

Surface Mining Technology
Professor. Kaushik Dey
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Indian Institute of Technology, Kharagpur
Lecture No. 43
Excavation with Bucket Wheel Excavator – 3


Let me welcome you to the lecture number 43 of NPTEL Online Certification Course: Surface Mining Technology. This is the second lecture of excavation with bucket wheel excavator and in this lecture, we will discuss the operation of bucket wheel excavator, its method and pit layout.

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INTRODUCTION

✓ **LEARNING BACKGROUND:**

It is expected that the students taking this course lectures have a preliminary understanding about the surface mining technology. The basic knowledge of explosives, blasting, formation of earth crust, geology etc are already covered in the previous courses. It is expected that a student must have passed a course on basic geology, explosive and blasting etc.




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INTRODUCTION

✓ **Learning Objectives of This Course:**

- To know the different unit operations associated with surface mining.
- Methods of surface mining.
- Deployment of machineries in surface mining.
- Productivity analysis of surface mining.
- Safety and environmental control of surface mining operations.
- Special methods of surface mining.



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INTRODUCTION

✓ LEARNING OUTCOMES:

It is expected that the students taking this course lectures will be able to envisage the surface mining operation and its technological nitty-gritty. It is expected that a student will be able to design the drilling and blasting rounds for surface blasting, will be able to choose, deploy and design the mine machineries for a set production target. The desired safety and environmental requirements will also be addressed.



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INTRODUCTION

✓ LEARNING OUTCOMES:

The student will also have an overall idea about the special methods of surface mining including sea bed mining, dimensional stone mining, highwall mining etc. The students will also able to deliver the technological and managerial requirements to the special safety requirements like slope stability and sump management etc.

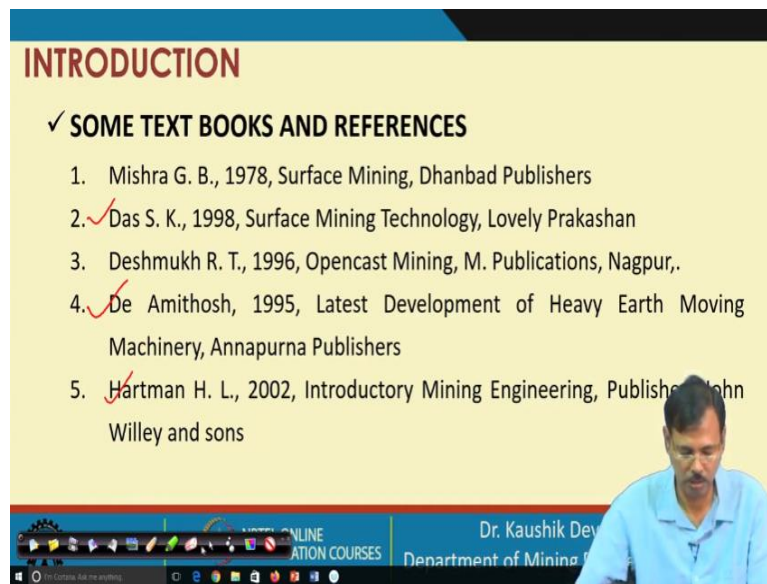


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So, as we do in every lecture, let us look once into the learning background required for the participant of surface mining technology course and the set learning objectives of the surface mining technology course. Expected learning outcomes from the participant of surface mining technology course.

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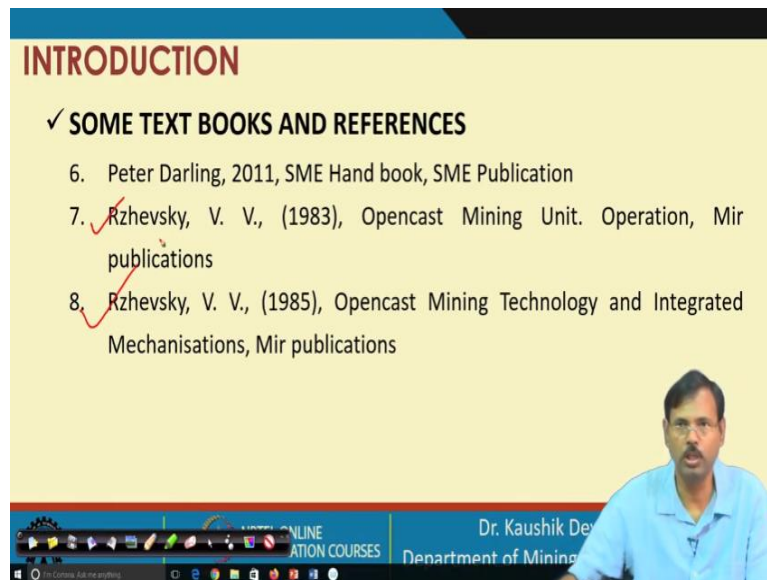
INTRODUCTION

