PUMPS

In plant protection equipments, a pump is necessary for the atomization of the spray fluid. It is the most important and expensive part of a sprayer. A sprayer may be equipped with one of the following type of pump:

1. Air Pump (Pneumatic Pump)
2. Positive Displacement Pump
    a) Piston or Plunge type
    b) Rotary
    c) Diaphragm Pump
3. Centrifugal pump

1. **Air Pump:** Used in compression sprayer. They force air into the airtight spray tank and not pump the liquid directly. The compressed air exerts pressure on the spray fluid which is then pushed out into discharge line.

2. **Positive Displacement Pump:** This pump takes definite volume of liquid from inlet and transfers it without any escape into outlet. They required especially in power sprayer, automatic (spring loaded) bi-pass valve to control the pressure and protect against damage.

    a) **Piston Pump:** Also known as reciprocating pump. Liquid is positively displaced by a piston moving up and down in a cylinder or a barrel. Thus output is proportional to the speed of pumping and is virtually independent of pressure. Since they are totally immersed in spray fluid, they should be non corrosive materials. Unidirectional valves and sleeves are required. Amount of liquid pumped is proportional to the number of strokes. High pressure up to 70 kg/cm^2. A compression chamber or air bottle is required to even out pulses of pressure and for uniform discharge.
    These pumps are suitable for high pressure equipments such as orchard sprayers and multipurpose sprayers (designed for both low and high pressure spraying). These are less suitable for viscous liquids. The capacity of the pump depends upon the number of cylinders, their diameter, length of stroke, the number of strokes per unit time and volumetric efficiency. For a good pump, the volumetric efficiency is above 90%. Volumetric efficiency is the actual volume of the spray fluid discharged divided by the plunger displacement.

    b) **Rotary Pump:** They can couple directly to the driving shaft of the power source. The most common type of rotary pumps is gear pump or roller vane pump.
    i) Gear Pump: It is very small and compact. It consists of two meshed gear turning in a closely fitted housing (cover). The spray fluid is trapped between the gear teeth and the housing and is carried to the outlet by both the gears. It is made of brass, bronze, nylon or high carbon and stainless steel. They cannot withstand abrasive materials and hence wettable powder cannot be sprayed with sprayers equipped with these pumps. The whole unit is to be replaced when efficiency reduced beyond

economic level and dry running is to be avoided. Since they develop only less power (4kg/cm^2), they are used in low pressure spraying.

ii) Roller Vane Pump: These pumps superseded gear pumps in many aspects. They require less force. Roller vane pump slotted eccentrically mounted rotor which runs in a housing. Rollers are fitted in the slots and are thrown out against the housing by centrifugal force. The liquid enters through the inlet port is trapped between the rollers, and then carried to the outlet port. This is also a simple and compact pump, but more expensive than gear pumps, but develops high pressure (8 kg/cm^2). It can be used for spraying suspensions too, nylon is the most suitable material for this kind of pump.

c) **Diaphragm Pump:** It consists of a diaphragm stretched across housing. The diaphragm is moved up and down a short distance by means of a rod which helps creation of vacuum. The main advantage is that the only moving parts that come into direct contact with the spray fluid are inlet and out let valve. The valves are disc or flap type, which are cheap and easy to replace. The flexible diaphragm usually made out of synthetic/ nylon reinforced rubber is also cheaper than pistons and cylinders and hence easy to replace, if necessary. They are simple and reliable, but bigger in size and require less energy for operation and need minimum maintenance. This can spray abrasive materials too. But these pumps are not common in sprayers due to low discharge rate and pressure.

3. **Centrifugal (Impeller) Pump:** In these pumps, which are fitted in many sprayers, the droplets are carried by a blast of air. So pressure is not required as in the case of hydraulic sprayers. It consists of a cylinder, inside which a multi bade impeller rotates at a high speed around a central axis. The pump takes in the liquid at the axis and throws it by centrifugal force to the periphery where it is collected by the casing and is directed to the outlet. At constant RPM of impeller, the output of the pump reduces with increase in the delivery pressure. So when nozzles are shut off, pressure will increase into a pre determined safe level when a 100% slip occurs and a pressure relief valve is not required. Advantage is that no risk as in the case of a displacement pumps in such situation. The pump has only one moving part, impeller. However, due to high rpm, wear and tear of the bearings may occur. Since continuous flow of large quantity is there, no pulse effect is seen and discharge is even. Centrifugal pumps works well up to 7 kg/cm^2, but are not suitable for high pressure. They are suitable for handling abrasive material and viscous liquids satisfactorily. But they are more expensive than gear and roller vane pumps.

