Design of Farm Machinery

Prof. Hifjur Raheman
Agricultural and Food Engineering Department
Indian Institute of Technology Kharagpur

Week - 01

Lecture - 01

Hi everyone, this is Professor H. Raheman from Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur.

I welcome you all to this course on Design of Farm Machinery under NPTEL platform.

Today I will start with tillage implements.

When I say tillage, these are the concepts which I am going to cover. Tillage, implements to carry out tillage and what are the different tillage implements and among these, we will discuss the moldboard plough.

When you try to prepare a seedbed, we have to make the soil conditions suitable for plant growth.

So, that is possible by tillage.

So, in other words we can define tillage is the process of mechanically modifying soil to create an environment conducive to grow crops, ok.

So, this is possible by utilizing some machinery, particularly some implements.

So, we will discuss those implements later.

So, what are the objectives of tillage?

There are four objectives. Number one is to develop a desirable soil structure for rapid infiltration, adequate aeration and least resistance to root penetration. So that the roots can easily get the nutrients and aeration and they can grow nicely.

The second objective is to destroy weeds and unwanted crop residues or crop plants.

The third objective is to incorporate and mix fertilizer and pesticides into the soil and the fourth objective is to reduce soil erosion by contour tillage and proper placement of trash.

So, to carry out tillage, there will be soil condition and tillage these are correlated.

So, based on the extinct of soil manipulation or soil condition, tillage operations for seedbed preparation are divided into two types one is primary tillage, the other one is secondary tillage.

So, when I said primary tillage that is related to the initial major soil tilling operation.

It is usually carried out to reduce soil strength, to cover the plant materials and rearrange the aggregates.

The operations performed to open up any cultivable land to prepare a seedbed for growing plants, they are known as primary tillage.

Hence, some of the implements which are used to carry out this primary tillage: they are moldboard plough, it could be disk plough, it could be subsoiler, it could be chisel plough and similar implements which are used for carrying out primary tillage.

In secondary tillage, the tillage operations are carried out after primary tillage to further reduce the soil condition that means, to prepare a seedbed, which will be good for sowing plants or seeds.

Then the secondary tillage will reduce the clod size and it will pulverize the soil. It will destroy the grasses and the weeds and it mixes crop residues with topsoil in the field.

So, the implements which are used for carrying out secondary tillage, they could be harrow, they could be cultivator, rotavator.

How do you classify the tillage implements? Because I have already told a few tillage implements under the banner of primary tillage, under the banner of secondary tillage.

So, now question arises, how do you say, what are the tillage implements available. That means, how do you classify tillage implements.

So, the basic thing is primary tillage implements, secondary tillage implements.

The implements which are involved in carrying out primary tillage that is simply called primary tillage implements.

The implements which are involved in carrying out secondary tillage is called secondary tillage implements.

So, this is one way of classification.

The other way of classification is passive tillage implements, active tillage implements and combined tillage implements.

So, when I said passive tillage implements, in this group of implements, the implement is pulled by the tractor, but the soil working elements they are not powered. They are not powered by the tractor. It is simply pulled by the tractor.

So, the examples will be moldboard plough, examples will be cultivator, examples will be disk plough.

So, the figure which I am showing here is a tractor drawn 3 bottom moldboard plough.

So, when I said 3 bottom means, there will be 3 tilling units, similar units and they are used for carrying out tillage simultaneously.

There is a 3 point linkage, there will be 3 moldboards, 3 shares, 3 landsides and they are connected to the frame. These are the components of a 3 bottom moldboard plough.

And we specify this kind of implement as 3 into the cutting width because 3 bottoms are there.

So, that is why I call it 3 × 30 centimeter, 30 centimeter is the cutting width of each moldboard.

So, 3 × 30 that will give you 90 centimeter, it could be 3 × 20.

So, this 20 or 30 refers to the cutting width of each moldboard plough and 3 or 2 will be the number of bottoms. So, that way you specify.

Similarly, if it is a disk plough you can specify.

So, this is a disk plough, tractor drawn 3 bottom disk plough.

So, there are 3 disks that is why I am calling it 3 bottom disk plough.

If there are 2 disks I can call it 2 bottom disk plough.

You can see there are 3 disks, there is a wheel at the rear side.

So, this is called rear furrow wheel and these are the disks. These are scrapers.