✓ **SOME TEXT BOOKS AND REFERENCES**

1. Mishra G. B., 1978, Surface Mining, Dhanbad Publishers
2. ✓ Das S. K., 1998, Surface Mining Technology, Lovely Prakashan
3. Deshmukh R. T., 1996, Opencast Mining, M. Publications, Nagpur,.
4. ✓ De Amithosh, 1995, Latest Development of Heavy Earth Moving Machinery, Annapurna Publishers
5. ✓ Hartman H. L., 2002, Introductory Mining Engineering, Publisher John Wiley and sons

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INTRODUCTION

✓ **SOME TEXT BOOKS AND REFERENCES**

6. Peter Darling, 2011, SME Hand book, SME Publication
7. ✓ Rzhovsky, V. V., (1983), Opencast Mining Unit. Operation, Mir publications
8. ✓ Rzhovsky, V. V., (1985), Opencast Mining Technology and Integrated Mechanisations, Mir publications

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And these are some of the text books and references. It is expected that the participants will follow specially these books, and these books also particularly for this excavation of the bucket wheel excavator but in last class we have seen bucket wheel excavator is a very highly productive machine.

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INTRODUCTION

✓ Retrospect Previous Lectures:

In previous lectures, the phases of mining a deposit are discussed. The unit operations associated in every phase is also explained. The commencement of mining excavation through opening of box cut is discussed. The unit operation, Drilling technology is discussed. The different drilling procedures, drilling patterns required and machine operations are also discussed. Blasting technology was also discussed in details. Blast – free excavation system i.e. excavation by  is also discussed.



INTRODUCTION

✓ Learning Objectives of This Lecture:

- To understand the bucket wheel excavator and its operating procedure.
- To understand the method of mining and pit layouts with bucket wheel excavator.
- To understand the performance of bucket wheel excavator.



INTRODUCTION

✓ Retrospect Previous Lectures:

Apart from these, the excavation of fragmented rock with excavators like shovel and transportation of the same with dumper are also discussed. The excavation of rockmass using surface miner is also discussed. The direct casting of overburden material using Dragline is also discussed. Extraction of locked coal through Highwall mining is also discussed.



Before discussing this bucket wheel excavator, we have already covered the current status of surface mining, we have covered the phases of mining a deposit, we have covered the opening of surface mining through the box cut and we have covered the technology unit Operations like drilling, blasting, excavation by ripper, excavation by surface miner, fragmented material handling by excavators, with and transporting them with the transport system with special emphasize to the shovel dumper operations and we have covered the direct casting of the material using the drug line.

As well as we have covered the high wall mining system for mining of the locked coal under the high wall slope. We have said the learning objectives for the three lectures on the bucket wheel excavator are to understand the bucket wheel excavator and its operating procedure to understand the method of mining and pit layouts with bucket wheel excavator: this will be covered in this class, and to understand the performance of bucket will excavator, will be covered in the next class.

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BUCKET WHEEL EXCAVATOR (Inal, 1984)

Working method

- The working methods commonly adopted can be classified as
 - Face or front working
 - Full block working
 - Face block or side block working
- Each of these methods can make use of terrace cuts, dropping cuts, or a combination of both.

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So, let us look into the working methods. Basically, we are having different types of working method as the excavation is carried out generally, we have discussed surface mining is nothing but the excavation with horizontal slices and whenever we are taking this is already discussed to you, so surface mining is basically taking the horizontal slices. How we take this horizontal slices? For taking this horizontal slices, we cut the material like this.

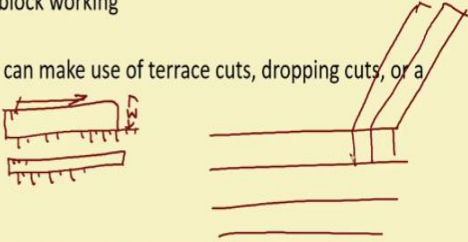
So, first we excavate like this then we take another slice like this so, then gradually it takes slices like this, so these are gradually removed, so this is basically horizontal slicing but whenever we are carrying out horizontal slicing.

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BUCKET WHEEL EXCAVATOR (Inal, 1984)

Working method

- The working methods commonly adopted can be classified as
 - Face or front working
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Along with that if this horizontal slicing we are thinking about in plan view, we are basically designing this along with this so where these are operating. So, these are basically the plan view so, we are taking this material as one block, so gradually as it is moving the new face is coming at this position, so we are also shifting this one, the new face is coming at this position.

So, this is the block width and these are the length of the block, so this is the block mining each slices, if we are considering this is another dimension, then this is the one block we are cutting, this is the next block we are cutting so gradually these blocks are taken out and this block mining is carried out. So, if the mining is carried out in blocks that is called full block working, sometimes side block workings are also carried out, sometimes front working is also carried out.