ENGINES

Heat engine is a machine for converting heat, developed by burning fuel into useful work (or) it is equipment which generates thermal energy and transforms it into mechanical energy. Heat engine is of two types: (i) External combustion engine, and (ii) Internal combustion engine.

External combustion engine: It is the engine designed to derive its power from the fuel, burnt outside the engine cylinder. Here combustion process uses heat in the form of steam, which is generated in a boiler, placed entirely separate from the working cylinder.

Internal combustion engine (I. C. Engine): It is the engine designed to derive its power from the fuel, burnt within the engine cylinder. Here combustion of fuel and generation of heat takes place within the cylinder of the engine.

Engine components: Internal combustion engine consists of the following parts:

- **Cylinder:** It is the basic part of the engine. It provides space in which piston operates to suck the air or air-fuel mixture.
- **Cylinder block**: It is the solid casting which includes the cylinder and water jackets (cooling fins in the air cooled engines).
- **Cylinder head**: It is detachable portion of an engine which covers the cylinder and includes the combustion chamber, spark plugs and valves.
- **Cylinder liner or sleeve**: It is a cylindrical lining either wet or dry which is inserted in the cylinder block in which the piston slides.
- **Piston**: It is a cylindrical part closed at one end which maintains a close sliding fit in the engine cylinder.
- **Head (crown) of piston**: It is top of the piston.
- **Skirt**: It is that portion of the piston below the piston pin which is designed to absorb the side movements of the piston.
- **Piston ring**: It is a split expansion ring, placed in the groove of the piston. Piston rings are fitted in the grooves, made in the piston. Piston rings are of two types: (a) Compression ring and (b) Oil ring.
- **Piston pin**: It is also called wrist pin or gudgeon pin. Piston pin is used to join the connecting rod to the piston.
- **Connecting rod**: It is a special type of rod, one end of which is attached to the piston and the other end to the crankshaft. It transmits the power of combustion to the crankshaft and makes it rotate continuously
- **Crankshaft**: It is the main shaft of an engine which converts the reciprocating motion of the piston into rotary motion of the flywheel.
- **Fly wheel**: Fly wheel is made of cast iron.
- **Crankcase**: The crankcase is that part of the engine which supports and encloses the crankshaft and camshaft. It provides a reservoir for the lubricating oil of the engine.
- **Cam shaft**: It is a shaft which raises and lowers the inlet and exhaust valves at proper time.

- **Timing gear**: Timing gear is a combination of gears, one gear of which is mounted at one end of the camshaft and other gear on the end of the end of the crankshaft.
- **Inlet manifold**: It is that part of the engine through which air or air-fuel mixture enters into the engine cylinder. It is fitted by the side of the cylinder head.
- **Exhaust manifold**: It is that part of the engine through which exhaust gases go out of the engine cylinder. It is capable of with-standing high temperature of burnt gases. It is fitted by the side of the cylinder head.

Internal engine classification: Internal combustion engines are classified in two types depending on the period required to complete a cycle of operation. They are four stroke and two stroke engines. 1. When the cycle is completed in two revolutions of the crankshaft, it is called *four stroke cycle engines*. 2. When the cycle is completed in one revolution of the crankshaft, it is called *two stroke cycle engines*.

I.C. engines are of two types: (i) Petrol engine (carburetor type, spark ignition engine), and (ii) diesel engine (compression ignition engine).

Petrol engine: It is the engine, in which liquid fuel is atomized, vaporized and mixed with air in correct proportion before entering onto the engine cylinder during suction stroke. The fuel is ignited in the cylinder by an electric spark.

Diesel engine: In this engine, during suction stroke, only air is entered into the cylinder and compressed. The fuel is injected through fuel injectors and ignited by heat of compression.

