Course Code: AGE 504

Course Title: Farm Power II

Number of Units: 3 Units

Course Duration: Two Hours of Lecture and Three Hours of Practical per Week

 Course Details

Course Coordinator: **Dr. Olawale Usman Dairo** *B.Sc, M.Sc. PhD*

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Other Lecturers: **Engr. Ola I. A**

Course Content:
The tractor power transmission system. Tractor design and constructional features. Stability analysis/mechanics of farm tractor chassis. Traction theory, human factors in tractor design and utilization. Tractor hydraulic system. Performance, operation and testing of agricultural power unit. Tractor selection, utilization and preventive maintenance. Tractor power cost estimation.

Course Requirement:
Students must have a minimum 70% attendance and participate in all practical classes.

Reading List:
1. Kepner R. A., Bainer R., Barger E. L. 1997. Principles of Farm Machinery. 2nd Ed. AVI Publishers Connecticut. USA
2. **Liljedahl J. B., Carlton W. M., Turnquist P. K., Smith D.W. 1997. Tractors and Their Power Units. 3rd Ed. John Wiley. New York**
3. **Richey L. B., Jacobson R., Hall C. W. Agricultural Engineers Yearbook. Mc.Graw Hill Co. USA**
4. **Stone A. A., Culvin H. E. Machines for Power Farming. 3rd Ed. John Wiley. New York**

Hydraulic Systems and Controls

- Lift, control, of mounted and trailed implements
- Steering system, change gear ratio, use on remote systems not directly accessible
- Components
  - Pump, motor, valve, lines &connections, heat exchanger, sump, stored energy, control, fluid, Actuators, Filters
  - System may contain all or some of the components

  - Pump is the heart of the hydraulic system

Components Description

- Pump
- Accumulator
- Valves
  - Directional, Pressure, volume control
- Hydraulic fluid
- Reservoir/ sump usually attached with filters
- Heat Exchanger
- Lines & couplers   strength dependent on diameter and inner reinforcement
- Actuator   cylinders and motors for manifesting effect of hydraulic system
  - Single acting and double acting cylinders

HYDRAULIC CONTROLS

- Nudging
- Auto- position control
- Auto- draft control

- Power steering
  - Hydro-mechanical power
  - Hydrostatic power

TRACTION & TRACTION DEVICES

- Ability to develop drawbar pull thro wheels and tracks called tractive devices
- Drawbar least efficient
- Wheels most predominant
- Traction depends on
  - Type of device
  - Amount of ballast
  - Lug design
  - Hitch mechanism

- Traction developed by interaction of tractive devices with soil
  - Theoretical, experimental & field tests to analyze and design tractive systems

Mohr-Coulomb failure Criteria

- Consider soil-plate of length l, width b acted upon by a normal force W, then force F required to shear off the plate of soil is given by
- F = Ac + W*tanØ
- Applying eqn above to tracks and wheels will be
- P = W/ bL   and
- P = W/0.78bl

- *** values for c and Ø are rarely known.

Traction Performance Equations and Terms

- Traction efficiency
- TE = Output power/ Input power
  - Factors affecting
  - Steering, rolling resistance, slip, friction, deflection of tractive devices
- Net Tractive Efficiency
  - Net Pull/ Dynamic Normal Load

Analysis of Pull-torque slip relation for tractive devices on soil

- Conditions of Operations
  - Towed, driving wheel and self-propelled slip

  Slip ….. A motion loss at the tractive device wheel or track) as a result of reactions developed from soil stress

  $S = 1 - V_a/ V_t$

  Rolling Radius…… distance traveled per revolution of the tractive device divided by 2π when operated on a hard surface with zero drawbar load

