

An Experimental Investigation of the Effect of Magnetic Field on Engine Cooling Water Properties

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ABSTRACT

There are many known problems in water cooling systems in the industrial applications such as corrosion, scale, fouling, microbiological growth, etc. Not only the same problems are expected in the cooling system of internal combustion engines but also the water leakage from cylinder liners or cylinder head to the combustion chamber has to be considered especially if the liner pitting is the reason. In the present paper the effect of magnetic field on the engine cooling water and engine material is investigated.

To compare the effectiveness of the magnetic field, the experiments were conducted at different magnetic intensities. Two different mechanisms to apply magnetic effect were compared to other treatment methods which are used commercially in the market such as anti freeze and anticorrosion fluids and systems.

The magnetic devices showed an effective impact on reducing cavitation or liner pitting because of lowering surface tension of water. It showed also a noticeable effect on the total hardness and pH which reduced scale, corrosion and the total suspended solids.

I. INTRODUCTION

The cooling fluid is an important part of the heat removal system for IC engines protection. Coolant plays a critical role of removing engine heat, thereby maintaining correct and recommended operating temperatures. Up to 40% of all engine problems can be directly or indirectly related to improper cooling system maintenance. Correct cooling

system treatment reduces engine operating costs and minimizes engine downtime.

Liner pitting, scaling, and rust formation are some examples of the cooling water problems which affect different engine components and systems, [figure \(1\)](#).

While several methods are used for water treatment, some other problems, such as high cost of added chemicals or new systems and/or the availability are accompanied. A more economical and convenient method was suggested and attracted many researchers is the magnetic treatment.

Although the mechanisms are not fully understood, magnetic treatment of water systems has been in existence for over a century [1, 2, 3]. There is special interest on using magnetic water treatment in the last decade which led researchers to deal with magnetic treatment in different applications [4, 5, 6, 7, 8, 9]. One of the major applications is to suppress water-scale deposition on the inner surface of boilers, heat exchangers and pipelines [10, 11].

The results were promising to initiate this work and use the same technique with a different application which is the water cooling system in engines.

In the field of IC engines, the traditional methods proposed to treat engine coolants are:

- using water with good inhibitors
- using corrosion resistors
- using coolant filters



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In the present study, the magnetic water treatment was adopted to explore its impact on the engine cooling water and to compare the results with the results of two other treatment methods.



Figure (1-a). *Pitting in the cylinder liner.*



Figure (1-b). *Thick layer of scale formation.*



Figure (1-c). *Corrosion of engine's water pump.*

Figure (1). *Examples of the problems resulted from untreated coolants in different engine components.*

II. REVIEW OF PREVIOUS WORK; MAGNETIC FIELD AND WATER STRUCTURE

The changes in the structure of water when exposed a magnetic field are important in various applications. The changes in the structure of water under the effect of an external magnetic field have been related to hydrogen bonds [12, 13, 14, 15]. It was mentioned by Zhou et al. [13] that magnetic field can change water-water interaction and increase the distance between water molecules. Toledo et al. [7] suggested that the magnetic field weakens the intra cluster

hydrogen bonds, breaking the larger clusters, forming smaller clusters with stronger inter cluster hydrogen bonds. Chang et al. [15] and Hosoda et al. [16] investigated the effects of the magnetic field on the hydrogen-bonded structure of water and found that the number of hydrogen bonds increased by approximately 0.34% when the magnetic field strength increased from 1 to 10 Tesla. Hosoda et al. suggested that the enhancement in the hydrogen-bonded strength under the magnetic field of 10 Tesla was caused by increased electron delocalization in the hydrogen-bonded molecules. The two-phase model used by Cai et al. [17] has proved that the proportion of free molecules has decreased by magnetic treatment.

Different changes in the molecular energy were reported in the literature [13, 17]. The change of molecular energy is an indicator of the reorientation or formation/breaking of hydrogen bonds [18]. The increase of hydrogen bonds indicates that some non-hydrogen-bonded molecules have converted to hydrogen-bonded ones.

Many of experimental studies have been carried out to investigate the dependence of temperature and hydrogen-bonding in water [19, 20, 21]. The water structure breaks down as the temperature increases due to the weaker hydrogen bonds [17]. Normally the surface tension of liquid water increases while the viscosity decreases as the temperature increases at atmospheric pressure. Accordingly, the effect of magnetic fields on water hydrogen bonds is similar to the effect of temperature decrease as resulted from the experiments done by Cai et al. [17].

