Dust, Water, and Coal…the Good News and The Bad News

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Table of Contents

1. Abstract

Dust has been an area of concern since coal was first transported. The thermal penalty, the heat needed to evaporate water, has been an area of concern since coal was first burned as a source of energy. These two concerns must be balanced in any coal handling operation.

This paper addresses some of the facts and assumptions regarding the use of water as a dust suppressant. To achieve effective dust control, water must be increased, however when moisture content is increased, so is thermal penalty. This paper discusses how to find the point where the material lost as dust is equal to the material lost to thermal penalty.

This assessment was conducted by calculating the water required to prevent the production of dust in a material stream, and then calculating the thermal penalty of that water. The results were then compared and balanced on the basis of percent moisture in a material stream. The testing was conducted in a laboratory setting and verified against actual field conditions.

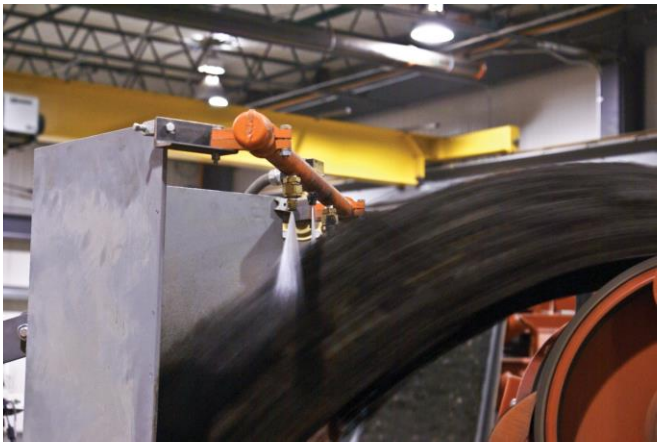
By the conclusion of this paper, the reader will have a better understanding of the quantifiable impact of water on coal in the areas of dust prevention and the thermal penalty associated with that water. The reader will also be exposed to the methodology for balancing these factors.

2. Introduction

Every facility transporting dry bulk solids must deal with dust in some way. In asking the question “how do I deal with my dust,” a facility will encounter many possible technologies and solutions. Many of these solutions involve the addition of water in one form or another. This leads to the next question, “How much water, if any, should I add?” This paper will address the approach used to answer this question.

3. The facts about moisture content

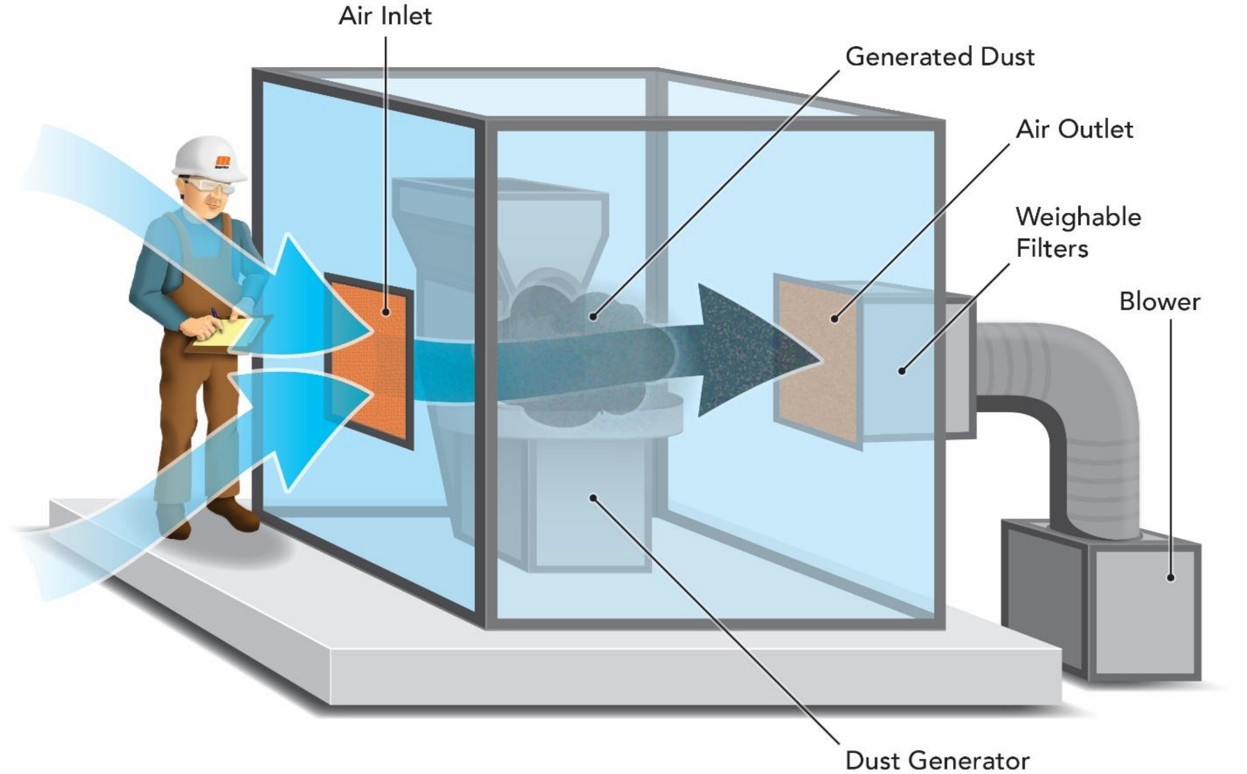
The simplest way to eliminate the creation of dust is to add water to the material stream. If the material is damp, it cannot create dust because the dust particles are “stuck” to the larger particles with water. The sand and gravel industry has utilized this method to eliminate dust for many years.



