Quantifying the Potential for a Frictional Ignition

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Summary

Frictional ignition occurrences in Queensland coal mines have been increasing during the past decade due to increased mechanisation of the mining process. A method to determine the energy emitted during a pick on rock strike has been found using the SIMTARS Friction Ignition Rig. A number of site samples have been used to simulate rock strikes as would occur with a continuous miner or longwall shearer contacting roof, floor, or dyke rock. Analysis of the three key indicators – hotspot size, temperature, and duration – allows the calculation of the amount of energy being emitted from the rock face. Due to the time-based nature of the rate of energy (heat) emission, a plot can be drawn from the data and used to rank frictional ignition potential between rock types and mine sites. Once comprehensive testing of a large sample of coal mine rocks has been completed, the mines that are at most risk of a frictional ignition can be advised as to how to best avoid such an occurrence. It has also been found that quartz content is not the primary indicator for frictional ignition potential.

Introduction

Frictional ignitions have been of great concern in the past few years due to the increasing occurrence of such incidents. They have the potential to cause disastrous consequences to a mine if a serious explosion were to result.

Regardless of the amount of research into the causes of frictional ignitions, only qualitative measures of the potential for a frictional ignition have been found. These measures were most often based on the quartz content of stone and measured as ignitions per thousand tonnes mined. This measure is in no way acceptable for accurate determination of frictional ignition potential.

Testing Procedure

The Friction Ignition Rig (rig) is an apparatus that pulls a machined pick through the surface of a rock sample. A rock sample is mounted with a vertical striking face, through which a hardened steel pick is forced at a constant rate. The pick speed is approximately 2m/s, a speed similar to that found on mining equipment. The tests are recorded using an infra red and natural light camera and are performed in darkness so that there are no reflections causing interference to the IR camera recording process. The images were stored on Super VHS tapes and reviewed.

The pick has an attack angle of 45° and a contact surface area of 1cm^2. Oberholzer (2000) recommends that the use of a significantly sized pick surface area will create a larger hotspot on the sample during a strike. It will also allow for a grinding action to occur at the trailing edge of the pick. The pick hardness was increases through tempering of the steel. The picks have a Rockwell hardness of 48 ± 2.

The reviewing process involved the measurement of the hotspot size and temperature and the counting of the number of fields that the image was recorded for.

Results

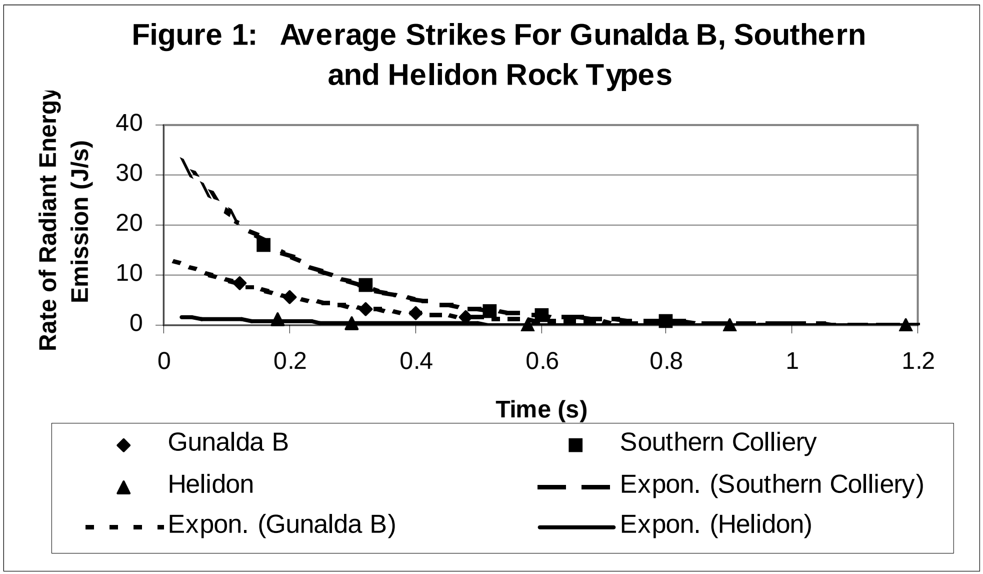
Once the data was collected from a range of strikes, the areas and times of each measurement were compiled along with an accurate determination of the emissivity of each rock type. This information was then used to calculate the energy at each point in time after the strike. The formula used was (Giancoli, 1985):

$$\Delta Q/\Delta t = \varepsilon\sigma A(T_1^4 - T_2^4)$$

where ε is the emissivity of the sample
σ is Boltzmann's constant (5.67×10^{-8})
A is the hotspot area (m^2)

T_1 is the hotspot temperature (°K)
T_2 is room temperature (°K)

Figure 1 shows a graph of the results obtained. The trend of the cooling curve is not only due to the radiation of energy from the sample face, but also a result of the reduction in hotspot size.



A point count was conducted for the samples to determine the key indicators for frictional ignition potential. Since the quartz content of a material has been generally accepted as a major factor in the potential of a material to cause a frictional ignition, it was of great significance. Table 1 shows the results of the mineralogical analysis.

Sample	Mineral	Content (%)
Gunalda B	Quartz	57.80
	Chert	5.00
	Mica	0.60
	Feldspar	30.70
	Clay	3.40
	Fine-grained volcanics	2.50
Southern Colliery	Quartz	32.50
	Organic material	16.75
	Muscovite mica	8.25
	Clay	32.25
	Fine-grained volcanics	10.00
	Plagioclase	0.25
Helidon Sandstone	Quartz	62.00
	Silica cement	37.75
	Clay	0.25

Table 1: Results of Point Count

Discussion

Autoignition temperature of methane is quoted in literature as between 537-750°C, depending on the experimental apparatus used. Surface area, rate of heating and the amount of turbulence in the mixture affect this (Bell, 1996). The amount of time required for the methane to start heating and then to ignite is not known. Once the time limits are determined, the curves found can be integrated to find the total energy output of the strike as a power/unit area figure.

It was recorded on many occasions that the surface temperature of the rock samples used reached temperatures in excess of 750°C. The rate of cooling from these temperatures varied. It is not known what the effects of using a vertical sample have on the radiation of the energy from the sample face. This is because of the internal heat absorption process and effects are not fully understood.

Expecting that high quartz content will eventuate in a high probability of a friction ignition occurring is not correct. Gibson (1998) suggests that a low ignition category (IGCAT) is associated with low quartz content of around 30%. It is then interesting to see that the quartz content of the Southern Colliery sample was 32.5% had the highest energy emission and therefore the highest potential for frictional ignition of the samples tested.

Another interesting discovery that the Southern Colliery samples showed was that a strike that was repeated on a cut where rock material had already been removed created more heat than the initial cut. A conclusion can be drawn from this that the grinding action of the pick face on the rock is a major component of the heating process. However, this was not the case in the other samples tested.

Conclusion

It is evident that the chance of frictional ignition is dependant on the temperature of the hot surface, its size and the time of exposure to the methane/air mixture (Jensen, 1993). The characteristics of what makes a rock more incendive than another is not understood fully. However, maintaining the process developed at SIMTARS to determine the rate of energy emission from a pick strike will allow, with a large number of samples, an accurate determination and ranking of the potential of particular mine rocks to cause a frictional ignition.

References

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