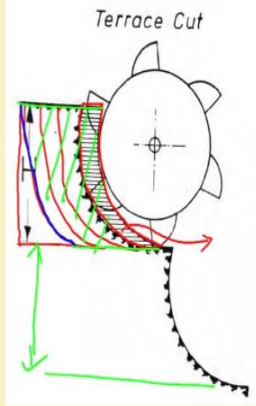
So, these are the different types of working procedure of the bucket wheel excavator and we can take out using the terrace cut and drop cut, terrace cut is basically cutting in the front direction, drop cut is basically cutting in the bottom direction. So, these are the two another type of working method possible with the Bucket Wheel Excavator.

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BUCKET WHEEL EXCAVATOR WORKING METHOD

Terrace cut

- When undertaking terrace cuts the buckets on the front side of the wheel do the cutting.



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So, let us look into them one by one, the terrace cut is basically cutting in the front direction, so a one bite one bite can be considered like this and the following bites will be like this and gradually the excavation is carried out in this form and this is the each bite: is basically excavated by the; once the complete rotation of the excavation is carried out.

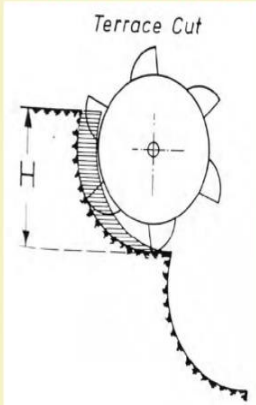
So, by this way up to H height, this much width is excavated and the new phase will generate at this position, so that this portion excavation from here to here is basically taken by the excavator. So, terrace cut is basically carried out with a particular bite height and the excavation is carried out in the front direction like this, so this is called terrace cut. So, one H is complete here the second H is taken here.

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BUCKET WHEEL EXCAVATOR WORKING METHOD

Terrace cut

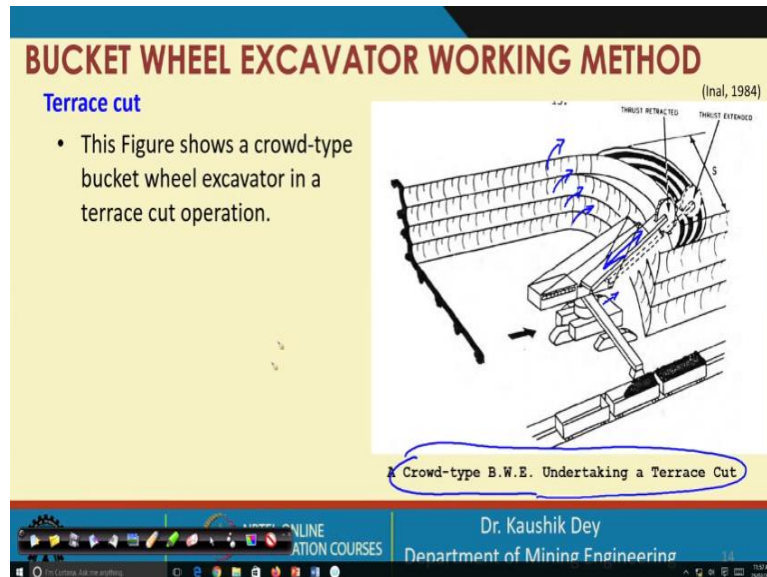
- When undertaking terrace cuts the buckets on the front side of the wheel do the cutting.



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So, if there is a complete face, this complete face may be excavated with a number of slices like this, so this is called Terrace cut.

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So, this is one figure of terrace cut you can see this is one terrace, second, third, fourth, the complete bench height is basically taken in four slice slices, with each slice a terrace cut height it is taken. So, this is called terrace cut and this is the front thrust provided, so the machine boom, the cutting boom is allowed to be forced in the front direction and it is often very beneficial if we are having a telescopic boom.

If the telescopic boom is not available then the machine has to move in front direction to give the thrust to cut in the front direction of the particular block. So, this is a crowd type bucket wheel excavator which is allowed to take the Terrace cut in the mine.

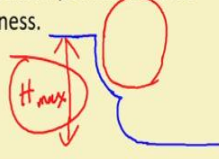
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BUCKET WHEEL EXCAVATOR WORKING METHOD

(Inal, 1984)

Terrace cut

- The block is excavated in a number of layers (terraces) of equal height, with between 40 and 70 per cent of the wheel diameter being actively involved in the cutting process, depending on the ratio of face height to diameter and the nature of the material excavated.
- At the start of the top terrace the wheel is in the retracted position, and at the end of each pass it is extended by the slice thickness.



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So, terrace cut is basically excavated in a number of layers of equal height in general between 40 to 70 percent of the wheel diameter actively involved in the cutting process and depending on the ratio of the phase side to the diameter and the nature of the material excavated. Terrace cut is preferred to start from the top, the benefit is that you can see the maximum bench height is utilized in the, if this is the machine and if we are having a machine which is having the maximum boom position at this, then we can have a terrace cut at this position.

