Daya dalam bidang pertanian I (Power in agriculture)

(x) Motor Bakar

(√) Traktor

Ekoyanto Pudjiono

Tractor is

- A mechanical horse
- A buffalo on wheels
- A mobile power supply
- A portable engine

Tractor Classification

- Number of axles
  - One – hand, walking
  - Two – conventional, riding
- Number of sets of driving wheels
  - Two
  - Four
- Ground drive elements
  - Rubber tyres
  - Lugs or cage wheels
  - Tracks
- Use of wheels
  - Propulsion
  - Cultivation
- Engine types (functionally less important)
  - Diesel
  - Petrol
- Transmission (functionally less important)
  - Belts
  - Gears

Forms of agricultural tractors (layout and design)

- Two or four wheel drive (rear or all driven, front steered)
- Four wheel drive (articulated)
- Tracklayer (skid steer)
- Tool frame

Tractor development

- 1890s: Internal combustion engine
- 1920s: Present (conventional) layout and the introduction of PTO
- 1930s: The use of pneumatic tyres
- 1940s: Implement controls
- 1970s: Walking tractors
- Recent improvement: more gears, external hydraulics, weight transfer with tailed implements, lower link draft control
- New forms, but limited population: Unimog (Germany), Vantage (USA), Intrac (Germany)

Reasons for no major change in the tractor layout

- The quality production of tractors by a few makers causes resistance to change
- The design of implements to suit the tractor (originally was a replacement for the horse)
- The conservatism of designers and users in accepting previous limitations
- The inherent advantage of weight transfer to the rear driving wheels

Functional requirements of agricultural tractors

- The provision of (up to full engine) power in the form of drawbar pull
- The provision of power as the basis for a transport system (on- and off-road)
- The provision of power, mobile support, and control for processing machines

Factors in determining the overall functional performance of tractors (power supply and control system)

- Fuel consumption – thermodynamic efficiency
  - Strictly limited (Carnot) and highly variable
- Transmission losses, wheel slip, and rolling resistance – traction efficiency
  - Highly variable according to soil deformation characteristics, both horizontally and vertically
- Choice of speed, reliability – work time efficiency
  - Generally good except in material handling with special machines using hydrostatics control
- Environment of operator – operator time efficiency
  - Highly variable depending on external environment, from acceptable to fatal
  - Improved environment (e.g. air conditioning, springing, roll-over protection) generally acceptable and becoming feasible

Power outlets

- Traction – the power originates at the engine flow to the implement attached to the drawbar
  - Travel speed (determined by engine speed and gear ratio)
  - Drawbar pull (determined by the attached implement, but limited by the capacity of soil as a reaction)
- Driving – through the power take-off
  - PTO speed, determined by two modes:
    - Engine speed mode – fixed ratio between engine and PTO
    - Ground speed mode – fixed ratio between wheel and PTO
  - PTO torque, determined by load being driven
- Driving – through the hydraulic system
  - Fluid flow (motor speed) – determined by engine speed
  - Fluid pressure – determined by the load being driven.

Clutches (Kopling)

Connects and disconnect power
(between the engine and the transmission)

Clutch types

- Disk- and Plate-Type
- Band Type
- Overrunning type (free wheel)
- Magnetic type
- Cone type
- Expanding shoe type

Disk- and –Plate-type Clutches

- Dry type disk clutch: operates dry, cooled by air
- Wet type disk clutch: operates in either oil bath or spray, cooled by oil

Dry Type Disk Clutch
(the construction of)

- Has a driven disk with friction facing molded to both sides
- The clutch pressure plate housing is bolted directly to the engine flywheel
- The driven disk is splined to the transmission input shaft

Operation (1)
(of Disk Clutch)

- ***When disengaged***
  - The pedal is depressed
  - The release bearing moves forward against the operating levers
  - The release levers pivot
  - The bolts pull the pressure plates rearward to compress the springs
  - The compressed springs release the pressure applied to the disk clutch
  - The driven disk is separated from the fly wheel and pressure plate
  - Power flow is stopped between the flywheel and the input transmission shaft

