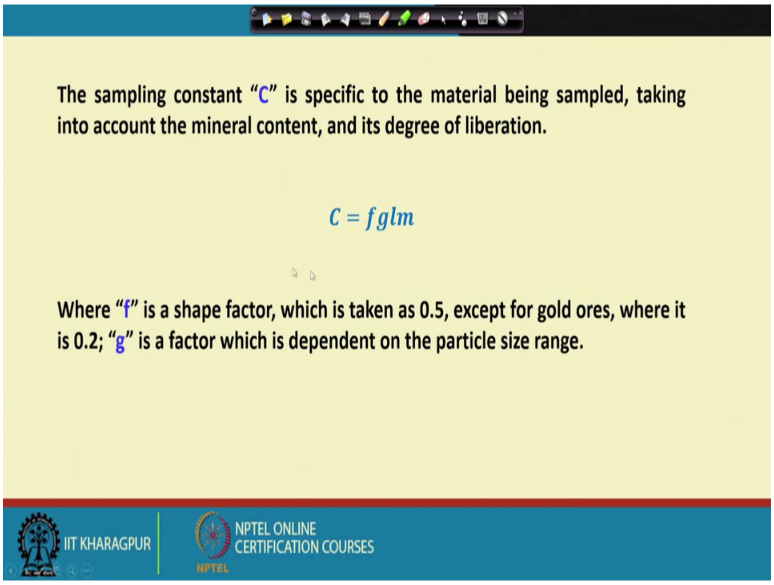
Introduction to Mineral Processing
Prof. Arun Kumar Majumder
Department of Mining Engineering
Indian Institute of Technology, Kharagpur

Lecture – 13
Sampling (Contd.)

Hello welcome back. So, we are discussing about Gy's equation. I have briefly explained you that, what is the meaning of that s and s square. Now how do we find the capital C?

(Refer Slide Time: 00:35)



The sampling constant "C" is specific to the material being sampled, taking into account the mineral content, and its degree of liberation.

$$C = fglm$$

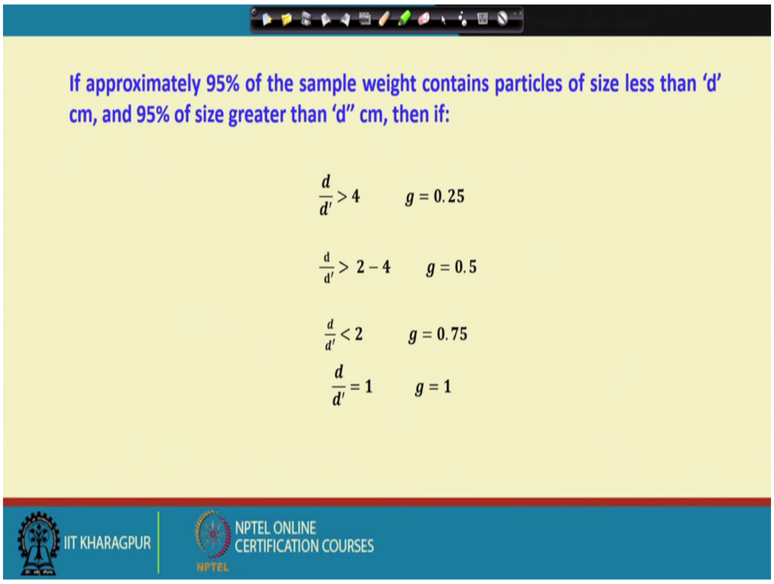
Where "f" is a shape factor, which is taken as 0.5, except for gold ores, where it is 0.2; "g" is a factor which is dependent on the particle size range.

That is a material specific constant. Now this is a specific to the material being sampled and it takes account takes into account the mineral content, and it is degree of liberation that is very, very important.

So, if my liberation choice is very fine. So, my amount of sample to be sampled will be different, than my coarser grain liberated particles. So, I should have some priori information before we go for sampling; that is, we should have some kind of your what is the liberation size of the it is material. There may be our colleagues from geology they can help us.