And that is why the maximum bench height, this H, can be maximum if we are using this terrace cut method of excavation. So, that is the benefit of this one and in the top slices terrace cut is the best utilization of the boom height.

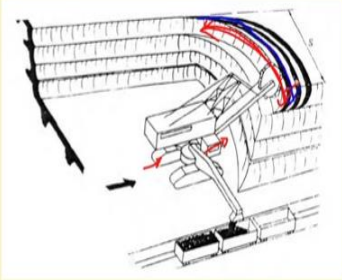
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BUCKET WHEEL EXCAVATOR WORKING METHOD

(Inal, 1984)

Terrace cut

- This shows a crowdless excavator. After each segment is finished the thickness of the next slice is set by moving the excavator forward by a distance equal to the slice thickness. The slice thickness varies across the face and depends on the angle of slew.



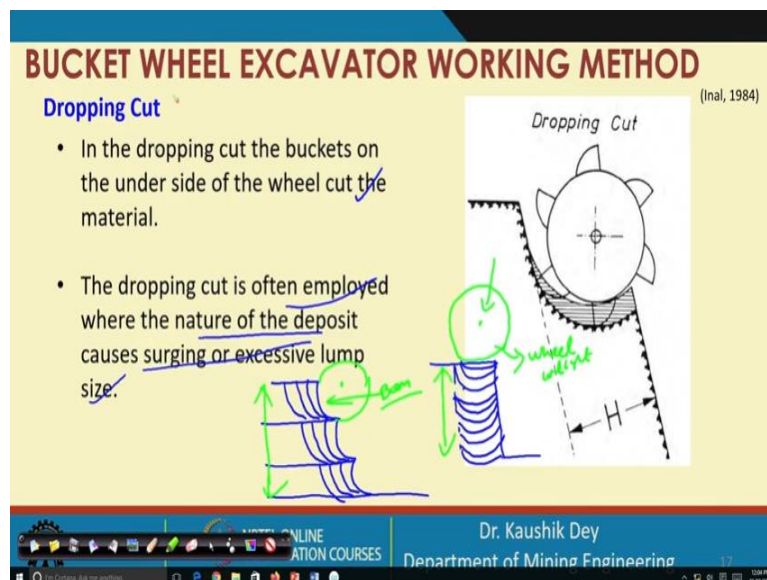
Crowdless-type B.W.E. in Terrace Cut

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So, earlier we have seen the crowded type bucket wheel excavator is having the facility to move its boom in the front direction because it is a telescopic type but if the bucket wheel excavator is crowdless, then it cannot move its bucket in this direction, instead it can rotate the bucket like this and by this way it can go for terracing the block and the machine has to move forward to take the front slice in the front direction.

So, that means in crowdless bucket wheel excavator this first width is taken this first slice is taken all along these, this first slice is taken then the machine move to the a little bit forward direction and the second slice will take at this position in the next turn. So, this is carried out specially for where we are having the crowdless type of bucket system in that case, this is the practice in general carried out using a crowdless bucket wheel excavator.

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Now next is drop cut, in drop cut the machine is allowed to cut in the bottom direction and that is why it is cutting a slice like this at this place so if we are comparing now two blocks side by side terrace and say this is three, so that means it will take each slice like this. The same one, when we are taking it using the drop cut, will be, so drop cut the buckets on the underside of the wheel, allow to cut the material, this is employed when the nature of the deposit causes the surge of exercise lump size.

So, in drop cut we are initially are positioning our bucket like this, whereas here we are positioning our bucket wheel like this, this is beneficial as the bucket wheel weight is providing a normal force, so that is the additional force we are obtaining and this is allowing the more normal force than the terrace cut.

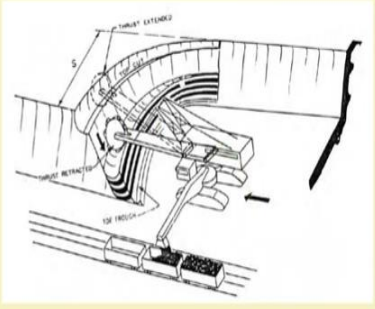
The Terrace cut, the force thrust, is given by crowding the boom or by movement of the crawler in this case, that movement is not required, or only dropping the bucket wheel on to the material is good enough to excavate this one, but here we are maximum utilizing the bench height here if this is the maximum height we can provide, then it is utilized here properly but here we have to have this bench height much lesser than the terrace cut involvement.

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BUCKET WHEEL EXCAVATOR WORKING METHOD (Inal, 1984)

Dropping Cut

- At the start of the block the wheel is lifted to a height sufficient to clear the face as shown in the Figure.
- The wheel is then set at the segment ends by lowering it an amount equal to the slice thickness and retracting the wheel to give the batter angle.