Operation (2)
(of Disk Clutch)

- ***When Engaged***
  - The pedal is released
  - The compressed springs force the pressure plate to move forward, pressing the clutch disk
  - The operating levers force the release bearing rearward
  - The pressure plate clamps the driven disk against the flywheel
  - Power flow is connected between the engine and the transmission input

Components
(of Dry Disk Clutch)

- Flywheel
- Pressure plate assembly
- Clutch disks
- Clutch shaft

Components (1)

Flywheel

- As a balancer for the engine to level out power impulses
- To provide surface for picking up torque
- To provide a ring gear for the engine starting motor to contact

Components (2)

Pressure plate assembly

- To engage and release the clutch disk
- Consists of:
  - (1) a clutch plate, (2) bracket, (3) release levers, and (4) springs

Components (3)

Clutch disks

- A circular disk fastened directly to a center splined hub
- A lining is attached to the disk clutch by bonding or riveting
  - asbestos wire-woven, ceramic, clay and metal substance

Components (4)

Clutch shaft

- Projects (in-line) from the front of the transmission
- A pilot (smaller) shaft at the front end rides in the pilot bearing in the engine crank shaft flange
- A splined area to allow for the clutch disk to move laterally
- A machined area to mount the release bearing carrier
- A trust-type ball bearing rests on the machined area

Service and maintenance
(of dry type disk clutch)

- Check the clutch release and pressure mechanism
- Check the clutch pedal free travel
- Check the clutch release setting
- Lubrication

Service and maintenance (1)

Check the clutch release and pressure mechanism

- Pressure should be even all around the clutch
- The release levers must be adjusted
  - Contact with release bearing will be uniform
  - The pressure plate will release evenly

Service and maintenance (2)

Check the clutch pedal free travel

- When the clutch is engaged
  - a retracting spring pulls the pedal back so that the release bearing fork does not contact the release bearing
  - Another spring pulls the release bearing carrier back so that the bearing doest not contact the plate levers
  - Thus in normal driving, the clutch release bearing is not turning
  - This is assured by having the correct free travel on the pedal

Service and maintenance (3)

Check the clutch release setting

- When the clutch disk becomes thinner due to wear
  - To engage the disk, the clutch plates move closer to the flywheel
  - The release fingers move closer to the release bearing
  - The clutch will start to slip and the release bearing will wear out rapidly

Service and maintenance (4)

Lubrication

- Do not use too much lubrication on
  - pilot bearing, release bearing, release fork
- Excessive lubrication can lead to erratic operation of the clutch
- Some release bearings are sealed units, never need lubrication

Wet-type Disk Clutch

- Operates in an oil bath or spray
- Operation is similar to dry-type clutch
- Disk facing
  - Cross hatch marks
  - Lining material:
    - bi-metal: (1) steel for driving plates, (2) bronze for driven plates

Mechanical Transmission (Transmisi Mekanis)

- Selects speed ratios
- Reverses the travel of the machines

Types of Mechanical Transmission

- Sliding Gear
- Collar Shift
- Synchromesh

Sliding Gear Transmissions

- Popular transmissions for use in farm and industrial machines
- Made up of spur gears and shafts
- Simple but gives varieties of speeds
- Two basic types
  - Input and output shafts parallel
  - Input and output shaft in line

Mechanical Transmission (Transmisi Mekanis)

- A train of gears to transfer and adapt the engine power to the drive wheels

- Two jobs:

(1) Selects speed ratios

(2) Reverses the travel of the machines

Types
(of Mechanical Transmission)

- Sliding Gear:
  - Parallel or in line shafts
  - Sliding spur gears arranged to mesh each other and provide a change speed and direction
- Collar Shift:
  - Parallel shafts
  - Gears in constant mesh
  - Using sliding collars, shifting is done by locking free running gears to their shafts
- Synchromesh:
  - Parallel shafts
  - Gears in constant mesh
  - Selection of gears without clashing, by synchronizing the mating parts before they engaged