The unknown item was always the amount of water required to stop the dust from being generated. This amount of water required is based on the material properties and varies from application to application. Martin Engineering developed a test apparatus and procedure to determine the effect of moisture on potential created dust.

4. The test

The test setup consists of a vibratory feeder dropping material a known height into a spinning hopper. When the material falls, it creates dust. This dust is contained under a large, airtight Plexiglas hood. Attached to this hood is a vacuum blower to pull all the air and dust from inside the enclosure through a 3 micron filter. Filtered outside air is let into the enclosure to create a flow.



The blower and openings are sized large enough to capture all of the dust before it has a chance to settle, but not so large as to actually interfere with the material stream.

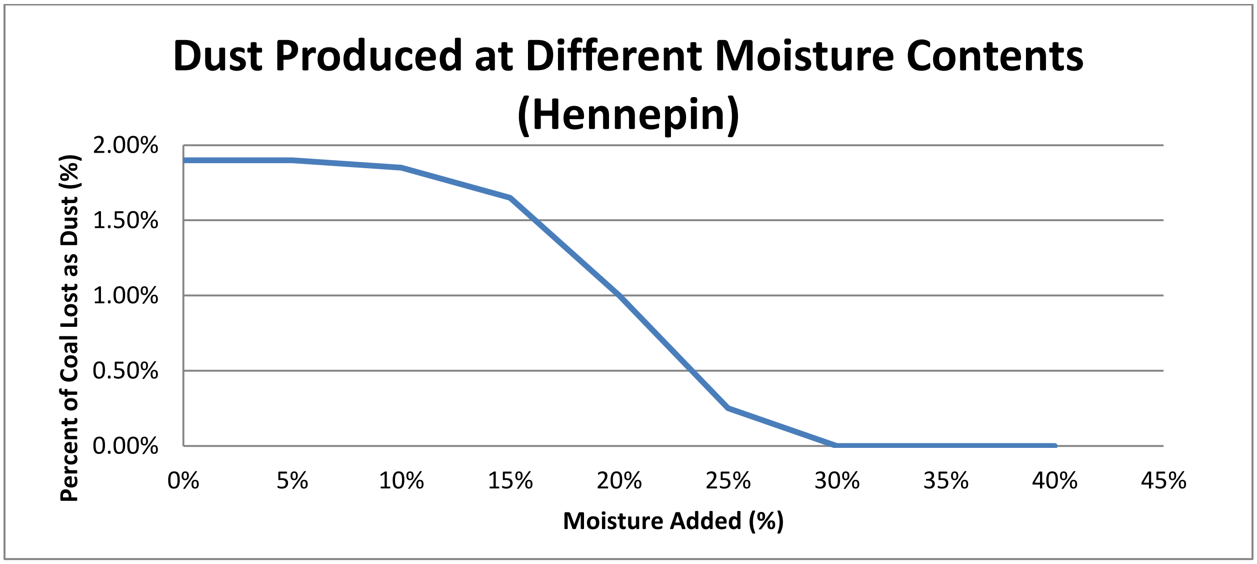
Since all of the airborne dust is pulled through the filter, the filter element is weighed before and after the test to determine the actual dust generated. This is then used to find the percentage of dust created out of the entire mass of the sample.

On November 11, 2010, a 5 gallon (0.018 m^3) sample was taken from the coal stream at the Hennepin Power Station. This facility uses Powder River Basin Coal. The entire sample was weighed, dried, and weighed again to determine the as-received moisture content. The sample was then mixed to guarantee uniform consistency and then broken into several test samples of approximately 1 gallon (3785 cm^3). These samples were combined with water to produce varying moisture contents. They were each blended in an identical fashion to guarantee uniform water distribution.