So, this capital C is equal to f g l m. These are all small. Where f is a shape factor; that means, what is the shape of this particle, which is normally taken as 0.5, except for gold ores where it is 0.2. And g is not the actual g what we are familiar with. That is your acceleration term. But here g is a factor which is dependent on the particle size range. So, here small g takes into account the particle size range from. What is the coarser size? What are the finest size of that deposit?

(Refer Slide Time: 02:23)



If approximately 95% of the sample weight contains particles of size less than ‘d’ cm, and 95% of size greater than ‘d’’ cm, then if:

$\frac{d}{d'} > 4$ $g = 0.25$

$\frac{d}{d'} > 2 - 4$ $g = 0.5$

$\frac{d}{d'} < 2$ $g = 0.75$

$\frac{d}{d'} = 1$ $g = 1$

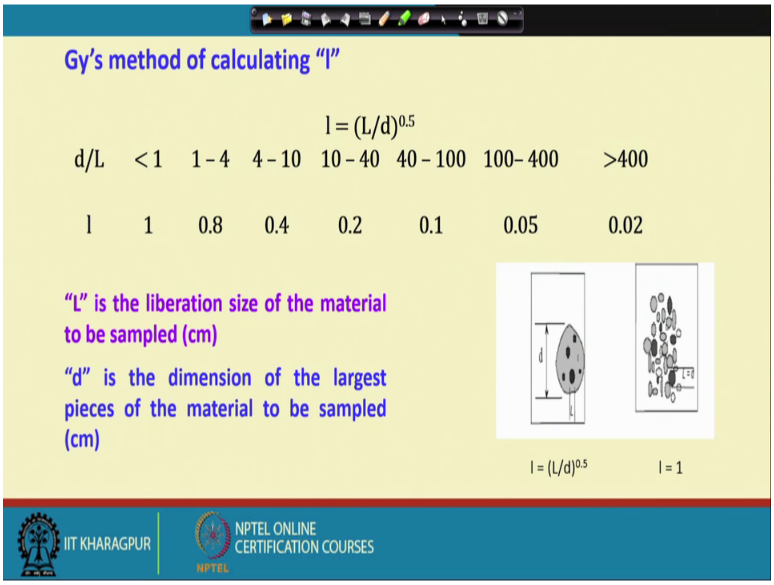
Now, there is a relationship that if approximately 95 percent of the sample weight contains particles of size less than d centimeter, and 95 percent of size greater than d dash centimeter; that means, if my the last week we have explained it that if my 95 percent passing size, or say if my 95 percent of the total population is finite that a particular size and is coarser than a particular size. So, suppose I have got a size distribution. So, 95 percent of my entire population is minor then maybe 1 meter. And 95 percent of my material is coarser than 100 micron or say 100 micrometer.

So, that d small d is basically one meter means thousand say 100 centimeter, and your 100 micron means, 100 micrometer means say your one micrometer means your 10 to the power 6 meter. So, you can say to 10 to the power minus 6 meter sorry. So, you can calculate it what is that.

So, there is a formula now, that if d by d dash that if the ratio off between the ratio between the largest and the smallest and largest I have defined, because it is very difficult to identify which one is the largest. So, we do sieve analysis and or maybe screen analysis, and we get to know what is the 95 percent passing size or 95 percent. Say, passing size of the 2 different sieves or the 2 extreme things.

So, the d by d dash is greater than 4; that means, if the race sure between the largest and the smallest size is greater than 4. Then g is 0.25 like that. If d by d dash is greater than 2 to 4, then it is g is equal to 0.5 if d by d dash is less than 2, as g is equal to 0.75 and d by d dash can theoretically be only 1; that means, all are of same size then is that d by d dash is equal to 1. So, in that case g is equal to 1.