  The three condition Towed, Driving Wheel and self-propelled is as shown

W   W   W

TF   TF

T   T

G

Towed
Wheel T =0

Driving
Wheel H > 0

Self
Propelled

5
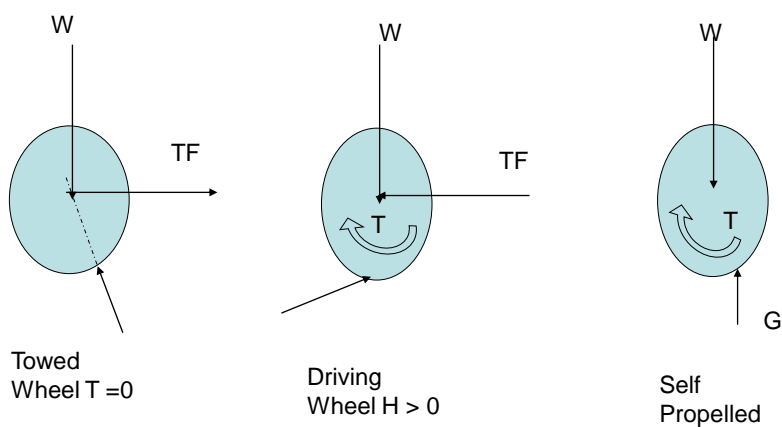
USING DIMENSIONAL ANALYSIS

- Motion resistance ratio
  - $\rho = TF/W = 1.2/C_n + 0.04$
- Gross Tractive force

  - $\mu_g = 0.75(1 - e\ 0.3Cn^2)$

  - Net Traction co-efficient
  - $\mu = \mu_g - 1$

  - Tractive Efficiency
    - $TE = HV_a/T\omega$

Traction Improvement Methods

- Weighting or Ballasting (addition of solution in wheels)
  - Prevent tipping over
  - Good steering control
- Traction Assist system
  - Built into mounted implement, hitch system of tractors

TRACTOR TEST & PERFORMANCES

- Power delivered through
    - Drive wheel or draft of drawbar
    - Rotary power thro Pto shaft or belt pulley
    - Hydraulic power thro hydraulic system
- Maximum drawbar most useful performance criteria
- Fuel consumption
- Torque curve ….. For stability
- Drawbar pull Vs speed curve

- DBP = FS/3.6 (kW)
- DBP = FS / 375 (hp)

- PTOP = 2π T N/ 60 (kW)

- Frictional Power
- Indicated Power
- Gross Indicated Power

ENGINE TESTING

- Dynamometer   …. Power determination by independent measurement of force, time and distance thro which the force is moved
- Types
    - Transmission & Adsorption
    - Adsorption measures and converts power into some other form of energy
    - Pony dynamometer
    - Others are
        - Hydraulic, Air or fan, Electric d.c, shop type & spring dynamometer

Power Train

- Useful power transmitted thro power train
- Power train consists of
  - Traction & pto friction clutches
  - Transmission
  - Pto drives
  - Mechanical front wheel drive
  - Transmission & hydraulic pump drive
  - Spiral bevel gear set
  - Differentials
  - Final drive
  - Individual axle brakes
  - Rear axles

- **Most systems have 1, 2, 7 & 8

TRANSMISSIONS

Contained in a box shaped housing btw clutch & final drive

Consists of gears, shafts and synchronizers coupled together to meet many speed and load requirements

Provides the operator control over engine power to the rear axles

Has four or six forward speeds with accompanying one or two reverse speeds….. Recently there are > 10 speeds and several reverse speeds

Ability to change speed ratios without stopping or dis-engagement…..under drive

Transmission Types

1. Sliding gear
2. Constant mesh
3. Synchronized or synchro-mesh
4. Power shift
5. Automatic
6. Hydrostatic
7. Hydro-mechanical
8. CVT COUNTINUOUS VARIABLE TRANSMISSION

1 – 4 are selective gear transmission
1 -3 are manually operated but not explicitly

Components

- Differentials
  - Allows the two rear wheels to turn at different speeds while power is transmitted to both wheels
- Final drives
  - A gear reduction located btw power train and drive wheel.
- Power-take-off shaft
  - Two standard speeds   540± 10rpm   and 1000 ± 25rpm   with 35mm diameter shaft

Operation, adjustment, maintenance & trouble shooting

- Adjustments
  - Fuel system
  - Ignition system
  - Valve train
- Maintenance
  - To prevent damage to engine and ensure continued good engine performance
  - Lubrication system
  - Cooling system
  - fuel/air system
  - Ignition system

Troubleshooting

Structured procedure to determine what is wrong with a machine or system

Engine fails to start, Over heating, Engine Knock, low oil pressure

Detonation in exhaust pipe, excessive fuel consumption, Smooky Exhaust

TRACTOR SELECTION & COST

- Power Selection
  - Use of Annual cost formula
  - By computer software
- Size selection
- Costs
  - Fixed Cost
  - Variable Cost
- Replacements
  - Damage of implement
  - Inadequate field capacity
  - Obsolescence
  - Performance of new machine is significantly superior
  - Anticipated costs for operating old machine exceeds cost for replacement