5.1: Combine Harvesters

A combine harvester (or simply "combine") is a machine that performs multiple harvesting operations in a single pass over the field — cutting, threshing, separating grain from straw, and cleaning the grain — combining what would otherwise be several separate operations (hence the name "combine").

5.2 Main Functional Units of a Combine Harvester

1. Header (cutting and gathering unit) – Cuts the standing crop and feeds it into the machine. Components include the reel (gathers crop toward the cutter bar), cutter bar (cuts the crop), and auger (moves cut crop toward the feeder house). Header width and type vary by crop (e.g., wider grain headers, specialized headers for maize/row crops).

2. Feeder house – A conveyor (chain-and-slat type) that transports the cut crop from the header to the threshing unit.

3. Threshing unit (cylinder and concave) – The rotating threshing cylinder (drum), fitted with rasp bars or spike teeth, rubs/beats the crop against a stationary concave, separating grain from the panicle/ear/pod. Cylinder speed and concave clearance are critical, adjustable settings that must be matched to crop type and condition to maximize threshing efficiency while minimizing grain damage.

4. Straw walker/separating unit – After initial threshing, straw (with some remaining loose grain) passes over straw walkers (reciprocating, perforated troughs) that shake out remaining grain from the straw before it is discharged from the rear of the machine. Some modern combines use rotary separators instead of straw walkers for higher capacity.

5. Cleaning unit (chaffer, sieve, and cleaning fan) – Grain (mixed with chaff and other light material) falling from the threshing/separating units passes over an oscillating chaffer and sieve, while a cleaning fan blows air upward through the material; heavier grain falls through the sieve into the grain pan/auger, while lighter chaff and trash are blown out of the rear.

6. Grain tank and unloading auger – Cleaned grain is elevated (via a grain elevator) into an onboard grain tank; when full, it is unloaded via an unloading auger into a trailer/truck, often while the combine continues moving (unloading on-the-go).

7. Engine and power transmission system – A diesel engine powers all functional units (header, threshing, separating, cleaning, grain handling) as well as the machine's ground drive.

8. Straw chopper/spreader (optional attachment) – Chops and spreads the discharged straw uniformly across the field width, useful where residue is to be retained/incorporated (e.g., for conservation tillage systems).

5.3 Types of Combine Harvesters

1. Based on mobility:

- Self-propelled combine – most common type; has its own engine and drive system, fully independent mobile machine.

- Tractor-mounted/PTO-driven combine – powered by a tractor via PTO; less common, generally lower capacity, used on smaller holdings.

2. Based on threshing/separating mechanism:

- Conventional (straw walker) combine – uses straw walkers for separation, as described above.

- Rotary/axial-flow combine – uses one or more large rotors that perform threshing and separation together through a rotary, axial-flow action; generally offers higher capacity and better grain quality (less damage) especially in high-yielding or tough-threshing crops, though typically at higher cost and power requirement.

3. Based on crop specialization:

- Grain combine (wheat, rice, etc.)

- Specialized combines/attachments for crops like maize (with row-crop headers), soybean, and other specific crops.

5.4 Working Principle (Overall Flow)

Cutting (header) → Conveying (feeder house) → Threshing (cylinder-concave) → Separating (straw walker/rotary separator) → Cleaning (chaffer, sieve, fan) → Grain collection (tank) → Unloading (auger) — with straw/chaff discharged from the rear (optionally chopped/spread).

5.5 Advantages of Combine Harvesters

1. Performs cutting, threshing, and cleaning in a single pass, drastically reducing harvesting time and labour compared to separate reaping + threshing operations.

2. High field capacity, suitable for large-scale and timely harvesting, especially important where narrow harvest windows exist due to weather risk.

3. Reduces post-harvest losses associated with multiple handling stages (less grain handling between field and storage).

4. Onboard cleaning delivers relatively clean grain ready for storage/sale, reducing separate cleaning operation needs.

5.6 Limitations

- Very high initial investment cost, often requiring custom hiring for small/marginal farmers rather than individual ownership.

- Requires relatively large, accessible, and reasonably leveled fields for efficient operation; less suited to small, fragmented, or irregularly shaped plots.

- Performance drops significantly in lodged or wet crop conditions.

- Requires skilled operators for proper adjustment (cylinder speed, concave clearance, fan speed, sieve settings) to minimize losses and grain damage.

