

Magnetic technology applied to mine ventilation systems achieves results through LHDs and heating systems

By

Dr Greg Baiden
Laurentian University
Canadian Research Chair - Robotics and Mine Automation
Director – School of Engineering

Chairman and Chief Technology Officer
Penguin Automated Systems Inc.

Brent Baiden
Director
Ontario Region, A.-T. Energy Management

Abstract

Mine ventilation systems provide air to underground mines through large fan systems and a series of raises and tunnels. Doors and barricades are put in to direct the flow of fresh air to the places it is needed in a mine. At present, the solution to meeting TLV's limits has been to increase the volume of air entering the mine to dilute it appropriately. As the pressure to improve the underground environment has been mounting the idea of magnetizing fuels for providing more complete combustion has been a potential solution that needed a fresh look. Demystifying magnetization and how it works to provide more complete combustion has been the major stumbling block to understanding the value of this idea. This paper describes two experiments that were done over the last two years to improve our understanding of how magnetization can make a potential difference.

The first experiment involved testing a diesel engine in a controlled environment without and with magnets. It did indicate something significant was happening. Due to these results a different experiment needed to be done on a larger scale. It was decided that a larger quantity of fuel being combusted continuously would speed getting results. Therefore, a heater house used for winter heating of mine ventilation air was selected. The results of magnetizing natural gas headers in a heater house were substantial. Over a two year test period, a total of 11.95% less gas was used to heat the mine air.

This paper will provide background for the reader into fuel magnetization theory, the initial diesel combustion experiment, the McCreedy East mine experience and then discuss the potential of this exciting new technology and future work that will be undertaken.

Introduction

Ventilation of a mine is one of the most important functions that allow miners to go to work everyday. Over the years, miners have always been concerned about the quality of the air they breath. Early miners carried canaries with them and observed the birds ensuring they were still alive. If the canary was dead the miner needed to leave the area immediately as the air was unsafe. Today, mine ventilation systems are quite sophisticated, millions of CFMs of air is blown into the mine through fan systems and mine ventilation specialists monitor that air for quality so that the miners running today's diesel equipment will be safe. Even with this approach, concerns are being raised about the potential impact of diesel emissions on the health and safety of miners.

A.-T. Energy Management in conjunction with Inco undertook an innovative approach to achieving more complete combustion on diesel engines used underground. It was projected that two benefits might potentially occur. The first was cleaner air leaving the diesel engine exhaust and the second was reduced fuel consumption. With these goals in mind a test program was devised. A controlled environment was created to understand if these results were possible. The results of the first experiment while indicating a significant shift in air quality and fuel consumption did not prove totally conclusive. Therefore a second experiment was devised using an increased volume of combustible fuel in a heater house that heats mine ventilation air in the winter. A one year period of monitoring was done on the heater house without magnets and the second year the magnets were installed on the headers of the heater house. This installation was monitored and after two years the results were completed in May 2002. The savings in natural gas as a result of the installation of magnets was 11.95% in 2001-2002 when compared to 2000-2001.

This paper outlines magnetic technology, the diesel engine experiment, heater house experiment, discusses the results and outlines future work that will be undertaken at Laurentian University.

Theory of Operation

In 1989 the Nobel Prize in Physics was awarded to Hans Dehmelt of the University of Washington in Seattle for his work on the fundamental properties of electrons. The Nobel Prize was a result of 40 years of research into the basic properties of the electrons.

The electron has only four known characteristics: mass, charge, spin and magnetism. And over the preceding years, mass and charge had already been measured to high levels of accuracy, but the electron's spin and magnetism were another story. The spinning analogy leads us to the electron's magnetism. For example, if an unmagnetized iron rod is placed into rotation about its cylindrical axis, (turned like an axle rather than lengthwise as a fan), the rod will become magnetized. This is known as the Barnett effect. Also, an electron by virtue of its mass, charge and spin is also a magnet. If electrons are provided with the precise amount of magnetic energy the spinning electron will absorb that energy and flip into alignment. The exact amount of

energy required to produce a "spin flip" is determined by the g-factor, known as the gyromagnetic ratio, discovered by Paul Dirac in 1928. Dirac noticed in his experiment whole atoms absorbing and releasing energy as the electrons undergo spin flips.