Comparison between diesel and petrol (carburetor) engines

S. No	Diesel engine	Petrol engine
1.	Diesel fuels are used.	Vapourizing fuels such as petrol, powerine or kerosene are used.
2.	Air alone is taken in during suction stroke.	Mixture of air and fuel is taken in.
3.	Fuel is injected into super heated air of the combustion space where burning takes place.	Air-fuel is compressed in the combustion chamber where it is ignited by an electric spark.
4.	Air-fuel ratio is not constant as the quantity of air drawn into the cylinder is always the same. To vary the load and speed the quantity of fuel injected is changed.	Air and fuel are almost always in the ratio of 15:1, but to vary the engine power, quantity of mixture is varied.
5.	Compression ratio of the engine varies from 14:1 to 20:1.	Compression ratio of the engine varies from 5:1 to 8:1.
6.	Specific fuel consumption is about 0.2 kg per BHP per hour.	Specific fuel consumption is about 0.29 kg per BHP per hour.
7.	4.5 litres of fuel is sufficient for nearly 20 hp hour.	4.5 litres of fuel will last about 12 hp hour.
8.	Diesel engine develops more torque, when it is heavily loaded.	This characteristic is not present in carburetor engines.
9.	Thermal efficiency varies between 32 and 38%.	Thermal efficiency varies between 25 and 32%.
10.	It runs at a lower temperature on part load.	Combustion gas temperature is slightly higher under part load.
11.	Engine weight per horse power is high.	Engine weight per horse power is

		comparatively low.
12.	Initial cost is high.	Initial cost is low.
13.	Operating cost is low.	Operating cost is comparatively high.

Comparison between two stroke and four stroke engines

S. No	Particulars	Four stroke engine	Two stroke engine
1.	No. of power stroke	One power stroke for every two revolutions of the crankshaft	One power stroke for each revolutions of the crankshaft
2.	Power for the same cylinder volume	Small	Large (about 1.5 times of 4 stroke)
3.	Valve mechanism	Present	Ports instead of valves
4.	Construction and cost	Complicated and expensive	Simple, cheap
5.	Fuel consumption	Little	High (about 15% more)
6.	Removal of exhaust gases	Easy	Difficult
7.	Durability	Good	Poor
8.	Stability of operation	High	Low
9.	Lubrication	Equipped with an independent lubricating oil circuit	Using fuel, mixed with lubricating oil
10.	Oil consumption	Little	Much
11.	Carbon deposit inside cylinder	Not so much	Much because of mixed fuel
12.	Noise	Suction & exhaust is noiseless, but other working is noisy	Suction & exhaust is noiseless, but other working is noise less
13.	Air tight of crankcase	Un necessary	Must be sealed
14.	Cooling	Normal	Chances of overheating
15.	Self weight and size	Heavy & large	Light & small

Storage of Food Grains

I. Introduction

The storage of food grains has been an age long practice with cultivators and traders. More pest-free storage is needed for handling crops at harvest time and to carry over reserves from year to year. Considerable losses both in quality and quantity of food-grains take place in storage due to a number of factors. Organisms directly responsible for causing loss in stored products are insects, mites, rodents, fungi and bacteria.

Among them, insects and mites are the most important hazards to the safe storage of grains. The insects that attack stored grains are rather general feeders, but some of them prefer certain grains. It is estimated that 5-10 per cent of the stored grain is lost every year due to insect damage in India. Some examples of the major insect pests of stored grain are *Rhyzoperthadominica*(lesser grain borer), *Oryzaephilussurinamensis*(saw toothed grain beetle), *Sitophilusoryzae*(rice weevil), *Trogodermagranaria*(khapra beetle), *Triboliumcastaneum*(red flour beetle) and *Plodiainterpunctella*(Indian meal moth).

II. Importance of Storage

Good storage facilities are important to the farmers all over the world. They help to ensure household and community food security until the next harvest and commodities for sale can be held back so farmers can avoid being forced to sell at low prices in the glut that often follows a harvest. Though considerable losses occur in the field, both before and during harvest, the greatest losses are noticed during storage.

1. Loss in quantity

Losses of the food grains in terms of weight are quantitative losses. Insects, rodents, birds etc. feeds on the product causing weight loss. These weight losses are not always apparent. For example, some insects eat only the centres of grain kernels so, even though the volume of grain may appear to remain the same, there can be considerable weight loss.