This disk will be rotated when you try to pull it with the help of 3 point linkage. When it is attached to the tractor, then we try to pull it, the disk will rotate ok.

So, this is also specified by number of bottoms and in the spacing between 2 adjacent disks that means, cutting width of each disk.

Then comes your harrow. In the previous classification I have included harrows are the secondary tillage implement. But in case of the classification which I made like passive tillage implement there the disk harrows are also coming under passive tillage implements, because the disks are not powered.

So, you may be wondering disks are rotating, but these are - these disks are rotating because of the friction between disk and soil.

So, when you try to pull it because of the friction, the disks are rotating, it is not rotating by taking power from the tractor PTO.

So, that is why, these are called passive tillage implements.

So, the harrow which is shown here, is tractor drawn double acting disk harrow.

There are two gangs, front gang, in each front and each rear gang there will be two sets of disks and they are mounted on a frame and that frame has 3 point linkage and it will be attached to a tractor.

So, this is a tractor drawn double acting disk harrow.

Now, coming to this figure.

This is a cultivator.

So, you can see there are number of tynes or bars you can say. Each bar or tyne will have some working elements, which will be utilized for preparing the seedbed, ok.

So, again these working elements are not powered. These are simply fixed to a frame that is called shank and the total unit is called tyne.

So, depending on the number of tynes, we can specify this as 9 tynes, 7 tynes, 11 tynes, 13 tynes.

So, they are arranged in 2 rows, ok. Either 5 in the front, 4 in the back or 4 in the front, 5 in the back.

There will be 2 rows and there will be a frame to which these tynes will be attached and the frame will have a 3 point linkage attachment, which will be connected to the tractor 3 point linkage.

Now, the other implement which I am showing is : this is a two way moldboard plough.

In the previous slide, I have shown a moldboard plough which is not a two way plough, it is a one way plough. It throws soil to one side that is why it is called one way plough.

It can throw soil to the left, it can throw soil to the right depending on the orientation of the moldboard.

Now, if you look at this figure, this is also a moldboard plough, but I have written an adjective you can call two way moldboard plough.

Two way moldboard plough means when you try to operate this plough then there will be no back furrows. Back furrows means 2 furrow slices they are coming together that is called back furrow.

In one go, if the plough is throwing soil to the right, while returning the moldboard will throw soil to the left side that means, there will be back furrows together.

So, that is not desirable in terrace land.

So, if you want to have the furrow slices to be thrown in one direction, then you have to orient. Then you have to reorient the moldboard plough. So that, they will throw soil in one direction.

So, how it is happening? By rotating. There will be 2 sets of moldboard plows : 2 here, 2 here.

So, when you operate in one direction it will throw soil to this side. While coming will engage the upper one, the lower 2 one will be lifted up and the upper 2 one will come in contact with the ground.

So, they will throw soil to the other direction that means, the orientation of furrow slices will be in one direction.

So, that is why, it is called 2 way moldboard plough.

So, these are all passive tillage implements. Here the working elements are not powered.

Now, I said there will be passive tillage implement, there will be active tillage implement.

When I said active tillage implement. This is also pulled by a tractor, but the working elements are powered, powered from the tractor. Usually the tractor PTO is used for powering the working elements.

Here, the working elements in this figure if you look at, the working elements are these blades and these blades are mounted on a common shaft.

And the shaft is rotated by taking power from the PTO with the help of a cardan shaft, ok.

The rpm is little lesser than rpm of the PTO, may be around half of the PTO rpm and rest of the things then there will be a 3 point linkage which will be connected to the 3 point linkage of the tractor and then this is attached to the tractor.

So, here the working elements are powered because shaft is rotating, the blades are attached to the shaft. So, blades are also rotating that means, we are powering the working element that is why it is called active tillage implement.

Another example is your powered disk harrow. I have shown a double acting disk harrow in my previous slide.

Now, this is a single acting disk harrow. There will be 2 gangs in the front and all those 2 gangs will be powered.

In fact, disk harrow is - if you do not power it will also rotate, but in addition to that rotation we are also powering those disks because those disks are mounted on the shaft and we try to power the shaft taking power from the PTO.

So, when the gang bolt will rotate, the disks which are mounted on the gang bolt will rotate.

