Increasing the Tire Life Span by Means of Water Cooling

Mohd Azman. Abdullah, Noreffendy. Tamaldin, Muhammad Khatib. Abdul Aziz, Ahmad Fadhli. Munawar, and Mad Nasir. Ngadiman

Abstract**—**The life of tires depends on the frequency of usage, tire pressure level, weather and friction level between tire and road surface. Heat and friction will increase the wear and tear of the tire during long distance travel. Consequently, the life of the tire is reduced. In order to reduce the heat on the surface of the moving tire, a tire cooling system with water jet spray is designed and tested. The amount of heat dissipated from the tire is determined based on the reduction of the tire surface temperature after the water is spayed on the tire. With the immediate availability of the system components, the purpose of reducing the tire surface heat is achieved thus increase the tire life span.

Keywords**—**Heat transfer, tire life span, tire wear, water cooling.

I. Introduction

TIRES are used to support the weight of a vehicle with the assistance of the air inside them [1]. Frequency of vehicle usage, tire pressure level, weather and road conditions are the main factors that affect the life of tires. During long distance travel or long hour operation of vehicle, heat is generated on the surface of the tires. Tires are also suffering from friction with road surface. These heat and friction increase the wear and tear of the tires and as a result, the tire life span is lessened. The heat generated in tires is due to the friction when the rubber structure is under deformation [2]. As the tire rolls and flexes, due to the tire hysteresis, the load and energy are transmitted and absorbed by the tire. The energy is then converted into heat and therefore the tire temperature is increased. This effect is motivated by the increment of load and speed, the reduction of tire inflation, uneven road conditions and unnecessary cornering. Operating temperature has significant impact on the tire life. This is because, the higher the operating temperature of the tire, the lower the life of the tire [3]..

With the increase of temperature, the properties of the rubber change, thus tire becomes more vulnerable to mechanical failures such as tread cut, cut through, tread separation, side cut and carcass break up [4]. In previous researches, heat transfer is improved by mean of improved conduction in the tire chamber. A number of metallic brushes are installed inside the tire chamber [5]. Since the thermal conductivity of metal is higher than rubber, sufficient and continuous heat transfer is achieved. Fluid transfer element is suggested to be incorporated with the rim in the tire chamber [6]. The fluid absorbs the heat and transfers it to the cooler side of the rim. Metallic ribbon is proposed to be attached to the inside tread surface of the tire [7]. This ribbon which is partially stick out of the rim, improves the heat transfer from the tire to ambient air. Another method which uses a closed-filled resilient-walled conduit is also proposed [8]. Since it is incorporated within the tire, another issue is arise which is the tire balance.

In this study, tire cooling system using water spray is designed to be used to reduce tire surface temperatures to prolong the operating life of the tire. The water jet nozzle is mounted facing the tire surface under the chassis. The system can either be operated manually or automatically based on the temperature rise of the tire.

Mohd Azman. Abdullah, Noreffendy. Tamaldin, and Mad Nasir. Ngadiman are with the Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia (phone: +606-2346845 ; fax: +6062346884 ; e-mail: mohdazman@utem.edu.my).

Ahmad Fadhli. Munawar was the undergraduate student at the Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

Muhammad Khatib. Abdul Aziz is the 4th year undergraduate student at the Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

II. Parameters

The basic information for the water jet tire cooling system consist of power supply to the pump, water mass flow rate, water volumetric flow rate and heat convection. Table 1 tabulates the parameters for the experiments.

TABLE I
PARAMETERS FOR THE EXPERIMENTS

Parameter	Value	Unit
Voltage supply	12	V
Current	3.5	A
Water volumetric flow rate	30	ml/s
Tire pressure	150-250	kPa
Nozzle area	2.419×10^{-5}	m^2
Diameter of rim	0.3048	m
Reynolds number	2.664×10^{5}	
Nusselt number	492.72	

III. Experiment

Water jet system for cooling the tire is mounted under the chassis facing the tire surface. The water jet nozzle is installed at a certain angle to the surface of the tire as shown by Fig. 1.