1. Sliding Gear Transmissions

- Popular in farm and industrial machines; Made up of spur gears and shafts; Simple but gives varieties of speeds
- Two basic types
  - Input and output shafts parallel
  - Input and output shaft in line

Parallel shafts
(Sliding Gear Transmissions)

- Input shaft drives output shaft: to transmit power
- A third shaft: to reverse or to vary power the power flow
- All three shaft are parallel and interact through the shifting of their gears
- Example: transmission with three forward speeds and one reverse speed. Identify (when operating):
  - Which gears are engaged?
  - Which direction is the output shaft turning?
  - What is the gear ratio?

Operation
(of sliding gear transmission with parallel shaft)

- Gears D and E change the speed and direction
- Both gears slide on the input shaft
- Both gears are splined to the shaft, so as to turn it
- Gear F turn freely on the output shaft
- All other gears are fixed on their respective shaft
- Shifting:
  - 1st gear: D + A (identify speed ratio and direction!)
  - 2nd gear: E + B
  - 3rd gear: E + F
  - Reverse: D + G (powered by H, which is in constant mesh with A)
  - Neutral: neither D or E are engaged with another gear

In line shafts
(Sliding Gear Transmissions)

- Input and output shafts: in a straight line but not connected
- A third shaft (a countershaft): transmits power between them
- Shifting:
  - 1st gear: A + D, F + C (identify speed ratio and direction!)
  - 2nd gear: ?
  - 3rd gear: ?
  - Reverse: ?
  - Neutral: ?

2. Collar shift transmissions

- Parallel shafts with helical gears in constant mesh
- Helical gears provide quieter operation than spur gears
- In neutral the gears (one in each mesh) are free-running
- When shifted the gears are locked to their shafts by sliding collars (a coupling device)

Shifter collar
(and mating gears)

- The gears carry short splines on its side
- The shifter collar splines internally to shifter gear, the shifter gear splines to the shaft
- Sometimes the shifter collar splines directly to the shaft without shifter gear
- When the collar is shifted, its internal splines are engaged with the external splines of shifter gear and driven gear
- The splines have rounded ends for easier shifting

Operation
(of collar shift transmission)

- illustration:
  - a transmission which provides eight forward speeds and four reverse speeds
- Power flow on 1st gear:
  - Collars A and B are locking gears 1 and 2 to their respective shafts
  - Power flows though the mating gears 3 and 4
- All eight speeds are obtained by locking different gears to the shafts, using collars (identify which collars are shifted for each?)

3. Synchromesh transmissions

- Used in automotives and tractors where on-the-go shifting is required
- Constant mesh, collar shift transmission – with extra device, i.e. synchronizer
- Synchronizer equalizes the speed of mating parts before engaged
- Friction is used to synchronize the mating parts

Types of synchronizer

- Block
- Disk and plate
- Plain
- Pin

Block-type synchronizer

- The parts
  - Blocking rings (bronze)
    - Have three slots to fit shifter plates
    - Cone-shaped inner surfaces provide frictional force
    - The surfaces match conical shape of gear soulders
  - Lock rings
    - hold the shifter plates out against the sleeve
  - Hub
    - splined to the shaft
  - Synchronizer sleeve
    - mounted on the hub
  - Shifter plates
    - fitted to block rings

Block-type synchronizer

- Operation
  - In neutral
    - No contact between blocking rings and shoulders
  - During synchronization
    - The sleeve is moved toward the selected (right) gear
    - This pushes the blocking ring to the right
    - The blocking ring contacts the shoulder of driven gear
    - This contact begins to synchronize the speeds of the two parts
  - To complete the shift
    - The sleeve teeth pass through the blocking ring teeth (because both are rotating at the same speeds)
    - The sleeve teeth also mesh the clutch teeth on driven gear
    - Power flows as shown: hub – sleeve – clutch of driven gear – shaft