Each sample was weighed and placed into the dust chamber. The material was agitated and dust was created and captured. The amount of dust captured in the filter was weighed. The airflow, feed rate, and drop height were held constant between tests.

5. The results

The following percentages were measured.



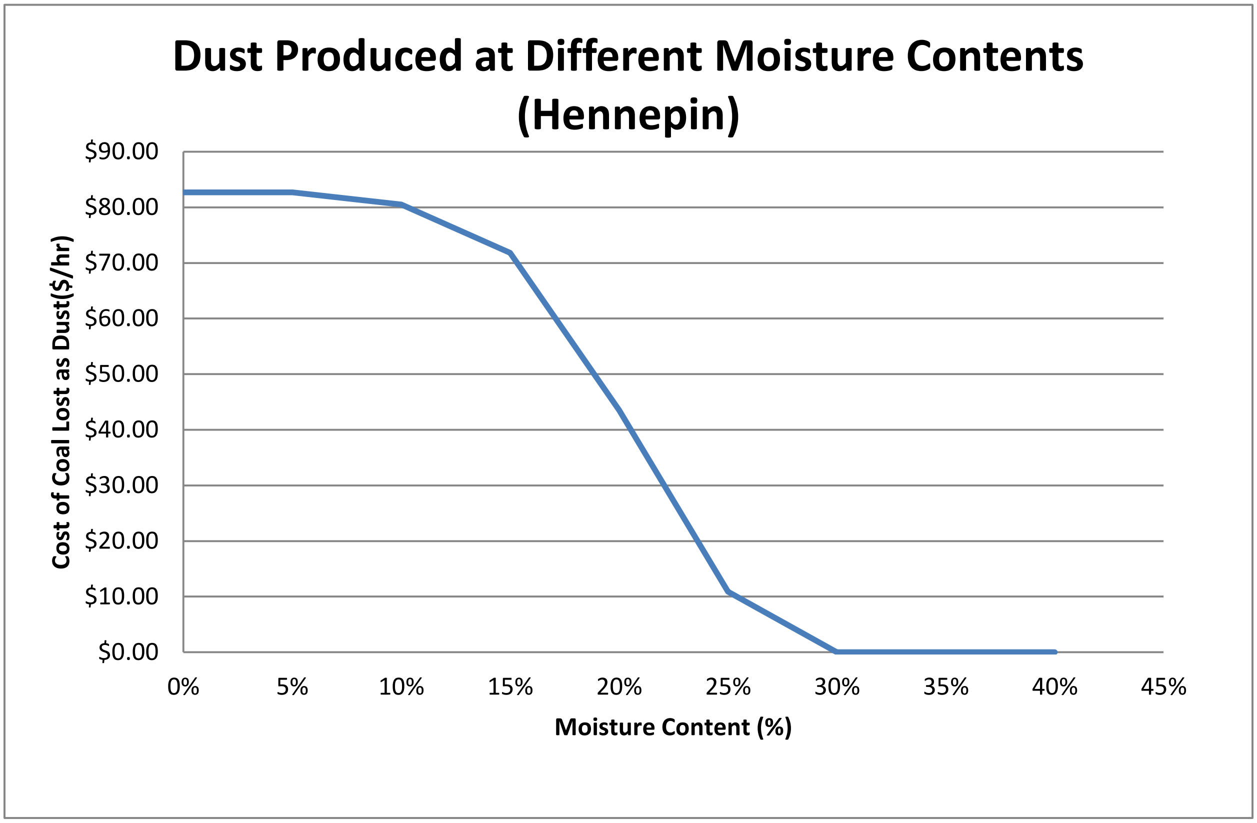
Several things can be taken from this graph.

1. There is a point below which adding water has no effect. In this case, that point is between 10% and 15% moisture content.

2. There is a point where the material is saturated and dust is not produced. In this case, this point is around 30% moisture content. Adding water beyond this point has no effect.

Ideally, water should be added to produce a moisture content that is near or slightly more than the saturation point.

This percentage can be converted to an actual expense by simply multiplying by capacity and then multiplying by cost per ton. This can give a facility some scale as to how much their dust problem is costing them. This facility uses 320 TPH and the price per ton is $13.60. The actual cost of this dust is shown below.



This graph shows that if this facility were to eliminate their dust entirely, they would save ~$80 per hour in lost material.

It is of note that the as-received moisture content of this sample was 37.37%. That is well beyond the saturation point, and should not have been able to produce dust. This correlated to reality in the fact that, at the point in the process where this sample was taken, dust was not a concern.