- High maintenance and spare parts requirement due to machine complexity.

6.1: Threshers

A thresher is a machine used to separate grain from harvested crop material (straw, panicle, pod) after cutting, but as a stand-alone operation distinct from combine harvesting. Threshers are widely used where crop is manually or reaper-harvested first (cut and bundled/stacked), and threshing is carried out separately, often at a central threshing floor/yard.

6.2 Main Components of a Thresher

1. Feeding unit/feeding chute – Where bundled crop material is fed into the machine, either manually or through a mechanized feeding conveyor in larger units.

2. Threshing cylinder (drum) – The main rotating component fitted with rasp bars, spike teeth, or wire-loop teeth (depending on crop type) that beats/rubs the crop material against the concave, separating grain from the straw/panicle.

3. Concave – A perforated, curved metal screen positioned below and around part of the cylinder; grain and small material pass through the concave openings while straw is retained and carried through/over.

4. Straw outlet – Discharges threshed straw from the machine, either directly or via a straw-walker mechanism for additional grain recovery (in larger threshers).

5. Cleaning unit (blower/fan and sieves) – Separates clean grain from chaff, dust, and broken straw using a combination of oscillating sieves and an air blast (blower fan), similar in principle to the cleaning unit of a combine harvester.

6. Grain outlet – Where cleaned grain is collected/bagged after passing through the cleaning unit.

7. Power source – Electric motor, diesel engine, or tractor PTO, depending on thresher size and location (fixed threshing floor vs field-portable units).

6.3 Types of Threshers

1. Based on crop specificity:

- Multi-crop thresher – Adjustable settings (cylinder speed, concave clearance, screen type) allow threshing of multiple crops (cereals, pulses, oilseeds) with the same basic machine.

- Crop-specific thresher – Designed and optimized for a single crop (e.g., paddy thresher, groundnut thresher, pulse thresher), often giving better efficiency and lower grain damage for that specific crop.

2. Based on cylinder type:

- Spike-tooth cylinder thresher – Cylinder fitted with projecting spikes/teeth; effective for most cereal crops.

- Rasp-bar cylinder thresher – Cylinder fitted with corrugated rasp bars; commonly used in paddy threshers, gives good threshing with relatively less grain damage.

- Wire-loop/hold-on type thresher – Used mainly for crops threshed by holding the bundle against the cylinder externally (hold-on type) rather than feeding the whole bundle in (throw-in/feed-in type).

3. Based on feeding method:

- Throw-in (feed-in) type – The entire crop bundle (including straw) is fed into the machine; grain, straw, and chaff are all processed and separated within the machine. Common for cereals like wheat, sorghum.

- Hold-on type – The operator holds the crop bundle by hand and presses only the grain-bearing portion (ear/panicle) against the rotating cylinder, while retaining the straw bundle in hand; commonly used for paddy in some traditional/semi-mechanized systems, allowing straw to be kept clean and separate for other uses (e.g., fodder, thatching).

4. Based on power source:

- Manually operated (pedal) thresher – foot-pedal driven cylinder; low capacity, suited to very small quantities.

- Power-operated thresher – electric motor, diesel engine, or tractor PTO driven; much higher capacity, most common in current use.

6.4 Working Principle

- Crop bundles are fed into the machine (throw-in type) or held against the cylinder (hold-on type).

- The rotating cylinder beats/rubs the crop against the concave, shelling grain from the panicle/pod/ear.

- Grain and fine material pass through the concave openings; straw is discharged separately (directly or after passing through a straw-walker for additional grain recovery in larger units).

- The mixture of grain, chaff, and dust falling through the concave passes over oscillating sieves, assisted by an air blast from the blower fan, separating clean grain from lighter chaff/trash.

- Cleaned grain is collected at the grain outlet; chaff/dust is blown out separately.

6.5 Advantages of Threshers

1. Much faster and less labour-intensive than traditional manual threshing methods (beating, trampling by animals).

2. Multi-crop threshers offer flexibility for farms growing different crops.

3. Reduces grain loss and damage compared to poorly controlled manual/animal threshing methods, when properly adjusted.

4. Portable/smaller units allow threshing to be done at the farm or a nearby threshing yard, reducing transport of unthreshed bulky crop material.