(Refer Slide Time: 05:11)



Gy's method of calculating "l"

$$l = (L/d)^{0.5}$$

d/L	< 1	1 - 4	4 - 10	10 - 40	40 - 100	100- 400	>400
l	1	0.8	0.4	0.2	0.1	0.05	0.02

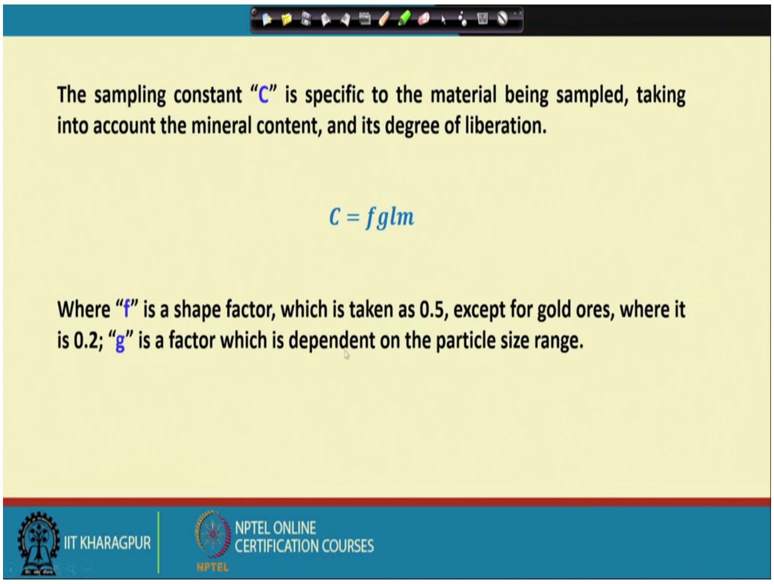
"L" is the liberation size of the material to be sampled (cm)

"d" is the dimension of the largest pieces of the material to be sampled (cm)

$l = (L/d)^{0.5}$ $l = 1$

Now, we said that is f g l m.

(Refer Slide Time: 05:25)



The sampling constant "C" is specific to the material being sampled, taking into account the mineral content, and its degree of liberation.

$$C = fglm$$

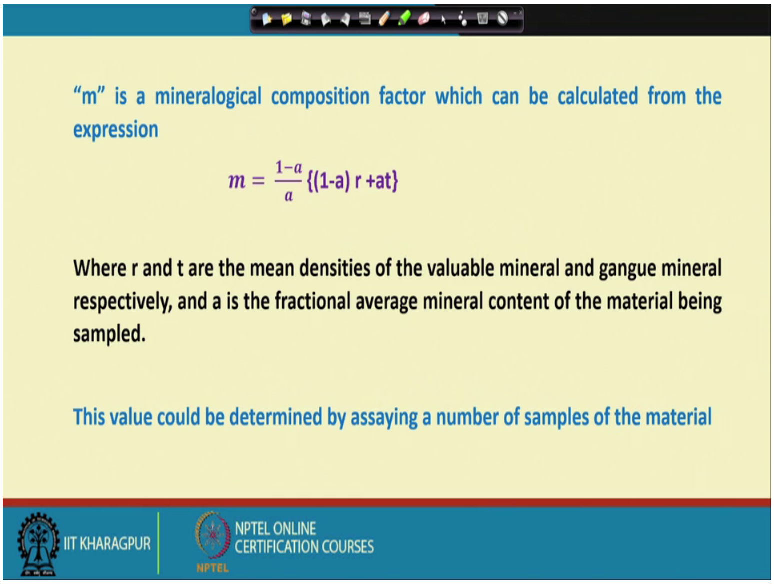
Where "f" is a shape factor, which is taken as 0.5, except for gold ores, where it is 0.2; "g" is a factor which is dependent on the particle size range.

So, we have said that there C, capital C is equal to f g l m. So, f is most of the cases it is 0.5, g we have got a set of conditions. And now look at the l. So, l is basically related to the your liberation size, or the meaning of that. Now suppose this is my entire rock sample, that is my average size of my material available into the deposit. And this is my wanted material, and that is the liberation size that is the denoted by say capital L.

So, the particle size is that d and this liberation size of my wanted material is l. So, that small l is equal to capital L by d to the power 0.5. And there are also correlations for that like that it is easily understandable, that if this ratio is less than 1, then l is equal to 1 and if this ratio goes on basically increasing; that means, if my entire rock is very big in relation to my liberation size, then it can go this value could be 0.02 also. So, like that. So, from this set of conditions, I can find out the value of l the small l, but the important criteria is that I should have the prior information of the liberation size.