So, that is why the working elements are powered. So, we call it powered disk harrow.

So, the difference is : the working elements are powered.

So, in passive tillage implement, the working elements are not powered that is the difference. That is why you call it as a passive tillage implement and active tillage implement.

Now, the third category of tillage implement which you call as combined tillage implement. This is a very interesting one. Combined tillage as the name says - combined tillage that means, we can combine few tillage operations to be done simultaneously and they are attached to the same tractor, ok.

So, this is possible when the tractor having higher horsepower, higher drawbar horsepower.

So, why you are combining tillage operations you must be wondering, why we are combining these tillage operations?

We are combining because to reduce the time required to prepare the seedbed, to reduce the fuel consumption, to reduce the time requirement.

Why the time requirement will reduce?

Why the fuel requirement will reduce?

In the normal way of preparing a seedbed, what we do is, we first take a plough to the field, carry out the ploughing operations, then we take harrow to the field, we carry out harrowing to further reduce the clod size and then if needed twice harrowing, then once cultivator and then planking. So, by this way you can go to the field for preparing seedbed at least 4 times.

Now, if you can combine these, then you can finish in 2 times.

If you can combine plough with harrow or harrow with cultivator, you can prepare the seedbed in less number of times.

So, when you move to the field less number of times, obviously, your time requirement for preparing the seedbed will reduce, your fuel consumption will reduce, your cost of operation will reduce.

So, the thing is, where we can combine these operations? This is possible when the implements which we design are not properly matched to the tractor size, because you must have seen a farmer when he wants to purchase a tractor,

when he wants to purchase a tractor, he goes to the manufacturer or the retailer and then he will say, ok give me a 45 HP tractor or 50 HP tractor and then give me some implements.

So, they do not bother about matching

The tractor is able to develop more power, but the implement which the manufacturer has or the retailer has supplied is of less drawbar power requirement.

So, there is improper matching between what the tractor is able to do and what the implement is requiring. So, there is a loss of power.

So, you are consuming fuel, but you are not utilizing the power which is developed by the tractor.

So, in order to best utilize the tractor, we have to match the implements with the tractor power.

So, then question arises, why to combine two tillage? You can go for a larger cultivator or a larger moldboard plough. But thing is, if you are going for a larger cultivator, their working width will be increased and it will create problem during turning.

Ok, the operator will find difficulty in taking a turn.

So, he will loose some time there.

So, that 's why and our field sizes are small, you cannot accommodate bigger size or bigger width implements.

So, the possibilities or you cannot go at a faster speed.

The land sizes are small. So, we have to go for combining different tillage operations.

So, that you can get the benefit like a reduction in fuel consumption, reduction in time requirement for carrying out tillage.

So, with that concept, combined tillage operations, combined tillage implements have been developed.

So, I am showing one figure here.

In the front gang there is : in the front gang there will be cultivator and the rear side there will be a gang of single acting disk harrow.

So, this is called cultivator-disk harrow combined tillage implement.

So, I have given another name you can see passive-passive combined tillage implement.

I said passive-passive because both the gangs, both in the front and the rear, we have passive tillage implement that is why it is called passive-passive combined tillage implement.

Another example of passive-passive combined tillage implement is your moldboard-disk harrow.

In the front, there will be moldboard, at the back side there will be gang of disk harrow.

So, both are passive. So, that is why we call it passive-passive tillage implement.

Then we can have a passive-active tillage combined tillage implement.

In the front there will be a cultivator with 5 tynes and in the back side there will be rotavator.

So, this is called passive-active combination or combined tillage implement or you can call it rota-cultivator.

Cultivator in the front, which is the passive tillage implement and the back side there will be rotavator which is an active implement.

So, we call it passive-active combined tillage implement.

The other one is active-passive combined tillage implement.

In the front gang, there will be a gang of disk which is powered by taking power from the PTO and the rear gang is not powered. It is simply rotating because of the friction. This is called combined offset disk harrow.

Here, the front gang is powered, rear gang is not powered.

So, these are some of the examples of combined tillage implement.

The other way of classifying tillage implement is pull type implement. Whether a moldboard plough is a pull type implement? It could be a trailed type implement or it could be a mounted implement or it could be a semi mounted implement.

So, when I said pull type implement or trailed implement, it is one that is pulled and guided from the single hitch point and is never completely supported by the tractor.