The temperature infrared sensor is fixed near to the nozzle optionally. The water reservoir is located in the vehicle trunk. The main power source of the system is the 12 volts car battery. Relay functions as a switch to activate the pump. Fig. 2 shows the circuit diagram of the system. The heat generated at the surface of the tire will give a temperature rise. Once the temperature sensor detects the rise, the relay will close the electrical circuit of battery and pump. The water will be pumped through the nozzle to the tire surface. The water is continuously sprayed on the moving tire until the tire temperature drops to a certain acceptable degree. In this study, the experiment is performed on Perodua Kancil EX660 tires. The tire surface temperature will rise depending on vehicle speed and air pressure in the tires [9]. The temperature reading is taken before and after the spray for each speed and tire pressure (Fig. 3). The temperature control unit as shown by Fig. 4 has temperature range from -55 to 125 ^{0}C.

Fig. 1 Location of water jet nozzle

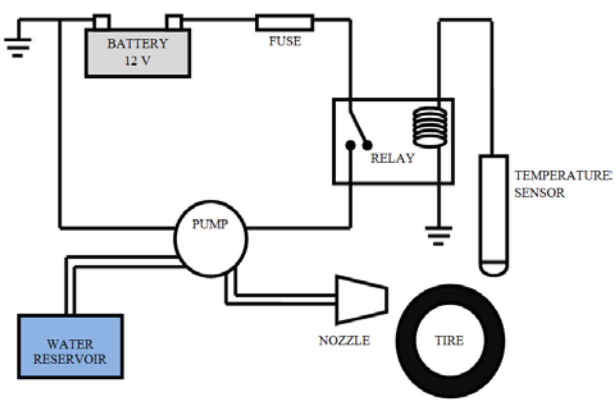

Fig. 2 Circuit diagram

Fig. 3 Temperature reading before and after spray

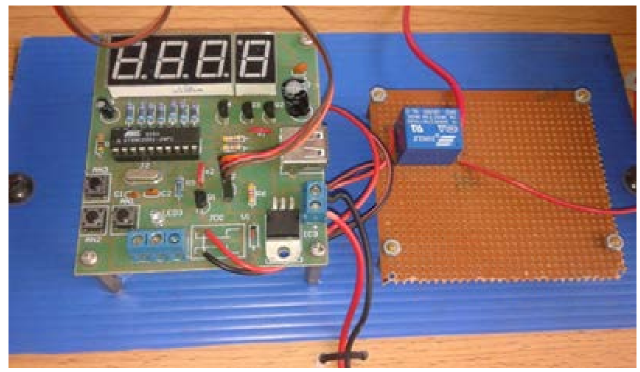

Fig. 4 Temperature control unit

IV. Results and Discussions

Fig. 5 shows the temperature results before and after spray at different speeds. The increment of speed help cooling the tire. Fig. 6 illustrates the results at different tire pressure level at constant speed of 50 km/h. In this figure, the effect of tire pressure is not so significant. Fig. 7 and 8 show the heat dissipated from the tire surface at different speeds and tire pressures respectively. Again, the vehicle speeds have significant contribution to the reduction of tire surface temperature.

