Technical English

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Spring Semester 2023-2024

Related Books:

1. **Lecture Note** and related **Books** including:
2. Fundamentals of Service (FOS), Engine
3. Fundamentals of Service (FOS), Power Train
4. Fundamentals of Service (FOS), Electrical Systems
5. Fundamentals of Service (FOS), Hydraulics
6. Fundamentals of Machine Operation (FMO), Tillage
7. Fundamentals of Machine Operation (FMO), Planting
8. Fundamentals of Machine Operation (FMO), Combine harvesting
9. Fundamentals of Machine Operation (FMO), Hay and Forage harvesting
10. Fundamentals of Machine Operation (FMO), Machinery Management
11. Mechanics of Materials, Ferdinand P. Beer & E. Russell Johnston

A Guide on Technical English for Agricultural Students

1. Preparation of the course note
2. Preparation of a pocket dictionary
3. Preparation of a small notebook
4. Taking part in class activities, 0.5 score would be given
5. Sharing your English knowledge to other students
6. Studying the previous lesson, class ahead
7. Carrying out your assessment and essay

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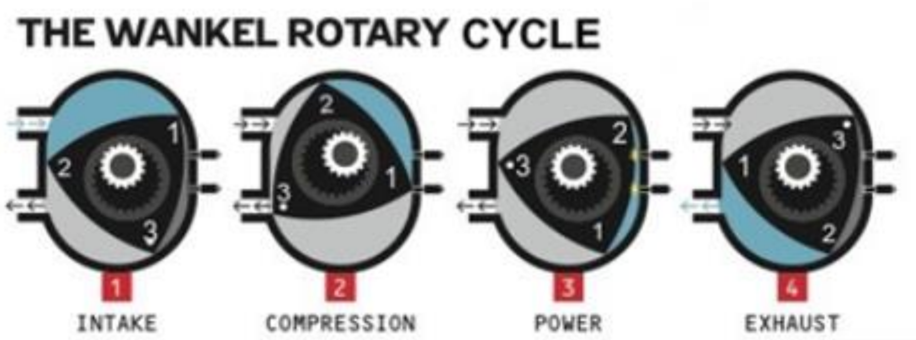
Chapter 1: Engine

In 1872, American George Brayton invented the first commercial liquid-fueled internal combustion engine. In 1892, Rudolf Diesel developed the first compression ignition engine. Afterwards, attempts were made on optimize piston-type four-stroke cycle engines until 1954 where German engineer Felix Wankel patented a "pistonless" engine using an eccentric rotary design.



Nowadays, engine development are mainly on reducing engine parts towards smaller engines. Downsizing of engines usually means that bearings are narrower and are therefore subject to increased stresses for the same load. Turbocharging and moving to direct injection further increases these stresses. Thinner oils with lower viscosity for fuel economy to gain more momentum is another challenge in engine development. Research is ongoing to identify the weak spots of new engines when using very thin oils. Additional additive technologies for enhanced wear protection will be required.

How engine works

The engine usually consists of a four fixed cylinder and a moving piston. A spark plug delivers electric current to the combustion chamber which ignites the air-fuel mixture in a gasoline engine.

The fuel does not ignite instantaneously when it is injected into the hot combustion chamber. A delay occurs, during which time the fuel begins to evaporate and mix with the air.

The expanding combustion gases push the piston down, which in turn rotates the crankshaft. The piston is able to do this because it is secured tightly within cylinder using piston rings to minimize the clearance between cylinder and piston. Ultimately, through a system of gears in the powertrain, this motion drives the vehicle's wheels.

The timing of the start of injection is selected to optimize the performance of each model of the engine but is typically in the range from 15° to 30° before piston approaches upper limit of the movement.

Engines consists of cooling system, lubricant system, electric system

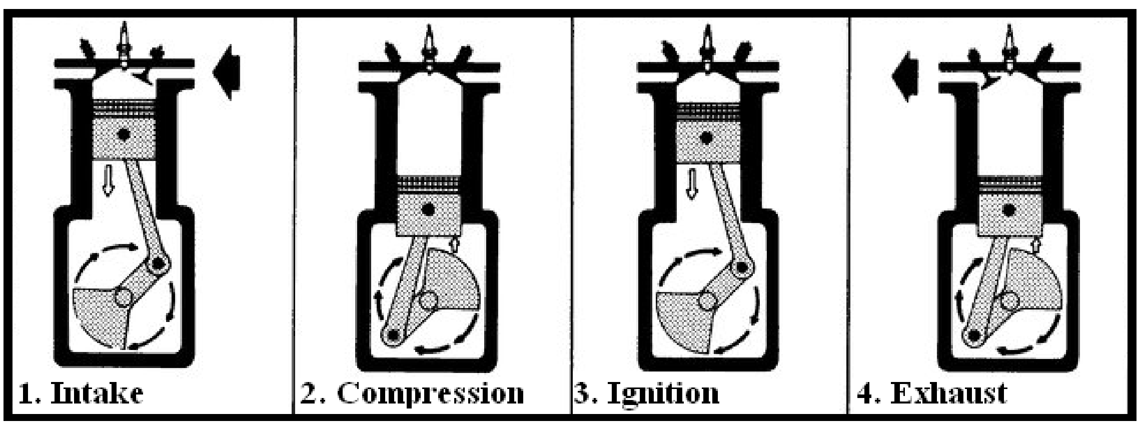


Figure 1. Four-cycle engine

Coolant, driven by a water pump, is pushed through the cylinder block. As the solution passes through these channels, it absorbs heat from the engine. Leaving the engine, this heated fluid enters the radiator, where it is cooled by the air flow entering through the radiator’s grill.

The electrical system consists of the battery, starter and magneto. The battery provides power to the starter. Electrical power is generated by the magneto which relies on the physics principle of electrical inductance to produce electricity; when a wire is moved through a magnetic field an electrical current is induced in the wire.

The oil drips onto the pistons as they move in the cylinders, lubricating the surface between the piston and cylinder. The oil then runs down inside the crankcase to the main bearings holding the crankshaft. Oil is picked up and splashed onto the bearings to lubricate these surfaces.

Following are the 6 main types of lubrication system:

Petroil system; In these types of the lubrication system, it is commonly used in the two-stroke petrol engines such as motorcycles. It is the simplest form of the lubricating system. For lubrication purpose, it does not have any separate part like an oil pump, oil filter, and oil strainer. But the lubricating oil is added to the petrol itself during filling in the petrol tank of the vehicle in a specified ratio. When fuel enters the crank chamber during engine operation, oil particles go down into the bearing surfaces and lubricate them. The piston rings, cylinder walls, piston pins, etc. are easily lubricated in the same way. If the engine is allowed to remain unused for a considerable time, the lubricating oil separates off from petrol and starts to clogging of passages in the carburettor, occurring in engine start problems. Thus is the main disadvantages of this system.

Splash system; In these types of lubrication system, the lubricating oil accumulates in an oil pan. A scoop or dipper is made in the lowest part of the connecting rod. When the engine runs, the dipper dips in the oil once in every revolution of the crankshaft and cause the oil to splash on the cylinder walls.

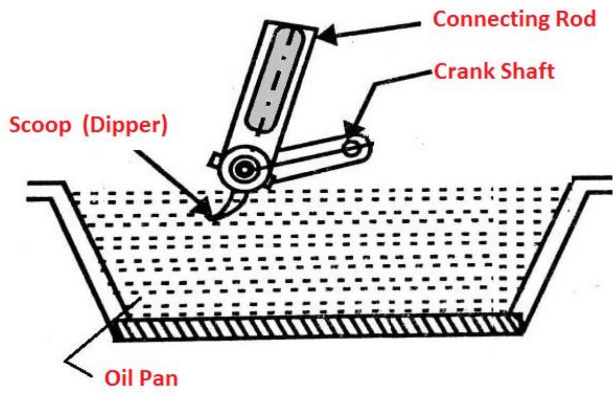


Figure 2. Splash type lubricating system

Pressure system; In these types of lubrication system, engine parts are lubricated under pressure feed. The lubricating oil is stored in a separate tank, from which an oil pump receives the oil through a strainer and transfers it through a filter to the central oil gallery at a pressure of 2-4 kg/cm^2.

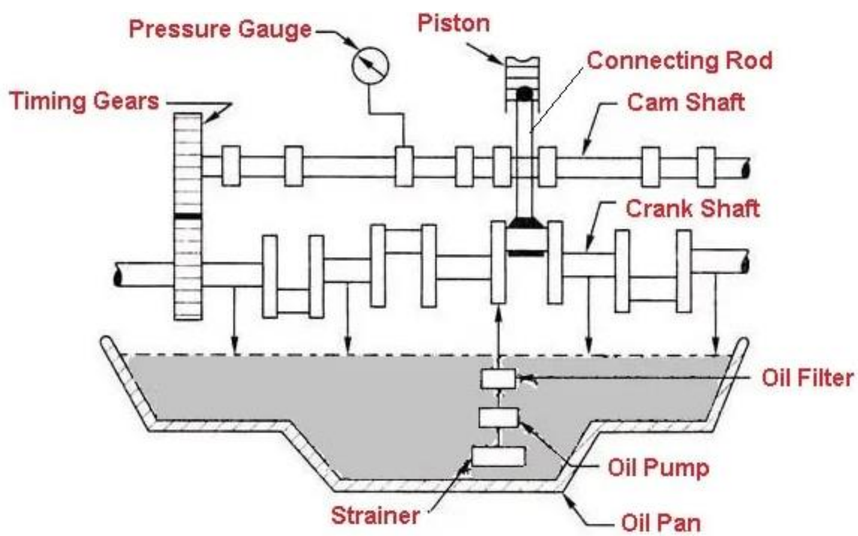


Figure 3. Pressure type lubrication system

The oil from the main gallery goes to the main bearings, after lubricating the main bearing, some of it goes back to the oil pan, some is splashed to lubricate the cylinder walls and the rest goes from a hole into the crank pin.

From the crankpin, it goes through a hole in the connecting rod eye to the piston pin, where it lubricates the piston rings. To lubricate the timing gears and camshaft, the oil is led through a separate oil line from the oil gallery.

The valve leg is lubricated by attaching the main oil gallery to the tappet guide surfaces through drilled holes. An oil pressure gauge on the instrument panel shows the oil pressure in the system. The oil filters and strainers in the system clear off the oil from dust, metal particles and other dangerous particles.

Semi-pressure system; It is the combination of a splash system and pressure system of the lubrication system. Some parts are lubricated by splash system and some parts by a pressure system. Almost all four-stroke engines are oiled or lubricated by this semi-pressure system.