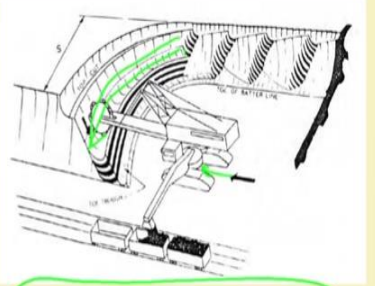
A Crowd-type B.W.E. in a Dropping Cut

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BUCKET WHEEL EXCAVATOR WORKING METHOD (Inal, 1984)

Dropping Cut

- Slewing to 90° is common, so that the front and side batter have the same slope.
- In the dropping cut the slice thickness remains constant but the segment slope height gradually decreases to zero at a slew angle of 90° .



A Crowdless-type B.W.E. in a Dropping Cut

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So, this is the drop cut figure with a crowd type bucket, so drop cut can be carried out, this is the possible layout possible layout with a crowd type bucket, excavator practicing drop cut, and this is for the crowdless type bucket will excavator practicing a drop cut only slewing

from this direction to this direction then it is moving and taking the next one. So, like that way it can operate using a drop cut in the practicing condition.


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BUCKET WHEEL EXCAVATOR WORKING METHOD

(Inal, 1984)

Dropping Cut

- When the wheel reaches the bench level a small toe ridge is left between it and the crawlers, which is often cleared by a bulldozer.
- Material handling on shiftable conveyors and the excavation of "hard digging" conditions are more efficient with the dropping cut, because it controls lump size better and allows the high speed conveyors to operate without the tendency to overload or clog the transfer points.



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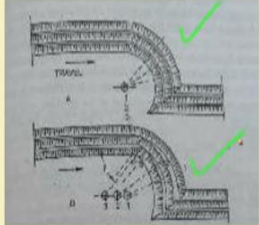
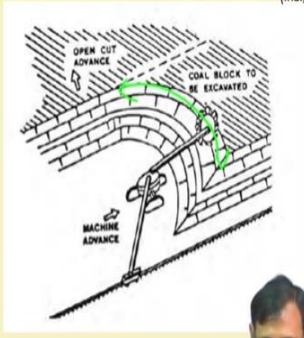
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SYSTEMS OF BUCKET WHEEL OPERATION

(Inal, 1984)


Full Block Working

- Full block working represents something close to the optimum operating method.



Block Working System of Bucket Wheel Excavator

P. TAVITI NAIKU et al., Performance and analysis of bucket wheel excavator in India
Volume: 07 Issue: 06, June 2020 www.ijget.net



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So, this is the more or less theory of the drop cut, if now we are looking at the other side when the full block method is practiced you can understand this is the block size, this is the layout of that one full block working system with bucket wheel excavator. If this is the block size, we are considering, this is the height of the block, a bucket fill is deployed like this, in that case the bucket will have to take the complete block width and this complete block width is taken by this bucket and that is why it is called full block method.

So, in full block method it can be carried out with, this is with the crowded type bucket wheel excavator, this is crowdless type bucket wheel excavator, these are the possible layouts with these systems and that can be practiced here.

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SYSTEMS OF BUCKET WHEEL OPERATION (Inal, 1984)

Full Block Working

- A full block is excavated in several bench cuts by raising, lowering and continuously slewing the bucket wheel, while at the same time the bucket wheel excavator is driven straight along the face length.
- The best results are obtained if the block is as wide as possible. The full block operation method can be undertaken by excavators of all sizes.

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So, this is the full block method, if we look into the details of this, a full block method is excavated in several benches cut by raising, lowering and continuously slewing the bucket while at the same time, the bucket wheel excavator is driven straight along the face length. So, if the block is kept as wide as possible then the better operation is possible in this case and this is also beneficial to use occasionally, when the shiftable belt conveyor has to move if we are using the larger block width the shifting of the shiftable belt conveyor can be reduced, a lot of the frequency of shifting can be reduced a lot with the more block width.

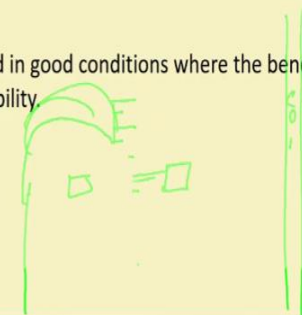
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SYSTEMS OF BUCKET WHEEL OPERATION

(Inal, 1984)

Face or Front Working

- In the face working method the excavator travels along the working face.
- Face working can only be applied in good conditions where the bench slope angle gives good slope stability.



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And in that case, it is expected that sometimes we can use a mobile transport conveyor or so for this. Bucket fill excavator can work from the front direction also that means, if we are drawing the layout like this and if we are having, this is our shift table conveyor, a bucket wheel excavator can initially operate to cut this portion and after cutting this this is creating an opening and in that case this is allowing a bench formation like this and it can move at this position to gradually cut the next slices like this position.