6. The facts about thermal penalty

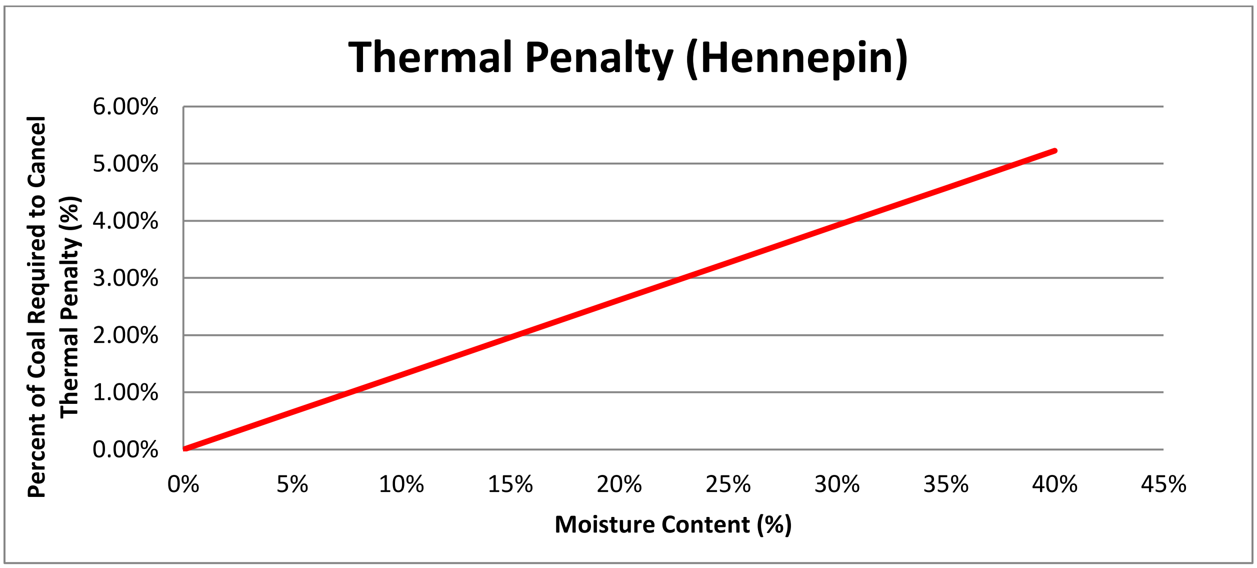
The addition of water to material has always created difficulties. Every industry has different consequences of additional water. The sand and gravel industry has to transport and process the water in addition to the material. In addition to transport, the coal industry must compensate for the phenomenon of thermal penalty.

Thermal penalty is the fact that additional coal is required to "burn off" entrained water in coal. If additional coal is required to evaporate the entrained water, the overall efficiency of the facility is decreased.

The method used to calculate thermal penalty is shown on page 320-321 of Foundations™ Fourth Edition [1]. For these calculations, PRB coal with 8800 BTU/lb energy content was used.

Results

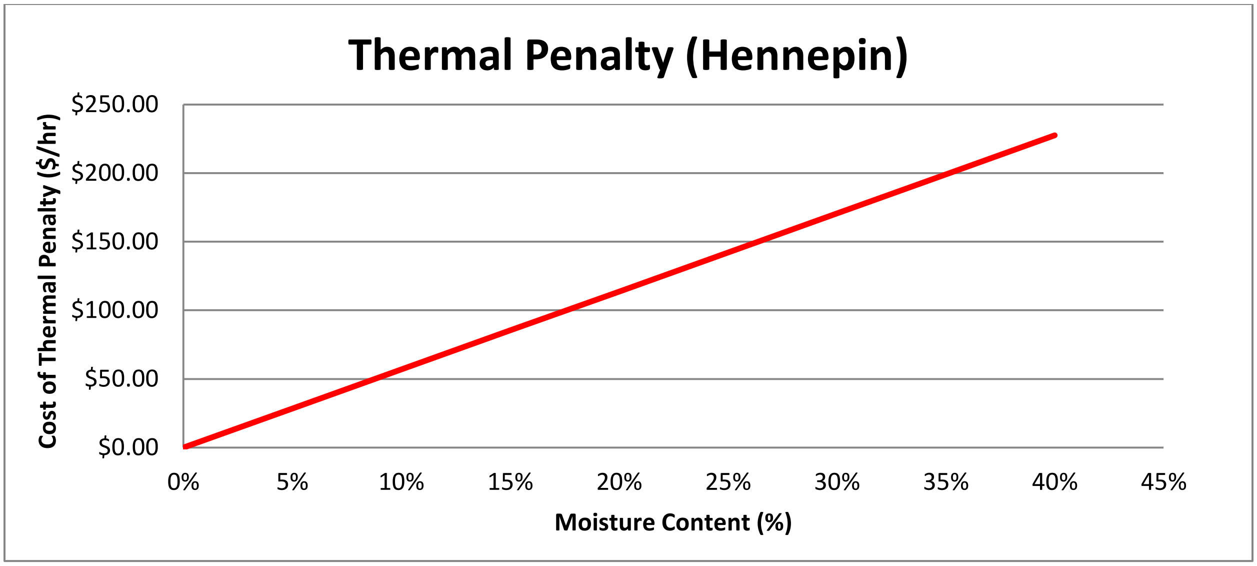
The following percentages were calculated.