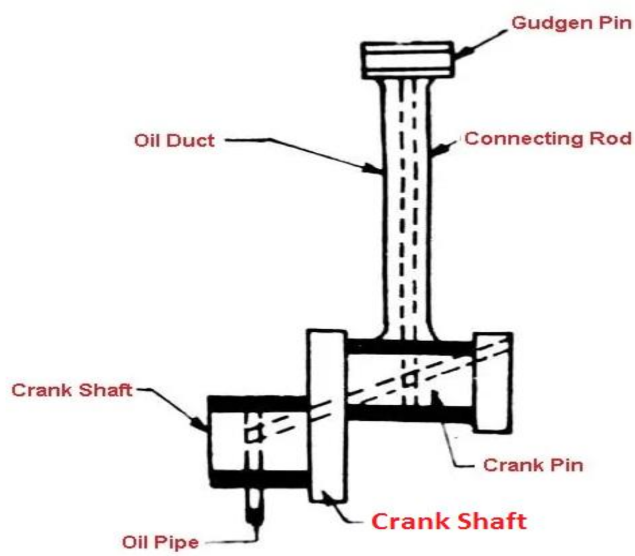


Figure 4. Semi-Pressure type lubrication system

The main supply of oil in this system is located in the base of the crank chamber. A filter is extracted from the bottom of the oil pan and delivered through a gear pump at a pressure of 1 bar.

Larger bearing ends are lubricated through a nozzle spray. Consequently, the oil also lubricates crankshaft bearings, cams, cylinder walls and timing gears.

The oil supply is measured with the help of oil pressure gauges. This system is less costly to install. This enables high bearing loads and engine speed to be applied than the splash system.

Chapter 2: Power Transmission

Clutch transmits engine power to the gearbox and allows the transmission to be interrupted while a gear is selected to move off from a stationary position, or when gears are changed while the tractor is moving. Most tractors use a friction clutch operated either by fluid (hydraulic) or, more commonly, by a cable. When a tractor is moving under power, the clutch is engaged. A pressure plate, bolted to the flywheel, exerts constant force, by means of a diaphragm spring, on the driven plate. Earlier tractors have a series of coil springs at the back of the pressure plate, instead of a diaphragm spring. The driven (or friction) plate runs on a splined input shaft, through which the power is transmitted to the gearbox. The plate has friction linings, similar to brake linings, on both its faces. This allows the drive to be taken up smoothly when the clutch is engaged. When the clutch is disengaged (pedal depressed), an arm pushes a release bearing against the center of the diaphragm spring which releases the clamping pressure. The outer part of the pressure plate, which has a large friction surface, then no longer clamps the driven plate to the flywheel, so the transmission of power is interrupted and gears can be changed.

When the clutch pedal is released, the thrust bearing is withdrawn and the diaphragm-spring load once again clamps the driven plate to the flywheel to resume the transmission power. Some tractors have a hydraulically operated clutch. Pressure on the clutch pedal inside the tractor activates a piston in a master cylinder, which transmits the pressure through a fluid-filled pipe to a slave cylinder mounted on the clutch housing. The slave-cylinder piston is connected to the clutch release arm.

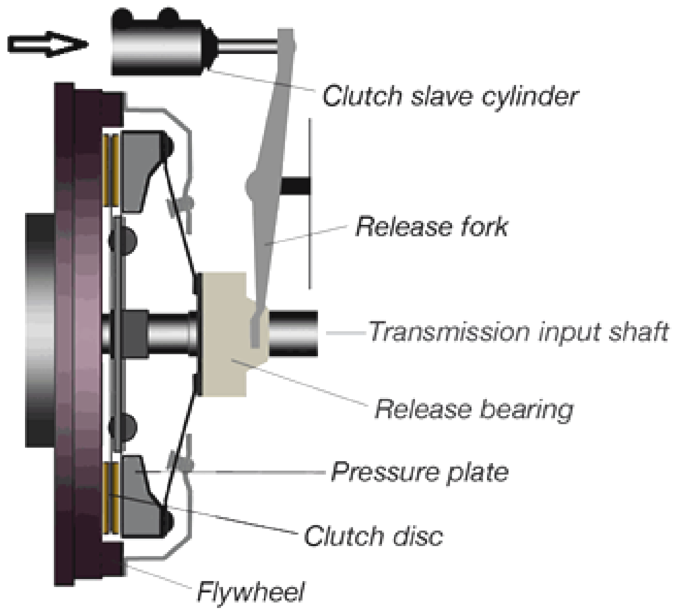


Figure 5. Tractor clutch terminology

While it would be very difficult to discuss all of the available transmission types available for farm tractors, it would be better to touch on (deal briefly) the more popular ones. The purpose of the transmission is to convert engine torque output into a tractor travel speed and direction that is suitable to the task needed (at hand). The early rubber-tired farm tractor transmissions starting out with three forward speeds and one reverse speed and it did not take long to have transmissions with 4 or 5 speeds. Then somebody figured out how to get more selections out of those existing gears, without actually adding more parts. Introducing a hi-lo shifter stick, with a minimum number of additional parts, range shift effectively splits each main gear into two different speeds, increasing the number of ground speeds available to the drive wheels. From that point, transmission technology has evolved into a very wide assortment of types, some of which will be now looked at in more detail.

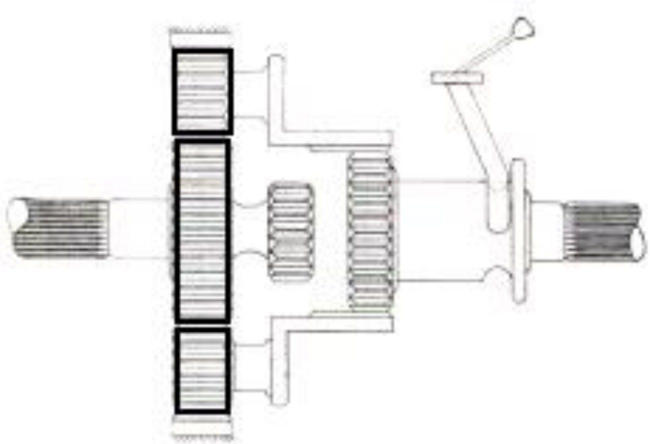


Figure. 7. A simple hi-lo system

Manual Shift: It was first introduced by Massey Ferguson in England. Manual shift transmission also called straight shift or crash shift gearbox. That is a pretty good name because that is exactly what occurs when you try to shift on-the-go. The two gears that you are attempting to mesh are rotating at different speeds, causing that grinding noise you hear.

Synchro-Shift: In order to achieve a smooth shift, the first thing that must happen is an equalization of the rotational speed of the gears that you wish to bring into mesh with each other. This is the chief function of the synchronizer.

Let's suppose our transmission is synchronized between 3rd and 4th gears. We'll start out in 3rd gear, and then shift into 4th. As we shift, the first occurrence in the chain of events is that we move the transmission out of 3rd gear, and into neutral. As we continue moving the shift lever towards 4th gear, a bronze internal cone moves towards an external cone applies friction to 4th gear, increasing or decreasing its speed to match that of the rotating collar. Then the balls push the springs and hide them self into the holes. Once the speeds have equalized, the gears still may not be lined up with each other, so there are little triangular shaped teeth around the outer circumference of the bronze cone, which serve to gear teeth into perfect alignment. This whole process occurs rapidly, usually allowing a straight-through shift, directly out of one gear and into the next. Synchro-transmissions range from simple, where only a single pair of gears are synchronized, on up to full synchronization of all speeds, including forward and reverse gear changing.

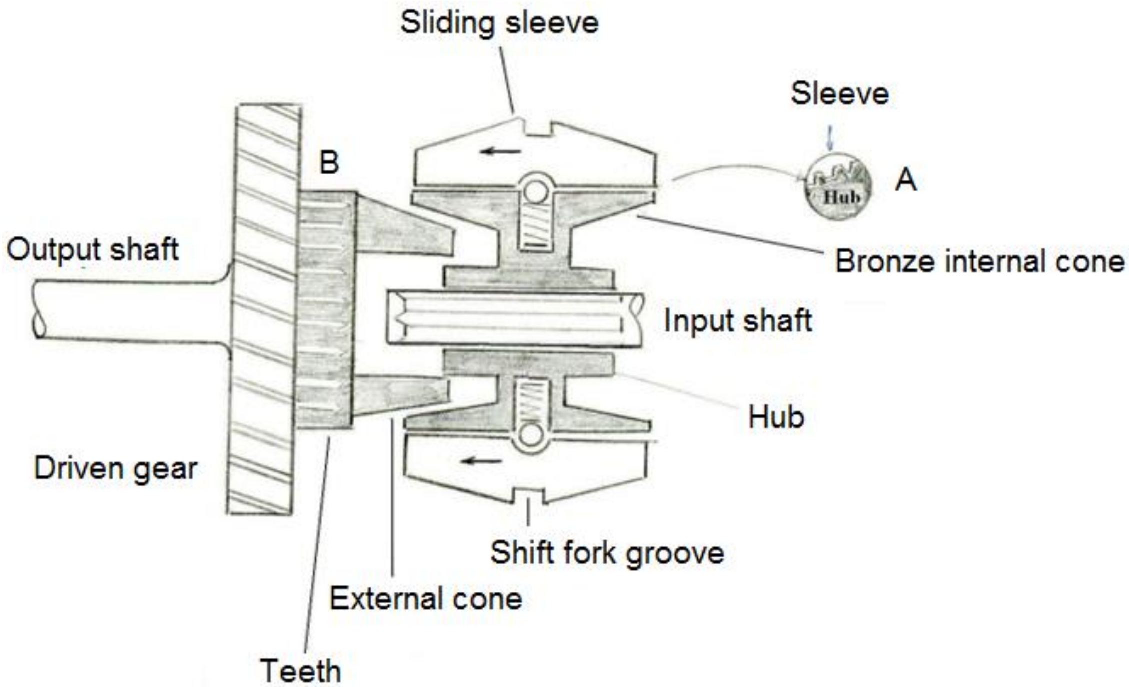


Figure. 8. Synchronizer mechanism

Chapter 3: Tractor Parts & Hydraulic Systems

Drawbar: Hauling heavy loads is still one of the most important jobs that a tractor does for a farmer. Tractors pull implements (farm machines such as plows, trailers, hay balers, manure spreaders, and so on) using a sturdy (strong) rod called a drawbar, which makes a secure but very flexible link between the tractor and whatever is following it. A pivot pin is used between the drawbar and pulled implements so a tractor can easily pull them around corners.

Hydraulic hitch: Because implements often have to be moved from one field to another, sometimes by driving them in public roads, modern tractors get around (overcome) this using a hydraulically powered lifting system at the back, known as a hydraulic hitch. This can rise off and lower down implements with a flick (knob or button) of a switch. The hitch makes it easy for a tractor to lower a plow when it is working in a field and then raises it up again to drive it somewhere else.

