Technical English
for
Agricultural Machinery

مولف

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Chapter One

Agricultural Mechanization

Agricultural mechanization

Agricultural mechanization: involves the design, manufacture, distribution,use and servicing of all types of agricultural tools, equipment and machines. It includes three main power sources: human, animal and mechanical with special emphasis on mechanical (tractive power).

Farm mechanization: is technically equivalent to agricultural mechanization but refers to only those activities normally occurring inside the boundaries of the farm unit or at the farm unit level (example: village, community, co-operatives etc).

Tractorization: refers to the application of any size tractor to activities associated with agriculture.

Motorization: refers to the application of all types of mechanical motors or engines, regardless of energy source, to activities related to agriculture.

Agricultural implements: are devices attached to, pulled behind, pushed, or otherwise used with human, animal or mechanical power source to carry out an agricultural operation.

Agricultural machinery: is a general term used to describe tractors, combines, implements, machines and any other device more sophisticated than hand tools which are animal or mechanically powered.

Agricultural equipment: generally refers to stationary mechanical devices such as irrigation pump-set.

Mechanization of agriculture is the application of mechanical implements or as a whole, the application of the modern (up-to-date) technologies in agriculture to increase productivity and to reach sustainable agriculture.Agricultural mechanization today has a very broad meaning. This broad meaning includes production, distribution and utilization of a variety of tools, machinery and equipment for the development of agricultural land, planting, harvesting and primary processing.

Agricultural mechanization is broadly defined to include the application of tools, implements and powered machinery and equipment to achieve agricultural production, comprising both crop and livestock production as well as aquaculture and apiculture. The science of budgeting and deploying agricultural machinery with the aim of increasing productivity and production and reducing labor difficulty.

Farmmechanizationis technically equivalent to agriculturalmechanization but refers only to thoseactivities occurring inside the boundariesof the farm unit covering production of crops,livestock and aquaculture.

Mechanization covers all levels of farming and processing technologies, from simple and basic hand tools to more sophisticated and motorized equipment. It eases and reduces hard labour, relieves labour shortages, improves productivity and timeliness of agricultural operations, increases resource use efficiency, enhances market access and contributes tomitigating climate relatedhazards. Sustainable mechanization considers technological, economic, social, environmental and cultural aspects when contributing tothe sustainable development of the food and agricultural sector.

Agriculture makes use of five levels of power sources:

a. Manual (with full reliance on human muscles)
b. Animal
c. Mechanical power (Tractors + Power tillers + Oil engines)
d. Electrical power
e. Renewable energy (Biogas + Solar energy + Wind energy)

a)Human Power

Human power is the main source for operating small implements and tools at the farm.Stationary work like chaff cutting, lifting, water, threshing, winnowing etc. are al so done by manual labour. An average man can develop maximum power of about 0.1 hp for doing farmwork.

b)Animal Power

Power developed by an average pair of bullocks about 1 hp for usual farm work. Bullocks areemployed for all types farm work in all seasons. Besides bullocks, other animals like camels, buffaloes, horses, donkeys, mules and elephants are also used at some places. The average force a draft animal can exert is nearly one-tenth of its body weight.

c)Mechanical Power

Broadly speaking, mechanical power includes stationary oil engines, tractors, power tillers and self-propelled combines. Internal combustion engine is a good device for converting liquid fuel into useful work (mechanical work). These engines are two types:

1. Spark ignition engines (Petrol engines)
2. Compression ignition engines (Diesel engines)

The thermal efficiency of diesel engine varies from 32 to 38 per cent whereas that of petrol engine varies from 25 to 32 per cent. In modern days, almost all the tractors and power tillers are operated by diesel engines. Diesel engines are used for operating irrigation pumps, flour mills, cotton gins, chaff cutter, sugarcane crusher, threshers, winnowers etc.

d) Electrical Power

Electrical power is used mostly in the form of electrical motors on the farms. Motor is a very useful machine for farmers. It is clean, quest and smooth running. Its maintenance and operation needs less attention and care. The operating cost remains almost constant throughout its life. Electrical power is used for water pumping, dairy industry, cold storage, farm product processing, fruit industry and many similar things.

e) Renewable Energy

It is the energy mainly obtained from renewable sources of energy like sun, wind, biomass etc. Biogas energy, wind energy and solar energy are used in agriculture and domestic purposes with suitable devices. Renewable energy can be used for lighting, cooking, water heating, space heating, water distillation, food processing, water pumping, and electric generation. This type of energy is inexhaustible in nature.

The main concept of farm mechanization is to apply the principles of engineering andtechnology to do the agricultural operations in a better way to increase crop yield. This includes the development, application and management of all mechanical aids for fieldoperation, water control, material handling, storage and processing. Mechanical aids includehand tools, animal drawn implements, power tillers, tractors, engines, electric motors, grainprocessing and hauling equipment.Table 1 shows Advantages and Disadvantages of different farm power sources inagriculture.

Table 1. Advantages and Disadvantages of different farm power sources

Advantages	Disadvantages
1. Human Power	
a. Easily available. **b.** Used for all types of work.	**a.** Costliest power compared to all other forms of power. **b.** Very low efficiency. **d.** Affected by weather condition and seasons.
2. Animal Power	
a. Easily available. **b.** Used for all types of work. **c.** Low initial investment. **d.** Supplies manures to the field and fuels to farmers. **e.** Lives on farm products.	**a.** Not very efficient. **b.** Seasons and weather affect the efficiency. **c.** Requires full maintenance when not in use. **d.** Creates unhealthy and dirty atmosphere nearthe residence. **e.** Very slow in doing work.
3. Mechanical Power	
a. Efficiency is high. **b.** Not affected by weather. **c.** Requires less space. **d.** Cheaper form of power.	**a.** Initial capital investment high. **b.** Fuel is costly. **c.** Repairs and maintenance needs technical knowledge. d. Not good for environment.
4. Electrical Power	
a.Very cheap form of power. **b.**High efficiency. **c.**Not affected by seasons. **d.** Good for environment. **e.** Can work at a stretch.	**a.** Initial capital investment high. **b.** Requires good amount of technical knowledge. **c.** If handled carelessly, it causes great danger.

The term agricultural mechanization covers the manufacture, distribution, repair and maintenance, utilization and management of agricultural tools, implements, equipment andmachines in agricultural production for land development, crop and livestock production, harvestingand storage, in addition to on farm processing and rural transportation.

Benefits of farm mechanization:

1. Timeliness of operation
2. Precision of operation
3. Improvement of work environment

4. Reduction in costs (Decrease in cost of production)
5. Reduce the need for labor (Increase in labor productivity)
6. Reduction of loss of crops and food products
7. Increased productivity (Increase in land productivity)
8. Increased economic return to farmer
9. Improved dignity of farmer
10. Progress and prosperity in rural areas

Constraints in farm mechanization (limiting factors):

1. Small land holdings
2. Less investing capacity of farmers
3. Adequate availability of draft animals
4. Lack of suitable farm machine for different operations
5. Lack of repair and servicing facilities for machines
6. Lack of trained man power
7. Lack of coordination between research organization and manufacturer
8. High cost of machines
9. Inadequate quality control of machine

Agricultural Mechanization Indices

Three specific indices are for the study and evaluation ofmechanization in different regions. These indices include degree, level, and capacity of mechanization (Almasi etal., 2000).Although developmental patterns for aregion can be provided after investigationinto the facilities and limitations of thatregion, it must be noted that we can never offer a certain pattern for agriculturaldevelopment alike for all regions since theyare not culturally, geographically,economically and socially identical.Tools, implements and powered machinery areessential and major inputs to agriculture. The term mechanization is generally used as an overalldescription of the application of these inputs (Clarke, 2000).

The three factors of degree, level, and capacity of mechanization are related to technology and technical factors, but organizational and management factors have a major impact on their efficiency.

Degree of Mechanization

The degree of mechanization is an index that examines quantity in the field of mechanization. In actually, Ratio of the area of mechanized operations (ha)per total mechanized operations required (ha). For example, this index is widely used to compare the mechanization growth process of any type of machine operation for each crop, which is very effective in analyzing their causes and factors and finding appropriate solutions.The degree of mechanization is presented in term ofpercentage (%) for each crop andoperation.The degree of mechanizationis calculated by the following formula:

$$D.M.\ (\%) = \frac{\text{The area of mechanized operations (ha)}}{\text{Total mechanized operations required (ha)}} \quad (1)$$

Level of Mechanization

The level of mechanization is an index that examines qualitative in the field of mechanization.The level of mechanization isthe ratio of total real power of tractors (hp or kW) percultivated area (ha). Increased levels of farm power and mechanization isone of the major factors required to increase production.The level of mechanizationis calculated by the following formula:

$$L.M.\ (hp/ha\ or\ kW/ha) = \frac{\text{Total real power of tractors (hp or kW)}}{\text{Total area under cultivated (ha)}} \quad (2)$$

To calculate the level of mechanization, the following conditions must be considered:

- Only the area under cultivation is calculated.
- Only tractors used for agriculture is calculated.
- In converting the tractors' nominal power to real power, a coefficient of 0.75 is usually recommended based on the manual.

Note 1: Increasing the level of mechanization should be increase of yield (unit of mass/unit of area). Proper management of machines use can be help to achieve this goal.

Note 2: The higher the degree of mechanization for different operations and the lower the level of mechanization (optimal limit) indicates that machine and crop management are better. That is to say, with minimal power, a high percentage of farms is cultivated by mechanized operations.

Note3: If the number of farmers is greater or the levels of farms are smaller, a higher level of mechanization is needed.

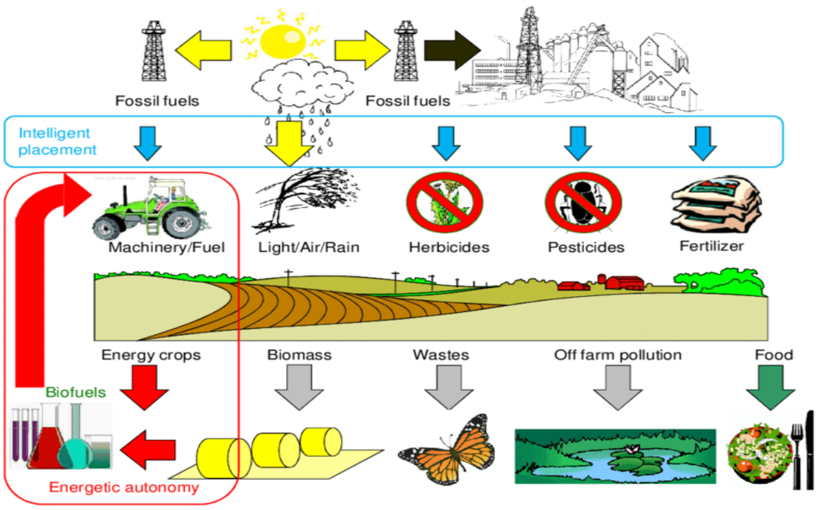
MechanizationCapacity

To assess the mechanization status based on the general concept of mechanization the Mechanization Capacity(MC) index was investigated by the ratio of total mechanical energy used (kW.h) per hectare of crop production (ha),using the following equation:

$$\text{M.C. (kW.h/ha)} = \frac{\text{Total mechanical energy used (kW.h)}}{\text{Area of crop production (ha)}} \quad (3)$$

Energy

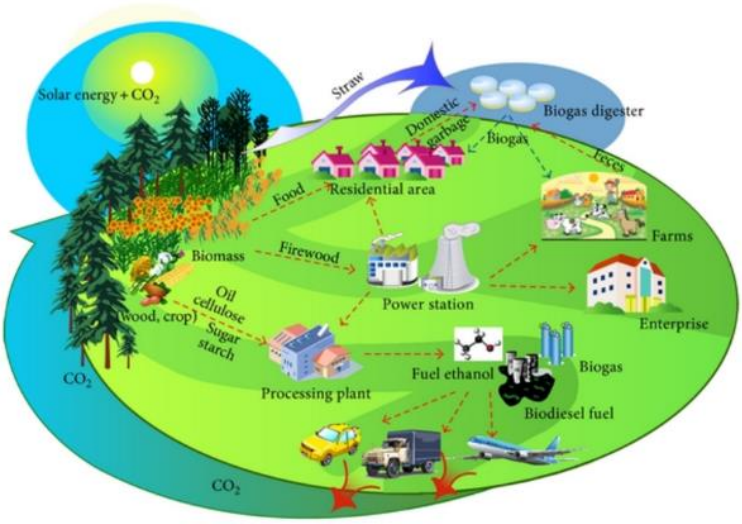
Energy can be neither created nor destroyed but only changed from one form to another.In the International System of Units (SI), energy is measured in Joules (J). One joule is equal to the work done by a one Newton force acting over a one meter distance. Picture 1 shows the energy flows in agricultural.