One very important thing can be taken from this graph, the more water that is added, the more coal is required to compensate for it.

It is of note that the as-received moisture content of this sample was 37.37%. This means that if the coal was burned at this point in the process, this user would lose 5% of their coal to thermal penalty.

Like the dust lost percentage, this percentage can be converted to an actual expense by simply multiplying by capacity and then multiplying by cost per ton. This can give a facility some scale as to how much a thermal penalty is costing. The actual cost of this thermal penalty is shown below.

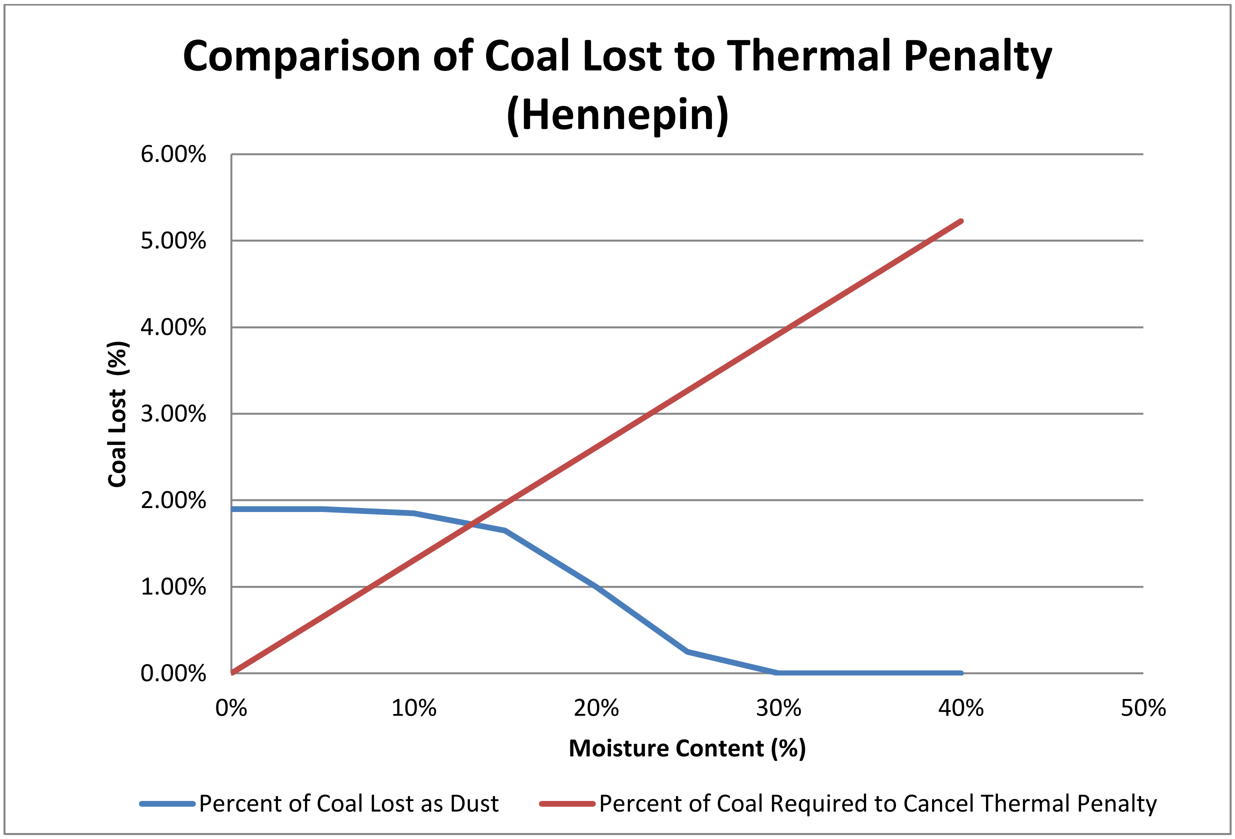


This facility receives coal at 37.37% entrained moisture. This facility loses ~$210 per hour just to dry out their coal.