Operation of synchromesh transmission

- Example: three speed transmission is synchronized in 2nd and 3rd gear
- Uses a sliding gear, a synchronizer, and in line shafts
  - Gear A splined to input shaft
  - Gear A is in constant mesh with gear D
  - Gear B turns freely on output shaft
  - 1st : C + F
  - 2nd: sliding the synchronizer towards gear B
  - 3rd: sliding the synchronizer towards gear A
  - Reverse: C+ G

Differentials
(Gardan)

- Avoiding stresses at axles and other parts

Two jobs of differential

1. Transmits power ‘around the corner’
   - From longitudinal transmission shaft to transversal drive shaft
2. Allows each drive wheel to rotate at a different speed
   - Still propel its own load

The main parts of differential

1. Ring gear and bevel gears
   - direct power to the axles
2. Bevel pinions
   - give the differential action
3. Pinion gear (at transmission shaft)
   - transmit power to ring gear → to perform a corner

Operation-1 (when moving straight ahead)

Both wheels are free to rotate

1. Power comes in on pinion gear
2. Pinion gear rotates ring gear
3. Bevel pinions and bevel gears are carried around by the ring gear (together with the housing)
4. All gears rotate as one unit
5. Each axle receives the same rotation → each wheel turns at the same speed

Operation-2 (when the tractor turns a sharp corner)

Only one wheel is free to rotate

1. Power comes in on pinion gear
2. Pinion gear rotates ring gear
3. Ring gear carries bevel pinions around with it
4. Right-hand axle is held stationary → right hand bevel gear is stationary
5. Bevel pinions are forced by ring gear (housing) to rotate on their own axis → 'walk around' the right-hand bevel gear
6. Left-hand bevel gear is forced by bevel pinions to rotate

Number of wheel revolution

- During one revolution of ring gear → left hand bevel gear makes two revolution
  - One with ring gear
  - Another as bevel pinions walk around the right-hand bevel gear
- When drive wheels have unequal resistance
  - The wheel with the least resistance turns more revolutions
  - The other wheel turns slower by the same amount
  - Both wheels still propel their own loads – but at different speeds

Differential Locks

- Directs power to both wheels by locking out the differential
- Prevents (tractive) power loss sent to slipping wheel
- Three types
  - Mechanical – the simplest
  - Hydraulic
  - Automatic

Mechanical Differential Locks

- Operation 1 – locking
  1. The upper lever is moved by the operator
  2. The fork rotates and slides the collar to the right
  3. This action engages the collar to the differential splines
  4. The collar is already on the axle splines
  5. The axle and the housing are forced to rotate as a unit
  6. The bevel gear on that axle is prevented from turning
  7. So, the differential is locked

Mechanical Differential Locks

- Operation 2 – unlocking
  1. The collar is spring-loaded
  2. Once the torsional forces are gone, the collar releases
  3. Thus, when drive wheels again have equal traction → the lock disengages automatically
  4. The lock can be engaged ‘on the go’
  5. But, it should be disengaged before turning the tractor

Final Drives
(Penggerak Akhir)

- The last phase of power train
- Gives final reduction in speed
- Gives increase in torque to drive wheels
- Lower the stress
- Eliminates extra gears and shafts in the transmission
  →simplify the transmission
- Must support the weight of the tractor
- Must withstand torque and shock load

Types of Final Drives

1. Straight axle – no extra gear reduction; used in automobiles
    a) Rigid axle shaft
    b) Flexible axle shaft
        i. Full-floating axles
        ii. Semi-floating axles
2. Pinion drives – use a spur gear and pinion for gear reduction on tractors
    a) Located within differential case
    b) Located on outer ends of final drives
3. Planetary drives – smaller and more compact than pinion drive
    a) Located next to the differential (inboard)
    b) Located at the outer ends the final drives (outboard)
4. Chain final drives – provide a greater clearance under the axle
    a) Plain or detachable link type – a series of formed links
    b) Roller chain type – alternate links and pin links with pins
    c) Silent chain type – a series of flat metal links

