ Plastic factories
  ✓ Automotive industries
  ✓ Cement factories
  ✓ Lather and Lather Products
  ✓ Textile and Garment Factories
  ✓ Breweries
  ✓ Soft drink factories
  ✓ Alcohol and liquor factories
  ✓ Food processing industries
  ✓ Construction industries, etc.
• Service industries
  ✓ Hotels and Resorts
1. INTRODUCTION

• What is Maintenance?
• Maintenance can be considered as a combination of activities directed towards preservation and restoration of the performance of a facility, machine or equipment.
• Which comprises:
  • service
  • repair,
  • replace, and
  • modify components of a machine/equipment.
1. INTRO. Cont.

- The main purposes of maintenance:
  - to eliminate system failures and hazards.
  - to ensure that equipment continues to work within the design tolerances and specifications.
  - to ensure the defined functions and standards of operations of the plant are maintained, and
  - to ensure equipment are capable of being performed for the required period.
1. INTRO. Cont.

Effect of Poor Maintenance

Inadequate or lack of effective and efficient maintenance system especially in a manufacturing enterprise gives rise to several undesirable consequences. These consequences include:

(i) Excessive machine breakdown
(ii) Frequent emergency maintenance work
(iii) Shortened life-span of the facility
(iv) Poor use of maintenance staff
(v) Loss in production output
(vi) Inability to meet delivery dates
(vii) Excessive overtime
1. INTRO. Cont.

• The level of maintenance required at the equipment operation stage is affected by factors at other stages through which the equipment passes. Theses are:

  1. Design stage:
  2. Installation stage:
  3. Commissioning stage:
  4. Operational stage:
1. **Design stage:**
Reliability and maintainability are the important factors which should be considered properly in relation to performance of equipment, capital and running costs.

2. **Installation stage:**
Maintainability is an important factor to be considered during the installation, for it is here that maintenance problems become clear.

3. **Commissioning stage:**
This is a stage of technical performance testing and also a stage of where primary design faults are located and designed out.

4. **Operational stage:**
The operational stage is a stage of learning where maintenance plays an important role.
2. Basics of Machine Installation

General Procedure of Machine Installation

Installation procedure of a machine involves a series of activities like:

a) Location and layout;
b) Positioning of machines;
c) Foundation;
d) Leveling and alignment;
e) Grouting;
f) Fitting of other parts, accessories, piping etc.;
g) Final leveling and test runs
a) Location and Layout

- The location of a machine depends on its purpose of installation, definite types and sizes and other special requirements, if any.
- For example, a centrifugal pump location should be as close to the source of water as possible when suction lift is present, or for a compressor location may be selected near the particular shop where maximum air will be consumed and at the same time a clear intake air will be available.
- Moreover the location plan should permit to have required wide space all-around for continuing the erection work and should facilitate regular inspection, repairing, etc.
- The location should also be finalized in such a fashion that it will not disturb or obstruct the operation and maintenance work of other nearby machines.
a) Location and Layout Cont.

- Once the location is finalized, the work of laying out the foundation plan is to be undertaken.
- Laying out means marking of the foundation plan. It may be done with the help of chalk on a concrete floor and by a string with a number of pegs.
- The general procedure is to indicate the outlines as per specification of the machine.
- The axis lines are to be drawn both longitudinally and crosswise to locate the center of foundation.
- Excavation of soil may be started only when the layout is completed as per the requirement.
b) Positioning of Machines

• Positioning of the machine at the location is an important job, which deserves care, skill an efficient teamwork.
• An equipment may have the weight of a few tons. But it is to be loaded or unloaded, to be moved vertically or horizontally to bring it at the site and to place it on the foundation as well.
• Different types of lifting devices like pulley blocks, chain-hoists, overhead cranes etc. may be used as per the availability and requirement.
• When the load is light, rope pulley blocks are widely used and chain pulley blocks may be useful, but for a very heavy load, electric cranes are generally employed.
• However, the slinging should be done with much care to avoid any impact shock, to avoid formation of any scratches and breakages, etc.
b) Positioning of Machines Cont.

• For a machine of about 2 tones, hemp rope or Manila rope of diameter about 4 to 5 cm may be used instead of chains, wooden blocks and felts should be interposed between rope and the machine, to avoid damage to the finishing.

