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
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Course Content:

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

Reading List:
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 through 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
  
  \[ F = Ac + W \tan \theta \]

- Applying eqn above to tracks and wheels will be
  
  \[ P = \frac{W}{bL} \quad \text{and} \]
  
  \[ P = \frac{W}{0.78bl} \]

- *** values for c and \( \Theta \) 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
  \[ S = 1 - \frac{V_a}{V_t} \]

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

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

• Motion resistance ratio
  \[ \rho = \frac{TF}{W} = 1.2/C_n + 0.04 \]

• Gross Tractive force
  \[ \mu_g = 0.75(1 - e^{-0.3Cn^2}) \]

  – Net Traction co-efficient
  \[ \mu = \mu_g \cdot 1 \]

  – Tractive Efficiency
    • \( TE = \frac{HV_a}{T\omega} \)

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

- \[ \text{DBP} = \frac{FS}{3.6} \text{ (kW)} \]
- \[ \text{DBP} = \frac{FS}{375} \text{ (hp)} \]
- \[ \text{PTOP} = \frac{2\pi TN}{60} \text{ (kW)} \]
- 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 COUNTERUOUS 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