6.6 Limitations

- Requires proper cylinder speed and concave clearance adjustment specific to each crop; incorrect settings increase grain damage or reduce threshing efficiency.

- Power-operated threshers pose safety risks (feeding accidents) if not operated carefully, requiring operator training and safety precautions.

- Fixed/large threshers require the crop to be transported to a central threshing point (unless portable/field type is used), adding a handling step.

- Dust and noise generated during operation require attention to operator health and safety (masks, ear protection).

7.1: Straw Reapers

A straw reaper (also called a straw combine or straw baler-collector in some designs) is a machine used to collect crop residue (straw/stubble) left in the field after combine harvesting, cutting and processing it into a form suitable for handling, transport, and use as fodder or other purposes. This operation has become increasingly important where combine harvesting leaves loose straw/stubble in the field that would otherwise often be burnt, causing air pollution and loss of a potentially valuable fodder/residue resource.

7.2 Need for Straw Reapers

1. Combine harvesters cut the crop at a relatively higher stubble height and leave loose straw/stubble scattered in the field, which is not directly usable as baled fodder or easily manageable residue.

2. Manual collection of this residual straw is highly labour-intensive and slow.

3. Left unmanaged, residual straw/stubble is often burnt by farmers to quickly clear the field for the next crop — a practice that causes significant air pollution and loss of organic matter/nutrients that could otherwise be recycled.

4. Straw reapers allow this residual straw to be efficiently collected and converted into a usable form (chopped/loose straw for direct use, or material ready for baling), providing farmers an economic alternative to burning.

7.3 Main Components of a Straw Reaper

1. Cutter bar/cutting mechanism – Cuts the remaining standing stubble left after combine harvesting, close to ground level.

2. Pickup/gathering mechanism – Gathers the loose straw lying on the field surface (left by the combine) along with the freshly cut stubble.

3. Chopping/cutting cylinder (flail or blade type) – Chops the gathered straw/stubble into smaller, more manageable pieces, typically driven by a high-speed rotating shaft fitted with flails or blades.

4. Blower and delivery chute/trailer loading system – A blower mechanism throws/conveys the chopped straw either into an attached trailer (direct loading type) or deposits it as a windrow on the field for subsequent baling.

5. Power source – Powered via tractor PTO, since straw reapers are typically tractor-mounted/trailed implements.

7.4 Types of Straw Management Machines

1. Straw reaper (chopper-cum-loader type) – Cuts, chops, and directly loads straw into an attached trailer in a single pass; commonly used where chopped straw is to be transported and used immediately (e.g., as loose fodder, or for further processing).

2. Straw reaper (windrower type) – Cuts and chops straw, leaving it in a windrow on the field, for later collection or baling using a separate baler.

3. Straw baler (related equipment) – While technically a separate machine, balers are often used in conjunction with straw reapers/windrowers: they compress loose or windrowed straw into compact bales (round or square/rectangular) for easier handling, transport, and storage.

7.5 Working Principle

- The straw reaper is attached to and powered by a tractor (via PTO), and operated over the field after combine harvesting has been completed.

- The cutter bar/pickup mechanism gathers standing stubble and loose straw from the field.

- The material is fed into the chopping cylinder, where flails/blades cut it into smaller, uniform pieces.

- The chopped straw is then either blown directly into a trailer being towed alongside/behind (direct-load type) or deposited onto the field as a windrow (windrower type) for later baling.

7.6 Advantages of Straw Reapers

1. Provides a practical, mechanized alternative to burning crop residue, reducing air pollution and associated health/environmental hazards.

2. Recovers straw as a useful resource — fodder for livestock, raw material for other uses (e.g., mushroom cultivation substrate, packaging, biomass energy) — turning waste into value.

3. Saves labour and time compared to manual straw collection.

4. Supports soil health indirectly by reducing the practice of burning, which destroys surface organic matter and beneficial soil organisms.

5. Chopped straw is easier to handle, transport, and store compared to loose/long straw.

7.7 Limitations

- Additional equipment and operational cost (fuel, tractor time) added after the combine harvesting operation.

- Requires timely operation soon after combine harvesting, adding to the overall harvest-season workload and machinery scheduling.

- Field conditions (wet/muddy soil after harvest, uneven stubble) can affect the efficiency of pickup and chopping.

- Not all farmers have ready access to straw reapers, especially smallholders, unless available through custom hiring services.