We should bear in mind that all materials experience magnetic effects. It is merely a question of degree of influence. All the known elements in the periodic chart fall into two categories - paramagnetic or diamagnetic. With paramagnetic materials, the flux draws the materials into the areas of stronger flux. Ferromagnetic are a special sub class of paramagnetics, since its (iron/magnet) attraction is extraordinarily strong. What we see on a daily basis is ferromagnetic interaction. Just because we don't see strong attractive forces with other materials doesn't mean that there is no effect. In many cases the term non-magnetic actually means non-ferromagnetic. Diamagnetic materials, on the other hand, are materials that are driven into the weaker areas of magnetic flux.

Most materials possess paired electrons. However, some materials, for example iron, have unpaired electrons. It is the action of spin of the unpaired electron that gives rise to the effect we call magnetism. It is simply the unpaired electron spin of the electron that gives rise to its magnetic moments and related field. As an example, hydrogen in its para or ortho spin form, can either be paramagnetic or diamagnetic depending on the spin orientation. Orthohydrogen with its coincident spins is far more unstable than its para counterpart where the electron/nuclear spins are in opposition. Hydrogen in its para form can be converted to its ortho form by the application of an appropriate magnetic field¹. This process makes the hydrogen more volatile or more combustible.

Magnetic Treatment of Fuel

Hydrogen is the lightest and most basic element known to man. With its simple structure comprised of only one proton and one electron, it is one of the major constituents of all hydrocarbon based fuels. It possesses two distinctive forms: ortho-hydrogen and para-hydrogen. In para molecules, the spins of the protons are anti-parallel, while in the ortho molecule the spins are parallel. The para molecules occupy the even rotational levels, and the ortho molecules occupy the odd levels. The orientation of the spins has a pronounced effect on the behaviour of the molecule. In fact, ortho-hydrogen is unstable and more reactive than its para-hydrogen counterpart. The liquid hydrogen fuel that is used to power the space shuttle is stored on the para-hydrogen form, which is less volatile.

The magnetic treatment of fuel represents a new technology. An American inventor, Peter Kulish, is responsible for founding the monopole technology, or in simple terms, the use of the single pole technique. This monopole application is why all prior systems to the Magnetizer could not show sufficient results. Consequently, the reactivity of the atom and related molecules are enhanced. The make up of natural gas is 78.8% methane. In methane (CH₄) the carbon content of the molecule is 66.6% while the hydrogen content is 33.3%. When the carbon portion of the molecule is combusted it will generate approximately 14,000 BTU per pound of carbon. On the other hand, the hydrogen which comprises only 33.3% of the molecular weight will generate an amazing 61,000 BTU of heat per pound of hydrogen. Thus we can see the importance of hydrogen in generating heat when a hydrocarbon molecule is burned. By altering the spin properties of the electron, we can enhance the reactivity of the fuel and related combustion process.

Diesel Engine Experiment

In 2000 A.-T. Energy Management proposed to Inco Limited the testing of magnets on diesel engines to achieve a reduction in fuel consumed and potentially a reduction in diesel emissions. The projection was a 3 to 4 % savings in fuel. While magnet technology had been proposed to Inco before it was decided to give the technology a fresh look in light of the new technology developed and patented by Mr. Peter Kulish.

An LHD at the Research Mine was selected. It quickly became apparent that this testing procedure would need to change as a much more controlled environment would be needed to verify the results. In the fall of 2000, a decision was made to ship a brand new DDEC Series 60 11.1L electronically controlled diesel engine to the CANMET Diesel Engine Testing Lab at Bell's Corners in Ottawa.