Power take-off shaft (PTO): Virtually all modern tractors can power implements or machines using what's known as PTO. It is a rotating shaft, usually at the back of a tractor, from which power can be taken from the tractor's engine. Two types of PTO's are engine driven and tire driven. The PTO shaft turns 540 or 1000 rpm (revolution per minute). To prevent damage those implements which function by 540 rpm shaft to the shaft turning 1000 rpm, they grooved by 6 or 21 slots, respectively. The PTO shaft is used to power implements such as rotary tillers, balers, mowers, sprayers, pneumatic seeders, fertilizer spreaders, hole digger, choppers, cubers, potato harvesters, elevators, and other kinds of equipment which function stationary such as threshers and farm sieves. Typically, this was done by looping a long rubber belt over the spinning wheel on top of the traction engine so it passed over a similar wheel on the machine that needed to be driven. To use the power-take-off, you need to hook up a special spinning rod (with clever, flexible connections called universal joints) between the tractor and the implement. A machine like a hay baler has spinning rakes, wheels, and gears inside it. When it is hooked to the back of a tractor, it is connected to the power-take-off so the tractor's engine powers the machinery inside the baler as well as driving its own wheels.

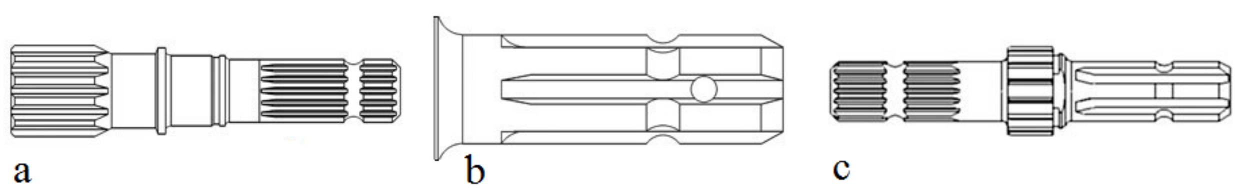


Figure 9. PTO shaft types, a) 1000 rpm/21 splines, b) 540 rpm/6 splines and c) reversible 1000 to 540 rpm shaft

Electrical sockets: It can be used to power things like brake lights on implements when they are being towed on the road.

Hydraulic System: The agricultural tractors at the beginning were used to pull and to carry implements for soil-tillage, most of them were ploughs (plow). Plowing is a field-operation with high energy requirements and consumption per area. With the mechanical power of the tractor, the farmers could do plowing quicker with only a few people. This was one of the most important steps to field-work mechanization. The hydraulic system was introduced solely for lifting and lowering the implements at the headland (no plowed land) and for transportation. When ploughing, the system was switched in the float position, so that the plough worked with constant working depth and could free follow the soil-surface even under undulated (wave shape movement) conditions. It was Harry Ferguson, a son of an Irish farmer, who invented in 1925 the so-called "draft-control" for the plow. The principle of this idea is still used and it is one of the most successful inventions of the agricultural engineering history. He found, that under wet field conditions the power of the tractor could not transfer to the soil because of high slippage. He knew that the wheel-slip could be reduced or the pulling force of the tractor could be increased by higher vertical forces on the pulling tractor-wheels. This can be done by ballast-weights or by a procedure of weight-transfer from the pulled implement to the tractor so that the tractor carries the plow partially during plowing. To realize this, the implement cannot be fixed in a constant position to the tractor, because of too large variations of the working depth of the plow on undulated soil-surfaces.

Apart from draft control, position control is implemented on today's tractors. It activated when an implement attached to a tractor which should be functioned at a certain height such as sprayer or fertilizer spreader. This system blocks the movement of the hydraulic fluid after setting up the implement at the proper elevation. This allows keeping uniform the pattern of the spreading while fertilizer or herbicide fluid tank is running out.

Response control is another hydraulic system assembly which is incorporated inside of the tractor hydraulic block. The system help to draft control reacts appropriately in soil with heavy texture where plow should not be lifted fast due to not existing dangerous obstacles such as stone or tree root. However, draft control should have enough agility while encountering an obstacle in light soils.

Chapter 4: Tillage & Tillage Implements

Tillage has been defined as those soil mechanical actions carried for the purpose of nurturing crop. The goal of proper tillage is to provide a suitable environment for seed germination, root growth, weed control, soil-erosion control, and moisture control avoiding moisture excesses and reducing the stress of moisture shortages.

Tillage requires well over half of the engine power expended on farms. Although, most tillage implements remain the as same as when invented, however, there have been more changes in tillage implements and methods in the last 100 years than in previous recorded history.

The primary objective of any cropping program is continued profitable production, so most farmers prefer to follow proven practices with readily available equipment. This offers reasonable assurance of predictable results with least risk. But no tillage operation can be justified merely (only, solely) on basis of tradition or habit. Any tillage practice which does not return more than its cost by increasing yield and improving soil conditions should be eliminated or changed.

Contrary to previous beliefs, soil needs to be worked only enough to assure optimum crop production and weed control. Any tillage activity beyond that is of questionable value.

Management of Crop Residue: Reduce interference with subsequent operations. Bury residue, mix it into the soil, leave it on the surface, or combine two or three of these effects.

Soil Aeration: Provide optimum air availability for plant growth without creating large voids (space) among clods or soil particles.

Weed Control: Kill growing weeds. Bury weed seeds found on the surface. Discourage (prevent) growth of more weeds by not bringing more seeds to the surface for germination. Permit effective use of chemicals.

Incorporation of Fertilizer: Provide maximum mix down of fertilizer with the soil. However, studies show that some uncultivated, minimum-tilled crops with surface mulch utilize surface-applied fertilizers just as effectively. Use accurate soil tests.

Moisture Management: Avoid excessive moisture at planting, and promote optimum moisture level during the growing season. Provide runoff control and loose surface for good moisture infiltration. Reduce surface evaporation during growing season. Provide drainage in heavy-rainfall areas and uniform surface to avoid ponding. Avoid or reduce soil compaction (such as plow sole), which restricts water movement. Prepare the soil for irrigation.

Insect Control: Bury residue to help control pests. However, pest control alone can not justify burial of all trash if other control measures such as shredding residue, crop rotation, resistant varieties, and pesticides are economically available.

Temperature Control for Seed Germination: Dry, bare soil warms faster in the spring than mulch-covered soil. More erosion and water loss through evaporation occurs. Colder soil temperature under mulch may be critical only in abnormally cold or wet seasons. Most locally adapted crops can tolerate more temperature variations than theneed to be controlled by altering tillage practices.

Improvement of Soil Condition: Incorporate organic matter into the soil. Work the soil only at proper moisture content. Maintain adequate fertility level. Encourage growth of soil organisms by adding extra nitrogen. Reduce soil density to improve root growth and increase moisture capacity.

Provide Good Seed-Soil Contact: Provide firm seed contact with moist soil for five to ten days for germination and root growth. For example, corn must absorb 30 percent of its weight in water to germinate or soybeans need 50 percent. But unnecessary soil compaction must be avoided.

Prepare Surface for Other Operations: Build or level beds for the next crop. Prepare soil surface for efficient harvest operation. Eliminate tracks or ruts (trace) form the previous harvest, but don't make the surface too smooth, for a smooth surface may reduce water infiltration and increase runoff and erosion.

Erosion Control: Provide loose, mulch-covered surface (best for erosion control). Use contour tillage, contour planting and no-till planting on erosion-prone (ready to be eroded soil) soils. Protect soil from wind and water erosion. Remember that the finest, most-fertile soil particles are usually lost first to wind and water erosion.

Energy Conservation: To reduce energy input, many tillage operations are being eliminated or combined with other operations. On many farms, moldboard plows are being replaced by chisel plows or heavy disk harrows which require less energy per acre (hectare). This is often called reduced tillage or conservation tillage if more residues are left on the surface. Tillage is normally classified as primary or secondary.

Primary Tillage: Primary tillage cuts soil and may bury trash by inversion, mix it into the tilled layer, or leave it basically undisturbed. Primary tillage is a more-aggressive, relatively deeper operation, and usually leaves the surface rough. Implements commonly used for primary tillage include:

- Moldboard, chisel, and disk plows
- Bedders and listers
- Subsoilers, and rippers
- Tandem disks
- Rotary tillers or rotivators

Secondary Tillage: Secondary tillage works the soil to a shallower depth. Provides additional pulverization, levels and firms the soil closes air pockets, kills weeds, and helps conserve moisture. Secondary-tillage tools include:

- Disks harrows
- Spring, spike, and tine-tooth harrows
- Field cultivators and row-crop cultivators
- Rod weeders
- Roller packers and roller harrows
- Rotary hoes

Chapter 5: Planting Equipment

The basic objective of sowing operation is to put the seed and fertilizer in rows at desired depth and seed to seed spacing, cover the seeds with soil and provide proper compaction over the seed.

The recommended row to row spacing, seed rate, seed to seed spacing and depth of seed placement vary from crop to crop and for different agro-climatic conditions to achieve optimum yields.

In the past, sowing include broadcasting manually, opening furrows by a simple plow and dropping seeds by hand in the furrow through a bamboo funnel attached to a plow. For sowing in small areas making holes or slits by a stick or tool and dropping seeds by hand, is practiced. Multi-row traditional seeding devices with manual metering of seeds are quite popular with experienced farmers. In manual seeding, it is not possible to achieve uniformity in distribution of seeds. A farmer may sow at desired seed rate but inter-row (seed spacing on each row) and intra-row (between rows) distribution of seeds is likely to be uneven resulting in bunching and gaps in the field. Poor control over depth of seed placement is another limitation of manual sowing.

The functions of a well-designed seed drill or planter are to:

i. Meter seeds of different sizes and shapes;
ii. Place the seed in the acceptable pattern of distribution in the field;
iii. Place the seed accurately and uniformly at the desired depth in the soil; and
iv. Cover the seed and compact the soil around it to enhance germination and emergence

Depending upon climatic and soil conditions, seeds are sown on well-prepared and leveled fields, on ridges, in furrows or on beds. Flat seeding and planting refer to operation when the field being planted is leveled and smooth. Seeds and tubers are planted on ridges either to improve soil drainage due to high rainfall or it may be a cropping requirement. Potatoes are usually sown on ridges. Seeding in furrows is done in arid regions to conserve soil moisture and improve plant growth. When two or more rows of seeds are planted in beds and separated by furrows, it is known as bed planting. Bed planting helps in conserving soil moisture, avoids soil compaction and promotes plant growth.