• Care must be taken to sling the machine upright with weight distributed evenly. Thus, the efficient fixing and passing of ropes or ‘chains’ through the machine structure deserves skill and experience.

• Two typical slinging diagram (Fig. 1: a & b) are given for a lathe and a vertical milling machine respectively to explain the complicacies of slinging.
Figure 1. (a) Slinging a Center Lathe; (b) Slinging a Universal Milling Machine.
c) Foundation

- The shapes and sizes of the foundation differ according to the type and size of the machines.
- They are also dependent on the property of the subsoil and the dynamic loads of the machine during operation.
- If the weight of the installed machine is not too much or if the dynamic loads are insignificant, the size of the foundation may be finalized on the basis of design considerations.
- But when the dynamic loads predominant, the foundation should also serve the purpose to protect the machine from external vibration and to lower down the frequency of natural vibration by increasing its total mass.
c) Foundation Cont.

Other Design Criteria for Foundation

• Besides the dimensions, as stated above, some other criteria are also considered for suitable foundation work.

i. Ground Condition

• The nature of soil is obviously a vital criterion. For a hard soil or for a normal soil, the construction of a concrete bed does not entangle too many complicacies. It is rather most straightforward to consider the foundation plan supplied by the manufacturer.

• But, for soft and loose soil, a large surface area with proper depth is needed for the foundation of a machine.
c) Foundation Cont.

- The problems encountered due to vibration may force to construct a concrete raft (1) on piles (2), as shown in Figure 2.

![Figure 2: (a) Raft on Piles; (b) Bondage of Raft with Pile.](image)

- The main structure of the machine is erected on the piles. The piles should have a stable and rigid bond with the raft as shown separately in the Figure 2b.

- The bond may be a reinforced concrete having a steel-rod within it.

- For water-logged soils also, mostly the pile driven raft construction is the means to avoid problems due to subsidence of soil.
c) Foundation Cont.

Vibration Consideration

- To avoid transmission of vibration to adjoining parts of buildings or other foundations, it is necessary to provide a suitable isolation between the equipment foundation and the joining structure.
- Usually a gap is maintained all around the foundation (like a trench), and is filled by sand to avoid such transmission of vibration.
- Any vibration isolating material, other than sand, such as rubber, lead sheet, felt etc. may also be used.
- As a rule, the equipment foundation shall not be allowed to serve as support for other structures or for machineries not related to the particular equipment.
- The impact type machines, like stamping press, drop and forging hammer, need special care during foundation. The depth of the foundation becomes very large to make the foundation heavy.
c) Foundation Cont.

- Figure 3a shows a sand-filled trench all-around the concrete foundation block. Such a foundation design reduces vibration transmission.
- Figure 3b shows that the foundation block is placed on some inserts, below which the concrete (reinforced concrete) base is there.
- The air gap is maintained all-around and at the same time there is an elastic support (to provide cushioning effect) in between the foundation block and the equipment.
- Such a design avoids vibration transmission and absorbs shock as well. The soft inserts may be cork or timber sleepers etc.

Figure 3: (a) Sand-filled trench around foundation; (b) Soft insert below foundation block.
c) Foundation Cont.

Foundation bolts

• To install the machineries, foundation bolts will be specified and supplied by the manufacturers. Some of the foundation bolts become rigid on pouring concrete and some may be removable and adjustable bolts.

• A few type of foundation bolts, very commonly used, are discussed below.

Eye foundation bolts

• They are generally made of mild steel or wrought-iron and can be readily forged according to the size. They are very much suitable to use for fastening the lids to tanks etc. (Fig. 4).

Figure 4: Eye Foundation Bolt.
c) Foundation Cont.

**Rag bolt**

• Rag bolts (Fig. 5a) are rectangular in cross-section but the width of the rectangle increases gradually. They are having an indented or grooved edge.

• After suspension of the bolts, the gap around them may be filled-up with molten lead.

• Such bolts cannot be removed easily after grouting.

**Lewis bolt**

• Such bolts can be removed easily, as a tapered key (1) is fitted through the side of the bolts to make it rigid.

• It may be noted that the key is fitted on the straight face of the bolt body. (Fig. 5b)

Figure 5: (a) Rag bolt; (b) Lewis bolt.
c) Foundation Cont.