Ok, the entire weight is supported on the ground. Tractor does not take any support.

The second one is mounted implement. It is one that is attached to the tractor through a hitch linkage in such a manner that it is completely supported by the tractor when it is in the raised position.

The linkage provides rotational stability about the longitudinal axis and it permits depth or height control by vertical support from the tractor.

So, you can hydraulically raise it or lower it. The entire weight is supported by the tractor during transport.

The third one is semi mounted implement. It is one that is attached to the tractor through a horizontal or nearly horizontal hinge axis and is partially supported by the tractor at least during transport.

But it is never completely supported by the tractor and the rear of the implement is guided by its own wheel that means, a wheel has to be provided to support.

The fourth category is self-propelled machine. It is one in which, the propelling power unit is an integral part of the implement.

When we are attaching an implement to the tractor, this is not a self-propelled machine.

The machine will have its own engine or power source, then you call it a self-propelled machine.

For example, vertical conveyor reaper. You do not have to attach it to a tractor, it has its own machine.

The machine could be a diesel, the engine could be a diesel one, it could be a petrol one.

So, that is called self-propelled machine.

The other way of classifying tillage implements is according to the power source.

If you are utilizing human power, then it is called human operated or hand operated tool.

If you are utilizing animal power, it is called animal drawn implement.

If you are utilizing tractor and power tiller, then these are called tractor or power tiller drawn implements.

Out of these three, the first one - now nowadays, the second one particularly nowadays are obsolete.

And due to shortage of labourers or working power, we cannot go for hand operated tools.

So, we basically use a power source like tractor and power tiller to carry out different operations.

So, these are different ways of classifying tillage implements.

Now, coming to moldboard plough, which is a primary tillage and it can also be called as passive tillage implement.

So, as I said, this is a three bottom moldboard plough. What are the components of a moldboard plough?

The major components are share, moldboard, landside and frog.

This together share, moldboard and landside, they are called plough bottom and they are attached to the frog. Share, moldoard, landside, all these three components are attached to the frog and we call it plough bottom.

Now if you look at the views, I have shown, one is the top view. The front one is the top view of a moldboard plough. The bottom one is the front side view you can say you can say side view of the moldboard plough.

So, there you can see, I have indicated the components very nicely. You can see there will be share. There is a moldboard and the landside.

Again share will have share point. This is the other end - is called share wing and from here to here, the cutting edge is called throat.

Then if you look at the side view, there will be shin and there will be gunnel.

These are parts of share and the landside you can see from the side. And the bottom of the landside is called heel.

So, these are the components of a moldboard plough.

Now coming to share, share what is the role of share?

It is the main bottom end of the plough. It cuts the underside of the furrow and slices it away from the land.

That means, the furrow slices which are cut that will be sliding over to the moldboard and the share is bolted to the front of the frog.

The main parts of the share as I said there is a share point, there is the wing and the gunnel.

Share point, it is the forward end of the cutting edge that actually penetrates into the soil.

It takes the greatest load. Because it is the first point or the first portion of the plough which will enter into the soil.

So, the greatest load is taken by the point of the share.

So, that is why it is provided from below with a gunnel which constitutes a material reserve in case of removing and resharpening, when it becomes dull.

Because it is coming in contact with the soil - that is there will be wear and tear.

So, to make the point sharpened, we have to have a gunnel to be reshaped.

Then wing of the share - is the outer end of the cutting edge of the share and it supports the plough bottom.

Gunnel is the vertical face of the share which slides along the furrow wall. It takes the side thrust of the soil and supports the plough bottom against the furrow wall.

So, these are the components of a share.

There are different types of shares available. It could be a slip share, slip nose share, shin share, bar share and barpoint share.

I will cover a little bit about this. What is a slip share and mostly the shares are made up of high carbon steel or cast iron.

And when I said slip share if you look at the figure, this is the slip share, is the common type of share, which is available in animal drawn ploughs.

Complete share is replaced once it is worn out, that means, use and throw kind of thing.

Then the slip nose share. If you look at, there is a small portion here in the front of the share, this portion is called nose.

The share point of such a share has a replaceable unit. Only the nose is replaced. You do not have to replace the entire share, and this is made up of cast iron.