The major difference in different designs of seed drills/planters is in the type of seed and fertilizer metering and furrow openers. Details of these devices are as follows:

Seed Metering Devices

Metering mechanism is the heart of sowing machine and its function is to distribute seeds uniformly at the desired application rates. In planters, it also controls seed spacing in a row. A seed drill or planter may be required to drop the seeds at rates varying across a wide range. A common type of metering devices used on seed drills and planters are:

a. Adjustable orifice with agitator

In this type of metering device, seed flow is regulated by changing the size of the opening provided at hopper bottom. An agitator fixed above seed opening helps in the continuous flow of seeds. This does not give precise control over the seed rate and uniformity of distribution in rows. Many designs of conventional animal and tractor operated machines have adopted this mechanism on account of its simplicity and low cost.

b. Fluted roller (Standard) and Studded Roller

A flutedroller, as well as studded roller metering mechanism, are amore positive metering device. Axial or helical flutes are machined or cast on an aluminum, cast iron or plastic roller. Rotation of fluted roller in housing, filled with seeds, causes the seeds to flow out from roller housing in a continuous stream. Seed rate is controlled by changing the exposed length of the fluted roller in contact with seeds and fairly accurate seed rate can be achieved for a variety of medium size seeds like wheat, soybean, sunflower, and barley. However, metering of small seeds likes lettuce or sesame at 2 to 5 kg/ha seed rate is not accurate with normal size flutes. It normally designed for seed rates of 20 to 120 kg/ha. Therefore, fluted rollers with smaller size flutes were developed.

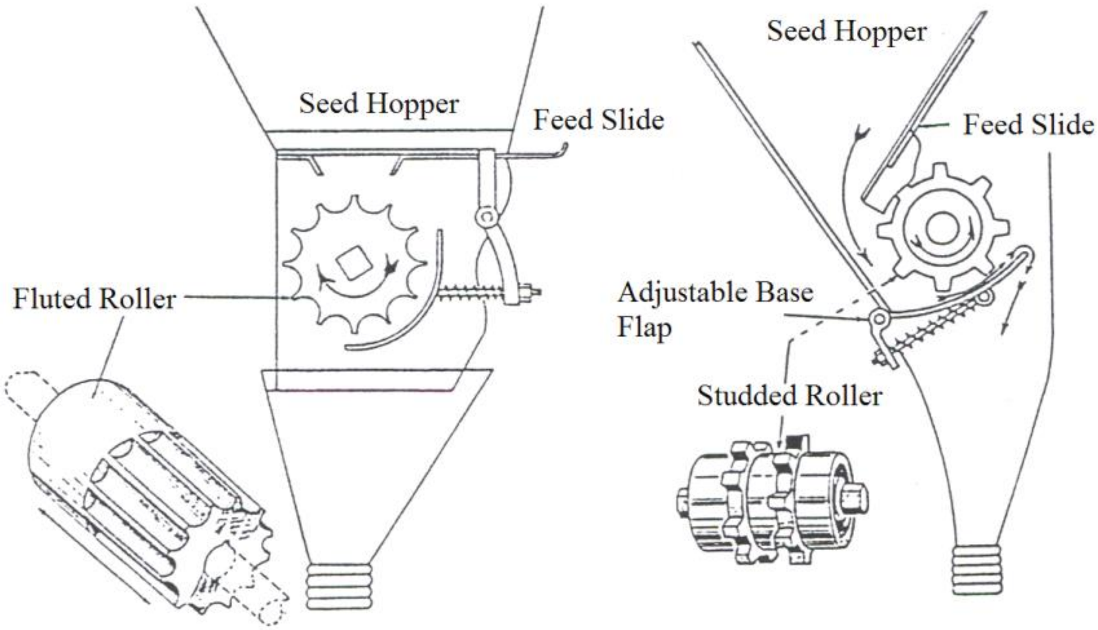


Figure 10. Fluted roller (left) and studded roller (right0 used to meter seed or fertilizer on drills

For sowing of small seeds like rape-seed (کلزا) and sesame, a fluted roller with small flutes has been developed at *Pantagar*, India. These can be fitted by replacing the standard fluted rollers on the seed cum fertilizer drill. The roller is provided with 10 small flutes of 2x2 mm size. Low seed rates of 3 to 5 kg/ha can be achieved with this metering roller with an accuracy of ±10 percent.

c. Vertical rotor/Roller with cells

Vertical rotors with cells are suitable for metering individual or hill of seeds. The rotor with grooves or cells on its periphery is fixed in the hopper. The size and number of cells on the rotor are according to the size of the seed and desired seed rate. A cut-off device is provided above the rotor for regulating the flow of seed to cells. In some designs, seed rotor is fixed in a secondary hopper and rotor lifts the seeds in cells and drops these into seed funnel. For varying the seed rate and sowing different seeds, separate rotors are required.

d. Plate with cells

Horizontal, an inclined or vertical plate with cell type metering mechanism picks and drops individual seed or a hill of seeds depending on the design of cell on the plate. The spacing between seeds/hills is controlled by drive ratio and number of cells on plate. Separate plates are required for sowing different crops. It is desirable that seeds be graded and has high germination percentage for achieving recommended plant population and uniform seed spacing.

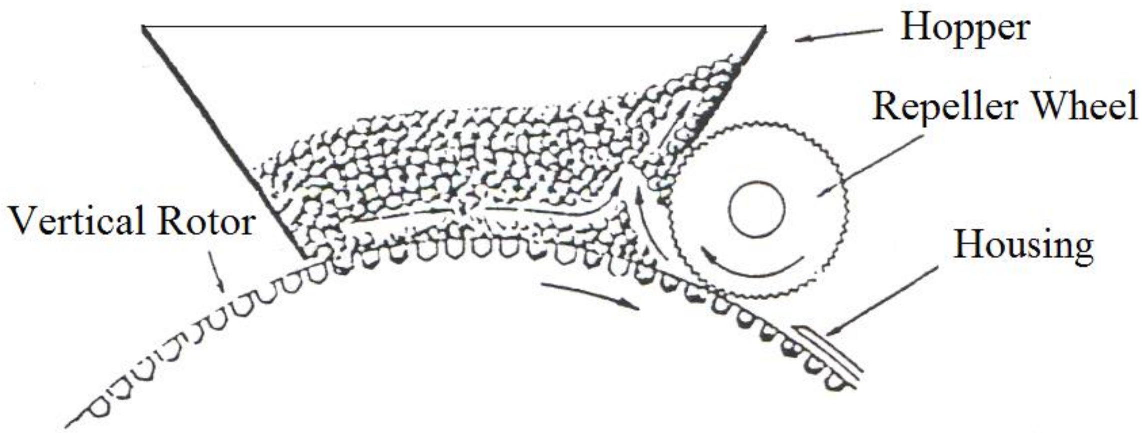


Figure 11. Vertical rotor or Fahse system

e. Belt Type Meter

The mechanism is simple. A mid-thickness-punched belt called pickup belt travels through a seedbox let each hole filled with a seed. The belt goes over a pulley and being vertical towards the seed tube. To prevent seed fallen, a retaining belt contributes to action, moves close to the pickup belt until approaching the position where two beltsleft each other made the seed fall into the seed tube.

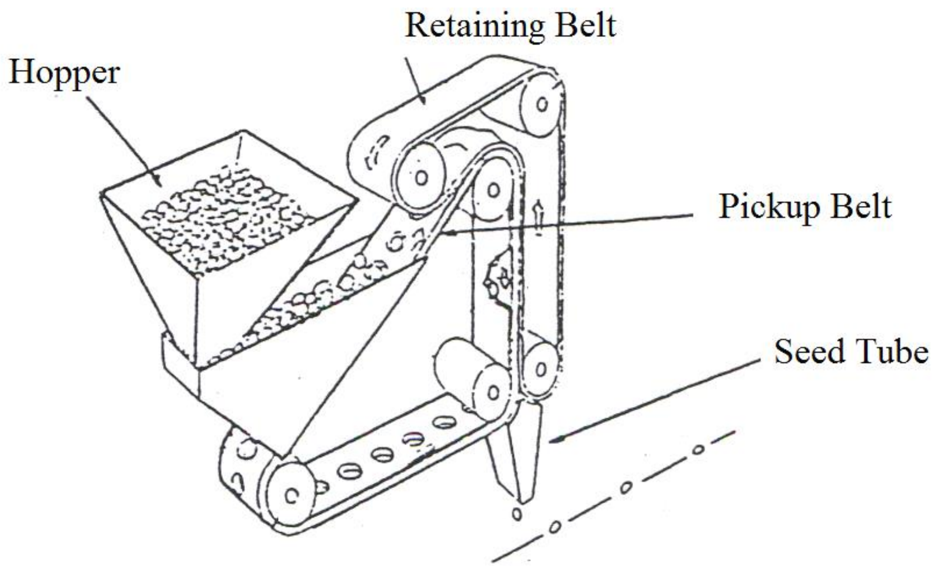


Figure 12. Belt type seed metering device

Factors Affecting Seed Germination and Emergence

Mechanical factors, which affect seed germination and emergence, are:

1. Seed damage during metering.
2. Uniformity of depth of placement of seed.
3. Uniformity of distribution of seed along rows.
4. Prevention of loose soil getting under the seed.
5. Uniformity of soil cover over the seed.
6. Mixing of fertilizer with seed during placement in the furrow.

Multifunctional Seed Drill

A seed drill refers to a planting device that is driven by a tractor. Usually, a seed drill has a tube containing seeds. The colter cut the soil open and seeds in the tube falling into the soil, then a rake covering the soil directly. Our corn planter integrates all the function, besides; it can also finish fertilizing process simultaneously. It applies to seed and fertilizes corn, soybean, and another suitable plant without plowing.

Chapter 6: Fertilizer Application

Fertilizer adds mainly fresh supplies of nitrogen, phosphorus, and potassium to the soil where these naturally nutrients have been depleted (run out). In areas where plants have been growing for a long time or are planted repeatedly, such as lawns and vegetable plots, the plants use the primary nutrients over time. Plants that are expected to produce flowers or fruits continuously over an entire season use up soil nutrients faster than even the most fertile soil can provide. Fertilizer fills these deficiencies. Soil with virtually no organic matter needs a lot of help from fertilizer. The rich, fertile soil needs less help from fertilizer. Look for fertilizers that are slow-acting. For general use, choose that fertilizer labeled "balanced" or "all-purpose". You can buy specially products for certain groups of plants, such as lawns, roses, acid-loving trees and shrubs, bulbs, and vegetables. Their formulations are adjusted to the needs of these plant groups.

Fertilizers are sometimes categorized as organic or synthetic. Both provide the same nutrition, but they vary in their sources of nutrients and the way the nutrients are released into the soil. The nutrients in synthetic fertilizers are manufactured from chemicals. In slow-acting products, they are coated to prevent them from immediately dissolving in water. They break down in moist soil gradually, so they are available over time to the plants. The nutrients in organic products are derived from natural plants and animal sources, such as manures, wood, paper, fish and bone meal, and seaweed. The microbes' activities in the soil release the nutrients and make them available to the plants.

Three major fertilizers are nitrogen (N), phosphorus (P), and potassium (K). A fertilizer containing all three major nutrients (NPK) is called a complete fertilizer. Accordingly, a product that supplies only one or two of them is an incomplete fertilizer. Using a complete fertilizer for every garden purpose seems sensible, but in fact, it is not always the best choice. If the soil contains sufficient phosphorus and potassium, however, is deficient only in nitrogen (as is often the case), you can save money by using an incomplete fertilizer that provides nitrogen alone (ammonium sulfate, for example). Regardless of its type, any fertilizer you buy will come with information about the nutrients it contains. Prominently featured will be the N-P-K ratio, the percentage the product contains by volume of nitrogen, phosphorus, and potassium. A 16-16-16 fertilizer, for example, contains 16% nitrogen, 16% phosphorus, and 16% potassium. A 25-4-2 formulation contains 25% nitrogen, 4% phosphorus, and 2% potassium.