Picture 1. Energy flows in agricultural.

Agriculture requires energy as an important input to production.Energy use in agriculture was developed in response to increasing populations, limited supply of arable land and a desire for higher standards of living.Efficient use of energy inputs is of prompt importance in terms of sustainable farming.

Energy requirements in agriculture are divided into two groups: Direct and Indirect. Direct energy is required to perform various tasks related to crop production processes such as land preparation, irrigation, intercultural operation, threshing, harvesting and transportation of agricultural inputs and farm production. Indirect energy consists of the energy used in the manufacture, packaging and transport of fertilizers, pesticides and farm machinery. Also energies are divided into two groups of Renewable and Non-renewable. Concepts and characteristics of energy in agriculture showed as diagram in picture 2.



Picture 2. Diagram of energy agriculture concepts and characteristics.

Energy Index

Generally, Energy indices are used to assess the level of energy consumption management in agricultural production. Energy consumption in the production of an agricultural products process depend on the amount of inputs used to produce it.To obtain an energy indices, it is generally necessary to have information about energy content of inputs.For example, table 2 shows the energy equivalentsfor different inputs and outputs insome crop productions.

Table 2. Energy equivalents for different inputs and outputs in some crops production

Particulars	Units	Energy Equivalent (MJ per unit)
A. Inputs		
1. Human labour a. Man b. Woman	 Man-hour Woman-hour	 1.96 1.57
2. Animals	Bullock/day	64.56
3. Diesel	Liter	56.31
4. Petrol	Liter	48.23
5. Electricity	kW.h	11.93
6. Machinery a. Electric motor b. Farm machinery	 h h	 64.8 62.7
7. Chemical fertilizers a. Nitrogen (n) b. Phosphates (P2O5) c. Potash (K2O)	 kg kg kg	 60.6 11.1 6.7
8. Dry Manure	kg	0.3
9. Chemicals	kg	120
10. Seed	kg	Equal to each output crop
B. Output (Examples)		
Rice (Dried) Wheat (Dried) Maize (Dried) Soybean Chickpea (Dried) Vegetable Mustard Apple	kg kg kg kg kg kg kg kg	14.7 15.7 15.10 18.14 14.7 3.91 22.72 2.4

Energy Ratio or Energy Efficiency (ER or EE)

Energy utilized through inputs and energy produced as products are calculated and expressed as Mega Joules. Energy efficiency can be worked out taking in account in the input and output energy for each treatment. This index calculates by formula 4:

$$\text{ER or EE (\%)} = \frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}} \times 100 \qquad (4)$$

Specific Energy (SE)

Specific energy can be calculated in terms of energy required to produce a kg of main product and expressed as MJ per kg. This index calculates by formula 5:

$$\text{SE (MJ/kg)} = \frac{\text{Energy input (MJ/ha)}}{\text{Grain Yield (kg/ha)}} \qquad (5)$$

Energy Productivity (EP)

Energy productivity means the amount of produced cropfor each MJ energy used and expressed as kg per MJ. This index calculates by formula 6:

$$\text{EP (MJ/kg)} = \frac{\text{Grain Yield (kg/ha)}}{\text{Energy input (MJ/ha)}} \qquad (6)$$

Net Energy Gain (NEG)

The usable amount of high-quality energy available from a given quantity of an energy resource is its net energy yield: the total amount of useful energy available from an energy resource minus the energy needed to make it available to consumers. A net energy gain is achieved by expending less energy acquiring a source of energy than is contained in the source to be consumed. That is calculates by formula 7:

$$\text{NEG (MJ)} = \text{Energy output (MJ/ha)} - \text{Energy input (MJ/ha)} \qquad (7)$$

Precision Agriculture

Precision agriculture (PA) seeks to use new technologies to increase crop yields and profitability while lowering the levels of traditional inputs needed to grow crops (land, water, fertilizer, herbicides and insecticides). In other words, farmers utilizing precision agriculture are using less to grow more.

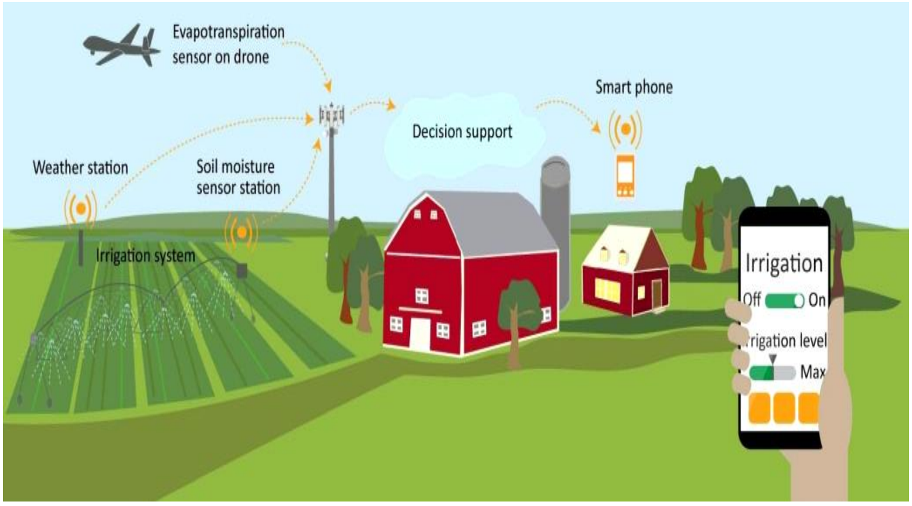
GPS devices on tractors, for instance, allow farmers to plant crops in more efficient patterns and proceed from point A to point B with more precision, saving time and fuel. Fields can be leveled by lasers, which means water can be applied more efficiently and with less farm effluent running off into local streams and rivers. The result can be a boon for farmers and holds great potential for making agriculture more sustainable and increasing food availability.

Precision agriculture is usually done as a four-stage process to observe spatial variability: Precision agriculture uses many tools but here are some of the basics: tractors, combines, sprayers, planters, diggers, which are all considered auto-guidance systems. The small devices on the equipment that uses GIS (geographic information system) are what makes precision. You can think of the GIS system as the "brain". To be able to use precision agriculture the equipment needs to be wired with the right technology and data systems. More tools include Variable Rate Technology (VRT), Global Positioning System (GPS)and Geographical Information System (GIS), Grid sampling and remote sensors.

Precision agriculture uses technology on agricultural equipment (e.g. tractors, sprayers, harvesters, etc.):

- Global positioning system (e.g. GPS receivers that use satellite signals to precisely determine a position on the globe);
- Geographic information system (GIS), i.e., software that makes sense of all the available data;
- Variable-rate farming equipment (seeder, spreader).

The main goal of PA is to define the crops and soil requirements for optimum productivity on one hand and to preserve resources, ensure environmental sustainability and protection on the other. A sample map of precision agriculture showed in picture 3.



Picture 3. A sample map of precision agriculture.

Selection of Tractor

Selection of tractors depend up on following factors:

1. Land holding: Under a single cropping pattern, it is normally recommended to consider 1 hp for every 2 hectare of land. In other words, one tractor 20-25 hp issuitable for 40 hectare farm.

2. Cropping pattern: Generally 1.5 hectare/hp has been recommended where adequate irrigation facility are available and more than one crop is taken. So a 30-35 hp tractor issuitable for 40 hectare of land.

3. Soil condition: A tractor with less wheel base , higher ground clearance and low overall weight may work successfully in lighter soils buy will not be able to give sufficient depth in black cotton soils.

4. Climatic condition: For very hot zone and desert area, air cooled engines are preferred over water cooled engines. Similarly for higher altitude air cooled engines are preferred because water cooled engines are liable to be frozen at high altitudes.

5. Repair facilities: It should be ensured that the tractor to be purchased has a dealer at nearby place with all the technical skills for repair and maintenance of the machine.

6. Running cost: Tractors with less specific fuel consumption should bepreferred overothers so that the running cost may be less.

7. Initial cost and resale value: While keeping the resale value in mind,the initial cost should not be very high, otherwise higher amount of interest have to be paid.

Note: The proper selectionand matching of tractor and implements is now become very important and difficult, because ofavailability of variety of general tractor models and powers ranging from 5.5 to more than 100 kW and variety of implement sizes. The matching and selection of a tractor-implement system involves many decision-making processesthat depend on different factors. These factors include tractor and implement specifications, soil conditions(firm, tilled or soft) and operation conditions (depth and speed operation) and etc. Decision Support Systems (DSS) and Expert Systems (ES) are developed for help to selection of tractors and implements for different farm sizes. For example A decision support software (DSS) was developed in Visual Basic 6.0 programming language formatching and selecting implements with tractors and time management of farm operations (Figure 1 and Picture 8 to 13) (Loghmanpour et al., 2018).

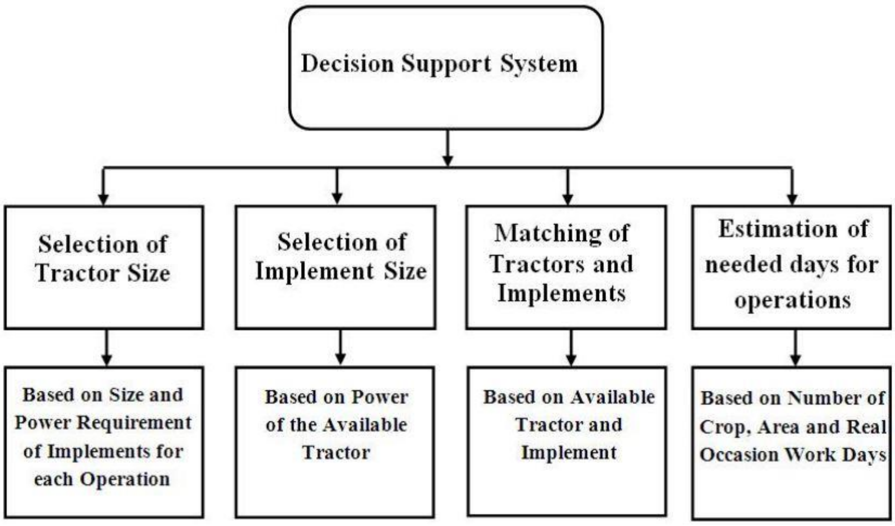
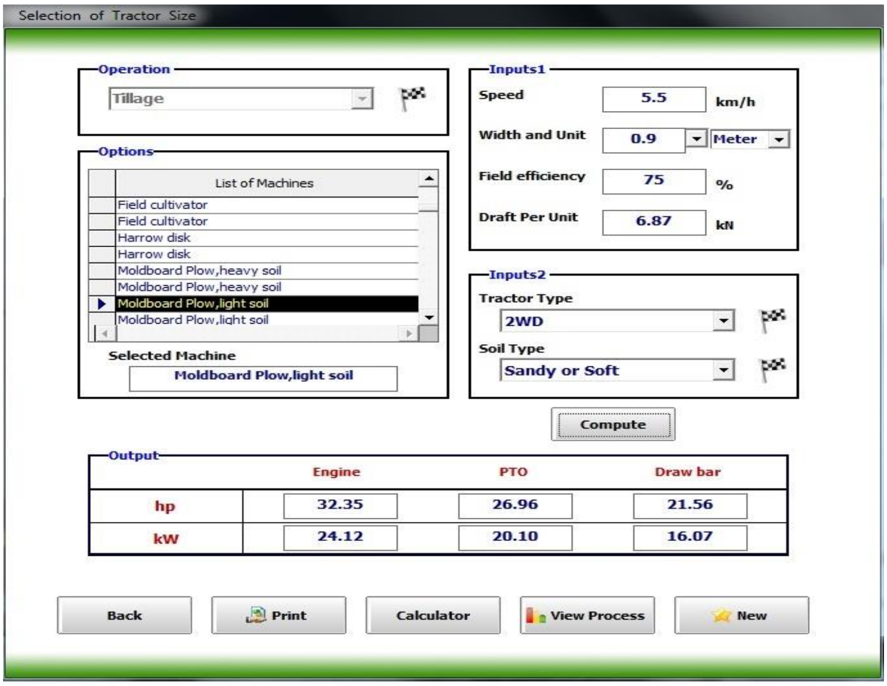
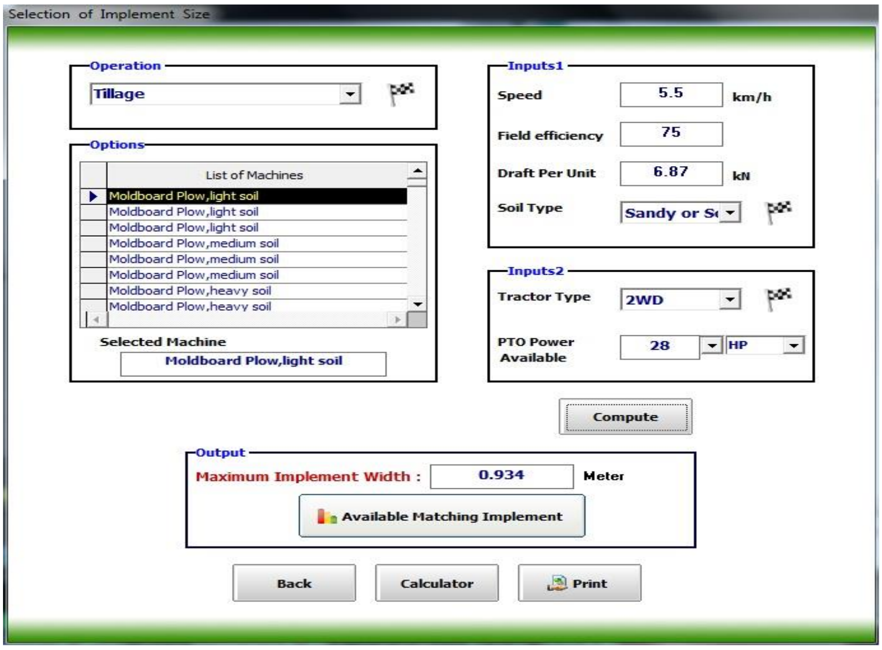


Figure 1. Description of the DSS for four main modules.