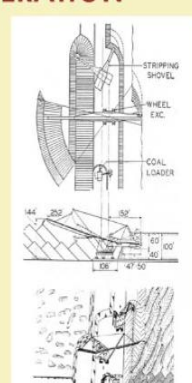
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SYSTEMS OF BUCKET WHEEL OPERATION

(Inal, 1984)

Face Block or Side Block Working

- Face block or side block working is the method most commonly adopted in the U.S.A. black coal mines, where a bucket wheel excavator operates in tandem with a shovel.
- The bucket wheel excavator removes the top layers and overcasts directly to the spoil pile.



Face or Side Block Working B.W.E., Used in Conjunction With a Shovel.

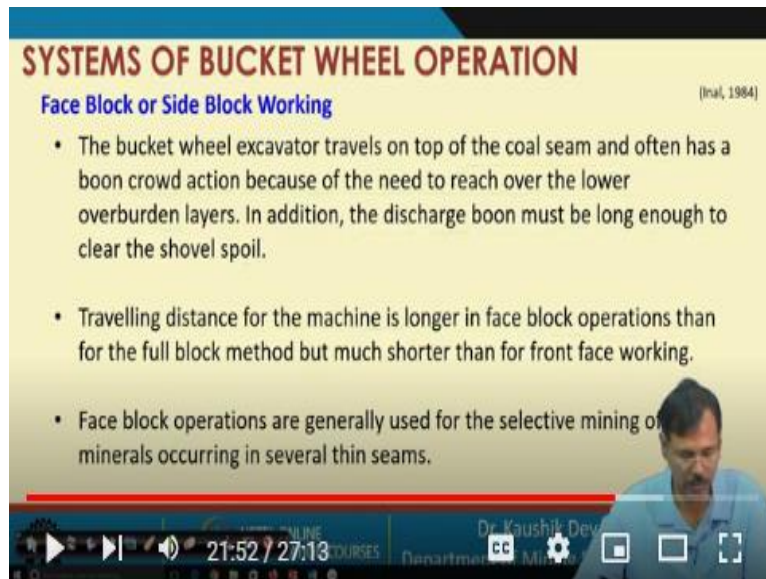
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SYSTEMS OF BUCKET WHEEL OPERATION

(Inal, 1984)

Face Block or Side Block Working

- The bucket wheel excavator travels on top of the coal seam and often has a boom crowd action because of the need to reach over the lower overburden layers. In addition, the discharge boom must be long enough to clear the shovel spoil.
- Travelling distance for the machine is longer in face block operations than for the full block method but much shorter than for front face working.
- Face block operations are generally used for the selective mining of minerals occurring in several thin seams.



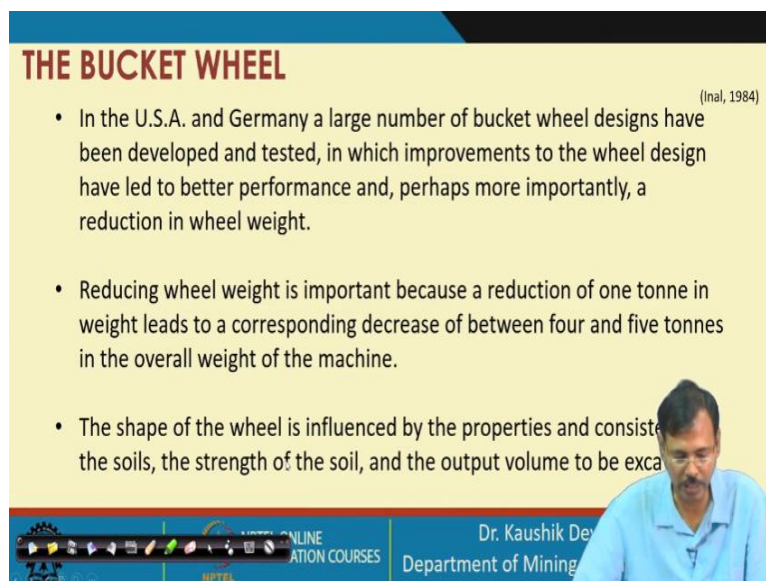
This is side block working layout. In side block working excavator travel on the top of the coal seam and often has a crowd action because it needs to reach over the lower overburden layer and in addition discharge boom must be long enough to clear the shovel spoil, travelling distance for the machine is longer in phase block operation than the full block operation.

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THE BUCKET WHEEL

(Inal, 1984)

- In the U.S.A. and Germany a large number of bucket wheel designs have been developed and tested, in which improvements to the wheel design have led to better performance and, perhaps more importantly, a reduction in wheel weight.
- Reducing wheel weight is important because a reduction of one tonne in weight leads to a corresponding decrease of between four and five tonnes in the overall weight of the machine.
- The shape of the wheel is influenced by the properties and consistency of the soils, the strength of the soil, and the output volume to be excavated.