**Cotter bolt**
- To install heavy-machines, ‘cottered bolts’ are commonly used (Fig. 6a).
- A hand hold must be provided in the foundation block for the insertion of the cotter (1).
- The bolt possesses a rectangular slot to receive the cotter. A cast-iron washer (2) is also used as a bearing surface of the cotter.

**Split end bolts**
- The end of theses bolts are made splitted. The bent split facilitates a rigid fixing of a bolt.
- Such bolts are mostly used for medium-size machine tools. (Figure 6b).

Figure 6: (a) Cotter bolt; (b) Split end bolt.
c) Foundation Cont.

Major activities of foundation work

• The foundation involves the activities like digging-up the soil (excavation), positioning of foundation bolts, concrete mixture pouring and setting.

• Suppose the foundation plan of a ‘center lathe’ is supplied by the manufacturer as shown in Figure (5.7) with proper dimensioning.

Figure 7:
Foundation plan of a ‘center lathe’.
c) Foundation Cont.

- The erection work is undertaken mostly when the foundation block has been set in and hardened.
- The machine tool is placed on the foundation with the help of spacers or pads, leveling wedges, etc.
- Foundation plates are also supported similarly, for different machines etc. At this time, a gap (minimum 50 to 70mm) depending on the type of the machine is maintained between the top of the foundation block and the bottom of the machine or base plate.
- The foundation bolts are positioned before positioning the machine and the exact location of the machine is guided by the insertion of the projected foundation-bolt ends through the holes, provided at the machine footings or base plate.
- The bolt-ends should remain sufficiently projected to accommodate the washers and nuts as well.
c) Leveling and Alignment

- After having the machine on the foundation, the important job is to level and align it with other accessories.
- The leveling is performed with leveling wedges, shoes etc. as stated before.
- The horizontal and slight vertical movements of the heavy mass of machine is performed by pipes, rollers as shown in Fig. 9a or using pinch bars (Fig. 9b).
- Straight edge, spiral level, dial indicator etc., are generally useful instruments to level the machine.
- The leveling is to be checked in the both, longitudinal and transverse direction.
Figure 9: (a) Rolling of Load, (b) Lifting of Load.
d) Leveling Cont.

• The parallelity, perpendicularity of different faces, axes should be leveled and aligned, as are required.
• When leveling is completed, the foundation bolt cavity along with the bolt may be made concreted. Pouring of cement concrete is generally made through the gap provided at the top of the foundation, as shown in Fig. 10.
• This concreting will provide a bondage of the foundation bolts with the foundation block while performing grouting, discussed later.
• Whenever, the foundation block is continuously made for a connected accessory, (say, the alternator with the turbine) the relative alignment should be established before concreting the foundation bolts.
Figure 10: Pouring concrete in bolt cavity.
d) Grouting

- Grouting is a procedure of connecting the machine with the foundation by a concrete mixture of plastic consistency or cement mortar. It is extensively used in installing most of the machines.
- Generally, a quick setting cement is used to perform grouting. The top of the foundation block is made roughened, made moistened with water and wooden partitions are placed all-around the machine.
- The heights of such wooden boards are kept much higher than the gap between the top or the foundation and the bottom of the machine.
- Quick setting cement is then poured within the boundary with care to eliminate any air gap within it.
- Once started, the pouring should be completed continuously and the machine must be felt undisturbed for a few days after grouting to provide it time to set.
e) Fitting of other parts

• When the machine is erected, the other accessories may be joined accordingly.
• But, while laying out the foundation plan, the overall requirement should be kept in mind.
• The auxiliary structures e.g. in case of a heavy-duty diesel engine foundation, the structures for outer bearing pedestal, water pump blocks etc. should be planned at a time.
• This will minimize the problem of internal fittings.
f) Final leveling and test runs

- Accurate leveling can be carried out only when the grouting has set in after a few days.
- The machine is to be made cleaned and leveled then. Such leveling involves minor adjustments.
- Whenever provided, the leveling screws as shown in Fig. 7. may be operated to achieve the final level.
- Everything should now be made ready to carry the test run. The style of testing will differ from machine to machine.
- For instance, for metal-cutting machine tools, they are always sent out with a test chart.
f) Final leveling Cont.

- ‘Test chart’ may be defined as the specification of accuracies of major typical points like ‘straightness of guide ways’ ‘Trueness of spindles’ etc. which should exist for the desired functioning of the respective machines.

- The accuracy shown in the chart will be re-obtained only if the machine is correctly erected.
and leveled