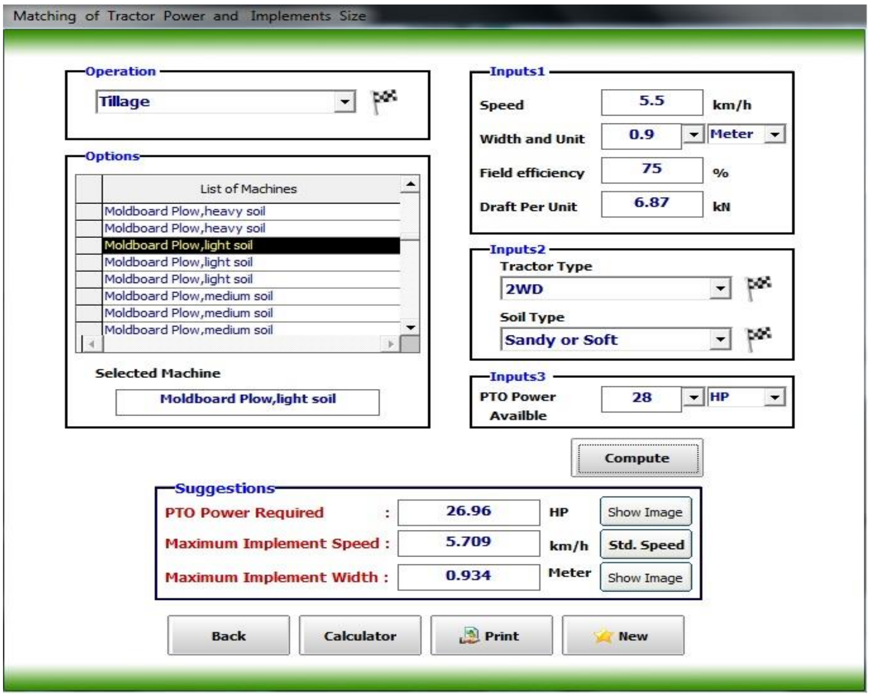
Picture 8. Decision Support System for machine and tractor management.



Picture 9. Decision Support System for selection of tractor size.



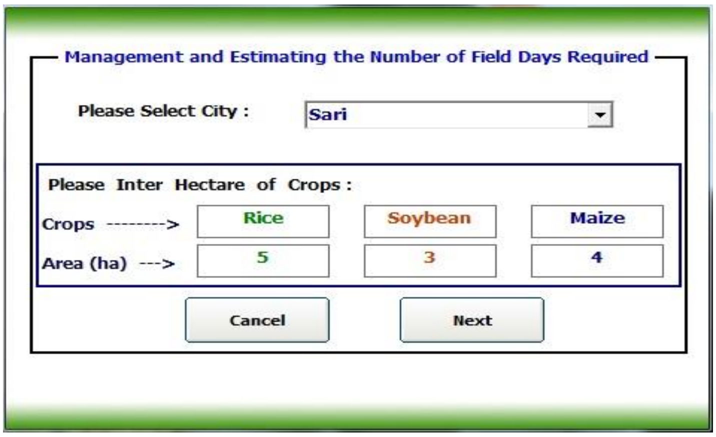
Picture 10. Decision Support System for selection of implement size.



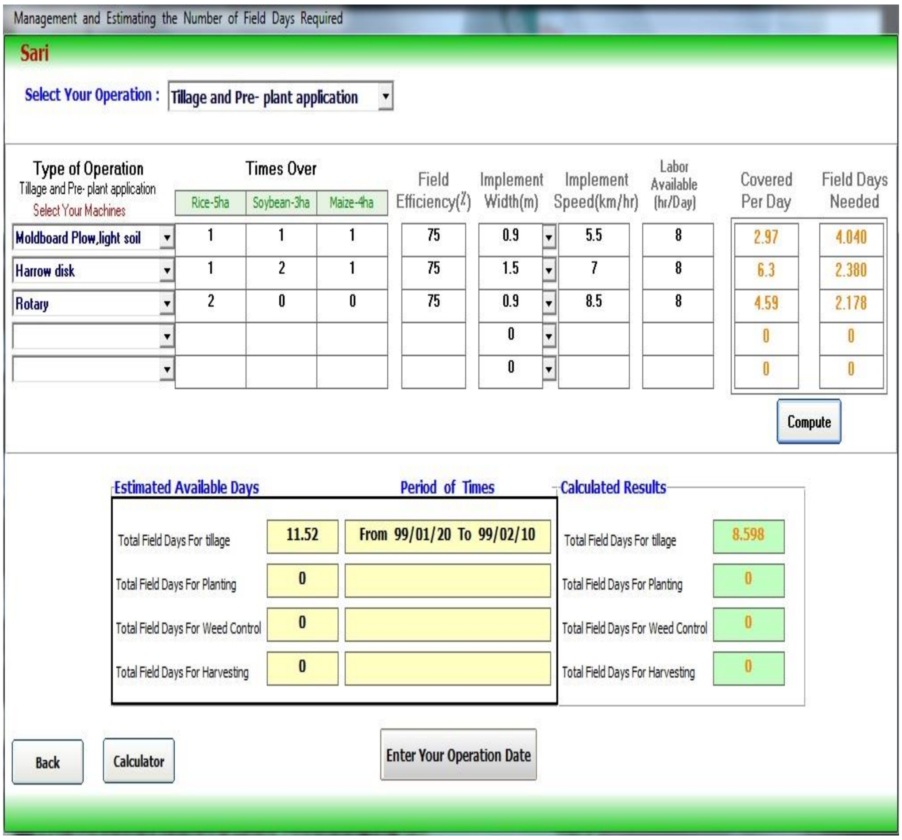
Picture 11. Decision Support System for matching of tractor power and implement size.

Some factors for agricultural machinery selection:

Power requirement, Cost of operation, Availability on custom hiring, Years of services expected, Economics of the equipment in relation to size of farm and work to be performedand Capacity of the machine.



Picture 12. Decision Support System for calculation of field days required.



Picture 13. Decision Support System for estimating the number of field days required.

Matching Equipment To Farm Needs

Before buying farm equipment, a farmer must decide which make, size, and type of machine will be the most efficient for both the farm and the equipment. It is a difficult job to match equipment to meet the farm needs. Farmers must decide whether or not their acreage, production, and especially income are sufficient to justify the purchase of expensive equipment.

Farmer must decide whether it is more economical to own the equipment and furnish the labor and supplies for its operation or to hire the equivalent services through custom work.

Ownership Essentials

When a farmer buys equipment for his farm, he must assume a number of expense items.These can be divided into fixed and fixed and variable costs.

The fixed costs include:

1. Original purchase
2. Deppreciation
3. Interest on investment
4. Taxes
5. Repair
6. Insurance
7. Shelter

The variable costs include:

1. Fuel (for self-powered units)
2. Lubricants
3. Labor
4. Tractor, fuel, oil, and grease.

Dictionary of Chapter 1

Words	لغات
Agricultural	کشاورزی
Agricultural Engineering	مهندسی کشاورزی
Agricultural Machinery	ماشین‌های کشاورزی
Biomass Energy	انرژی زیست توده
Chemical Fertilizer	کود شیمیایی
Chickpea	نخود
Compression ignition engine	موتور اشتعال تراکمی
Crop	کشت، محصول
Cultivate	زراعت
Depreciation	استهلاک
Digger	چاله‌کن
Direct Energy	انرژی مستقیم
Energy Consumption	مصرف انرژی
Energy Economic	اقتصاد انرژی
Energy Efficiency	بازده انرژی
Energy Productivity	بهره‌وری انرژی
Energy Ratio	نسبت انرژی
Environment	محیط زیست
Equivalent energy	محتوای انرژی
Farm	مزرعه
Geographic Information System	سامانه اطلاعات جغرافیایی
Global Positioning System	سامانه موقعیت‌یاب جهانی
Harvesting	برداشت
Herbicide	علف‌کش
Horse Power	اسب بخار
Implement	تجهیزات-ادوات
Indirect Energy	انرژی غیرمستقیم
Input	نهاده
Insecticide	حشره‌کش

Irrigation pump	پمپ آبیاری
Words	**لغات**
Maize	ذرت
Manure	کود دامی
Mechanical Power	توان مکانیکی
Mechanization Index	شاخص مکانیزاسیون
Mechanized Operation	عملیات مکانیزه
Mustard	قارچ
Net Energy Gain	انرژی خالص
Non-Renewable	تجدیدناپذیر
Output	ستانده
Petrol Engine	موتور بنزینی
Planter	کارنده
Precision Agriculture	کشاورزی دقیق
Primary Energy	انرژی اولیه
Renewable	تجدیدپذیر
Rice	برنج
Sensor	حسگر
Solar Energy	انرژی خورشیدی
Soybean	لوبیا
Spark ignition engine	موتور اشتعال جرقه‌ای
Specific Energy	انرژی ویژه
Sprayer	سمپاش
Timeliness Cost	هزینه بموقع انجام نشدن
Variable Rate Technology	فناوری نرخ متغیر
Vegetables	سبزیجات
Wheat	گندم
Wind Energy	انرژی باد
Yield	عملکرد محصول

Questions of Chapter 1:

1. What is the agricultural mechanization?..
....
....
....

2. What are five levels of power sources in agriculture?..
....

3. Which one is the main source for operating small implements?

a) Electrical power **b)** Human power **c)** Animal power **d)** Mechanical power

4. What are types of internal combustion engines?..
....

5. Biogas is a non-renewable energy. True ☐ False ☐

6. Which one is the constraint of farm mechanization?

a) Reduction in costs **b)** Timeliness of operation
c) Precision of operation **d)** Small land holdings

7. What are the benefits of farm mechanization? (four items)..............................
....

8. What are the mechanization indices?..
....

9. Ratio of the area of mechanized operations (ha) per total mechanized operations required (ha) is ....

a) Level of Mechanization **b)** Degree of Mechanization **c)** Mechanization Capacity

10. What is the Mechanization Capacity?..
....
....

11. When does the level of mechanization need more?..
....

12. Increasing the level of mechanization should be decrease of yield.

True ☐ False ☐

13. What are the types of energy classifications?..
....

14. Why are energy indices calculated?..
....

15. What are the energy equivalents?..
....

16. What are the energy indices?..
....

17. ....is the amount of energy required to produce a kg of mainproduct.
a) Energy Efficiency b)Specific Energyc)Energy Productivity d) Net Energy

18. What is the Precision agriculture?..
....
....

19. What technologies are used on agricultural equipment for precision agriculture?...
....

20. What is the goal of precision agriculture?..
....

21. Solar energy is a .... energy.

22. The cheapest source of energy is ....

23. Calculate energyconsumption indices for Rice production by following information. (use table 1)

Items	Quantity (unit per ha)
Man Woman	240 hours 312 hours
Diesel	20 L
Petrol	4 L
Electricity	25 kW.h
Farm machinery	30 h
Nitrogen (N) Phosphates (P2O5) Potash (K2O)	20 kg 8 kg 5 kg
Seed	80 kg
Yield (Rice)	5500 kg

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Chapter Two

Engine and Tractor

Tractor

Definitions of tractor

Tractors have large and powerful diesel engines and, in theory, that means they should be able to go incredibly fast, just like sports cars. But in a tractor, the engine's power is designed to be used in an entirely different way: for pulling big and heavy loads. What makes this possible is the tractor's gearbox, which converts the high-speed revolutions of the mighty diesel engine into much lower-speed revolutions of the wheels, increasing the force the tractor can use for pulling things at the same time.