2. Loss in quality

Losses of this type can be nutritional, chemical, through contamination with toxic moulds or foreign matter. Pests that selectively eat a part of the food-stuff (such as the nutritious germ of the grain) will reduce the value of the food-stuff as a whole. Also, there is the loss of vitamins through the action of sunlight and temperature. Chemical changes are particularly common in fatty foods through the development of rancidity.

Aflatoxin (a toxic substance) producing moulds like *Aspergillusniger*, can grow on many products which pose a long term health risk. As maize, coconut and peanuts are particularly susceptible, storage of these products need special care.

General contamination can result in many ways and shows up in the form of insect fragments, rodent hairs, excreta and urine, as well as dust and other materials that enter the product through human mis-handling. The presence of rat urine can cause serious problems as rats are carriers of Weils disease. Sieving is often used to reduce the obvious signs of foreign matter contamination.

Farmers store the produce for two reasons; for home consumption and marketing. Farmers may not accept improvements which incur costs when storing primarily for home consumption. In many cases, these need only small improvements to make the difference between simply having enough for subsistence and creating a surplus for sale.

III. Principles of Storage

Most developing countries are in the tropics, often in areas of high rainfall and humidity. These conditions are ideal for the development of micro-organisms and insects which cause high levels of deterioration of crops in store. Food losses during storage are the result of biological, chemical or physical damage.

In order to reduce the amount of food grains lost, the environment in the store needs to be controlled so as to lower the possibility of:

- biological damage by insects, rodents and micro-orgamsms.

-chemical damage through rancidity development and flavour changes, etc.

-physical damage through crushing, breaking, etc.

Good storage thus involves controlling the factors, like temperature, moisture, light, pests and hygiene.

I. Temperature

The temperature within a store is affected by the sun, the cooling effect of radiation from the store, outside air temperature, heat generated by the respiration of both the food in store and any insect pest present.

Most of the micro-organisms thrive between 10 and 60°C temperature where as insects between 16 and 45° centigrade. Normally, in tropics and sub-tropics storage temperature lies between 25 and 35°C which is favourable for the survival of the micro-organisms and insects. Direct temperature control is not usually possible, so other measures, particularly reducing the moisture content of the stored produce, are necessary.

Running is a method of controlling insect pests involving heat. The produce will be laid out in a thin layer in the hot sunlight. At high temperatures (40 to 45^{o} C) the insect pests tend to leave the grain. It should be noted, however, that running does not always destroy eggs or larvae.

Improper maintenance of storage temperature can result in biological and chemical damage to the food stuff being stored. Examples include the loss of germination ability in seed materials and the accumulation of sugars in some commodities which need relatively low storage temperatures.

Temperature also controls chemical damage. The speed of chemical change in a food depends upon the temperature and the food's moisture content. A 10°C rise in temperature causes an approximately two-fold increase in the rate of reaction. Thus, cold storage will retard such changes as fat oxidation and vitamin loss. Many dried food grains benefit from even a small reduction in their storage temperature, and cool and dry conditions can greatly reduce the rate of development of brown discolouration and off-flavours.

Physical damage involves melting of fats in the products at high temperatures and crystallization of sugars in sweet foods at low temperatures.

2. Moisture

All micro-organisms, including moulds, require moisture to survive and multiply. If the moisture content in a product that is to be stored is low, micro-organisms will be unable to grow, provided that the moisture inside the storage structure is also kept low. Moisture should therefore, be pre- vented from entering the store.

All materials that have been dried will try to come back into equilibrium with the climate around them. In tropical countries this usually means absorbing moisture. The moisture level below which micro-organisms cannot grow is referred to as the safe moisture content. The Table 1 below lists the safe moisture content levels for cereals and pulses valid to temperatures up to 27^{o} centigrade. Slight variations in safe moisture contents arise depending upon the variety.

Table 1. Safe moisture content levels

Sl.No	Safe moisture product	Content (%)
1	Cereals: Maize (shelled)	13.5
	Maize flour	11.5
	Paddy rice	15.0
	Milled rice	13.0
	Sorghum	13.5
	Millet	16.0
	Wheat	13.5
	Wheat flour	12.0
2	Pulses: Broad bean,cow pea	15.0
	Lentil, pea	14.0

While in general it is essential that all food-stuffs are below their safe moisture content before they enter the store, the safe moisture content is to some extent related to the required storage time. Moisture levels above the safe moisture context can be tolerated if only short storage times are required.