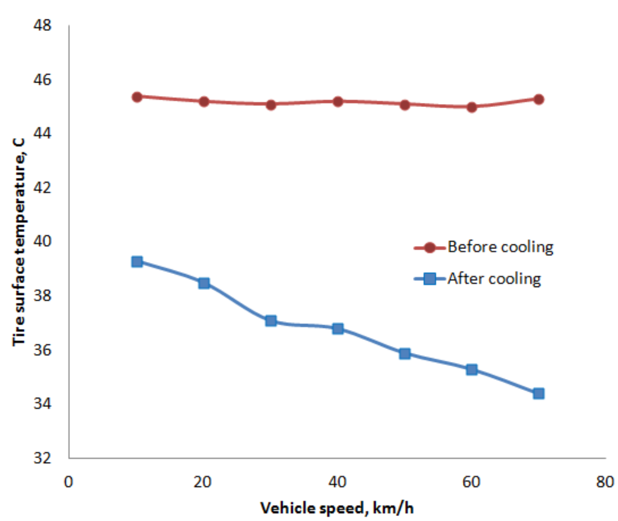

Fig. 5 Temperature results at different vehicle speeds

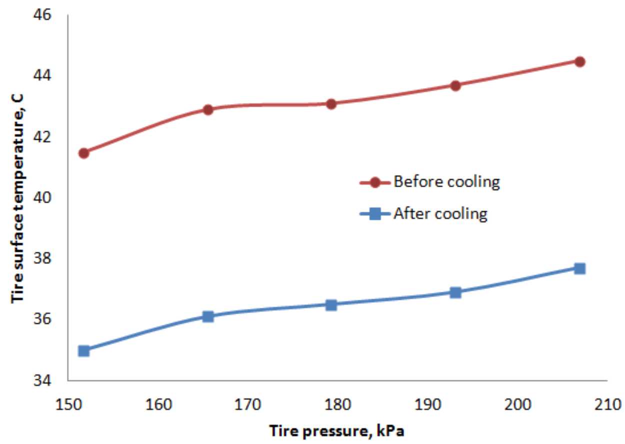

Fig. 6 Temperature results at different tire pressures

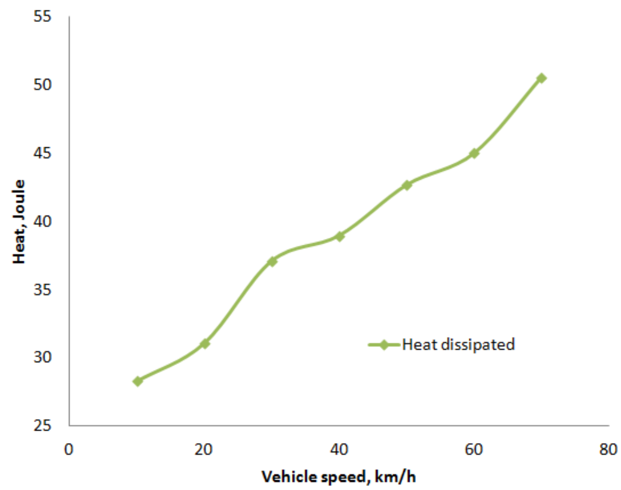

Fig. 7 Heat dissipated at different speeds

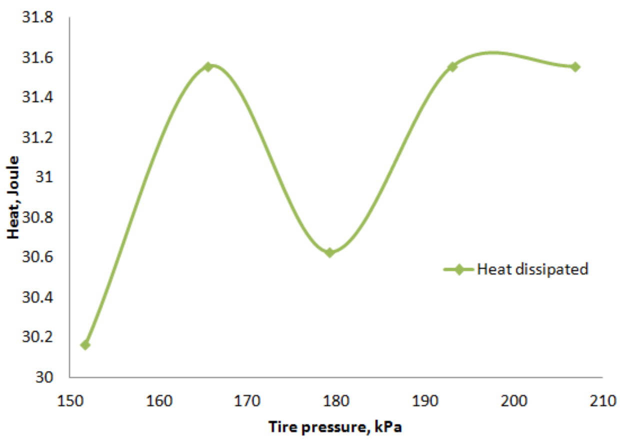

Fig. 8 Heat dissipated at different tire pressures

V. Conclusion

Since the relationship between tire life span and tire surface temperature is proportional, it can be concluded that, the tire life span can be increased by the reduction of tire surface temperature during operation. The experiments have proven that, the tire surface temperature can be reduced by means of water cooling. The amount of heat dissipated from the tire is determined based on the reduction of the tire surface temperature after the water is spayed on the tire. With the immediate availability of the system components, the purpose of reducing the tire surface heat is achieved thus increase the tire life span.

Acknowledgment

The authors gratefully acknowledged the financial support from Universiti Teknikal Malaysia Melaka under short term grant: PJP/2011/FKM(26C)/S00981.

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Mohd Azman Abdullah is a senior lecturer at the Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Malaysia. He graduated from Universiti Tenaga Nasional, Malaysia in Bachelor in Mechanical Engineering in 2002. In 2005, he finished his Master of Science in Automotive and Motorsport Engineering from Brunel University, UK. He pursued and finished his doctorate study at Tokyo University of Agriculture and Engineering, Japan in Mechanical Control Systems in 2011. His expertise is in mechanical vibration and control system.