Rigid axle shaft

- Connected to the differential output by a splined coupling
- The coupling is enclosed in axle housing
- The axle housing forms an integral part of differential housing
  → a long housing from drive wheel to drive wheel

Flexible axle shaft

- The (swing) axles are connected to differential by universal joints
- The drive wheel is free to move vertically
- Used when drive wheels are independently suspended
- Used in compact automobiles with engines located in the rear

Full-Floating Axle

- Used in heavy duty trucks
- Each drive wheel is
  - on the outer end of the axle housing
  - on a pair of tappered or ball bearings
- The bearings
  - are positioned outside the axle bearing
- The axle housing
  - takes the full weight of vehicle
  - absorbs all stresses or end thrust (due to turning, skidding, etc.)
- The axle shaft
  - only transmits the torque from the engine
  - ‘floats’ in the axle housing
  - is connected to the drive wheel through a bolted flange
  - can be removed or serviced without removing the drive wheel

Semifloating Axles

- Used in automobiles and light trucks
- Floating
  - in the differential in the same way as full-floating axles
  - the main different is at the outer ends of the axle housing
- A single bearing assembly
  - is positioned between the axle shaft and axle housing
  - two types – (1) tapered roller bearings, (2) ball bearings
- The shaft
  - supports the weight of the vehicle
  - transmits the engine torque
  - takes all stresses (due to turning, skidding, etc.)
  - outer end is tapered (wheel hub is keyed and locked with a nut) or flanged
- A thrust block or spacer
  - Is located between inner ends of the two axle shafts within the differential carrier
  - To transmit shaft end trust equally to the bearings

Pinion Drives within Differential Case

- Directly driven from differential
- Advantages
  - ★ Enclosed within the differential-transmission case → more compact unit and only one lubrication is needed
  - ★ Straight line final drive, straight axle shaft → a large range of wheel tread adjustment for various range of row-crop spacings
- Power flow
  - ★ differential output → pinion gears → larger final drive gears → axle shaft
- The axle shaft
  - ★ carried on two tapered bearings
  - ★ supports the weight of tractor
  - ★ absorbs end thrust
  - ★ transmits the engine torque
- Pinion gears
  - ★ connected to the differential output
  - ★ mesh with the larger final drive gears
- Final drive gear
  - ★ is splined to the inner end of the shaft
- The bearings
  - ★ are positioned internally at both ends of the shaft
  - ★ between the axle housing and the shaft

Pinion Drive on Outer Ends of Final Drive

- More clearance under the axle – good crop clearance
- A separate gear housing
  - attached to the end of drive shaft housing
  - own oil resevoir
- Shaft housing is attached to the differential case
- The entire final drive assembly caries the weight of tractor

operation of Planetary Drive

- Final drive shaft
  - receives power from differential
- Sun gear
  - integral part of, and turns with, final drive shaft
  - meshes with the planet pinions
- Planet pinions
  - mounted in the carrier
- The operation
  - Sun gear turns → forces the planet pinions to walk around the inside ring gear → forces the carrier to rotate → delivers power to drive wheels
- To which direction are they rotating?
- What is their speed or gear ratio?

Planetary Drive Mounted Next to Differential

- Straight in line axle
- Wheel tread adjustment for various crop row width
- One compact housing of gears
- The construction
  - Axle shaft is carried on two tapered bearings
  - Its inner end is splined to planet carrier
  - Bearings at both shaft ends, between axle housing and shaft
  - Axle shaft supports weight of tractor, absorbs end thrust, and transmit engine torque

Planetary Drive at outer end of final drives

- Enclosed in one rigid housing
  - Differential housing, both axle housings, planetary gear housing are connected
- Full-floating type of axle shaft
- Planetary carrier drives wheel hub