Here in this case you see that this particle, interestingly here both l and d, suppose now if I suppose I have crossed it. And then I have liberated it. And then I am saying that what is the l by d. So, this is here l is equal to d. So, here I is equal to 1. L is equal to 1. M, so, we have defined that we have explained that how do we get f g and l, now where is the m? So, m is a mineralogical composition factor which can be calculated from the expression m is equal to 1 minus a divided by a in the bracket 1 minus ar plus at with this equation, where small r and t are the mean densities of the valuable mineral and gangue mineral respectively.

(Refer Slide Time: 07:45)



"m" is a mineralogical composition factor which can be calculated from the expression

$$m = \frac{1-a}{a}\{(1-a)\,r + at\}$$

Where r and t are the mean densities of the valuable mineral and gangue mineral respectively, and a is the fractional average mineral content of the material being sampled.

This value could be determined by assaying a number of samples of the material

IIT KHARAGPUR

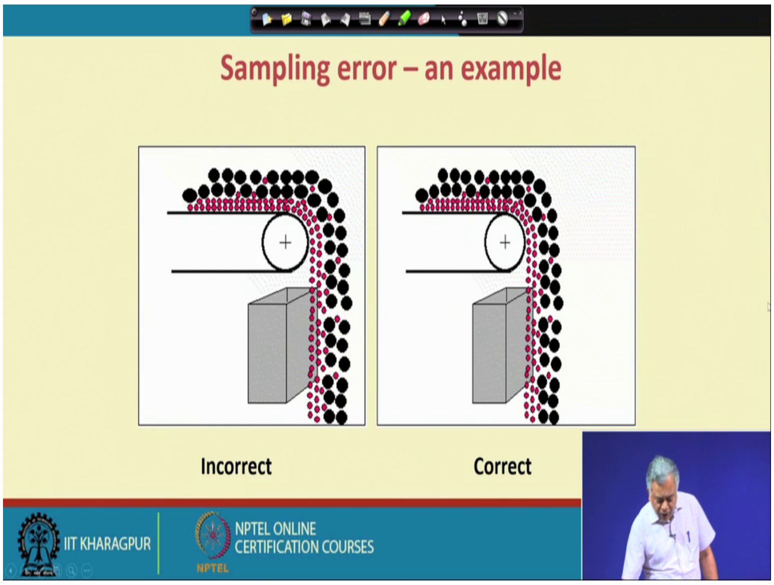
NPTEL ONLINE CERTIFICATION COURSES

I means what is the density of your wanted material, and what is the density of your gangue material. And a is the fractional average mineral content of the material being sampled; that means, what is the average mineral content of that material being sample. How do I know this value now this value could be determined by a saying a number of samples of the material; that means, when you are doing geological exploration, you have to do the analysis of that. And the more number of samples you take for analysis you get the better value of this a.

I will show you that now we are saying that how much of sample we should get. And for that also even I have to know, that what is the your average as a content what is the mineralogical composition, what is the largest particle size what is the smallest particle size and so on.

So, we adapt some sampling technique. What are the common mistakes as I said that these days you can rely your analysis, but still I think the how to take out the sample that is most neglected, subject in entire mineral processing industries across the globe. One common error that is what I will try to show you through this animation.

(Refer Slide Time: 10:03)