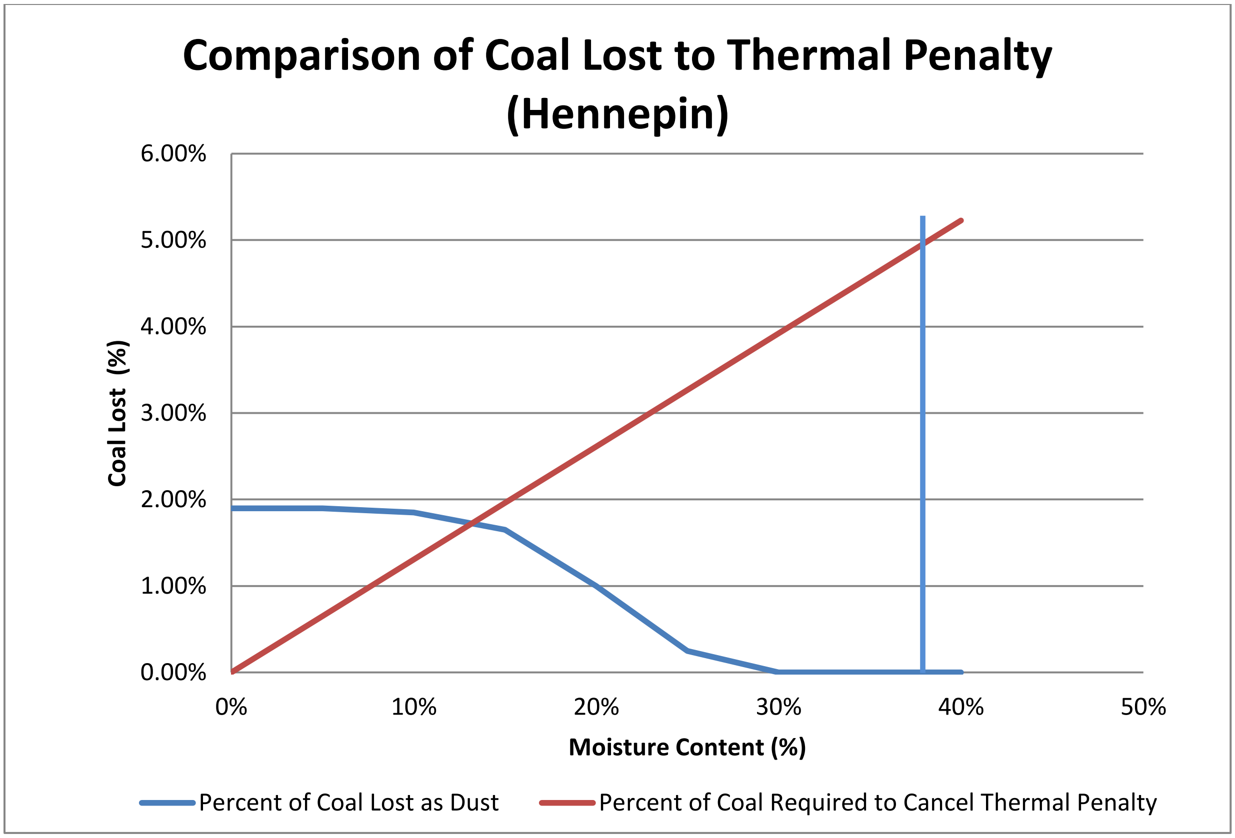
7. Balancing moisture content and thermal penalty

The question that coal plants must answer is, "should I use a water dust suppression system." To answer this question, it is necessary to overlay the dust produced graph and the thermal penalty graph. Once combined, the breakeven point becomes visible.

The graphs are combined below.