Condensation of moisture can cause storage problems. If the walls of a store are cooled below their dew point by low night temperature, condensation can occur and increase the moisture content in the layers of the produce. The siting and the ventilation of the store is important.

It is also important to note here that most stored food products are "alive" and respiring, thus giving off moisture, as well as heat.

IV. Tips for Storage of Food Grains

This has been reported that up to 10 million tonnes of food-grains are lost each year in India through faulty storage techniques. If saved, it would have been more than enough to meet any world food deficit. It has been estimated that 10 percent loss in storage may be sufficient enough to feed 72 million people. The large stocks of grain in storage pose various problems which are unique and quite different from those of smaller lots. Therefore, adequate attention must be paid in the large scale storage of food-grains. To minimize the storage losses some practices for large scale storage of food grains has been developed.

1. The grains must be checked in the field before harvest to make sure that the grains are free from insects and diseases.

2. The harvesting and transporting implement must be cleaned before a new crop is harvested.

3. The grains must be harvested and threshed to avoid any breakage of grains, because broken grain will not store well.

4. The threshing yards which are free from insect infestation should be used.

5. Before storage the grains should be cleaned and graded. Unclean grain contains small amounts of straw, weed seeds and dirt, which not only decrease the value of food-grains but also cause the grains to deteriorate during storage.

6. No food-grains with a moisture content higher than the safe acceptable level should be accepted for storage. Dry the moist grain before storage because, it respires more quickly and gives off more heat and moisture, which encourages build of insect population and mould growth and hot spots develop in bulk grains.

7. The grains should be spread over plastic sheets or cemented floor while drying, otherwise it will pick up the moisture from the ground. The grains should be kept cool and dry between the time of harvest and storage.

V. Storage for Different Periods

The duration of storage is of vital importance in deciding the most appropriate storage practice. Thus, storage can be classified into the following categories.

A. Transit storage

This is the shortest term storage where the grain is being transported from one place to another or where some kind of rotation is practised so that the old stock moves out as the fresh stock comes in. Many of the Government go downs, godowns at seaports and go downs of retailers are examples of transit storage.

Transit storage has been maintained in a variety of sheds available on an emergency basis, from time immemorial. In these sheds, bag storage has generally been practised with the bags arranged in stacks. However, the best method will be to have proper go downs with permanent cubicles in which the bagged grain can be suitably stacked. These cubicles should be constructed so that they can be made air-tight both for storage and fumigation, if need be. This would provide ideal storage conditions and also the necessary handling facilities for bags needed for transit storage.

B. Short-term storage

This type of storage is practised by cultivators who generally like to store their seed grain from harvest to sowing and foodgrains from harvest to harvest. Storage structures generally use for short-term are bukhari, kothar, morai, etc., which are examples of non-airtight bulk storage.

From ancient times grain has been stored in India in bulk in mud bins. These earthem structures of various shapes and sizes provide the easiest and most economic methods for the storage of grains under rural conditions in India. However, in this type of storage, one often finds the grains infested with insects. In some places rats also pose a serious problem since they easily cut through the mud walls. In some wet regions of the country, grains are also found to be affected by the high humidity conditions. As a result, the loss of food grains in storage is often quite considerable. With a view to reduce these losses an ideal storage structure has been devised by the Indian Agricultural Research Institute, Pusa Road, New Delhi. It is called the Pusa Bin.

In the Pusa Bin, a thin sheet of polythene film (0.17 - 0.18 mm thick) is embedded in the mud wall of an ordinary earthem structure. The idea behind the sandwiching of the polythene film within the body of the wall is to combine the mechanical strength of the mud wall with the effective imperviousness of polythene films to vapours and gases. Also, this film is impervious enough to oxygen with the result that the oxygen tension within the structures reduced to such an extent that insect multiplication becomes impossible. At the same time, the earthem layers both inside and outside the polythene film keep the film safe from mechanical injuries due to abrasion and handling stress and strain.

Thus, the Pusa Bin combines all three major requirements of safe storage, namely,

(a) it is moisture proof,

(b) it is sufficiently air-tight, and

(c) its walls have poor thermal conductivity.