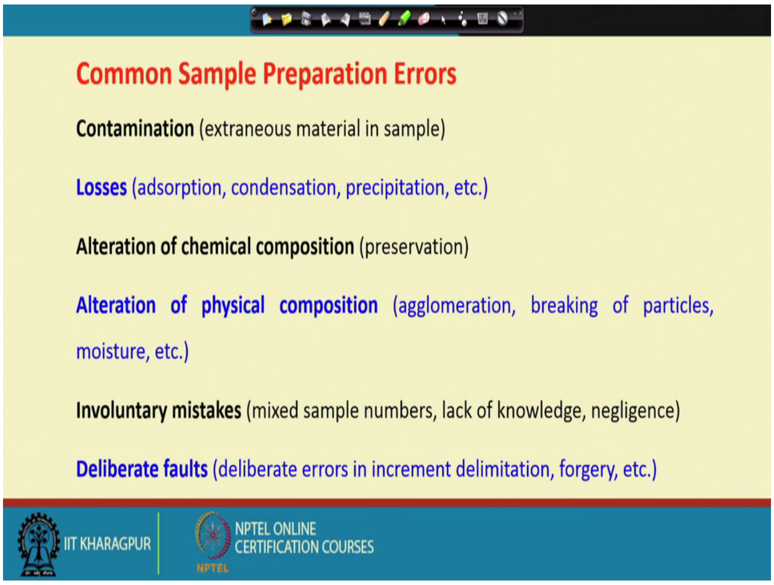


Sampling error – an example

It is not so, for some reason it is not working. So, here it was showing that this container was moving up to this and coming back. But that is incorrect. Because what is happening if it goes up to this and then comes back, so that means, you are collecting more of these rate particles. But it is the entire population it is coming from the conveyor belt and that is your red and black particles you want to know that how much of red particle is there or how much of black particle is there, and then what are their relative sizes and all these. And you see that how we can induce bias towards the red particle if the container if the cutter or the sampling system ever just stops here and comes back, because you are giving more residence type or these red particles to be collected.

So, you are inducing a bias towards the red particles, but here that is the correct sampling that it should go out from the entire stream and then comes back so that you are giving equal opportunity of the black and red colored particle to be collected at the same rate. So, that is one example that how you can induce bias, and how you can overcome the biases in during the sample collection steps.

(Refer Slide Time: 11:59)



Common Sample Preparation Errors

Contamination (extraneous material in sample)

Losses (adsorption, condensation, precipitation, etc.)

Alteration of chemical composition (preservation)

Alteration of physical composition (agglomeration, breaking of particles, moisture, etc.)

Involuntary mistakes (mixed sample numbers, lack of knowledge, negligence)

Deliberate faults (deliberate errors in increment delimitation, forgery, etc.)

What are the common sample preparation errors? Before you analyze as I said at the beginning that that there may be a lot of delay in between your collection of samples and you are when you are basically doing the sa analysis or say size analysis or something else.

So, it is very common that there is a chances of there is the chances of contamination. Suppose I have collected a sample from a mine site 10 days back, and I have brought it to my laboratory for analysis, but I have left it in the open atmosphere. So, it may pick away it may pick up extraneous materials, which may contaminate my sample. So, when I am analyzing I might see that there is late, and then I may start saying that look you will be going to mind this sample, but there is late. A late is very harmful.

But that late has not come from your mind sample it has been basically say contaminated by some other sources. Then there could be losses like your absorption condensation precipitation, like I want to do moisture analysis of that, and if I have not taken precautions if I am giving it in open atmosphere. And so, suppose the atmosphere is humid then it might give me more moisture, then what exactly what exactly it was having.

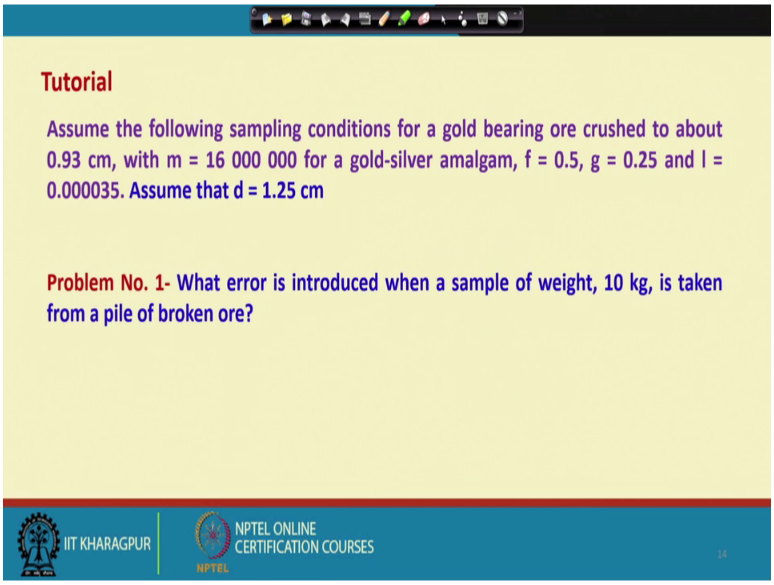
If it is a summer then my moisture may get start evaporating out. So, my actual moisture analysis, or my actual moisture contained in the sample is different than what I will be analyzing, then alteration of chemical composition many times my sample may start getting oxidized. Because if I have not taken precaution because of the your since a good example again is the pine coal. They will leave it just open it may start getting oxidized.