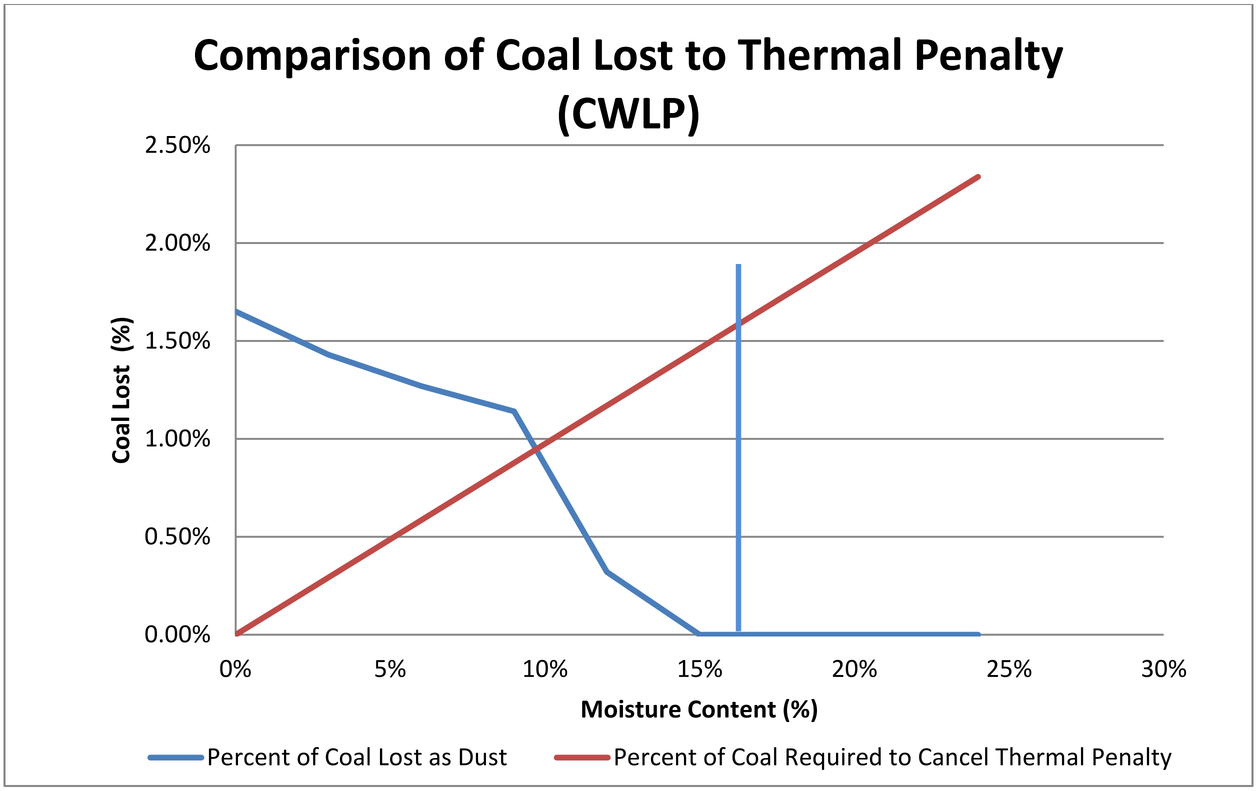
This graph shows the point at which adding water costs more in thermal penalty than the amount of coal lost due to dust (about 13%). It is also useful to add the "as-received moisture content" onto this graph as shown below.



This shows that the coal comes in with 37.75% moisture entrained. The operation is already losing ~5% of its coal to correct for this. At this level of moisture, dust is not created anyway. It does not make sense for this company to add water at this point in the process assuming the moisture content remains at 37.75%

Every material has different properties and therefore reacts to water differently. Not only do properties vary from material to material, they can change as a function of time of day, location within transport method, frequency of handling, or any number of other things that are encountered in an industrial setting.