A tractor is an engineering vehicle specifically designed to deliver a high tractive effort (or torque) at slow speeds, for the purposes of hauling a trailer or machinery used in agriculture or construction. Most commonly, the term is used to describe a farm vehicle that provides the power and traction to mechanize agricultural tasks, especially (and originally) tillage, but nowadays a great variety of tasks. Agricultural implements may be towed behind or mounted on the tractor, and the tractor may also provide a source of power if the implement is mechanized.

Tractor is a self-propelled power unit having wheels or tracks for operating agricultural implements and machines including trailers. Tractor engine is used as a prime mover for active tools and stationary farm machinery through Power-Take-Off (PTO) or belt pulley.

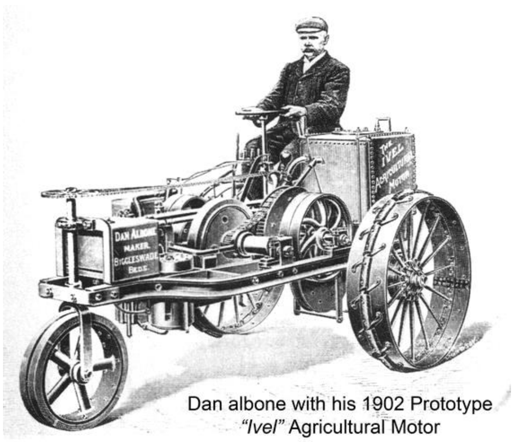
The most common use of the term "tractor" is for the vehicles used on farms. The farm tractor is used for pulling or pushing agricultural machinery or trailers, for plowing, tilling, disking, harrowing, planting, and similar tasks.

History of Tractors

Modern tractors play an important role in achieving these goals. Human beings as power units or engines are limited to less than 0.1 kW continuous output and are therefore worth almost nothing as a primary source of power.

If agricultural workers are to receive an adequate return for their labor,they must be efficient producers by controlling power rather than being the source of power.

Evolution of the tractor has accompanied changes in farm technology and sizes of farms. The tractor has progressed from its original primary use as a substitute for animal power to the present units designed for multipleuses. Traction power, belt power, power-take-off drives, mounted tools, and hydraulic remote control units, as well as climate-controlled cabs and power steering, all serve to extend the usefulness and efficiency of the modern tractor. The early steam engines furnished belt power, but they had to be pulledfrom place to place by horses or oxen. The next step in the evolution in farm power was the conversion of the steam engine into a self-propelled traction engine. Successful steam plows were developed in the decade of the 1850s, and continuous development occurred until 1900. Picture 1 shows the first commercially successful light-weight petrol-powered general purpose tractor.



Picture 1. A design tractor in 1992.

Classification of Tractors

Tractors can be generally classified by number of axles or wheels, with main categories of two-wheel tractors (single-axle tractors) and four-wheel tractors (two-axle tractors); more axles are possible but uncommon. Among four-wheel tractors (two-axle tractors), most are two-wheel drive (usually at the rear); but many are two-wheel drive with front wheel assist, four-wheel drive (often with articulated steering), or track tractors (with steel or rubber tracks).

The many uses, adaptations, and refinements of the tractor have resultedin the gradual evolution of several recognized classifications. One descriptive classification, listed below, is based on steering method, the arrangement ofthe frame, and traction members:

1. Crawler
2. Standard row-crop
3. High-clearance
4. Utility
5. Orchard steering wheels (Picture 2)
6. Multipurpose
7. Lawn and garden articulated frame steering
8. Power tiller
9. Tree skidder
10. Skid-steer loader
11. Four-wheel drive with smaller front
12. Four-wheel drive with equal-sized wheels

Picture 2. An Orchard steering wheels tractor.

Also Tractors can be classified into three classes on the basis of structural design:

1. Wheel tractor

Tractors having three or four pneumatic wheels are called wheel tractors. Four wheel tractors are popular every where. Pictures 3 and 4 show number of wheels of tractors.

Picture 3. Three wheel tractor.

Picture 4. Four wheel tractor.

Components of wheel tractor:

Engine	Real wheels	Power-take-off	Differential	Final drive
Clutch	Front wheels	Steering mechanism	Hydraulic	hitch system
Brakes	Gear box	Tractor pulley	Control panel	Draw bar

2.Crawler tractor

This type is also called Track type tractor or Chain type tractor. In such tractors, there is endless chain or track in place of pneumatic wheels3. Picture 5 shows a crawler tractor.

Picture 5. Crawler tractor.

Crawler tractor or chain type tractor has the following characterizes:

1. It is designed to secure good adhesion and transmit high drawbar pull in difficult field conditions, where wheel tractors fail to secure adequate grip on the soil.

2. It provides large area of contact with the ground.

3. It is useful at places where adhesion is difficult and rolling resistance is high.

4. It is most suited for heavy work, especially earth moving work and reclamation work.

5. It is used for all types of agricultural works with heavy implements.

Crawler type tractors mainly consists of:

1. Track frame assembly
2. Track chain
3. Steering clutch
4. Steering brake

3. Walking type tractor or Power tiller

Power tiller is a walking type tractor. This tractor is usually fitted with two wheels only. The direction of travel and its controls for field operation is performed by the operator, walking behind the tractor. Picture 6 shows a Power tiller.

Picture 6. Walking Wheel Tractor.

In agricultural power tillers areused for plowing, sowing, spraying, harvesting and transporting works. It is the most wanted machine for paddling operation in rice cultivation.

Components of power tiller:

1. Engine
2. Transmission gears
3. Clutch
4. Brakes
5. Rotary unit

Power tillers uses for:

1. Paddling operation in paddy fields- using rotary tines
2. Cutting and pulverizing the soil in dry lands and in garden lands
3. Cutting and pulverizing the stubbles of sugarcane, maize and cotton
4. Sowing and inter-cultivation works
5. Spraying of orchard trees
6. Transporting purposes

Classification of wheel tractors

On the basis of purpose, wheeled tractors are classified into three groups (picture 7):

a. General purpose tractor

It is used for major farm operations such as plowing, sowing,harvesting and transportingworks. Such tractors have: i) low ground clearance, ii)Increased engine power, iii) good adhesion and iv) widetiers.

b. Row crop tractor

It is used for row crop cultivation. Such tractor is provided with replaceable driving wheels of different tread widths. It has high ground clearance to save damage of crops. Wide wheel track can be adjusted to suit inter row distance.

c. Special purpose tractor

It is used for definite jobs like cotton fields, marshy lands, and hill sides, garden. Special designs are there for special purpose tractor.

General purpose tractor | Row crop tractor | Special purpose tractor

Picture 7. Classification of wheel tractors.

Operating a Tractor

Tractors are the main cause of accidental deaths on farms. Over the years, many farmers, farm workers and others living on or visiting farms, have been killed or seriously injured falling from moving tractors, being run over by tractors, or being crushed when a tractor rolls sideways or backwards.

Make the changes

- ✓ Read and follow safety procedures in the manufacturer's manual.
- ✓ Ensure an approved cab or rollover protective structure (ROPS) is fitted.
- ✓ Fit and use a seatbelt on tractors with ROPS.
- ✓ If there is a risk from falling objects, fit a fall-on protective structure (FOPS).
- ✓ To reduce risk of back strain, fit a seat with side restraints and a backrest.
- ✓ Wear hearing protection, and remember, not all tractor cabs are sound proof.
- ✓ Keep children away from tractors and machinery.
- ✓ Remove starter keys when tractors are not in use.
- ✓ Have an up-to-date maintenance schedule.
- ✓ Follow safe maintenance and jacking procedures. (See Tractor Maintenance.)
- ✓ Ensure the operator is properly trained for each type of tractor work.
- ✓ Always mount and dismount on a tractor's left side - to avoid controls.
- ✓ Adjust the seat so all controls are safely and comfortably reached.
- ✓ Keep all guards in place, including the power take-off (PTO).
- ✓ Operate the self-starter from the operator position only.
- ✓ Never carry passengers.

When operating a tractor

- ✓ Drive at speeds slow enough to retain control over unexpected events.
- ✓ Reduce speed before turning or applying brakes.
- ✓ Watch out for ditches, logs, rocks, depressions and embankments.
- ✓ On steep slopes, without a trailed implement, reverse up for greater safety.
- ✓ Engage the clutch gently at all times, especially when going uphill or towing.
- ✓ Use as wide a wheel track as possible on hillsides and sloping ground.
- ✓ Descend slopes cautiously in low gear, using the motor as a brake.
- ✓ Never mount or dismount from a moving tractor.
- ✓ Ensure the park brake is on and operating effectively before dismounting.

- ✓ Take short breaks regularly when working long hours.

When towing implements

- ✓ Fit attachments according to the manufacturer's instructions.
- ✓ Always attach implements to the draw bar or the mounting points provided by the manufacturer.
- ✓ Never alter, modify or raise the height of the draw bar unless provided for by the manufacturer.
- ✓ Regularly check safety pins on towed lift-wing implements, to ensure they are not worn.
- ✓ Ensure all guards on towed implements are in place before operating.
- ✓ Never hitch above the centerline of the rear axle, around the axle housing or to the top link pin.
- ✓ Never adjust or work on implements while they are in motion.
- ✓ Never attach implements unless the PTO shaft is guarded.
- ✓ When parking, always lower the three-point linkage and towed implement.

To avoid strain injury

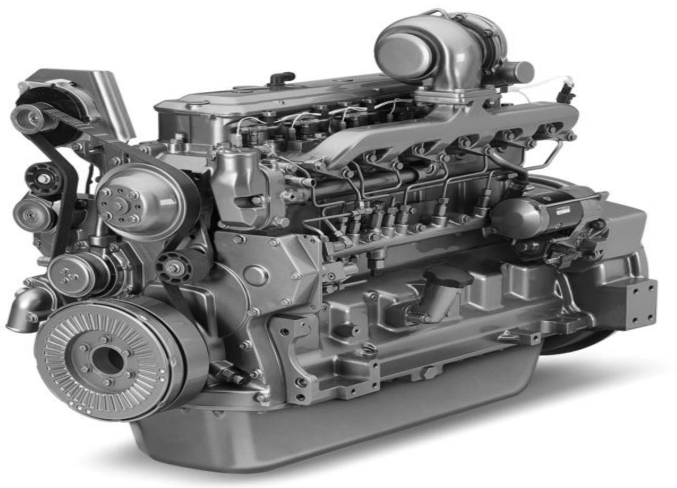
- ✓ Adjust the tractor seat for back support and comfort.
- ✓ When buying a tractor, ensure seating is safe and comfortable.
- ✓ Check seat height, seat depth, backrest height and angle, fore and aft movement, seat tilt, firm padding, partial pivoting (if you have to spend long periods looking behind you), and vibration-absorbing suspension.
- ✓ Dismount every hour or so, and spend 5 or 10 minutes doing something active.
- ✓ Plan for your next tractor to include suitably low steps, handgrips, adequate doorway and cab space, and a safe mounting platform.
- ✓ Dismount by climbing down - not jumping down - and use each provided foot and handhold.

Engine

Many sizes and types of engines have been used for tractors. Most tractors have a four-stroke-cycle engine, although some two-stroke-cycle diesels are in successful operation. Tractor engines are designed for a high load factor, that is, the poweroutput may be 85 to 90 percent of the maximum brake power at rated speed, and the engine is expected to be able to produce this power for long periods of time.

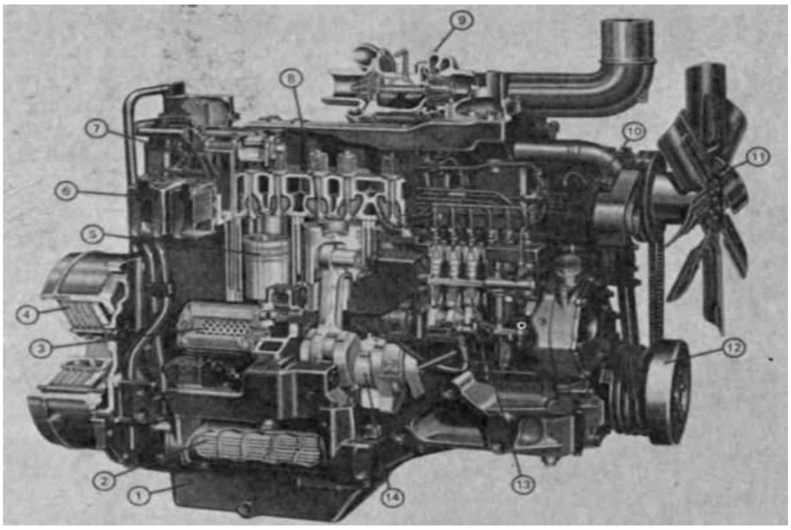
Tractor engines were designed with one to four cylinders. Single-cylinder engines were only slight modifications of stationary units. Although simple in construction, they were much larger and heavier for a given amount of power than the two- and four-cylinder engines, and a large proportion of the power was necessary to propel the machine itself.