Studies have found that the magnetic field also influences the viscosity. An increase of water viscosity under the influence of magnetic field has been reported and explained on the basis of stronger hydrogen bonds [7, 22, 23].

III. MATERIALS AND PROCEDURES

The experiments were conducted on a four-cylinder Poloniz 82 HP engine with a cylinder bore of 77 mm and a stroke of 79.5 mm. The compression ratio of the engine is 9.2.

Three different magnetic coils were used. The first one is a permanent magnetic device SIKE model which is used commercially in the market. The other two electromagnetic coils were made with specifications shown in [table \(1\)](#).

Table (1). Electromagnetic coils specifications

	Iron Coil	Fiber Coil
Core Material	Iron	Fiber
Wire length (L)	55 m	55 m
Number of wire turns (N)	500	500
Magnetic flux intensity (B)	5.56*I mTesla Where I is the current	5.56*I mTesla
Current (I)	0.18 – 6.66 Amp.	0.18 – 6.66 Amp.

After preliminary tests for the two electromagnetic coils at different magnetic densities it was agreed to use the iron coil at the highest intensity where both choices, iron and high intensity, proved to be more effective.

A commercially available corrosion resistor was used for the comparison. A corrosion resistor is some kind of filters which is used in diesel engines to trap magnesium and calcium which are the main components of scale.

Four different types of cooling fluids (water in different conditions) were tested:-

1. Normal drinking water.
2. Distilled water.
3. Used water with rust.
4. Coolant glycol (mono ethylene glycol) which is used as a coolant in the market.

The total time of operation was adjusted depending on two settings, one pass setting which represents the time required for the water to move one complete cycle starting from the radiator to the engine block and returning back to the radiator and the other is 3 hours setting.

IV. WATER TREATMENT ANALYSIS

In this section, detailed analysis for some of the water properties which affect the engine cooling system is presented. Sample of the coolants is analyzed before and after the magnetization process.

In the early stage of this research and as a preliminary test a graph is plotted to show the behavior of the coolants, treated and untreated ones, to the temperature increase, [figure \(1\)](#).

The figure shows that the temperature increases over a 20 minutes period of time for all type of coolants. Treating drinking water by an electromagnetic field has increased the water temperature by 4 degrees over the normal temperature and by 2 degrees over the effect of the permanent magnet.

This can be explained by the tendency of magnetic field to change the pure water energy as mentioned earlier.

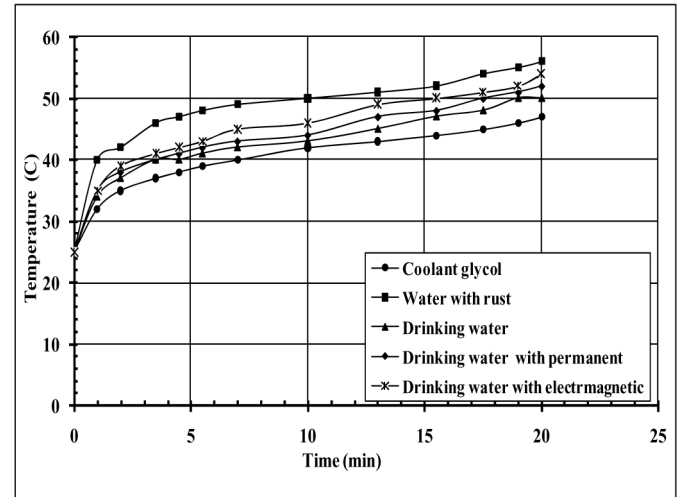


Figure (2). Effect of the magnetic water treatment and coolant types on coolants temperatures.

IV.1. pH of Water

Water pH represents a measure of the degree of acidity or alkalinity of a solution which is the negative logarithm of the hydrogen-ion activity. At 25°C, the value of 7.0 represents the neutral value. Values less than 7.0 indicate an increase in the acidity while values above 7.0 mean alkalinity.

Corrosions in engines usually occur when the pH value of cooling fluids is less than 7. The cooling fluid becomes acidic due to the degradation of antifreeze and existing of sulphates in the cooling system which leads to general corrosion of cylinder liners, cylinder blocks and/or cylinder heads, and also the water paths and hoses. A very high pH value causes damage to the gaskets and to the softer metal components. Therefore, the pH value in an ideal cooling system always needs to be between 8 and 10.5.

The effect of the magnetic water treatment devices on the pH value of the coolants which are used in the present study compared to other treatment methods is shown in [figure \(3\)](#).