All fertilizers contain at least one of these components; if any is missing, the ratio will show a zero for that nutrient (a 12-0-0 fertilizer contains nitrogen but no phosphorus or potassium, for instance). Boxed, bagged, and bottled products display the N-P-K ratio on the label. For fertilizers sold in bulk from self-serve bins, the ratio is noted on the bin; for future reference, be sure to write the information on the bags you fill and bring home.

Follow this advice whenever you use fertilizers.

- Avoid overuse of fertilizers.
- Water plants well before using water-soluble products.
- Delay fertilizing newly planted trees and shrubs for a year.
- Do not fertilize plants stressed by drought.
- Do not fertilize and lime the lawn simultaneously.

Broadcast Spreaders for Dry Fertilizer

Most farm-owned spreaders for lime and fertilizer are either full-width hopper broadcast spreaders or central-hopper broadcast spreaders. Other similar equipment found on farms includes row-crop units for planters and cultivators and grain drill attachments. Other machines, which are used more commonly on a custom, rental, or loan basis, include trailer-type bulk spreaders, bulk spreader trucks, and aircraft spreaders.

Full-width broadcaster

The simplest spreader is the full-width, gravity-flow type, which has a number of v-shaped openers. Fertilizer falls by gravity through holes (gates) in the bottom of the cut trough (furrow). Changes in gate size control the rate of application. A rotating, ground-driven agitator crushes lumps of fertilizer and aids in keeping material flowing freely and uniformly through the gates. Advantages of the gravity-flow spreader are: low profile to minimize draft and produce a uniform, full-width sheet of fertilizer over the application area. Disadvantages of the gravity-flow spreader are:

a. Because of the gravity control, the application rate is not linear with ground speed (greater rates are applied at lower speeds);
b. Effective field capacity is low (a 10-feet unit with a 15 cubic feet hopper will cover about 4 acres per hour); and
c. Maneuverability around objects is poor.

Spinner Spreaders

It consists of a hopper, a feeding device and a distributing wheel or rotating disk.

The primary advantages of spinner spreaders include:

a. Possibility of spreading widths up to 20 meter
b. Typical effective field capacities approach 7 hectare per hour
c. Variable spreading width and direction of distribution can be controlled (right, left, both sides, or full spread)
d. Fertilizer can be placed up or down slopes, under fences and under and around trees.

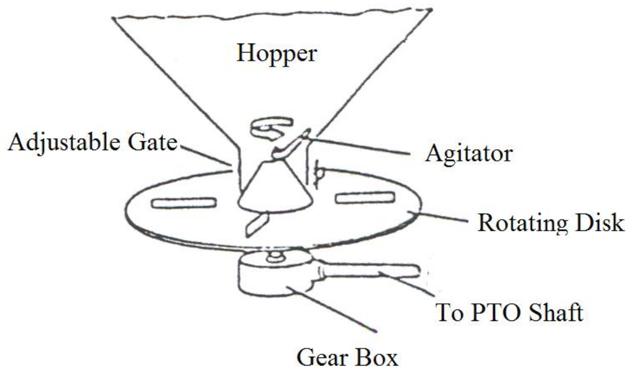


Figure 13. Spinner type fertilizer applicator used for dry materials

Problems associated with spinner spreaders include:

a. Uneven distribution patterns
b. Lack of operator understanding of calibration and adjustment procedures
c. Material drift
d. Heavy weights of equipment
e. Higher initial cost

The Distribution Pattern

The simple objective when broadcast spreading lime and fertilizer is to distribute the proper amount of material uniformly over the soil. As a first step in determining the distribution pattern, it is necessary to calibrate the spreader to determine how much of the material is actually being delivered. Although, manufacturers usually give directions for equipment settings for different materials and application rates, the best way is to measure the amount being metered from the hopper in a given amount of time (Engine- driven PTO) or as a known area is covered (Wheel-driven PTO). The actual fertilizer material should be used in the calibration. If a different material is used, a new calibration should be carried out.

The uniformity of a field pattern depends upon the location of the spread pattern center- line and the uniformity of the spread pattern itself. The traditional method for evaluating a field machine uses a series of trays placed on the ground in a line perpendicular to the direction of travel. One or more passes of the spreader in the same direction deposits material in the trays. A plot of the material weight from each tray versus the location of the tray gives a visual picture of the distribution pattern. Kits available for this calibration include a set of plastic or glass cylinders (or test tubes). Material from the trays is poured into the tubes in order, and the height of fertilizer in the tubes assists in visualizing the spread pattern.

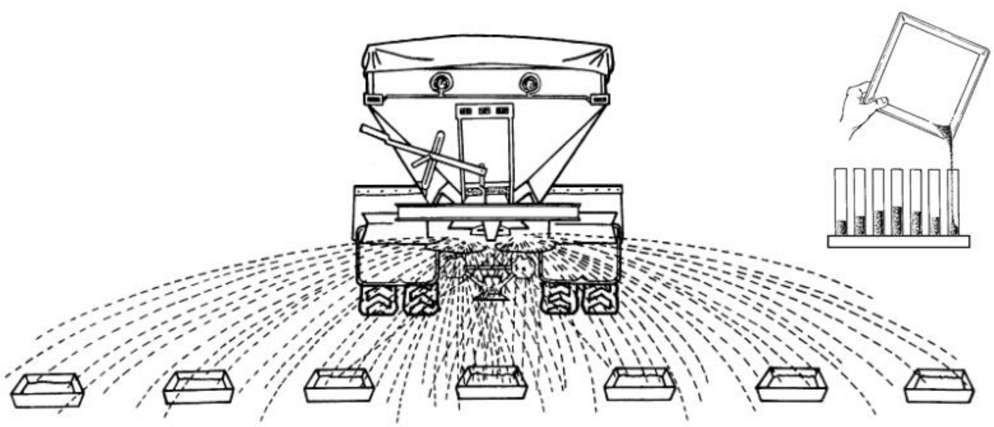


Figure 14. The tray system for evaluating distribution pattern

Theoretically, the ideal distribution pattern for a broadcast spreader is shown. Since there are equal amounts of material on each side of the spreader centerline, subsequent passes of the equipment would overlap adjacent spread patterns halfway up each respective side of the graph.

Most broadcast spreaders actually produce a distribution pattern as shown. The oval (ellipse) that results produces a rather large span in the center of the pattern where the material is uniformly distributed, but this drops off at the ends of the swath (application width). Effective coverage with this pattern is about 60 percent; that is, about 20 percent of the swath width must be overlapped in subsequent passes in order to produce uniform distribution. For example, an oval pattern 12.5-m in width would have an effective width of 7.5 m. Overlap of 2.5 m would be required in subsequent passes. A large number of spreaders produce the pyramid pattern. Although, this is an acceptable pattern, the effective application width is only about 50 percent of the theoretical width.

Chapter 7: Equipment for Spraying of Liquid Chemicals

Farm sprayers are used to apply pre- and post-emergent liquid chemicals to control weeds, insects, and diseases. Surface spraying is generally used for liquid chemical including pesticide, insecticide, fungicide, liquid fertilizer for direct plant nutrition, chemical for blossom loosening and other liquids required in farmlands (ranch).

Boom-type sprayers are used on tractors and always are mounted on tractor three-point-hitch so that; the boom height could conveniently be adjusted for providing desired spray pattern. The application rate ranges from 50 to 200 L/ha under pressure operation of 150 to 350 kPa. However, in some ultra-low volume (ULV) applications, the rates may be as low as 10L/ha to a few mL/ha. Tank-on-tractor mounted sprayers hold from 575 to 1000 L. For application in the standing row crop, high-clearance sprayers have been developed. They have a frame high enough to strew (spray) on corn, cotton, and other tall crops. The spray boom may be raised or lowered depending upon the crop height.

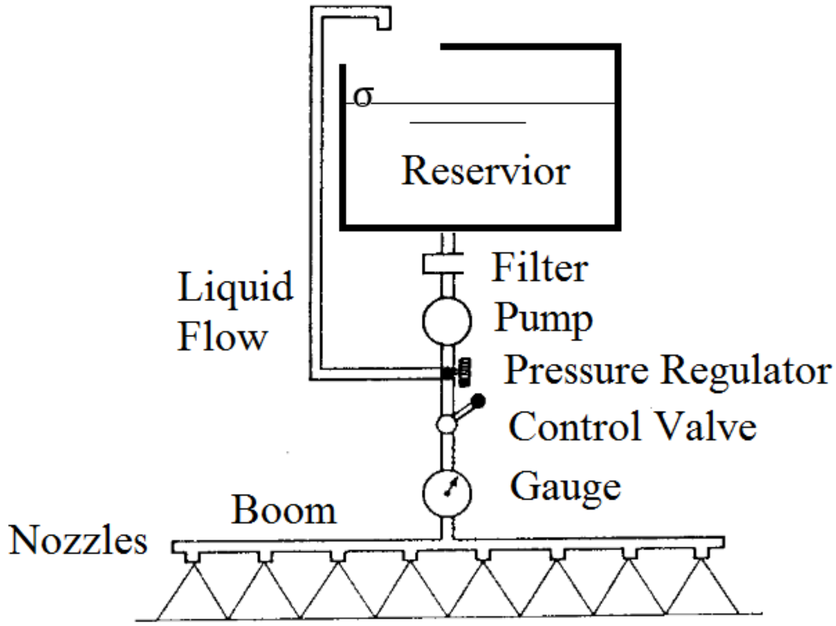


Figure 16. Flow diagram of a simple crop sprayer

A tractor-mounted sprayer consists of a tank to hold the liquid chemical, an agitation system to keep the chemical well mixed and uniform, a pump to create flow, a pressure regulator valve to control rate of flow, a series of nozzles to atomize the liquid and miscellaneous components such as boom, shut-off valves, fittings and strainers.

Droplet Size and Size Distribution

When liquid is atomized, droplets of various sizes are formed. The spray droplets are classified by their diameters, typically measured in microns (μ). The performance and effectiveness of an atomizer depend upon the droplet size and size distribution. The area covered and the volume of liquid in individual droplets is important in achieving effective and efficient application. Smaller droplets of the same volume provide more coverage. For example, one 200 μ droplet when broken into 64 droplets of 50 μ diameter will cover four times more area than the 200 μ droplet. The droplet distribution is also important from the point of view of spray drift. As can be concluded that, the smaller the droplet size the longer it takes for it to settle and the higher the probability of drift. Note also that droplets evaporate in flight, becoming smaller and thereby increasing the chances of drift. Droplet size distribution can be represented by a plot of the number of particles of given diameter, as in Fig. 15. This kind of plot is called a histogram. A smooth curve through the center points of the maxima of each size class gives the distribution curve. This curve represented by a function, f(x), is commonly called a distribution function. If the distribution function is known explicitly, then only a few parameters (e.g., mean diameter and standard deviation) are needed to define a given distribution. Minimum and maximum size is additional parameters, often associated with a distribution. Sometimes, the surface area or the volume of a droplet is more relevant in certain applications rather than the diameter. If this is used as the ordinate then the curve would skew to the right because of the weighting effect of the surface area or volume associated with a droplet diameter.