The tractor manufacturer must determine, usually by survey, the percentage of spark ignition and compression ignition engines to build. The problem of choosing a gasoline or diesel engine is largely one of economics. New engines correspond essentially to current models but contain changesor modifications made possible by improvement in design, fuels, lubricants,or materials. The first step of any design problem is to select the speed, type, number, and size of cylinders and the arrangement of the cylinders for the required output. The second step is to calculate the sizes and materials of the parts to withstand the stresses. Picture 8 shows a model of diesel engine.



Picture 8: A model of diesel engine (John Deere).

Tractor engines are subjected to unusually large and fluctuating loads during most field operations. The important engine parts including the block, crank-shaft, connecting rods, pistons, bearings, and valves are made heavier and stronger than their automobile engine counterparts. Picture 9 shows most of the parts that would exist on any diesel engine for a tractor.



Picture 9: Parts of six-cylinderdiesel engine for a tractor (John Deere).

Guide of 14 Keys:

1. Oil pan	2. Oil cooler	3. Oil filter	4. Wet clutch
5. Piston and rings	6. Fuel filter	7. Fuel injector	8. Valve
9. Turbo charger	10. Alternator	11. Fan	12. Damper
13. Fuel pump	14. Crankshaft		

Types of Engine

Engines are machines that convert a source of energy into physical work. If you need something to move around, an engine is just the thing to slap onto it. But not all engines are made the same, and different types of engines definitely don't work the same.Probably the most intuitive way to differentiate between them is the type of energy each engine uses for power.

1. Thermal engines: a) Internal combustion engines or IC engines and b) External combustion engines or EC engines
2. Reaction engines
3. Electrical engines
4. Physical engines

Thermal engines

In the broadest definition possible, these engines require a source of heat to convert into motion. Depending on how they generate said heat, these can be combustive (that burn stuff) or non-combustive engines. They function either through direct combustion of a propellant or through the transformation of a fluid to generate work. As such, most thermal engines also see some overlap with chemical drive systems. They can be air breathing engines (that take oxidizer such as oxygen from the atmosphere) or non-air breathing engines (that have oxidizers chemically tied in the fuel).

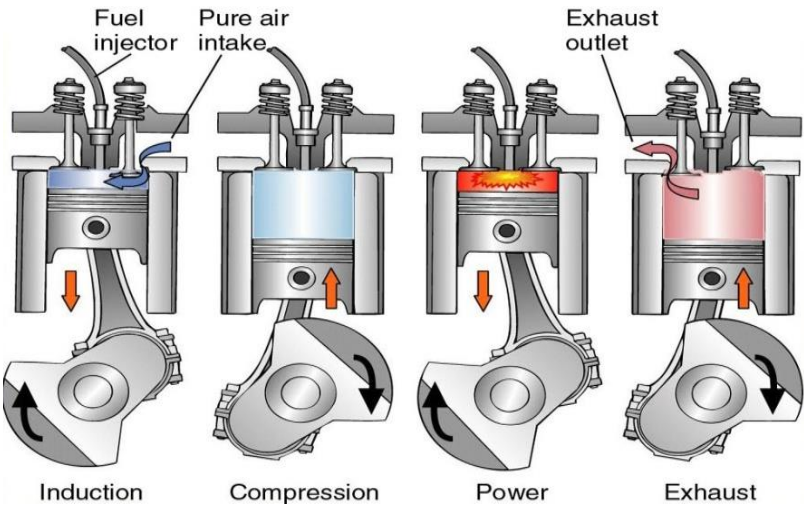
Internal combustion engines (IC engines)

IC engines are device converting the energy of a fuel-air mixture burning within a combustion chamber into mechanical energy.IC engine is derive energy from fuel burned inside a specialized area of the system called a combustion chamber. The process of combustion generates reaction products (exhaust) with a much greater total volume than that of the reactants combined (fuel and oxidizer). This expansion is the actual bread and butter of IC engines-this is what actually provides the motion. Heat is only a byproduct of combustion and represents a wasted part of the fuel's energy store, because it doesn't actually provide any physical work.

IC engines are differentiated by the number of 'strokes' or cycles each piston makes for a full rotation of the crankshaft. Most common today are four-stroke engines, which break down the combustion reaction in four steps:

1. Induction or injection of a fuel-air mix (the carbureted) into the combustion chamber.
2. Compression of the mix.
3. Ignition by a spark plug or compression-fuel goes boom.
4. Emission of the exhaust.

For every step, a 4-stroke piston is alternatively pushed down or back up. Ignition is the only step where work is generated in the engine, so for all other steps, each piston relies on energy from external sources (the other pistons, an electric starter, manual cranking, or the crankshaft's inertia) to move.Other criteria for differentiating IC engines are the type of fuel used, the number of cylinders, total displacement (internal volume of cylinders), distribution of cylinders (inline, radial, V-engines, etc.), as well as power and power-to-weight output. Picture 10 shows the Internal Combustion engine (IC).

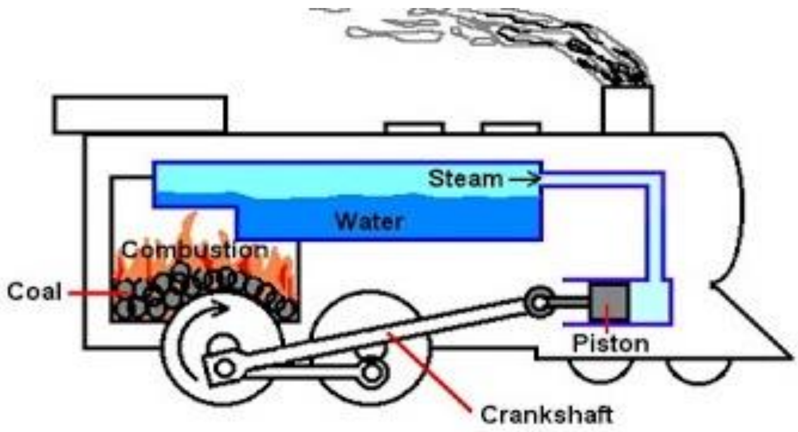


Picture 10. Four-strokeInternal Combustion engine (IC)-Diesel.

External combustion engines (EC)

EC engines keep the fuel and exhaust products separately-they burn fuel in one chamber and heat the working fluid inside the engine through a heat exchanger or the engine's wall. Fuel used for combustion is coal, wood etc.

An external combustion engine (EC engine) is a heat engine where a working fluid, contained internally, is heated by combustion in an external source, through the engine wall or a heat exchanger. The fluid then, by expanding and acting on the mechanism of the engine, produces motion and usable work. Steam engines are best examples of EC engines (Picture 11).



Picture 11. An External Combustion engine (EC).

Difference between Internal engine and External combustion engine:

1. External combustion engine run smoothly and silently where of internal combustion engines are very noisy due to the sound produced from continuous explosions inside the cylinder of IC engine.

2. Working pressure and temperature in external combustion is low whereas in I.C engines working pressure and temperature is high.

3. External combustion engines have 15-20% efficiency whereas internal combustion engine have 35-60%.

4. An external combustion engine requires a boiler and other components to transfer energy.Thus it is a heavy engine whereas in an I.C engine parts are light and compact.

5. External combustion engine cannot be started instantaneously whereas internal combustion engine starting is quick and easy.

6. In external combustion engine, combustion of fuel takes place outside the cylinder whereas in IC engine, combustion of fuel takes place inside the cylinder.This is a constructional difference between IC engine and external combustion engine.

7. Due to exposure to low pressure and temperature ordinary alloys can be used for the manufacture of engine cylinder of EC engines and its parts whereas in IC engines, due to high pressure and temperature, special alloys are used for manufacture of engine cylinder and its parts.

8. Steam engine,steam turbine and sterling engine are examples of external combustion engine.

9. Petrol engine,Diesel engine and Wankel engine are examples of internal combustion engine.

10. Cost of external combustion engine is very high whereas I.C engine is cheap.

11. Large space is required for external combustion engine whereas I.C engine does not need large space.

The pictures 10 and 11 present a scheme of a typical four-stroke reciprocating combustion engine.The diesel engine consists of four cylinders in different phases of the engine cycle (intake, compression, expansion and exhaust). Each cylinder has an inlet and exhaust valves, opening and closing of which is controlled by the cam mechanism. Each piston is joined to the crank pin of the crankshaft though the connecting rod.

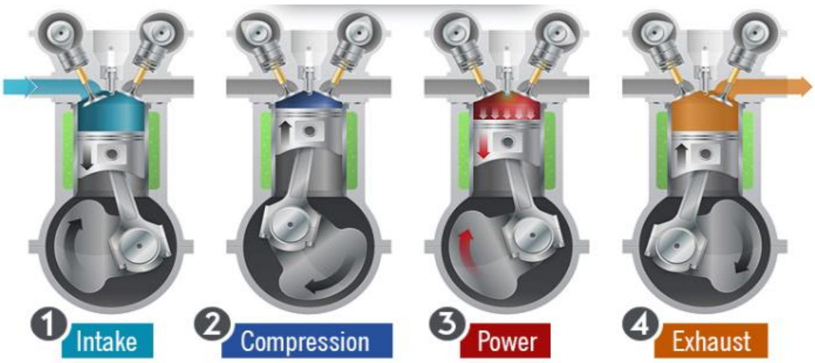
The four-stroke cycle (Picture 12):

1. Intake: The intake valve is open. The piston moves downwards from the Top Dead Center (TDC) to the Bottom Dead Center (BDC) sucking the fuel-air mixture into the cylinder.

2. Compression: Both valves are closed. The piston moves from BDC towards TDC compressing the gaseous fuel-air mixture. The compression causes pressure and temperature increase of the gas in the cylinder. When the crankshaft reaches some angle before TDC the fuel-air mixture is ignited and fuel combustion starts. Combustion further increases the gas pressure and temperature. In the gasoline (petrol) engines ignition is as a result of a spark produced by the spark plug. The engines of such type are called Spark Ignition (SI) engines. In the diesel engines the fuel-air mixture is ignited by the heat of the compressed gages. The engines of such type are called Compression Ignition (CI) engines.

3. Power (expansion): Both valves are closed. The piston travels from TDC to BDC under the high pressure of hot burning gases. The power of the gases is transmitted to the crankshaft through the connecting rod. Just before the piston reaches the Bottom Dead Center the exhaust valve opens.

4. Exhaust: The exhaust valve is open. The piston moves towards TDC forcing the combustion gases out of the cylinder. When it reaches TDC the exhaust valve closes and the intake valve opens - the cycle returns to the initial state.



Picture 12. Four-strokeInternal Combustion engine (IC)-Spark.

Two Stroke Cycle Engine (Petrol Engine)

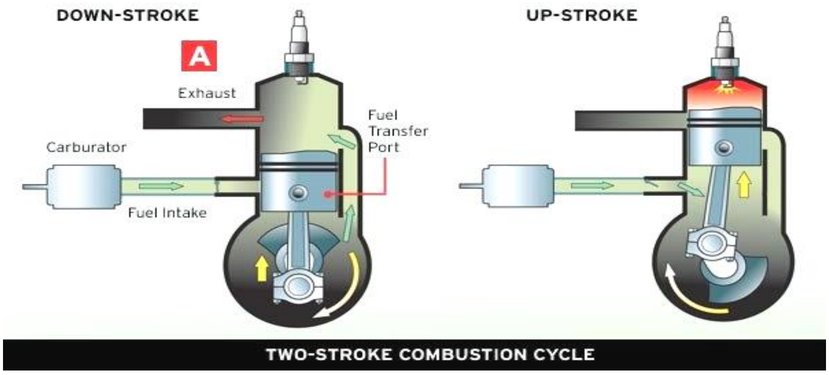
In two stroke cycle engines, the whole sequence of events i.e., suction, compression, power and exhaust are completed in two strokes of the piston i.e. one revolution of the crankshaft. There is no valve in this type of engine.

Upward stroke of the piston (Suction + Compression):

When the piston moves upward it covers two of the ports, the exhaust port and transfer port, which are normally almost opposite to each other. This traps the charge of air- fuel mixture drawn already in to the cylinder. Further upward movement of the piston compresses the charge and also uncovers the suction port. Now fresh mixture is drawn through this port into the crankcase. Just before the end of this stroke, the mixture in the cylinder is ignited by a spark plug. Thus, during this stroke both suction and compression events are completed (Picture 13).