The engine was first run without Magnetizer magnets attached to get a base line. For the next phase of the test Magnetizers were installed on the intake fuel line, intake air, intake and return coolant lines. The bench testing was conducted at all the 8-mode operating points as described in MAPTEST report². The 8-mode test cycle is specified by the International Organization for Standardization (ISO) as ISO 8178-4, cycle C1, for 'Off-road vehicles, diesel-powered off-road industrial equipment'.

Steady-state measurements for engine parameters and exhaust emissions were made before and after the application of Magnetizer's magnet product on the engine. The measurements for engine parameters included, speed, torque, fuel consumption, intake air mass flow rate and exhaust temperatures. The exhaust emission measurements included, CO, CO₂, NO, NO_x, Total Hydrocarbons (THC) and diesel particulate matter (DPM). The SO₂ and Exhaust Quality Index (EQI) were calculated. During the engine testing a low sulphur fuel with sulphur content of 0.036% by weight was used.

The results achieved are shown in Table 1 below. As can be seen in the table, some significant changes occurred during the engine testing. There were increases of 17% in CO and 8.8% in NO₂. At the same time, a number of the measured parameters showed decreases. Very significant changes occurred in total hydrocarbon production (-20.6%) and diesel particulate matter (-10.7%). Given the conclusions from the test were questionable, A.-T. Energy Management was consulted. Upon consultation it was determined that the break-in period was too short and a more suitable break-in period would be 2 to 4 weeks. It can be seen though that something is happening to the combustion process of the engine. Therefore, further investigation was warranted. At this point, a different controlled test was needed with higher consumption of hydrocarbon fuel and the appropriate controls to measure the inputs and outputs to the system. After careful review a heater house was chosen.

	Without Magnetizers	With Magnetizers	% Magnetizer Effectiveness
Speed, rpm	1623	1623	Nil
Torque, ft.lb.	532	532	Nil
Power, hp	174	174	Nil
Fuel rate, lb/hr	61.9	61.9	Nil
CO, gr/hr	58	68	- 17.2 %
.CO ₂ , gr/hr	80378	79253	1.4 %
NO, gr/hr	447	434	2.9 %
NO ₂ , gr/hr	34	37	- 8.8 %
NOx, gr/hr	481	471	2.1 %
THC, gr/hr	34	27	20.6 %
DPM, gr/hr	8.4	7.5	10.7 %
EQI	55.6	53.7	3.4 %

Table 1 – Diesel Engine measurements without and with magnets on the fuel line.

Heater House Application

Mines in northern climates require the heating of air to create a workable underground environment. Typically the air is heated today using a heater house (figure 1) installed on surface in series with ventilation fans to blow the air into the mine. Many approaches have been tried to minimize consumption. Typically, these have included turning off natural gas when not in use and sophisticated monitoring and control systems. To date little work has been done in preparing the fuel for more complete combustion.



Figure 1 – Typical Mine Heater House

The first step in this experiment was to monitor gas consumption. Inco's - McCreedy East Mine was approached as a test site due to the fact that gas consumption was monitored. This made this the ideal place for a test. Information from the 2000-2001 heating season was collected for later analysis. With this information in place magnets from A.-T. Energy Management were obtained and installed in the summer of 2001. This installation is shown in figure 2. With the magnets in place the monthly data for the 2001-2002 heating season was collected.