So, I may get different ages. So, you must preserve the sample. Alteration of physical composition like I want to do size analysis of that, but because of the handling and transportation they may and if they are basically the very same brittles specimen. So, I may get a different size distribution, when I will be analyzing then actually what it was collected. Then it for verifying particles there is a chance of that particle may start getting agglomerated, if it is exposed to moisture, because moisture acts like a binder.

Then many cases it is involuntary mistakes, makes sample numbers. Because we may be collecting 200 different samples and my sample tags for identifying that this sample I have collected from that location. But if they are basically miss say actually misplaced or say actually if they are basically wrongly done that is I that sample number 1 the description what I am thinking that is that level has gone to the sample number 10. So, that my entire reporting of data will be erroneous many times when we are under pressure of producing data and all this there are chances of deliberate ports. Like, we want to I think I do not have to explain that more, and I would strongly advise everyone that please do not get into this.

So, let us solve one small problem. I wanted to show that how do I use the Gy's equation. And first simplifying the problem I have given the values of most of the factors.

(Refer Slide Time: 16:41)



Tutorial

Assume the following sampling conditions for a gold bearing ore crushed to about 0.93 cm, with m = 16 000 000 for a gold-silver amalgam, f = 0.5, g = 0.25 and l = 0.000035. Assume that d = 1.25 cm

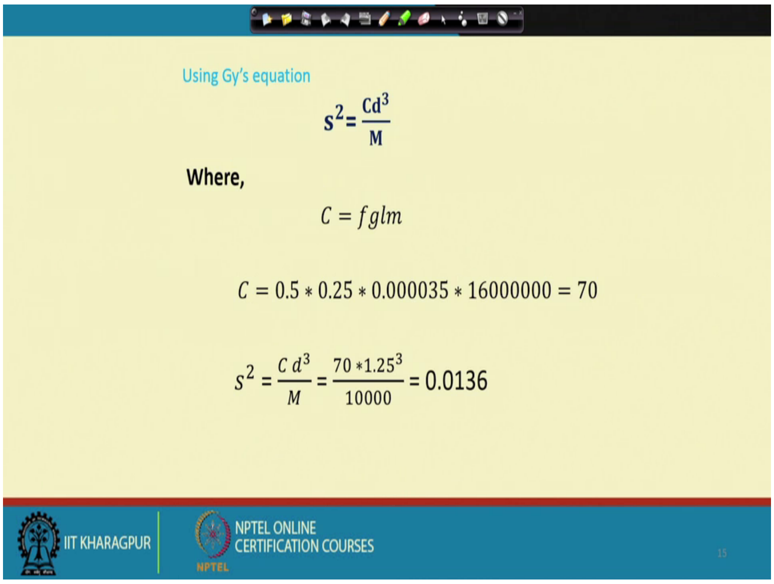
Problem No. 1- What error is introduced when a sample of weight, 10 kg, is taken from a pile of broken ore?

The problem is assume the following sampling conditions for a gold bearing ore cross to about 0.93 centimeter. So, I have used a crosser which is supposed to cross all the material below 0.93 centimeter. But actually, you may have some oversized particles. With m that m value I have given is 16 into 10 to the power 6, for a gold silver amalgam. F is 0.5, g is equal to 0.25 at l is equal to 0.000035. Assume that the size of the largest pieces of that particle is 1.25 centimeter.