Downward stroke (Power + Exhaust):

Burning of the fuel rises the temperature and pressure of the gases which forces the piston to move down the cylinder. When the piston moves down, it closes the suction port, trapping the fresh charge drawn into the crankcase during the previous upward stroke. Further downward movement of the piston uncovers first the exhaust port and then the transfer port. Now fresh charge in the crankcase moves in to the cylinder through the transfer port driving out the burnt gases through the exhaust port. Special shaped piston crown deflect the incoming mixture up around the cylinder so that it can help in driving out the exhaust gases. During the downward stroke of the piston power and exhaust events are completed (Picture 13).



Picture 13. Two Stroke Cycle Engine.

Comparison between two stroke and four stroke engines:

Four stroke engine	Two stroke engine
One power stroke for every two revolutions of the crankshaft.	One power stroke for each revolution of the crankshaft.
There are inlet and exhaust valves in the engine.	There are inlet and exhaust ports instead of valves.
Crankcase is not fully closed and air tight.	Crankcase is fully closed and air tight.
Top of the piston compresses the charge.	Both sides of the piston compress the charge.
Size of the flywheel is comparatively larger.	Size of the flywheel is comparatively smaller.
Fuel is fully consumed.	Fuel is not fully consumed.
Weight of engine per hp is high.	Weight of engine per hp is comparatively low.
Thermal efficiency is high.	Thermal efficiency is comparatively low.
Removal or exhaust gases easy.	Removal of exhaust gases comparatively difficult.
Torque produced is even.	Torque produced is less even.
For a given weight, engine would give only half the power of two stroke engine.	For same weight, two stroke engine gives twice the power that of four stroke engine.
All types of speed are possible (high and low).	Mostly high speed engines are there.
It can be operated in one direction	It can be operated in both direction

only.	(clockwise and counter clockwise).

Working principle of diesel engine

The basic components of diesel engine are cylinder, piston, injector, valves, connecting rod and crankshaft. In diesel engines only air is drawn into the cylinder. The engine has high compression ratio hence the air in the cylinder attains very high temperature and pressure at the end of the compression stroke. At the end of the compression stroke, the fuel is sprayed into the cylinder in atomized form using injectors. Due to high temperature, the fuel gets ignited, begins to burn and produce lot of heat. Due to the heat the gases expand, move the piston downward and rotate the crank shaft. The torque available at the rotating crank shaft is used to do any mechanical work.

Special features of diesel engine

1. Engine has high compression ratio ranging from 14:1 to 22:1.
2. During compression stroke, the engine attains high pressure ranging from 30 to 45 kg/cm2 and high temperature of about 500°C.
3. At the end of the compression stroke, fuel is injected into the cylinder through injectors (atomizers) at a very high pressure ranging from 120 to 200 kg/cm2.
4. Ignition takes place due to heat of compression only.
5. There is no external spark in diesel engine.
6. Diesel engine has better slogging or lugging ability i.e. it maintains higher torque for a longer duration of time at a lower speed.

Comparison of diesel engine with petrol engine

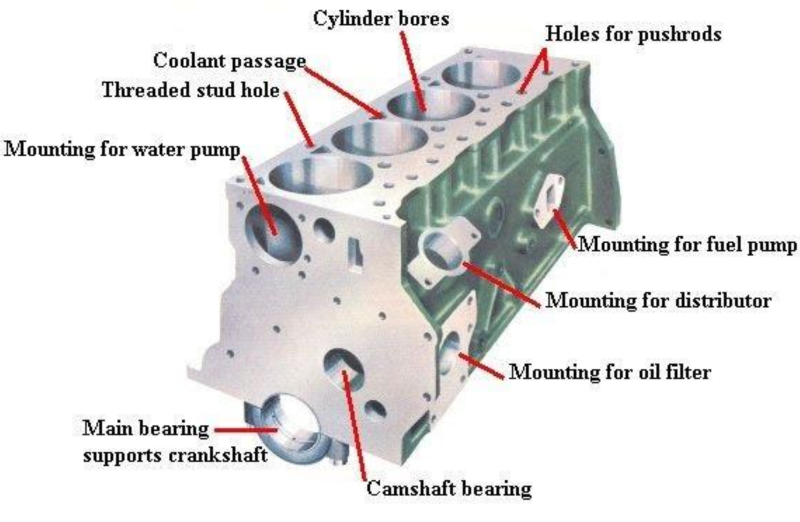
Diesel engine	petrol engine
It has got no carburetor, ignition coil and spark plug.	It has got carburetor, ignition coil & spark plug.
Its compression ratio varies from 14:1 to 22:1	Its compression ratio varies from 5:1 to 8:1.
It uses diesel oil as fuel.	It uses petrol (gasoline) or power kerosine as fuel.
Only air is sucked in cylinder in suction stroke.	Mixture of fuel and air is sucked in the cylinder in suction stroke.
It has got fuel injection pump and injector.	It has got no fuel injection pump and injector, instead it has got carburetor and ignition coil.
Fuel is injected in combustion chamber where burning of fuel takes places due to heat of compression.	Air fuel mixture is compressed in the combustion chamber when it is ignited by an electric spark.

Thermal efficiency varies from 32 to 38%	Thermal efficiency varies from 25 to 32%
Engine weight per horse-power is high.	Engine weight per horsepower is comparatively low.
Operating cost is low.	Operating cost is high.
Compression pressure inside the cylinder varies from 35 to 45 kg/cm2 and temperature is about 500°C.	Compression pressure varies from 6 to 10 kg/cm2 and temperature is above 260°C.

Engine components

Internal combustion engine consists of a number of parts which are given below:

1. Cylinder: It is a part of the engine which confines the expanding gases and forms the combustion space. It is the basic part of the engine. It provides space in which piston operates to suck the air or air-fuel mixture (Picture 14 and 16). The piston compresses the charge and the gas is allowed to expand in the cylinder, transmitting power for useful work. Cylinders are usually made of high grade cast iron.



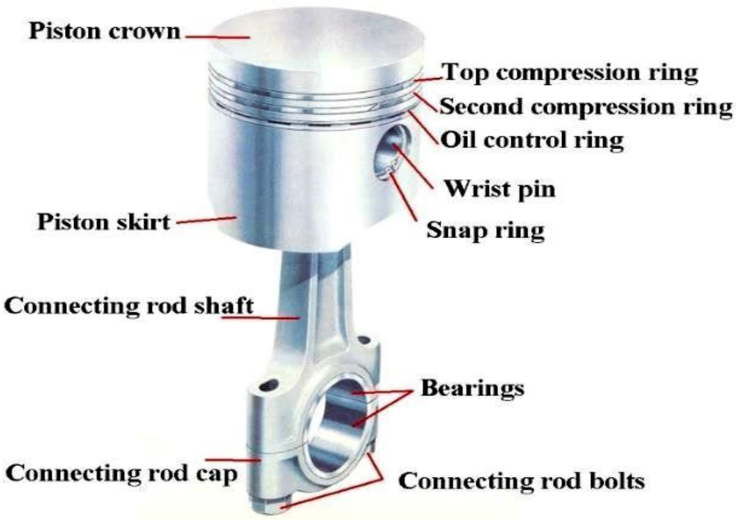
Picture 14. A block of four cylinder.

2. Cylinder block: It is the solid casting body which includes the cylinder and water jackets (cooling fins in the air cooled engines) (Picture 14).

3. Cylinder head: It is a detachable portion of an engine which covers the cylinder and includes the combustion chamber, spark plugs or injector and valves (Picture 14).

4. Cylinder liner or sleeve: It is a cylindrical lining either wet or dry type which is inserted in the cylinder block in which the piston slides. Liners are classified as: (1) Dry liner and (2) Wet liner. Dry liner makes metal to metal contact with the cylinder block casing. Wet liners come in contact with the cooling water, whereas dry liners do not come in contact with the cooling water (Picture 14).

5. Piston: It is a cylindrical part closed at one end which maintains a close sliding fit in the engine cylinder. It is connected to the connecting rod by a piston pin. The force of the expanding gases against the closed end of the piston, forces the piston down in the cylinder. This causes the connecting rod to rotate the crankshaft. Cast iron is chosen due to its high compressive strength. Aluminum and its alloys preferred mainly due to it lightness (Picture 15).



Picture 15. A piston and its components.

Piston ring: It is a split expansion ring, placed in the groove of the piston. They are usually made of cast iron or pressed steel alloy (Picture 15). The functions of the rings are as follows:

1. It forms a gas tight combustion chamber for all positions of piston.
2. It reduces contact area between cylinder wall and piston wall preventing friction losses and excessive wear.
3. It controls the cylinder lubrication.
4. It transmits the heat away from the piston to the cylinder walls.

Piston rings types are Compression ring and Oil ring. Compression rings are usually plain, single piece and are always placed in the grooves of the piston nearest to the piston head. They prevent leakage of gases from the cylind er and helps increasing compression pressure inside the cylinder. Oil rings are grooved or slotted and are located either in lowest groove above the piston pin or in a groove above the piston skirt. They control the distribution of lubrication oil in the cylinder and the piston.

Piston Pin: It is also called wrist pin or gudgeon pin. Piston pin is used to join the connecting rod to the piston.

6. Connecting rod: It is special type of rod, one end of which is attached to the piston and the other end to the crankshaft. It transmits the power of combustion to the crankshaft and makes it rotate continuously. It is usually made of drop forged steel.

7. Crankshaft: It is the main shaft of an engine which converts the reciprocating motion of the piston into rotary motion of the flywheel. Usually the crankshaft is made of drop forged steel or cast steel. Crankshaft is provided with counter weights throughout its length to have counter balance of the unit (Picture 16).

8. Flywheel: Flywheel is made of cast iron. Its main functions are as follows:

1. It stores energy during power stroke and returns back the energy during the idle strokes, providing a uniform rotary motion of flywheel.
2. The rear surface of the flywheel serves as one of the pressure surfaces for the clutch plate.
3. Engine timing marks are usually stamped on the flywheel, which helps in adjusting the timing of the engine.
4. Sometime the flywheel serves the purpose of a pulley for transmitting power.

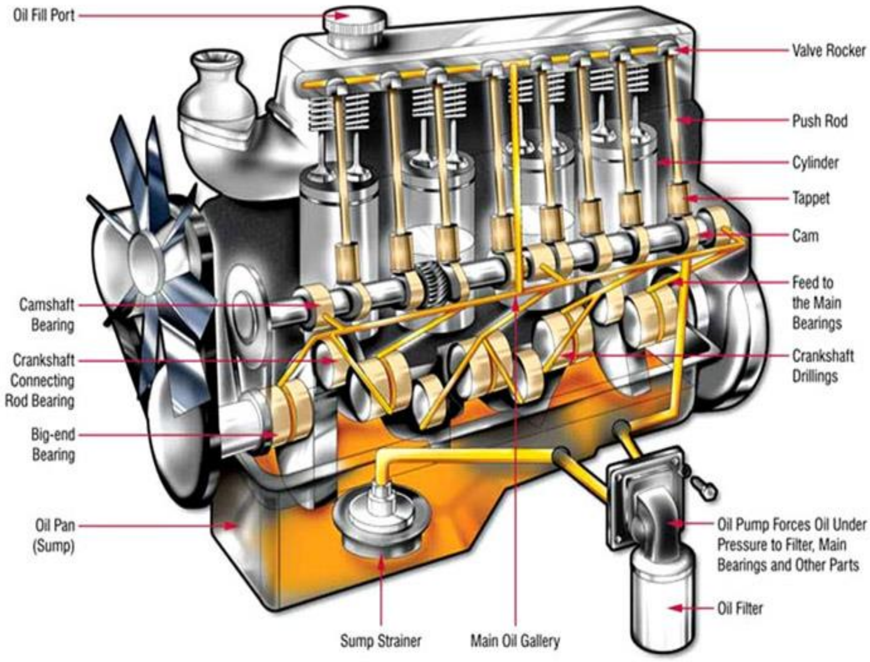
9. Crankcase: The crankcase is that part of the engine which supports and encloses the crankshaft and camshaft. It provides a reservoir for the lubricating oil. It also serves as a mounting unit for such accessories as the oil pump, oil filter, starting motor and ignition components. The upper portion of the crankcase is usually integral with cylinder block. The lower part of the crankcase is commonly called oil pan and is usually made of cast iron or cast aluminum (Picture 16).

10. Camshaft: It is a shaft which raises and lowers the inlet and exhaust valves at proper times. Camshaft is driven by crankshaft by means of gears, chains or sprockets. The speed of the camshaft is exactly half the speed of the crankshaft in four stroke engine. Camshaft operates the ignition timing mechanism, lubricating oil pump and fuel pump. It is mounted in the crankcase, parallel to the crankshaft (Picture 16).