Planetary Final Drives

- Greater clearance under the axle – for operation in high standing crops
- Disadvantages – tends to loosen due to wear and stretching
  - Operates in oil bath
  - Eccentric bearing for provision to take up chain slack
  - A tightener sprocket on the slack side

Power Take-Offs (PTO)

- Transmission driven
  - Stop operating when the clutch is disengaged
- Continuous running
  - With two clutches – for transmission and PTO
  - PTO can operate when transmission disengages (tractor stopped)
  - Transmission cannot be engaged again while PTO is operating
- Independent
  - Completely separate clutch from engine transmission clutch
  - PTO can operate while tractor travel is stopped
  - Can be engaged and disengaged while tractor is travelling (which is impossible with continuous type)

Operation of PTO

- Gear driven from transmission
- Power sent through a shaft to PTO outlet
- Two speeds – 540 rpm and 1000 rpm
  - Using different interchangable stub shafts installed in the PTO outlet
- PTO drives
  - Universal joints – joining two rotating shafts in different planes
  - Drive shafts – solid type and telescoping type
- ASAE-SAE Tractor Standards
  - Number of plines: 21 (1000 rpm), 6 (540 rpm)
  - Other dimensions: ground clearance, drawbar clearance, rear wheel clearance

RINGKASAN

TRANSMISI DAYA (POWER TRAINS)

oleh:
Ekoyanto Pudjiono

Penerusan (Transmisi) Daya

- Daya motor diteruskan ke:
  - roda penggerak (traktor)
  - mesin pertanian
  - Sistem hidrolis
- Power trains:
  - power trains = rangkaian penerus daya dari motor ke roda
- Fungsi alat penerus daya
  - menghubung dan memutus daya
  - memilih kecepatan
  - mengubah arah (maju/mundur)
  - menyeimbangkan daya pada roda kiri & kanan (untuk belok)

PENERUS DAYA

- bagian-bagian pokok:
  - kopling
    - *menghubung dan memutus daya*
  - gigi transmisi
    - *memilih/merubah kecepatan*
    - *merubah arah gerak*
  - gigi diferensial
    - *menyeimbangkan daya ketika belok*
  - penggerak akhir (poros roda)
    - *mengurangi kecepatan*
    - *meningkatkan torsi pada poros roda*
  - roda penggerak
    - *menjalankan traktor*

PENERUS DAYA

- Cara kerja
  - kopling (contoh: tipe piringan)
    - *Dua buah piringan terpasang pada poros masing-masing.*
    - *Selama keduanya tidak saling menyentuh, kita dapat memutar salah satu piringan tanpa mempenguruhi yang lain.*
    - *Bila keduanya bersentuhan maka perputaran pada salah satu piringan akan menyebabkan perputaran pada yang lain. Jadi kedua poros ikut berputar.*
    - *Pada kondisi sebenarnya, kedua piringan itu selalu bersentuhan karena ditekan oleh pegas yang kuat. Pemisahan kedua piringan terjadi bila tekanan pegas dilepas, yaitu pada waktu kita menginjak pedal kopling*

PENERUS DAYA

- gigi transmisi
  - ★ *memungkinkan perubahan kecepatan roda penggerak*
    - *kecepatan rendah digunakan pada saat mesin atau kendaraan mulai berjalan*
    - *kecepatan lebih tinggi digunakan pada waktu kerja sesuai kondisi dan beban*
  - ★ *untuk mobil (pada awal gerak)*
    - *diperlukan gaya putar (torsi) lebih besar pada roda belakang (penggerak)*
    - *diperlukan perbandingan kecepatan putar tinggi antara motor dan roda sebab motor pada kecepatan putar (rpm) rendah tidak mampu menghasilkan daya yang cukup*
  - ★ *untuk traktor*
    - *perbandingan kecepatan putar yang lebih tinggi*
    - *diperlukan untuk memberikan torsi yang lebih besar untuk gaya tarik roda (traction) dan menarik beban alat pertanian*