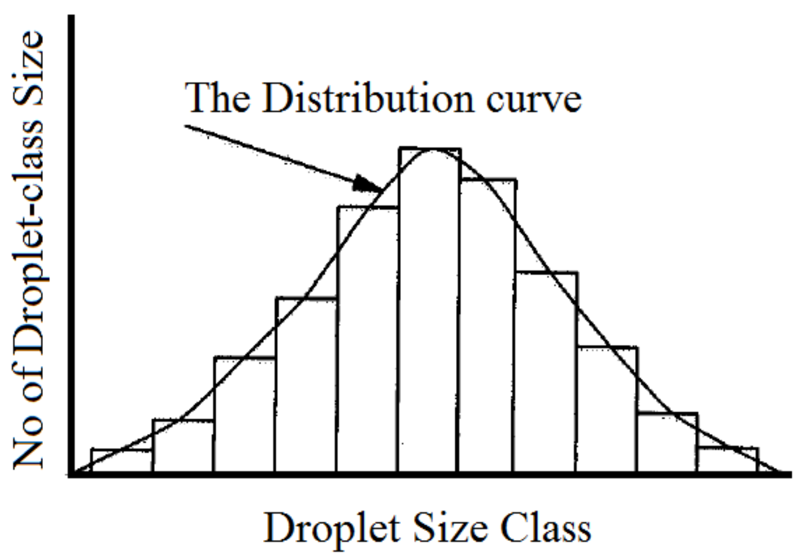


Figure 17. The frequency of droplet size

Chapter 8: Hay & Forage Harvesting Machinery

Domesticated animals have been used as power sources and/or as food during the entire recorded history of agriculture. Through grazing, animals are able to make use of grasses, legumes, and other forage crops that people cannot consume directly. The two most common methods of preserving forage crops are as direct cut at a given moist called ‘hay’ and chopped at higher moisture and preserve it in a silo so-called ‘forage’. Forages is chopped by chopper, stored in silo in higher moisture content. Hays are cut and field dried in either a swath or a windrow. A mower cuts hays stands and leave them down as a swath behind of the tractor. To make the hay cut suitable for pick up unite of a baler, windrower can be employed. Sometimes the mower is equipped with two convergent plates made hays set in a narrow windrow which so called mower-windrower.

Leaves dry faster than stems with most crops. The leaves, especially in legumes, are higher in nutritional value than the stems. Brittle, dry leaves maybe lost during raking and harvesting. To reduce such losses, the hay will be conditioned so that the stems dry at a rate approaching that of the leaves. Conditioning is physical process of crushing or abrading (wear) the stems using two parallel spring-loaded rollers. Depends on the outer face of the roller, conditioner is classified in two types of crimper and crusher. This process increases the stem-drying rate by reducing the natural resistance to moisture removal from the stems.

Grass and legume are usually cut with a machine that combines the cutting and the conditioning process, called mower conditioner. This machine can place the hays either a wide swath or a narrow windrow. The last is equipped with two convergent plates made hays set in a narrow windrow after conditioning so called mower-conditioner-windrower.

After the hay dries to 23% moisture or less, it is usually compressed to some degree before being transported to storage. Baling the hay into small rectangular bales of 25 to 40 kg mass provides hay packages that can are convenient to store and can be lifted by a single person. Because they do not resist water penetration very well, rectangular bales are usually transported and stored under a roof soon after baling.

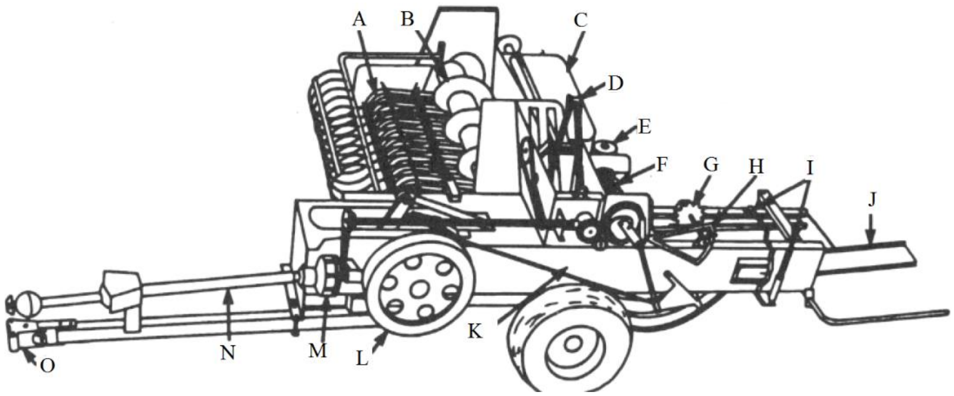


Figure 18. A baler that compresses hay into rectangular bales: A: pickup, B: feed auger, C: twine box, D: feed fork, E: hydraulic pump for density control, F: knotter, G: metering wheel, H: metering arm, I: density control rams, J: bale chute, K: bale chamber, L: flywheel, M: slip clutch, N: PTO drive, O: hitch

Hay can be harvested as bulk hay or as chopped hay, but baling is the most popular method of hay harvest. The two types of balers in popular use are rectangular balers and round balers.

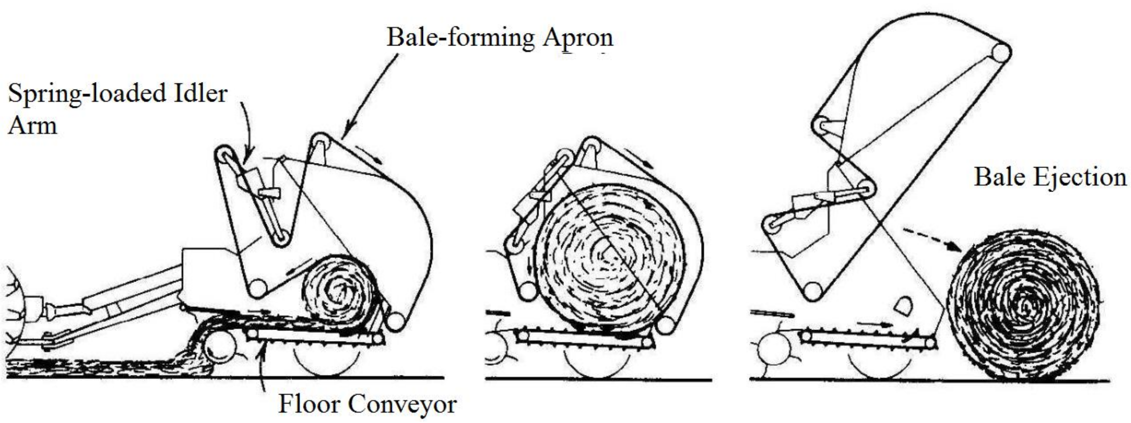


Figure 19. Bale forming in a round baler

Virtually all rectangular balers have the baling chamber oriented in the direction of travel of the baler. A windrow pickup unit feeds the windrow into a cross conveyor which, in turn, feeds the hay into the baling chamber. There are three types of cross conveyors. In one type, an auger conveys the hay to a set of packer fingers that sweep the hay into the bale chamber. In a second type, linear moving packer fingers travel the full width of the pickup in conveying the hay into the bale chamber. In the third type, rotating finger wheels move the hay laterally to the packer fingers.

The bale chamber is fed from the side or from below in current balers. Feeding from the bottom allows the baler to travel directly behind the tractor. In all feeder designs, the packer fingers must be timed to the movement of the reciprocating plunger so that the fingers are out of the bale chamber except when the plunger is in a forward position. As the feeder delivers each charge of hay, a knife on the edge of the plunger and a counter shear at the rear edge of the feed opening shear off the charge of hay as the plunger moves rearward. Continued movement of the plunger compresses the charge of hay and pushes previously accumulated compressed hay through the bale chamber. Controlled convergence of the bale chamber provides resistance to bale movement and thus controls bale density. Fixed wedges and spring-loaded dogs extend into the bale chamber and minimize re-expansion of the compressed hay during forward movement of the plunger. During compression, a star wheel at the top of the bale chamber is driven by the moving bale to trigger the tying mechanism when a bale of sufficient length has been formed. When the plunger reaches its rearmost position after the tying mechanism has been triggered, needles move through slots in the plunger face to deliver twine or wire to the knotter. The knotter completes the knots and the needles retract as the plunger begins moving forward. When the bale tying mechanism is triggered by the star wheel through a limited-motion pawl clutch, the needles rise through the plunger slots, carrying the twine strands to the respective knotters. The needle has brought the twine around the bale and placed it in the twine holder. The large rectangular bales will not shed water and thus cannot be stored outdoors, but are better suited to shipping by truck than are large round bales. In addition to those mentioned above, numerous other methods have been developed for harvesting hay. These include pelleting, stacking the hay into stacks in the field, compressing the hay into large loaves, and other methods. Specialized equipment has been developed to support each of these methods. Space does not permit an engineering analysis of all of this diverse equipment, so such analyses will be confined to mowing, conditioning, raking, forage chopping, and baling. Further discussion can be found in related text-books.

In another alternative, the hay is rolled into large round bales of 100 to 500 kg mass that is more resistant to water penetration, especially if plastic wrapped, and are sometimes stored outdoors, although storage losses will be higher. The large round bales are too heavy to be handled by hand, so specialized powered equipment has been developed for handling and transporting such bales. Another approach is to package the hay into large rectangular bales that are similar in weight and density to large round bales.

Machines to make large round bales entered the marketplace in 1971.Early machines employed a variety of techniques for forming bales, including the use of variable-geometry chambers, fixed-geometry chambers, and chambers without a floor (not shown) in which the forming bale is rolled on the ground. A pickup similar to those on rectangular balers but smaller in diameter is used to convey the windrow into the baler. When the windrow is narrower than the bale chamber, a certain amount of weaving is required by the operator to deliver hay to the full width of the chamber. Typically, the belts are each 100 to 150 mm wide and have 50 to 100 mm wide spaces between them. The rollers on spring-loaded idler arms retract and allow the chamber to enlarge as the bale grows to full size.