11. Timing gear: Timing gear is a combination of gears, one gear of which is mounted at one end of the camshaft and the other gear at the crankshaft. Camshaft gear is bigger in size than that of the crankshaft gear and it has twice as many teeth as that of the crankshaft gear. For this reason, this gear is commonly called half time gear. Timing gear controls the timing of ignition, timing of opening and closing of valve as well as fuel injection timing.

12. Inlet manifold: It is that part of the engine through which air or air-fuel mixture enters into the engine cylinder. It is fitted by the side of the cylinder head.

13. Exhaust manifold: It is that part of the engine through which exhaust gases go out of the engine cylinder. It is capable of withstanding high temperature of burnt gases. It is fitted by the side of the cylinder head.



Picture 16. Components of Engine.

Different systems available for efficient functioning of an engine are as follows:

1. Fuel supply system
2. Iubrication system
3. Ignition system
4. Cooling system
5. Governor

Fueling System

The fuel system is made up of the fuel tank, pump, filter, and injectors or carburetor, and is responsible for delivering fuel to the engine as needed.

Fuel supply system in spark ignition engine

The fuel supply system of spark ignition engine consists of:

1. Fuel tank

2. Sediment bowl
3. Fuel lift pump
4. Carburetor (Injection pump)
5. Fuel pipes
6. Injector

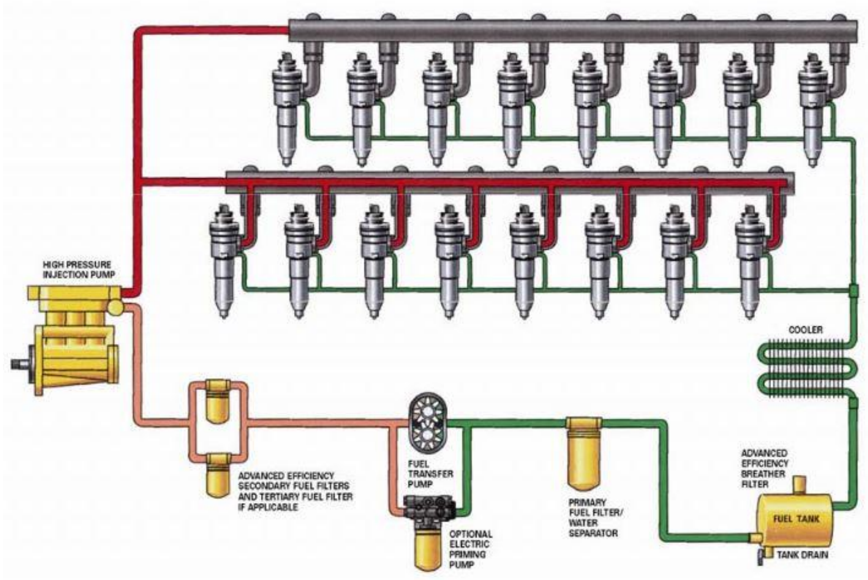
In some spark ignition engines the fuel tank is placed above the level of the carburetor. The fuel flows from fuel tank to the carburetor under the action of gravity. There are one or two filters between fuel tank and carburetor. A transparent sediment bowl is also provided to hold the dust and dirt of the fuel. If the tank is below the level of carburetor, a lift pump is provided in between the tank and the carburetor for forcing fuel from tank to the carburetor of the engine. The fuel comes from fuel tank to sediment bowl and then to the lift pump. From there the fuel goes to the carburetor through suitable pipes. From carburetor the fuel goes to the engine cylinder through inlet manifold of the engine.

Fuel supply system in diesel engine

Fuel supply system is a seperate system used to deliver diesel at correct time in correct quantity, to a diesel engine. Fuel supply system of diesel engine consists of the following components (Picture 17 and 18):

1. Fuel tank
2. Fuel lift pump or fuel feed pump
3. Fuel filter
4. Fuel injection pump
5. High pressure pipe
6. Over flow valve
7. Fuel injector

Fuel is drawn from fuel tank by fuel feed pump and forced to injection pump through fuel filter. The injection pump supplies high pressure fuel to injection nozzles through delivery valves and high pressure pipes. Fuel is injected into the combustion chamber through injection nozzles. The fuel that leaks out from the injection nozzles passes out through leakage pipe and returns to the fuel tank through the over flow pipe. Over flow valve installed at the top of the filter keeps the feed pressure under specified limit. If the feed pressure exceeds the specified limit, the over flow valve opens and then the excess fuel returns to fuel tank through over flow pipe.



Picture 17. Fuel supply system in diesel engine.

Fuel tank: It is a storage tank for diesel. A wire gauge strainer is provided under the cap to prevent foreign particles entering the tank.

Fuel lift pump: It transfers fuel from fuel tank to inlet gallery of fuel injection pump.

Preliminary filter (sediment bowl assembly): This filter is mostly fitted on fuel lift pump. It prevents foreign materials from reaching inside the fuel line. It consists of a glass cap with a gasket.

Fuel filter: Mostly two stage filters are used in diesel engines:

1. Primary filter 2. Secondary filter

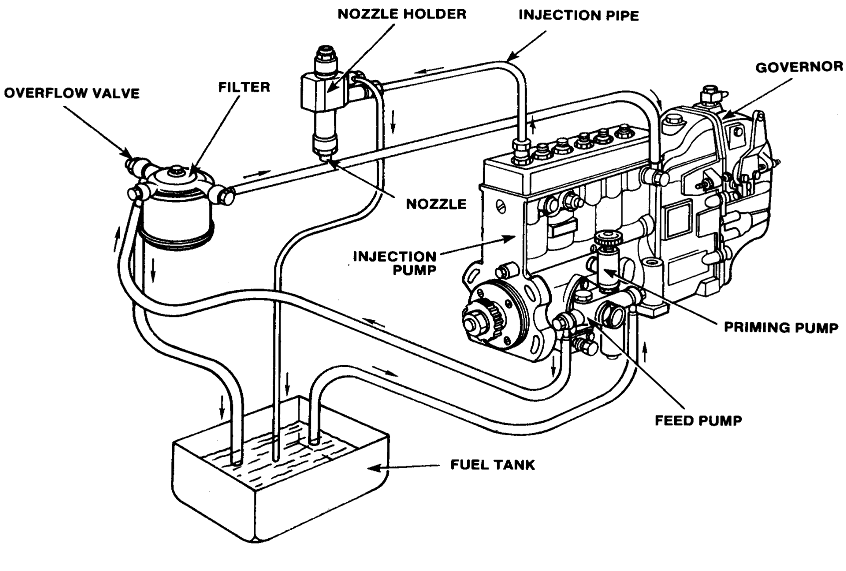
Primary filter removes course materials, water and dust. Secondary filter removes fine dust particles.

Fuel injection pump: It is a high pressure pump which supplies fuel to the injectors according to the firing order of the engine. It is used to create pressure varying from 120 kg/cm2 to 300 kg/cm2. It supplies the required quantity of fuel to each cylinder at appropriate time.

Air venting of fuel system: When air has entered the fuel lines or suction chamber of the injection pump, venting should be done properly. Air is removed by the priming pump through the bleeding holes of the injection pump.

Fuel injector: It is the component which delivers finely atomized fuel under high pressure to combustion chamber of the engine. Modern tractor engines use fuel injectors which have multiple holes.

Main parts of injectors are nozzle body, and needle valve. The needle valve is pressed against a conical seat in the nozzle body by a spring. The injection pressure is adjusted by adjusting a screw. In operation, fuel from injection pump enters the nozzle body through high pressure pipe. When fuel pressure becomes so high that it exceeds the set spring pressure, the needle valve lifts off its seat. The fuel is forced out of the nozzle spray holes into the combustion chamber.



Picture 18. Fuel supply system in diesel engine.

Lubrication System

Lubricating system is a mechanical system of lubricating internal combustion engines in which a pump forces oil into the engine bearings. IC engine is made of moving parts. Duo to continuous movement of two metallic surfaces over each other, there is wearing of moving parts, generation of heat and loss of power in engine. Lubrication of moving parts is essential to prevent all these harmful effects.

Purpose of lubrication

1. Reducing frictional effect
2. Cooling effect
3. Sealing effect
4. Cleaning effect

Types of lubricants

Lubricants are obtained from animal fat, vegetables and minerals. Vegetable lubricants are obtained from seeds, fruits and plants. Cotton seed oil, olive oil, linseed oil, caster oil are used as lubricants. Mineral lubricants are most popular for engines and machines. It is obtained from crude petroleum found in nature.. Petroleum lubricants are less expensive and suitable for internal combustion engines.

Engine lubrication system

The lubricating system of an engine is an arrangement of mechanisms which maintains the supply of lubricating oil to the rubbing surfaces of an engine at correct pressure and temperature.

The parts which require lubrication are:

1. Cylinder walls and piston]
2. Piston pin
3. crankshaft and connecting rod bearings
4. Camshaft bearings
5. Valve operating mechanism
6. Cooling fan
7. Water pump and
8. Ignition mechanism

Types of lubricating systems

1. Splash system
2. Forced feed system

Ignition System

Fuel mixture of IC engine must be ignited in the engine cylinder at proper time for useful work. Arrangement of different components for providing ignition at proper time in the engine cylinder is called Ignition system.

Types of ignition systems

1. Ignition by electric spark or spark ignition
2. Ignition by heat of compression or compression ignition
3. Ignition by hot tube or hot bulb
4. Ignition by open fire

Only the first two are important methods for modern engines.

Spark ignition

the purpose of spark ignition is to deliver a perfectly timed surge of electricity across an open gap in each cylinder at the exact moment so that the charge may start burning with maximum efficiency. Two types of spark ignition are a) Battery ignition b) magneto ignition.

Cooling System

Fuel is burnt inside the cylinder of an internal combustion engine to produce power. The temperature produced on the power stroke of an engine can be as high as 1600 ºC and this is greater than melting point of engine parts. The best operating temperature of IC engines lie between 140 ºF and 200 ºF and hence cooling of an IC engine is highly essential. It is estimated that about 40% of total heat produced is passed to atmosphere via exhaust, 30% is removed by cooling and about 30% is used to produce power.

Purpose of cooling

1. To maintain optimum temperature of engine for efficient operation under all conditions.
2. To dissipate surplus heat for protection of engine components ike cylinder, cylinder head, piston, piston rings, and valves.
3. To maintain the the lubricating property of oil inside engine.

Methods of cooling

1. Air cooled system
2. Water cooled system

Air cooling system

Air cooled system is generally used in small engines say up to 15-20 kW. The air system is used in the engines of motorcycles, scooters, aeroplanes and other stationary installations. In countries with cold climate, this system is also used in car engines. Air cooled engines are those engines in which heat is conducted from the working components of the engine to the atmosphere directly.

Principle of air cooling: The cylinder of an air cooled engine has fins to increase the area of contact of air for speedy cooling. The cylinder is normally enclosed in a sheet me tal casing called cowling. The fly wheel has blades projecting from its face, so that it acts like a fan drawing air through a hole in the cowling and directed it around the finned cylinder. For maintenance of air cooled system, passage of air is kept clean by removing grasses etc. by a stiff brush of compressed air.

Advantages of air cooled engine

1. It is simple in design and construction.
2. Water jackets, radiators, water pump, thermostat, pipes, hoses are not required.
3. It is more compact.
4. Lighter in weight.

Disadvantages

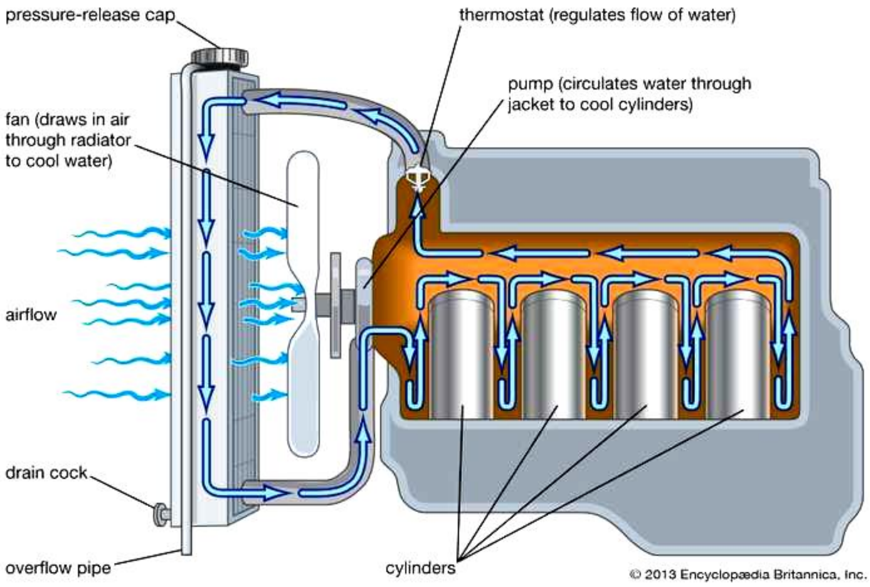
1. There is uneven cooling of engine parts.
2. Engine temperature is generally high during working period.
that about 40% of total heat produced is passed to atmosphere via exhaust, 30% is removed by cooling and about 30% is used to produce power.