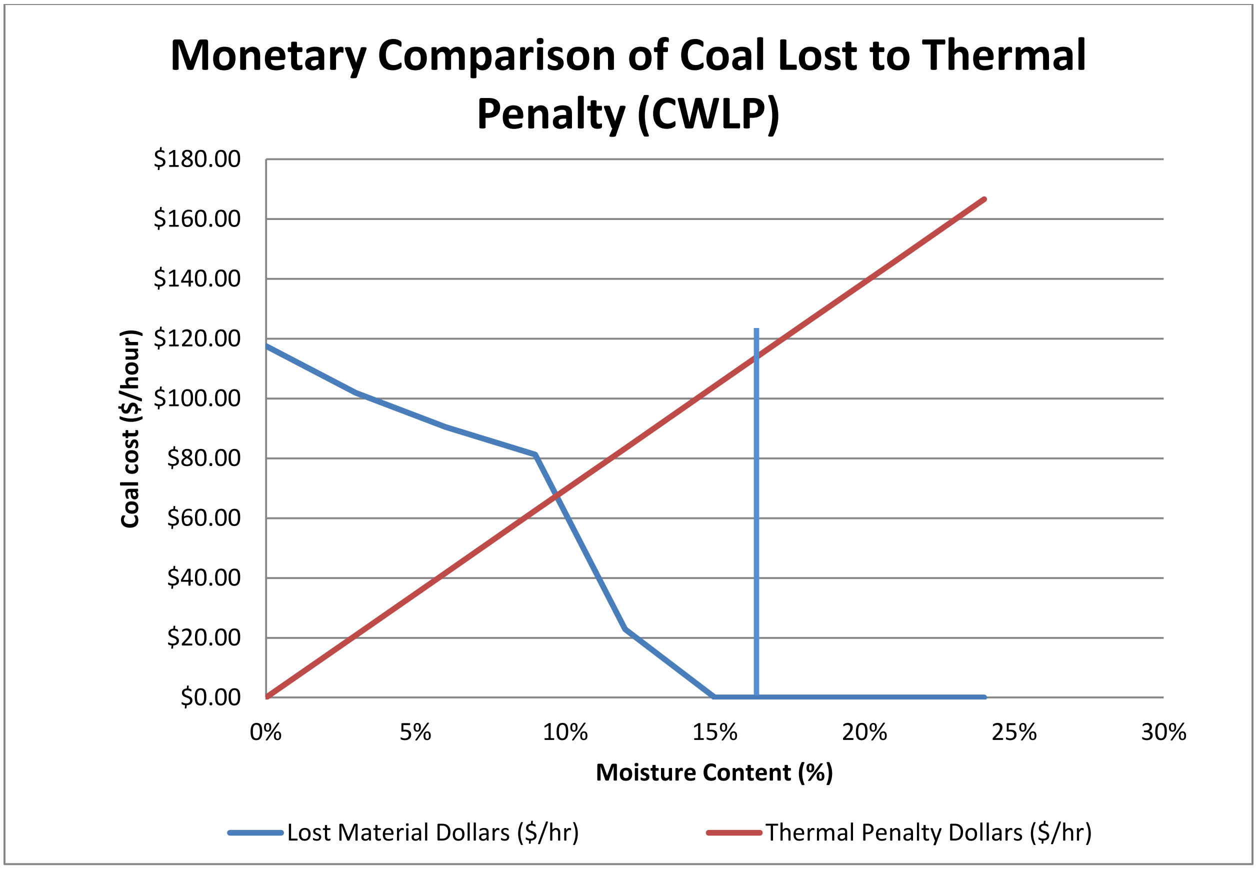
This change becomes apparent when another material is examined. A different facility, CWLP, uses Illinois Basin coal and the as-received moisture content is 16%. A sample was retrieved on December 8, 2010 and the material was tested in an identical fashion to the Hennepin material. The dust generation and thermal penalty relation is shown below.



In this situation, the coal behaves completely different in regards to dust generated. The amount of dust generated drops to zero when the material contains ~15% moisture. This facility could eliminate up to half of their dust before the thermal penalty becomes so large that it costs more to evaporate the water. It is a moot point as the as-received moisture content is 16% so the coal should not generate any dust. In this situation, the as-received moisture content is just above the saturation point. If a load comes in a little drier than normal or the humidity is low causing the coal to dry out, some dust may be produced.

This tracks well with the reality of what happens at this facility.

In this application, it makes sense to install a water system that the user can activate on dry days to keep the moisture just above the saturation point. The thermal penalty is still higher than the dust loss, but this facility has to operate at this level of thermal penalty anyway. This level is ~$117 per hour as shown below.



Monetary Comparison of Coal Lost to Thermal Penalty (CWLP)
$180.00
$160.00
$140.00
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
Coal cost ($/hour)
0%
5%
10%
15%
20%
25%
30%
Moisture Content (%)
Lost Material Dollars ($/hr)
Thermal Penalty Dollars ($/hr)

8. Conclusion

A facility must know the point at which water must be added. This point can be found in the field through trial and error, or a knowledgeable laboratory can be used to find this critical point.

This relationship offers a baseline to compare moisture content to dust costs. Once the comparison is in dollars, other factors can be added or substituted into this graph. A single EPA or OSHA fine will push the cost of dust higher, while the maintenance due to wet material will push the cost of water higher.

These relationships can be replicated for any industry and any situation.

Each facility will need to collect their own data and recreate this comparison to make the determination whether or not to use water dust suppression themselves. Knowledgeable suppliers can be of great use in performing these comparisons.

The Difficult question of “How much water, if any, should I add?” can be answered very systematically. The answer will be thorough and insightful and allow the decision makers of a facility to proceed with confidence.

9. References

1 Marshall, Daniel. "Chapter 19 Dust Supression." Foundations. Ed. Andy Marti. 4 ed. Stevens Point, WI: Worzalla Publishing Company, 2009. 320-321.

10. About the Author

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A self-described “numbers guy,” Daniel Marshall holds a B.S. in Mechanical Engineering from Northern Arizona University. He joined Martin Engineering in 2000 as a Research and Development Engineer, and has moved to Product Development and Application Engineering. Marshall is instrumental in the design and application of dust suppression systems and other systems to improve the conveying of bulk materials.