Power must be supplied to the chamber belts so that the moving periphery of the chamber will rotate the incoming hay and cause it to form a tight roll. Peripheral speeds of the belts and floor conveyor typically range from 1.3 to 2.8 m/s. The chamber forms a bale with a low-densitycore. As additional layers are added, the density increases and is controlled by the belt tension. When the bale reaches the desired diameter, the operator stops forward motion and engages a wrapping mechanism as the bale continues to rotate. A manual or powered traversing guide spaces twine wraps at 150 to 200 mm intervals across the face of the bale. The twine is not tied; the twine end is inserted into the chamber, wraps on the bale as it rotates, is cut and left with a free end when the bale is completed. On some balers, dual-tying mechanisms allow both ends of the bale to be tied simultaneously for faster tying. As an alternative to tying with twine, the baler may be equipped with facilities for wrapping the bales in a full-width plastic netting. Only 1.5 to 2.5 turns of the bale are needed to wrap with netting, compared to 10 to 20turns to wrap with twine. The netting gives the exterior of the bale a more closed structure, thus reducing leaf loss and improving weatherability (able to withstand the effects of weather)

compared to twine wrapped bales. Although the netting is more expensive than twine, the improved productivity from faster wrapping, coupled with the reduced losses and improved weatherability, generally offset the higher cost of the netting. After tying, the operator backs the baler approximately 6 m and raises the tailgate to eject the completed bale onto the ground. The baler is moved ahead 6 m before lowering the tailgate to allow the gate to clear the discharged bale and then baling resumes.

In some methods of forage harvesting, the forage is formed into windrows that can then be picked up directly by the harvester. This is common practice when harvesting forage for silage or where the climate is very dry. When dry hay is desired in humid climates, the forage is placed in a swath and then raked into a windrow. Tedders are sometimes used to spread swaths to fully and uniformly cover the field area. A side delivery rake can be used to roll swaths left by the mower, or tedded forage, into windrows. Rakes can also be used to invert previously-formed windrows to promote faster drying, especially after the rain has wetted the windrows. Dry matter losses during raking typically range from 3% to 6% and more leaves than stems are usually lost. Thus, gentle handling is an important goal in rake design. Popular types of side delivery rakes are the finger-wheel and rotary.

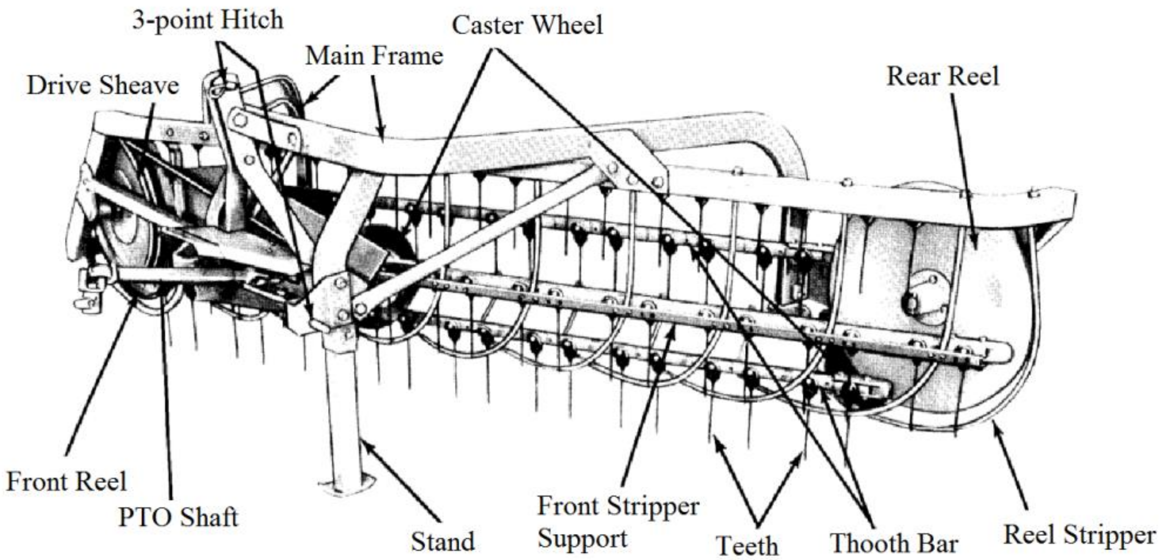


Figure 20. Side deliver rake or parallel bar rake

The two reel-heads are parallel but at an acute angle with the tooth bars. Thus, when one of the reel-heads is driven, either by PTO power or by a ground wheel, every rake tooth follows a circular path in a plane parallel to the reel-heads. All teeth automatically maintain parallel positions, usually vertical, but the pitch of the teeth can be changed by changing the tilt of the reel-head axes. Pitching the bottoms of the teeth forward gives amore vigorous raking action in heavy crops.

Chapter 9: Grain Harvester

The purpose of grain harvesting is to recover grains from the field and separate them from the rest of the crop material in a timely manner with minimum grain loss while maintaining highest grain quality. The methods and equipment used for harvesting depend upon the type of grain crop, planting method, and climate. The major grain crops are rice, wheat, corn, soybeans, barley, oats, sorghum, and dry beans (navy beans, pinto beans, etc.).

The entire harvesting operation may be divided into cutting, threshing, separation, and cleaning functions. Threshing is breaking grain free from other plant material by applying a mechanical force that creates a combination of impact, shear, and/or compression. It is important to avoid damaging grain during threshing–a challenging task under certain crop conditions. For example, at high moisture content, it is harder to break grain away from the crop material but easier to damage grain. The operation of separation refers to separating threshed grains from bulk plant material such as straw. The cleaning operation uses air to separate fine crop material such as chaff from the grain.

Depending upon the method employed for harvesting, these functions are performed by different machines, often with time allowed for windrowing or curing between the cutting and the threshing functions, or all the functions may be performed by one machine in a single pass over the field. The modern grain harvesters that combine all of these operations in one field-going machine are commonly called combines.

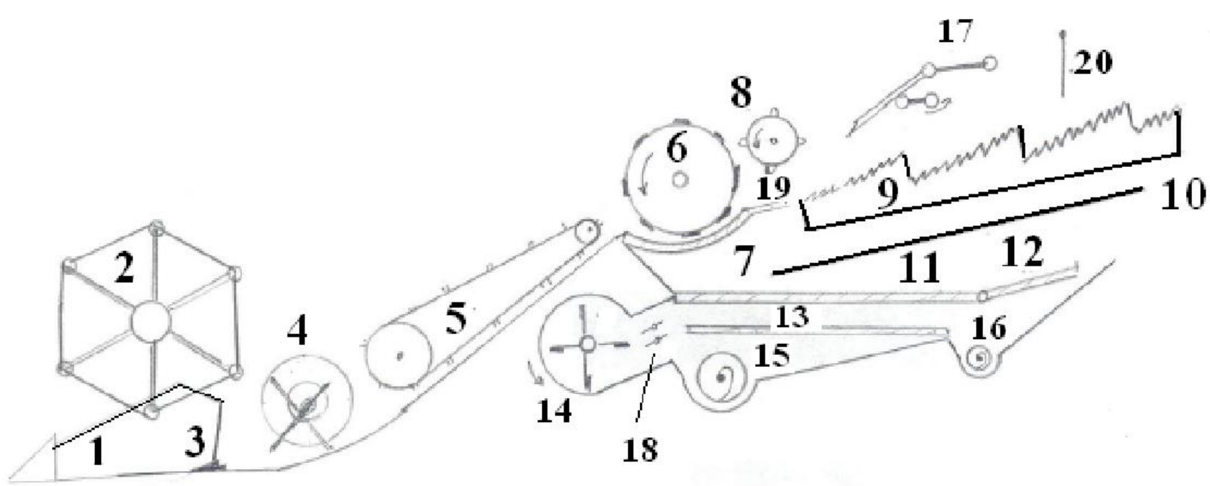


Figure 21. Full cross section of a conventional grain combine, 1.Divider, 2. Reel, 3. Cutterbar, 4. Double side auger, 5. Feeding conveyor, 6.Thresher cylinder, 7. Concave, 8. Cylinder beater, 9.Straw

walker, 10. Grain return pan, 11. Chafer, 12. Chafer extension, 13. Sieve, 14. Fan, 15. Clean grain auger, 16. Tailing auger, 17. Agitator, 18. Adjustable wind deflectors, 19. Transition gate, 20. Retarder curtains

In the direct harvesting method, all functions, from cutting to cleaning, are performed by one machine called the combine. All major crops mentioned above can be harvested directly. There are two main kinds of combines, conventional types and rotary types. Either of these types may be self-propelled or pulled by a tractor and powered by the PTO drive. Different manufacturers have different designs but the functional components are similar. During combine operation the uncut standing crop is pushed by the reel against the cutterbar and onto the platform. The cut crop is conveyed towards the center of the platform from either side by the platform auger and conveyed to the threshing cylinder by the feeder conveyor. The crop is threshed by the threshing cylinder. The threshing cylinder rotates at a very high speed (about 30 m/s peripheral

speed). About 80% of the grain, along with some chaff and small pieces of straw, is separated through the grate. The bulk of the straw, chaff, and the remaining grains pass through the concave-cylinder gap where the beater causes it to slow down. Then this material is delivered to a separator. In a conventional combine the separator is made of oscillating channel sections called the straw walkers. Since early 1970s separator design has changed to a rotary design. Rotary types of combines are discussed below. The separated material falls into the channels, moves towards the front of the combine, and is delivered on top of an oscillating grain pan where it is combined with the grain-chaff mixture separated at the cylinder-concave. This mixture of chaff and grain moves rearward due to the oscillating action of the pan and falls on the oscillating cleaning shoe. The cleaning shoe generally consists of two sieves and a fan to blow air upwards through the bottom of the sieves towards the rear of the combine. The top sieve is designed so that the openings may be adjusted. It is referred to as the chaffer. The air blows the chaff and the straw pieces off towards the rear of the combine while the clean grain falls through the sieves to the bottom of the cleaning shoe. The clean-grain auger carries the grain to the grain tank. Unthreshed grain heads that are too heavy to be blown off with chaff and too large to escape through sieve openings are called tailings and they are collected by the tailings auger and carried to the threshing cylinder for re-threshing. In some combine designs, multiple conventional threshing cylinders are used. Each cylinder rotates faster successively to thresh out increasingly hard-to-thresh grains.