Then shin share. It is also made up of cast iron. Shin share - if you look at this, this portion is called, this portion is called shin.

This is similar to slip share, but an extension is provided to fit by the side of the moldboard.

It reduces the wear of moldboard from its cutting edge.

The fourth one is your bar share. This is your bar share. You can see a bar here.

So, it is also made up of high carbon steel. It is provided with an extension on its gunnel side which acts as the landside of the plough bottom.

Then bar point share is high carbon steel - made up of high carbon steel.

In addition to the main share, a long steel bar is used. It is pushed forward when the point of the share wears out.

So, replacement of complete share is avoided that means, this bar once the point is worn out, you can push the bar forward that will act as the point.

So, these are different types of share.

Similarly moldboard - the function of a moldboard is to turn. First it lifts then turns and breaks the furrow slice that means, the inversion, pulverization are taking place in moldboard.

It receives the furrow slice from the share and moldboard has been designed in different shapes because the soil conditions are different. To suit different soil conditions for different crop requirements, the moldboards are of different shapes and we classify the moldboard into 5 types.

One is general purpose, the other one is stubble type, the third one is sod or breaker type, fourth one is slat type and fifth one is high speed type.

So, types of moldboard, I have given you the classification and the general purpose is: the moldboard is having a medium curvature and the slope of the surface is gradual.

It turns the furrow slice and pulverizes the soil thoroughly.

It has a fairly long moldboard with a face being slightly convex. Ok.

Now, stubble type - it is a short but broader moldboard with a relatively abrupt curvature which lifts, breaks and turns the furrow slice, is used in stubble soils.

It is used for ploughing in old ground where good pulverization is required.

Then sod or breaker type - it is used in grassy land, where it is desired to have complete inversion.

And a slat type - this is used in sticky soils, because if the soil will not flow then draft will increase there will be accumulation of soil.

So, to prevent that, the moldboard is not continuous. You can see gaps between two adjacent strips. So, the soil will fall through this gap.

So, that - this is a slat type.

Then high speed type. High speed bottoms are used with tractor drawn ploughs for general farm use.

It will have moderate inversion and pulverization.

The other important component is your landside, a component which slides against the furrow wall and transmits the lateral thrust of the plough bottom to the furrow wall.

It basically gives stability to the plough during operation.

The rear bottom end of the landside is known as heel which rubs against the furrow sole and the other component which is called frog.

This is a triangular piece of metal to which the other components of the plough bottom are attached.

Components means the share, the moldboard and the landside. They are attached to the frog.

It is made of mild steel and it is sturdy and usually it does not get damaged during any accident.

So, there are some plough accessories.

The basic purpose of providing plough accessories is to make the surface clean, so that the plough during operation should not clog.

If the land is grassy or the weeds are present, then we have to have this plough accessories.

Among the plough accessories, we can have colters, we can have jointers.

I have shown you colters of four varieties. We can say a plain colter, which is used in sod or relatively clean fields. The notched colter, where the edges are notched. This is used in heavy trash and the rippled edge colter which is used in grassy land and the concave or disk colter which is also used in grassy land.

Then jointer - this is a miniature plough.

Plough bottom you can say that is usually used in conjunction with a rolling colter and cuts a narrow shallow furrow ahead of the share.

So that, it reduces the work load, work load of the main plough bottom.

This is a complete picture of a moldboard plough fitted with jointer and colter.

Then one way and reversible plough which I have already discussed.

Then, there are two adjustments - important adjustments, which are to be kept in mind.

One is your vertical suction, the other one is horizontal suction.

They are required for proper penetration and efficient operation.

If a straight edge is placed under the point of the share and the landside there will be clearance which is indicated here.

So, that is called vertical clearance and if you look at the top view, if you put a straight edge, there will be clearance between point and landside, between the share where it joins to the landside that is a clearance, that clearance is called horizontal suction.

If the share wears out, then the clearances are very much reduced.

So, the functionality of the plough will reduce because it will not penetrate.

So, these two important adjustments, one has to take care of.

So, after a few hours of operation, we have to check whether these clearances are still there or not, if not you have to again reset the share point.

So, these are my references and the conclusion is I have discussed about tillage what are the classification of tillage and then what are the implements involved and to carry out tillage and classification of tillage and details of moldboard plough.

Thank you.