Water cooling system

Engines using water as cooling medium are called water cooled engines. Water is circulated round the cylinders to absorb heat from the cylinder walls. The heated water is conducted through a radiator to remove the heat and cool the water (Picture 19).

Methods of water cooling

1. Open jacket or hopper method
2. Thermo siphon method
3. Forced circulation method



Picture 19. Typical gasoline engine cooling system (Water cooled engine).

Open jacket method

There is a hopper or jacket containing water which surrounds the engine cylinder. So long as the hopper contains water the engine continues to operate satisfactorily. As soon as the water starts boiling it is replaced by cold water. The hopper is large enough to run for several hours without refilling. A drain plug is provided in a low accessible position for draining water as and when required.

Thermo siphon method

It consists of a radiator, water jacket, fan, temperature gauge and hose connections. The system is based on the principle that heated water which surrounds the cylinder becomes lighter and it rises upwards in liquid column. Hot water goes to the radiator where it passes through tubes surrounded by air. Circulation of water takes place due to the reason that water jacket and radiator are connected at both sides i.e. at top and bottom. A fan is driven with the help of a V belt to suck air through tubes of the radiator unit, cooling radiator water. The disadvantage of the system is that circulation of water is greatly reduced by accumulation of scale or foreign matter in the passage and consequently causing over heating of the engine.

Forced circulation system

In this method, a water pump is used to force water from radiator to the water jacket of the engine. After circulating the entire run of water jacket, water comes back to the radiator where it loses its heat by the process of radiation. To maintain the correct engine temperature, a thermostat valve is placed at the outer end of cylinder head. Cooling liquid is by-passed through the water jacket of the engine until the engine attains the desired temperature. The thermostat valve opens and the by-pass is closed, allowing the water to go to the radiator.

The system consists of the following components:

1. Water pump
2. Radiator
3. Fan
4. Fan-belt
5. Water jacket
6. Thermostat valve
7. Temperature gauge
8. Hose pipe

Water pump

It is a centrifugal pump. It draws the cooled water from bottom of the radiator and delivers it to the water jackets surrounding the engine.

Thermostat valve

It is a control valve used in cooling system to control the flow of water when activated by a temperature signal.

Fan

The fan is mounted on the water pump shaft. It is driven by the same belt that drives the pump and dynamo. The purpose of radiator is to provide strong draft of air through the radiator to improve engine cooling.

Water jacket

Water jackets are passages cored out around the engine cylinder as well as around the valve opening.

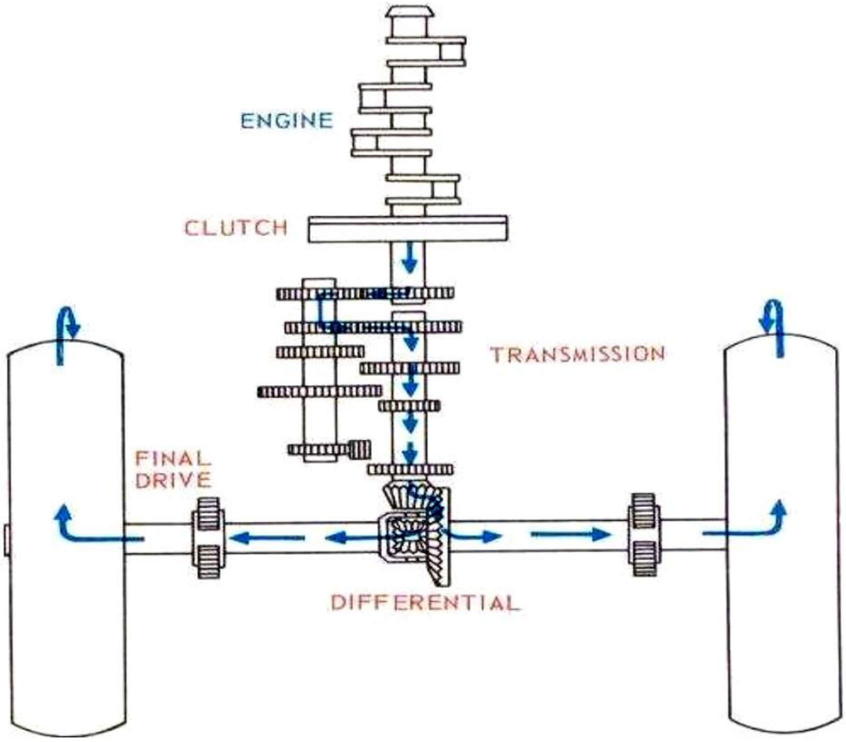
Tractor Systems

1. Power Transmission System

A power transmission system for a tractor has two functions: To disconnect the engine from the road wheels when desired. To transmit the torque in a smooth manner without shocks and jerks. To reduce the engine speed as desired based on tyre size and forward speed required.

To transmit power from the engine to the rear wheels of the tractor, to make reduced speed available, to rear wheels of the tractor, to alter the ratio of wheel speed and engine speed in order to suit the field conditions and to transmit power through right angle drive, because the crankshaft and rear axle are normally at right angles to each other. According to picture 20, the power transmission system consists of:

a) Clutch	b) Transmission gears	c) Differential
d) Final drive	e) Rear axle	f) Rear wheels



Picture 20. Power transmission system.

a) Clutch:

Clutch is a device, used to connect and disconnect the tractor engine from the transmission gears and drive wheels. Clutch transmits power by means of friction between driving members and driven members. Necessity of clutch in a tractor are:

1. Engine needs cranking by any suitable device. For easy cranking, the engine is disconnected from the rest of the transmission unit by the clutch. After starting the starting the engine, the clutch is engaged to transmit the power from engine to gear box.

2. In order to change the gears, the gear box must be kept free from engine power, otherwise the gear teeth will be damaged and engagement of gears will be difficult. This work is done by clutch.

3. When the belt pulley of the tractor works in the field it needs to be stopped with out stopping the engine. This is done by a clutch.

b) Transmission gears:

A tractor runs at high speed, but the rear wheel of the tractor requires power at low speed and high torque. That"s why it becomes essential to reduce the engine speed and increase the torque available at the rear wheel of the tractor.

c) Differential:

Differential unit is a special arrangement of gears to permit one of the rear wheels of the tractor to rotate slower or faster than the other. While turning the tractor on a curved path, the inner wheel has to travel lesser distance than the outer wheel. The inner wheel requires lesser power than the outer wheel. This condition is fulfilled by differential unit, which permits one of the rear wheels of the tractor to move faster than the other at a turning point. Differential lock is a device to join both half axles of the tractor so that even if one wheel is less resistance, the tractor comes out of the mud etc. as both wheels move with the same speed and apply equal traction.

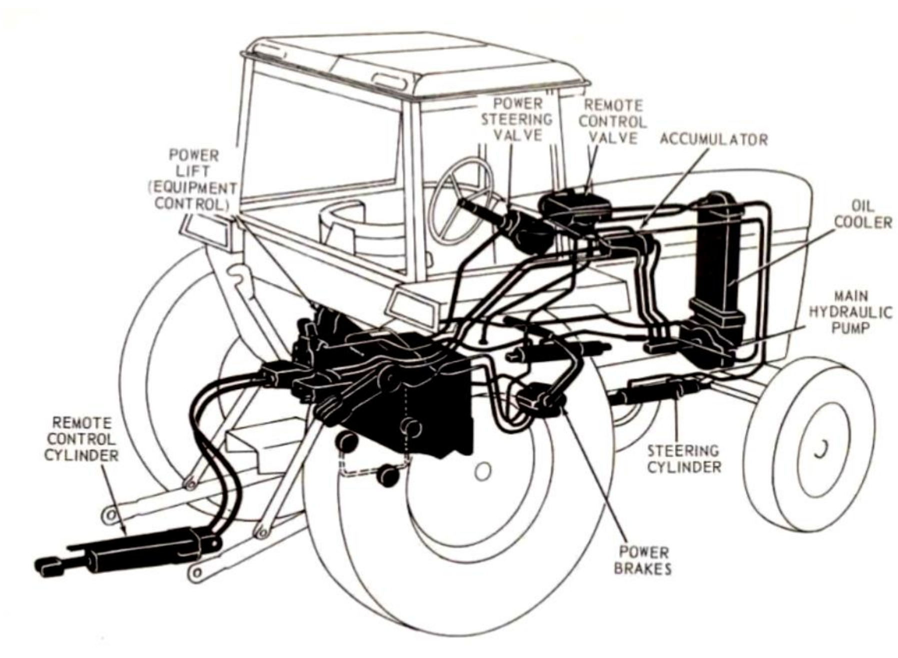
d) Final drive

Final drive is a gear reduction unit in the power trains between differentials and drive wheels. Final drive transmits the power finally to the rear axle and the wheels. The tractor rear wheels are not directly attached to the half shafts but the drive is taken through a pair of spur gears. Each half shaft terminates in a small gear which meshes with a large gear called bull gear. The bull gear is mounted on a shaft, carrying the tractor rear wheel. The device for final speed reduction, suitable for tractor rear wheels is known as final drive mechanism.

Hydraulic System

A hydraulic system consists of part or all of the following components (Picture 21):

1. Pump	2. Motor	3. Valves
4. Lines and connections	5. Heat exchanger	6. Sump
7. Accumulator (stored energy)	8. Controls	9. Fluid
10. Actuators	11. Filters	



Picture 21. hydraulic system.

Pumps and motors are often quite similar and can sometimes be interchanged in their purpose. The simplest type of pump or motor is a hydraulic cylinder.

Hydraulic pump convert mechanical energy from prime mover (engine electric motor) into hydraulic energy (pressure energy). The pressure energy is used then operates actuator Pumps push on the hydraulic fluid and create flow.

All pumps create flow. They operate on the displacement principle. Fluid is taken in and displace to another point. Pump the discharge liquid in a continuous flow or non-positive displacement type. Pump the discharge volume of liquid separated by period of no discharge are positive displacement type.

In a hydraulic system the pump generates the flow of oil which is to be fed to the cylinder or other actuator. The pressure energy is fed to the actuator through a number of control blocks called valve. Hence the valve is nothing but a device which is necessary to control the oil energy. Various types of valve are used in hydraulic system to control or regulate the flow medium. Basically valves are expected to control: a) Blocking or stopping of flow. b) Direction of flow. c) Pressure of flow media. d) Flow quantity. e) Other special function.

Filters are essential component of any hydraulic system. To keep the hydraulic components performing correctly, hydraulic liquid must beas clean as possible. Foreign matter and tiny metal particles from normal wear of valve, pump and other components are going to enter a system. Strainers, filters and magnetic plugs are used to remove foreign particles (like dust, dirt, worn out metallic parts and liquid material like water, acid& paints) from a hydraulic liquid. To enhance the operational efficiency of hydraulic components and service life, filters play important role.

Hydraulic Control Systems

The implement is connected to the tractor hydraulic system has two bottom links and top links. Both the bottom links are connected to two lift arms through lift links. The lift arms are directly mounted on rock shaft which is further connected to the piston rod. Any movement in piston is transferred to the bottom links. The top link is adjustable for maintaining the implement level and suction angle. Draft sensing is done by top link which is spring loaded (Picture 22).

Picture 22. Hydraulic control system in tractor.

Nudging system

This system is used to raise, lower, or position an implement, either mounted or trailed by moving a hand lever either forward or backward from its neutral position. If the control lever is moved (nudged), the hydraulic cylinder will move a complete stroke. if the lever is returned manually to its neutral position before the end of the complete stroke, the cylinder will stop and remains in that position, provided leaks do not exist in the system. In the nudging system there is no relationship between the positions of the hand control lever and the cylinder piston. In control language the nudging system is an open loop system.

Automatic position control system

This system provides automatic control of an attached implement and allows the operator to preselect and to position the implement as determined by the position of the hand control lever. The relative position of hand lever and the hydraulic cylinder are always identical, within the limit of the relief valve controlling the maximum pressure, the hydraulic cylinder will automatically move the implement to its predetermined position and maintain it there, regardless of any leakage in the system.

Automatic draft control system

These systems will be automatically raise or lower an implement as the draft or resistance of the attached implement increase or decrease. The sensing device which tells the hydraulic system to lower or raise the hitch system is located on either the lower links or upper link, depending on the sizeof the tractor. The position of hand control lever in effect establishes the draft to be maintained.

Different operating position of implements

1. Lowering
2. Lifting
3. Neutral

Dictionary of Chapter 2

Words	لغات

Questions of Chapter 2:

3

Chapter Three

Tillage Implements