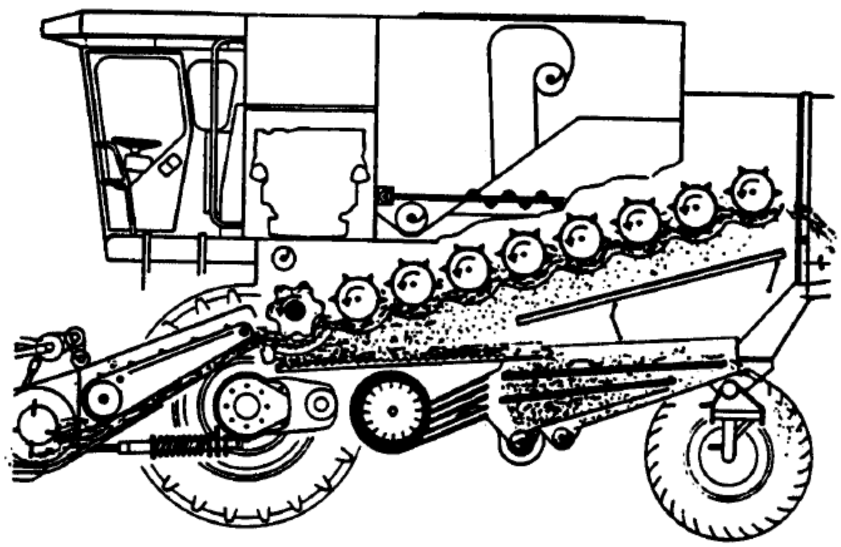


Figure 22. Combine with multiple threshers

Chapter 10: Postharvest Handling and Food Processing

Food processing is seasonal in nature, both in terms of demand for products and availability of raw materials. Most crops have well-established harvest times– for example, the sugar beet season lasts for only a few months of the year in the UK, so beet sugar production is confined to the autumn and winter, yet demand for sugar is continuous throughout the year. Even in the case of raw materials which are available throughout the year, such as milk, there are established peaks and troughs in the volume of production, as well as variation in chemical composition. Availability may also be determined by less predictable factors, such as weather conditions, which may affect yields or limit harvesting. In other cases demand is seasonal, for example, ice cream or salads are in greater demand in the summer, whereas other foods are traditionally eaten in the winter months, or even at more specific times, such as Christmas or Easter. In an ideal world, food processors would like a continuous supply of raw materials, whose composition and quality are constant, and whose prices are predictable. Of course, this is usually impossible to achieve. In practice, processors contract ahead with growers to synchronize their needs with raw material production.

The selection of raw materials is a vital consideration to the quality of processed products. The quality of raw materials can rarely be improved during processing and, while sorting and grading operations can aid by removing oversize, under size or poor quality units, it is vital to procure materials whose properties most closely match the requirements of the process. Quality is a wide-ranging concept and is determined by many factors. It is a composite of those physical and chemical properties of the material which govern its acceptability to the 'user'. The latter may be the final consumer, or more likely, in this case, the food processor. Geometric properties, color, flavor, texture, nutritive value and freedom from defects are the major properties likely to determine quality. An initial consideration is a selection of the most suitable cultivars in the case

of plant foods (or breeds in the case of animal products). Other pre-harvest factors(such as soil conditions, climate and agricultural practices), harvesting methods and postharvest conditions, maturity, storage and postharvest handling also determine quality. These considerations, including seed supply and many aspects of crop production, are frequently controlled by the processor or even the retailer.

The timing and method of harvesting are determinants of product quality. Manual labor is expensive, therefore mechanized harvesting is introduced where possible. Cultivars most suitable for mechanized harvesting should mature evenly producing units of a nearly equal size that are resistant to mechanical damage. In some instances, the growth habits of plants, e.g. pea vines, fruit trees, have been developed to meet the needs of mechanical harvesting equipment. Uniform maturity is desirable as the presence of over-mature units is associated with high waste, product damage, and high microbial loads, while under-maturity is associated with poor yield, hard texture and a lack of flavor and color. For economic reasons, harvesting is almost always a 'once over' exercise, hence it is important that all units reach maturity at the same time. The prediction of maturity is necessary to coordinate harvesting with processors' needs as well as to extend the harvest season. It can be achieved primarily from knowledge of the growth properties of the crop combined with records and experience of local climatic conditions.

Food units of regular geometry are much easier to handle and are better suited to high-speed mechanized operations. In addition, the more uniform the geometry of raw materials, the less rejection and waste will be produced during preparation operations such as peeling, trimming and slicing. For example, potatoes of smooth shape with few and shallow eyes are much easier to peel and wash mechanically than irregular units. Smooth-skinned fruits and vegetables are much easier to clean and are less likely to harbor insects or fungi than ribbed or irregular units. Agricultural products do not come in regular shapes and exact sizes. Size and shape are inseparable but are very difficult to define mathematically in solid food materials. Geometry is, however, vital to packaging and controlling fill-in weights. It may, for example, be important to determine how much mass or how many units may be filled into a square box or cylindrical can. This would require a vast number of measurements to perform exactly and thus approximations must be made. Size and shape are also important to heat processing and units. It is described that numerous approaches by which the size and shape of irregular food units may be defined. These include the development of statistical techniques based on a limited number of measurements and more subjective approaches involving visual comparison of units to charted standards. Uniformity of size and shape is also important to most operations and processes. Process control to give accurately and uniformly treated products is always simpler with more uniform materials. For example, it is essential that wheat kernel size is uniform for flour milling. Specific surface (area/mass) may be an important expression of geometry, especially when considering surface phenomena such as the economics of fruit peeling, or surface processes such as smoking and brining. The presence of geometric defects, such as projections and depressions, complicate any attempt to quantify the geometry of raw materials, as well as presenting processors with cleaning and handling problems and yield loss. Selection of cultivars with the minimum defect level is advisable. There are two approaches to securing the optimum geometric characteristics: firstly the selection of appropriate varieties, and secondly sorting and grading operations.

Chapter 11: Machinery Management

Because of the seasonal nature of farm work, farm machinery is used during relatively short periods of the year. With the growth in average farm size, machines of high capacity are required to accomplish their task during these short periods. Unlike factory machines, whose costs can be amortized over thousands of hours of annual use, farm machines are typically amortized over hundreds of hours of annual use. The need to amortize machine costs over low hours of annual use puts tight constraints on the manufacturing costs of farm machines. At the same time, since lost time is very costly during the limited periods of annual use, farm machines must be designed to have high reliability and high field efficiency. As early as 1924, it was noted that “time is the essence of farming” and that whatever helps to shorten the time required for planting and harvesting will help overcome the effects of adverse weather. Thus, machinery selection and management techniques are of great interest to both the designer and user of farm machinery. Some major definitions are coming after to have more clarity.

Machinery Costs

Machinery costs include costs of ownership and operation as well as penalties for lack of timeliness. Ownership costs tend to be independent of the amount a machine is used and are often called fixed or overhead costs. Conversely, operating costs increase in proportion to the amount the machine is used. Total machine costs are the sum of the ownership and operating costs. Ownership, operating, and total machine costs can be calculated on an annual, hourly, or per-hectare basis. Total per-hectare cost is calculated by dividing the total annual cost by the area covered by the machine during the year. A custom cost is a price paid for hiring an operator and equipment to perform a given task. A farm operator can compare total per-hectare costs to custom costs to determine whether it would be better to purchase a machine or to hire the equipment and an operator to accomplish a given task. Per-hectare ownership costs vary inversely with the amount of annual use of a machine. Therefore, a certain minimum amount of work must be available to justify the purchase of a machine and, the more work available, the larger the ownership costs that can be economically justified.

Ownership Costs

Ownership costs include depreciation of the machine, interest on the investment, and cost of taxes, insurance and housing of the machine.

Depreciation

Depreciation is the reduction in the value of a machine with time and use. It is often the largest single cost of machine ownership, but cannot be determined until the machine is sold. However, several methods are available for estimating depreciation. One of these is to estimate the current value using various price guides for used equipment.

Annual depreciation is generally highest in the first year of the life of a machine and declines each year. The sum-of-the-year digits and the declining-balance methods both give rapid depreciation in the early years and lower depreciation as the machine ages. Rapid early depreciation is used by many machine owners to obtain the income tax advantages associated with such methods. For simplicity in machinery management calculations, straight-line depreciation can be used. With straight-line depreciation, the difference between the purchase price and the salvage value is divided by the machine life to obtain the annual depreciation. Alternatively,

the cost of depreciation and interest can be recovered through these of a capital recovery factor. The capital recovery factor is discussed in the Total Annual Ownership Costs section.

Machine Life

The estimated life of machinesis based on a total number of hours until the machine is worn out. The life of a machine can be terminated by wear out or by obsolescence (put aside). Wear out does not occur at a definite point in time. Rather, the repair costs required to keep the machine operational gradually increase until it becomes uneconomical to continue making repairs. Obsolescence occurs when the machine is out of production and repair parts are no longer available, or when it can be replaced by another machine or method that will produce a greater profit. The number of years of life until wear-out can be obtained by dividing by the annual hours of use. In many cases, because of limited annual use, machines will become obsolete before reaching the wear-out lives. The term economic life is defined as the length of time after the purchase of a machine that it is more economical to replace the machine with another than to continue with the first, whether because of wear-out or obsolescence. The economic life is then the appropriate life to use in calculating ownership costs.

Interest on investment

The money spent to purchase a machine is unavailable for other productive enterprises. Therefore, the cost of ownership includes the interest on the money that is invested in the machine. If a loan is used to purchase a machine, the interest rate is known. If a machine is purchased for cash, the relevant interest rate is the prevailing rate that could have been obtained if the money had been invested instead of being used to purchase the machine. The principal on whom the interest is assessed is equal to the remaining value of the machine in any given year. For simplicity, when the straight-line method of depreciation is used, the annual interest cost is assumed to be constant over the life of the machine. It is calculated on the average investment, i.e., the average of the new cost and salvage value of the machine. Alternatively, it can be included in the capital recovery factor.

Taxes, Insurance, and Shelter

Taxes include sales tax assessed on the purchase price of a machine and property tax assessed on the remaining value in any given year. For simplicity, both kinds of taxes are distributed over the life of the machine. Some states have neither a sales tax nor property tax and, in such states, no tax cost should be included. The machine designer

may not know which tax rate to use, especially if a machine can be used in any of a number of different states. If actual taxes are unknown, it is reasonable to estimate the annual tax charge at 1% of the purchase price of the machine. Machines may be insured against loss by fire or other causes, in which case the cost of insurance is known. If no insurance policy is purchased, the owner has elected to carry the risk himself but an insurance cost should still be included. Insurance costs should be based on the remaining value of a machine. If insurance costs are unknown, a reasonable estimate of annual insurance cost is 0.25% of the purchase price of the machine. There are no conclusive data to prove the economic value of sheltering farm machines. Nevertheless, providing shelter is often associated with better care and maintenance of machines that can result in longer life, improved appearance, and better resale value. If shelter is provided, the cost of providing that shelter can be calculated. If no shelter is provided, there is probably an economic penalty associated with reduced machine life and/or resale value. Thus, a shelter cost should be included whether or not shelter is provided. The annual cost of shelter is considered to be constant over the life of the machine. If shelter cost data are unavailable, it is reasonable to estimate annual shelter cost as 0.75% of the purchase price of the machine. The total cost of taxes, insurance and shelter can be estimated at 2% of the purchase price of a machine unless more accurate data are available. Although taxes, insurance, and shelter are small relative to total ownership costs, they should be included.