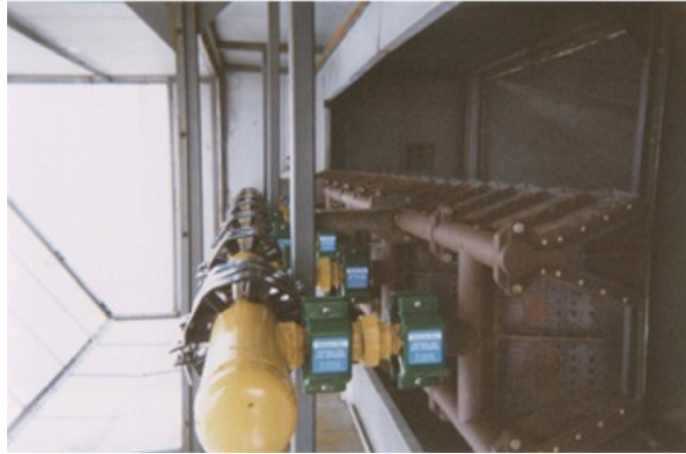


Figure 2 – Magnets installed on the headers of heater house

Collection of natural gas consumption between two heating seasons needed a method of normalizing the data. Year 2001-2002 data was collected and normalized using degree-days methodology. Degree-days normalize temperature data between multi-years. Typically, the temperatures are collected by government meteorological stations. This normalized temperature data was collected at the Sudbury Airport and applied to mine heater house data on natural gas consumption.

Table 2 shows the data for the two heating seasons. As can be seen in the table the 2000-2001 heating season used an average of 383.93 cubic meters per degree day without magnets. Once the magnets were installed in the next season, the average consumption for the 2001-2002 heating season was 338 cubic meters per degree day. This change from the 2000-2001 to 2001-2002 season was the result of installing magnets on the heater. Careful care was taken to ensure no other changes took place in the two seasons. Given these results the change amounted to an 11.95% reduction in natural gas for the same mine once normalized. This result is extremely impressive through only the addition of magnets to natural gas headers in a heater house.

Period						Gas Consumption Total (M3)	Number of Days	Degree Days (DD)
From			To					
Y	M	D	Y	M	D			
2000	Dec	20	2000	Dec	31	173,184.0	11	344
2001	Jan	1	2001	Jan	31	390,024.0	30	884
2001	Feb	1	2001	Feb	28	382,314.0	28	828
2001	March	1	2001	March	31	247,332.0	31	706
2001	April	1	2001	April	30	16,939.0	30	390
Total						1,209,793.0	130	3,151
Average Gas Consumption without Magnets: 383.93 M3/DD								

Period						Gas Consumption Total (M3)	Number of Days	Degree Days (DD)
From			To					
Y	M	D	Y	M	D			
2001	Dec	20	2001	Dec	31	52,289.0	11	272
2002	Jan	1	2002	Jan	31	320,448.0	30	805
2002	Feb	1	2002	Feb	28	319,258.0	28	775
2002	March	1	2002	March	31	293,279.0	31	790
2002	April	1	2002	April	30	60,621.0	30	451
Total						1,045,895.0	130	3,094
Average Gas Consumption with Magnets: 338.04 M3/DD								

Table 2 – Normalized Heater House Gas Consumption Data

Summary

Magnets were installed on both a diesel engine and the headers of a heater house at Inco. The magnets yielded very interesting positive results. While, the test was inconclusive for the diesel engine it yielded results that require further investigation.

The second part of the experiment used a monitored heater house. This experiment was conducted over a two year period. This experiment showed very impressive results reducing natural gas consumption by 11.95% once adjusted for degree-days to normalize the information.

Future Work

Given the results achieved on the Inco – McCreedy East heater house a decision has been made to install more magnets in the McCreedy East complex. The results outlined in this paper will continue to be tracked for the 2002-2003 and 2003-2004 seasons to get more data on the applications of magnets to more complete combustion in mine heater houses.

With the positive results achieved in the heater house experiment, the diesel engine results will now be reinvestigated. A.-T. Energy Management will install magnets on one of a fleet of two LHDs at McCreedy East Mine. The first machine without magnets will be used as a baseline to measure the improvements with magnets installed. Inco will supply emission results for two LHDs in the mine over a one year period to determine the outcomes of this work.

References

- 1 Ruskin, S.L. Process for the conversion of Hydrogen, U.S. Patent #3228868, May 28th, 1958.
2. M. Gangal, D. Young and V. Feres, Laboratory Evaluation to Determine the Effect of Magnetizers on a DDEC Series 60, 11.1L Engine Emissions, October 2000.