So, problem number one is given the data. What error is introduced, when a sample of weight 10 kg is taken from a pile of broken ore. Suppose if I collect a 10 kg of sample, how much is the error introduced? Because many times we have to compromise, that how much of material we should collect because more materials we want to collect more cost you will be requiring.

But I must know that with this amount of sample how much is the error. So, what I have to do?

(Refer Slide Time: 18:17)



Using Gy's equation

$$s^2 = \frac{Cd^3}{M}$$

Where,

$$C = fglm$$

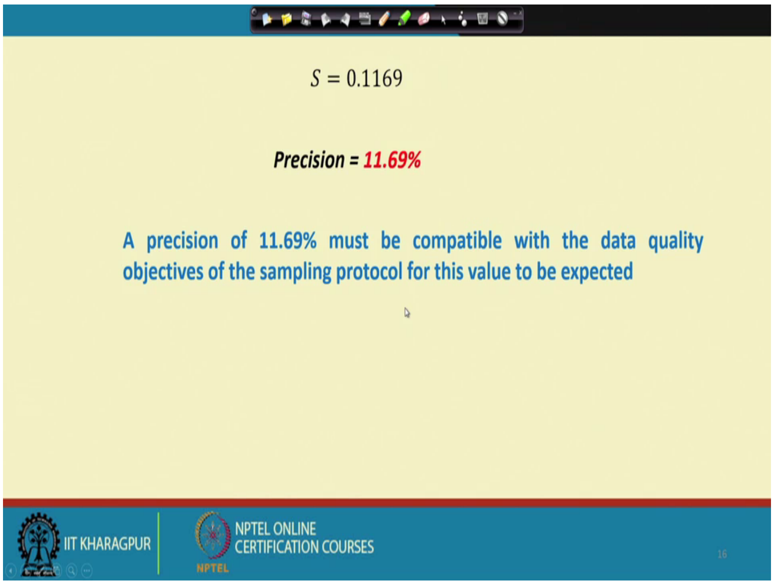
$$C = 0.5 * 0.25 * 0.000035 * 16000000 = 70$$

$$s^2 = \frac{C\,d^3}{M} = \frac{70 * 1.25^3}{10000} = 0.0136$$

If I use Gy's equation, you remember that M is equal to Cd cube by s squared. So now, here we want to find out the value of s, that what is the error? Because s square is the sum of square errors. So, let us find out first s square by putting the values. And we also know that c is equal to f g l m. So, what is the value of C? Capital C, now if I put the value of capital C, that is f is it is given f is 0.5 g is 0.25 l is equal to 0.000035, and m is 16 into 10 to the power 6, which will give you a value of 70.

So, what is the a square? A square is equal to Cd q by m, and d is the largest size of the particle I said that this is 1.25 centimeter. So, it is 70 into 1.25 cube divided by m is I say 10 kg. So, 10 kg you have to take it into gram. So, it is 10,000. So, that is giving you 0.0136. So, what I have to do now?

(Refer Slide Time: 20:04)



$S = 0.1169$

Precision = 11.69%

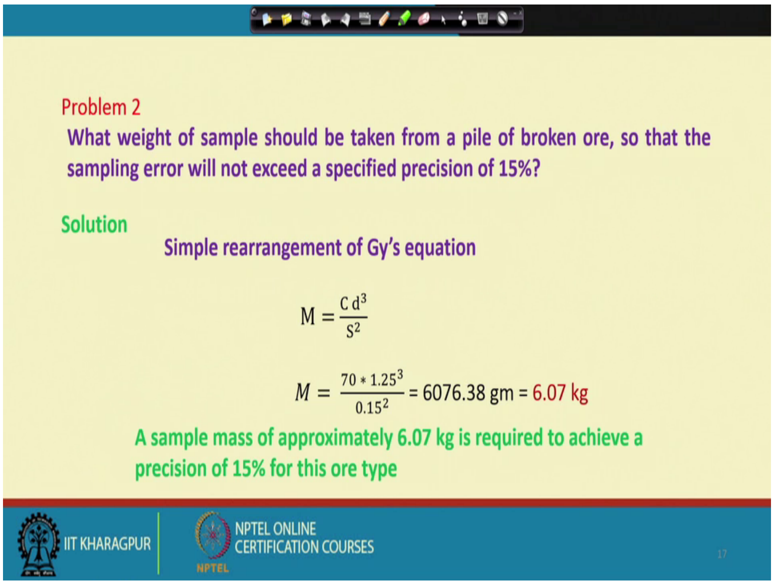
A precision of 11.69% must be compatible with the data quality objectives of the sampling protocol for this value to be expected