C. Long-term storage

This type of storage is for long periods as required by large-scale trade stockist and Government agencies desiring to keep buffer stocks or maintain food banks. For long-term storage, careful planning and implementation of the storage practices is required. Prior to the storage of grain, it should be thoroughly dried as the moisture content of the grain is the most vital factor for safe storage. Grain can be dried in the sun but it is highly advisable that a suitable grain dryer be provided for each storage godown.

Air-tight bulk storage is best if the stock has to be maintained on a long-term basis. It is generally in the form of modem silos above ground or as airtight moisture-proof under ground pits. Large-sized structures constructed on the basis of the Pus a bin will also serve well for long-term storage. Such storage structures housed in storage godowns are permanent means of long-term storage. The cost of such storage is quite cheap in the long run. The go downs should have adequate provision for making the whole structure sufficiently air-tight for fumigation and proper aeration after fumigation. This can be easily managed by having ventilation fitted with proper exhaust fans and also a suitable arrangement for closing the ventilator air-tight.

VI. Requirements for Safe Storage

Based on the above mentioned storage considerations we can make the grains less susceptible to insect attack by the use of efficient cleaning and drying equipment and by the application of fumigants and good storage practices. After harvesting and drying, grain and seed should be stored in clean, insect-free, weather-proof storage places from which nearby sources of insect infestation have been eliminated. The sources of insect infestations in stored grains vary with crop and region.

In most cases infestation begins in the field because enormous stocks of grains are stored on the farm either as feed or as market grain. Besides field infestation, infestation in stored grain originates in storage facilities or from nearby stores or accumulation of feed, or other infested dry food products. Therefore, the safe storage of food grains depends upon the storage structure, duration of storage, the local climatic conditions and the quantity to be stored. The storage structures should be of modem construction, easily cleaned and tight enough for fumigation. Every effort should be made to eliminate dead spaces in walls and floors where accumulations of grain offer food and housing for insects. Steel bins that are easy to clean and can be made air-tight are best for storage of small grains. The advantages and disadvantages of air-tight storage are given here.

1.Advantages

Sealed air-tight storage provides a cheap method of insect pest control. Due to the respiration of the stored product and of any insects present, oxygen is used and carbon-di-oxide is formed, which results in the death of insect pests. In order to accelerate this process, a lit candle can be placed in a tin at the top of the silo just before closing it. The burning candle quickly uses a great deal of the oxygen present. It is important to fill the silo to the top, as the oxygen present is then used up faster. Another main advantage of air-tight storage is the fact that moist outside air cannot enter the silo.

2. Disadvantages

Important dis-advantage of air-tight storage is that further drying of the produce in the store is impossible. Therefore, the crop needs to be well dried before placing in the store.

Additionally, it is not convenient if the user regularly needs to open the stock to remove food. However, when this happens the whole principle of air-tight storage is lost, because every time the store is opened fresh air enters. It is also extremely difficult to provide regular control of the productthrough inspection without letting the air inside.

VII. Damage by Insect Pests

Much of the damage to stored grains by insect pests is done directly to the kernels. Their larvae destroy many times their own weight of food during their growth period. Besides, many species feed on the germ of the grain, so that its viability is reduced and germination is impaired or destroyed. They frequently cause grain to heat resulting in a musty odour. Deterioration and rotting of the surface grain sets .in as a result of grain heating and consequent moisture migration in storage. Degree of damage depends on three factors namely.

(i) moisture content of the stored grains;

(ii) temperature inside the storage place, and

(iii) oxygen level, besides food supply and human activities.

It has been established that most insects do not thrive below 9 percent moisture content of the grains. So, it is essential that before grains are put into storage, the moisture level should be 8 percent and absorption of the moisture from the air should be prevented. Higher temperature favours the multiplication of insects, hence the inside storage temperature should be maintained low. Oxygen content inside the container under air-tight conditions also has a deciding influence on the infestation of grains and multiplication of insects. (For more details please refer Booklet No 376 on "Stored Grain Pests and their Control.")

VIII. Types of Storage

When storage is for a long period or/and in large quantity, it is referred to a bulk storage and is generally in the form of warehouses, silos above ground or pits underground. Storage of food grains for short periods or/and in small quantity is usually in bags and is known as bag storage.

NOTE:

Also Refer Basic Mechanical Engineering principles and Blowers