So, this is one another method where the hub block or that type of operation is carried out where two weights are mentioned maintained in the bucket.

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THE BUCKET WHEEL (Inal, 1984)

- For these reasons, an optimum shape for each individual operating condition must be pursued as far as possible.
- The three most common wheel configurations are the cell, cell-less and semi-cell types.

Cell Type Wheel

- With the cell type wheel, the wheel continues into the appropriately shaped cell wall without a break.
- The individual cell walls are joined to the cone shell of the wheel boom where they are rounded.

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Now let us look into what are the possible different types of buckets available, we are having cell type bucket where each bucket is having a different cell and it can withstand the material a little bit so the safe cell is a wall available without a break and this self-cell can contain some of the material around it.

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THE BUCKET WHEEL (Inal, 1984)

Cell Type Wheel

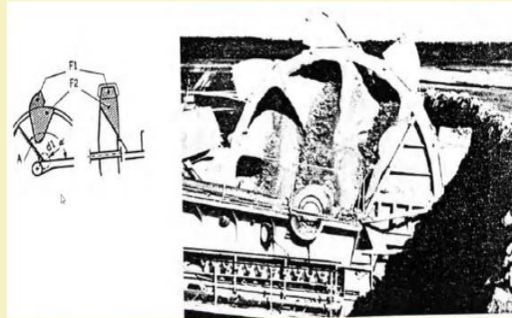
- The cell contours are mostly arranged at a tangent to the rotating axis of the wheel.
- The interior cell itself takes excavated materials to the point of transfer to the primary haulage system, i.e. next to the open-side of cell there are two vertical chutes down which the material is tipped and which prevents a lateral emptying of the material during the cutting and filling processes.
- A cell type wheel requires a longer wheel boom for deep excavation gives the best results, especially when operating in coarse and lumpy material. However, this design is not suitable for sticky material.

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THE BUCKET WHEEL

Cell Type Wheel

(Inal, 1984)



THE BUCKET WHEEL

Cell-less Type Wheel

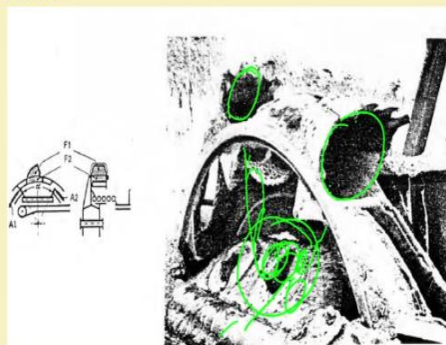
(Inal, 1984)

- In the cell-less type bucket wheel, there is only a short continuation of each bucket into the wheel body, and this increases the capacity of the buckets.
- The advantage of the cell-less wheel, compared to the cell type, is the very short distance covered by material in the buckets before it leaves the rotating ring space, and the almost free discharge.
- Thus a higher wheel speed and a consequently higher output can be achieved.

THE BUCKET WHEEL

Cell-less Type Wheel

(Inal, 1984)



Cellless-type Bucket Wheel

In cell type, this is a photograph of the cell type bucket and you can see the material can be taken in this if this is the cell type bucket, this is the bucket cell. So, this each cell contained its material and allowing that material to discharge into the conveyor like this ok, so this is another cell which is also allowing the material to coming here.

There are second one available which is a cell less bucket, so cell less bucket is only having the bucket teeth or bucket lips are there, so that is cutting the material, then the material is left inside the wheel and that is allowing its discharge automatically. If you see this is the cell less bucket you can see this cell less bucket basically cutting the material and after cutting this there is no cell, the material is transferred to the man inside the wheel and the from inside the wheel the material is then transferred to the conveyor.

So, all these buckets are basically sending this material in a cell less type inside the wheel and from there the material is transferred to the conveyor system. So, this is cell less type and as obviously we are having a cell type and cell less type.

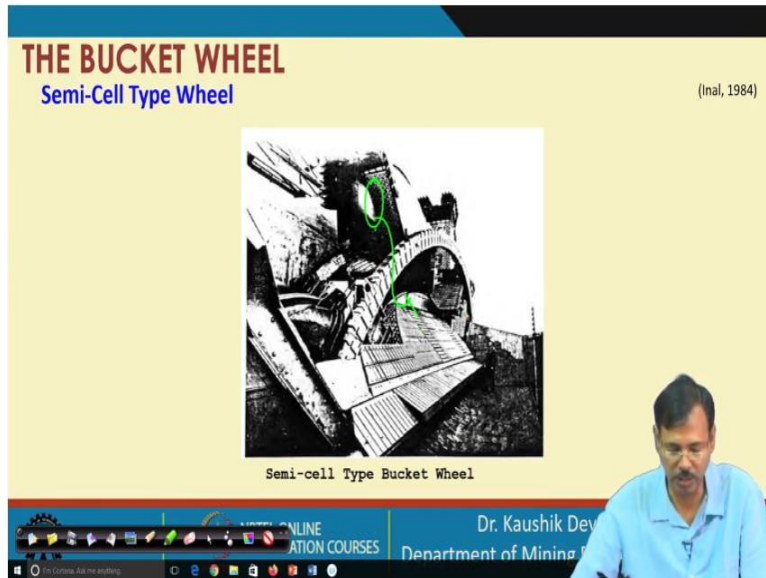
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THE BUCKET WHEEL
Semi-Cell Type Wheel (Inal, 1984)