I have to find out the s, that is square root of that value. So, that will give you a value of 0.0069. So, that means, precision is 11.69 percent; that means, my average value the main value will have a deviation of plus minus 11.69 percent. So, a precision of 11.69 percent must be compatible with the data quality objectives of the sampling protocol for this value to be expected.

Now, question comes whether you are happy with this 11.69 percent; that means, if your sa analysis is pi ppm, and your when you do the exact analysis, that value may be 5 percent plus or minus 11.69 percent of plus or 5 percent. Whether you accept that a value or not? That is your prerogative.

Now, if I want to minimize this. I said that no I am not happy with the 11.69. I need 5 percent precision. So, then you have to redo their calculation, and that is what I have the next problem based on those data are giving that, suppose I say 11.69 percent is 2 less maybe I can have up to 15 percent, I am happy with up to 15 percent.

(Refer Slide Time: 21:45)



Problem 2

What weight of sample should be taken from a pile of broken ore, so that the sampling error will not exceed a specified precision of 15%?

Solution

Simple rearrangement of Gy's equation

$$M = \frac{C\,d^3}{s^2}$$

$$M = \frac{70 * 1.25^3}{0.15^2} = 6076.38 \text{ gm} = 6.07 \text{ kg}$$

A sample mass of approximately 6.07 kg is required to achieve a precision of 15% for this ore type

So, that is why I have given this problem that what weight of samples should be taken from a pile of broken ore.

So, that the sampling error will not exceed a specified precision of 15 percent; that means, so, what will happen? Naturally that with 10 kilogram of samples you are getting an error of 11.69 percent. Now I am just trying to evaluate that 10 kg is too much. Can I reduce this weight. So, you have to increase your precision value. I say, that up to 15 percent is acceptable. Let me see that what are the reduction in the weight.

So, here what I have to do I have to rearrange, that that M is equal to Cd q by s square that is the original equation. Now if I put the value of C, C is 70 we have already calculated. D we know 1.25 centimeter, that is 1.25 to the per cube. Now in this case is s square is equal to 0.15 because this is in percentage. So, 0.15 square. So, that will give you a sample weight of 6.07 kg.

So, this is a good example of telling you showing you that if you reduce the quantity of your material to be collected from the lord; that is, for original population. You can do that provided you are prepared to compromise with the precision level.

Similarly, you can practice it, that if I want 5 percent precision, what will be the additional sample weight I require? So, that means, if I want 5 percent position the minimum weight to be collected should be more than 10 kilograms. So, a sample mass of approximately 6.07 kg is required to achieve a precision of 15 percent of this ore type. Similarly, if I want a lower level of precision I have to increased the sample weight, and I have to use this Gy's equation.

Now you see that Gy's equation, I can apply it for knowing that what is the minimum sample weight I should have based on the my the various characteristics of my deposit. Starting from the liberation size, your size distribution, even the densities of your wanted material and gangue and everything, but what it does not tell us that how the material how the that 10 kilogram or 6-kilogram samples what I am suggesting, that how it should be collected? It is only telling that how much we should collect, but it is not telling that how it should be collected.

So, in my next lecture, I will try to show you that how the samples are being collected in actual operations. And before you collect the sample what are the planning is required. Because planning is very important for this sampling campaign we call it sampling campaign. So, how you plan ahead, and what are the ways you can collect the representative samples from a plant from a mine site from a say stockpile, and what are the common mistakes we do while collecting these samples.

And that will probably help some of the industry people to rectify their sampling related issues. And even the students will be joining the industries in due course of time. If they have this prior knowledge in sampling, I think in most of the processing industry most of the other industries also; the sampling is a very, very important issue.

Thank you very much.