- The semi-cell type wheel is a compromise between the cell type and the cell-less type wheel.
- The ring space is enlarged by a semi-cell, thus reducing the load pressure of material on the ring chute and also the wear on the ring chute.
- The buckets empty onto a slope sheet fitted in front of an extra large hub.
- Compared to the other two forms of the wheel design, the semi-cell wheel has the highest degree bucket fill, with the best emptying characteristics, even for sticky soils.

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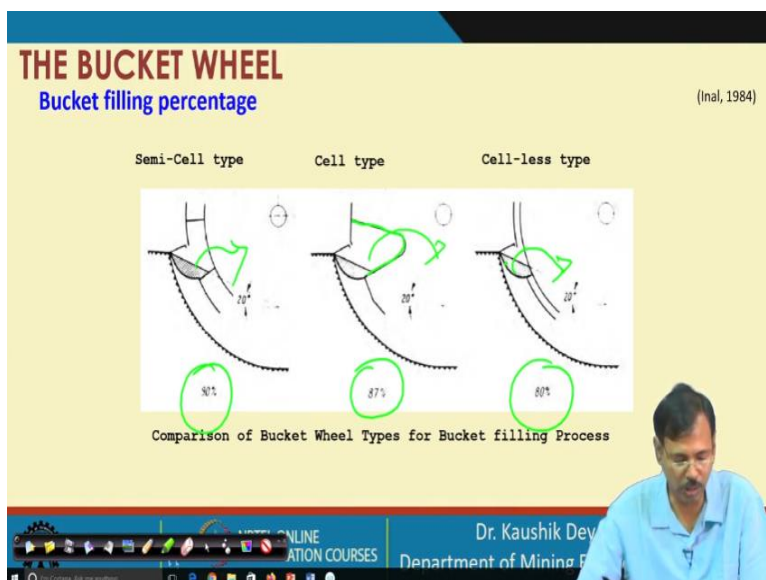
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There is an intermediate system which is called a half cell or semicell type wheel so there is a little bit cell wall is provided to guide the material so that it will not jump into the lower side of the wheel there will not be spillage from that side to avoid that one semi-cell type is provided in semi-cell type.

If we are looking into the figure in semi-cell type, the material is guided little bit and then after excavating there is a little bit guidance is provided at this position and from there, we are allowing the material to coming into the discharge and coming into the primary conveyor.

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Now, if we are looking in this way you can see this is the semi-cell type, a particular cell is provided here the full cell is provided and there is no cell provided at this so the material taken means, it is directly transferring into the wheel part here, it is retaining and then it is

transferred. And here it is guided only a little bit. So, in semicell type this is our filling percentage, this is in cell type and in cell less type our filling percentage is relatively very poor. So, that is why we have opted for either cell type or semicell type because that is having the better percentage of filling.

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SLEWING MECHANISM

(Inal, 1984)

- When a bucket wheel excavator is employed in a block cutting operation, the excavation process requires a continuous slewing of the superstructure.
- In full block operation, the slewing mechanism provides the necessary motion for cutting the sickle-shaped segments, ensuring a constant output. In face or front operations the travel mechanism is used for this task.
- The main slewing mechanism consists of two components, the slewing gear for rotating the superstructure and the turntable for transmitting the loads.

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SLEWING MECHANISM

(Inal, 1984)

- The slewing drives are needed not only to slew the superstructure during operation, but also to hold the superstructure during nonoperational periods.
- To achieve this, slewing gears are provided with an infinitely variable DC motor, and three brakes (wind, service and overload brakes).
- The slewing gear motor must be rated so that the superstructure can be slewed with certainty under any operational loads, such as inclination, wind, and a lateral force at the wheel circumference.

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Slewing mechanism is very important because it is providing the crowding action and that is why bucket wheel excavator for the block mining should have a suitable boom and that slewing mechanism provides the necessary motion for cutting the sickle shaped segments ensuring a constant output and the main slewing mechanism consist of two components: the slewing gear and the turntable, also transmitting the load and these are the details about the slewing systems.

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And let us stop at this position we will continue with the performance of the bucket wheel excavator in the next class.