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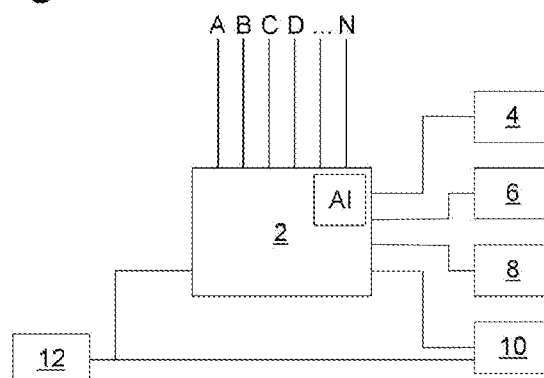
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REGULATION SYSTEM FOR A VEHICLE COMPONENT TEMPERATURE.

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The invention is directed to a system (1) and a method to regulate the temperature of a component of a vehicle. The system (1) comprises a heating actuator (4), a cooling actuator (6), a temperature sensor (8) and a thermogenerator (10). The component is preferably a tyre of the vehicle. The regulation enables to optimize the car consumption, the safety, the tyre lifetime, or any combination thereof.

Fig. 1

REGULATION SYSTEM FOR A VEHICLE COMPONENT TEMPERATURE

Description

Technical field

[0001] The invention is directed to the regulation of the temperature of a component of a vehicle. In a preferred and non-limiting embodiment, the component is a tyre.

Background art

[0002] As vehicle consumption becomes critical, some have tried to extract the energy from the tyre heat to convert it into electricity (EP 2 017 095 A1). The use of a passive thermogenerator implies that the electricity generated cannot be properly controlled.

[0003] Also, the amount of extracted energy does not substantially impact the actual consumption of a car and in particular of an electric car.

[0004] Additionally, the efficiency of a thermogenerator relies on a difference of temperatures: the warmest the tyre is in comparison to the ambient temperature, the most electricity is generated. However, for safety reasons or for enlarging the lifetime of the tyre, it may not be convenient to seek this high tyre temperature.

[0005] There is therefore a need to further more adequately use heat generated by the tyres.

Summary of invention

Technical Problem

[0006] The invention has for technical problem to provide a system and a method that improves the overall experience when driving a car by obtaining a desired trade-off between the car consumption, the safety, and other component-related parameters such as the tyre lifetime.

[0007] The examples of the invention are given here in relation to a tyre, but the invention may likely be used for other components of a land vehicle.

Technical solution

- [0008] The invention relates to a system for regulating the temperature of a vehicle tyre, the system comprising: a heating actuator configured to heat the vehicle tyre; a cooling actuator configured to cool down the vehicle tyre; a temperature sensor configured to measure the temperature of the vehicle tyre; a thermogenerator configured to collect electric energy from the vehicle tyre; and a control unit connected to the heating actuator, to the cooling actuator to the temperature sensor and to the thermogenerator, wherein the control unit is configured to control the heating actuator and the cooling actuator as a function of the measured temperature and at least one of: one or more target indicators; one or more vehicle parameters; one or more environment parameters; and one or more driver parameters.
- [0009] According to an advantageous embodiment, the one or more target indicators are automatically or manually selected and comprises at least one of: a vehicle consumption; a tyre lifetime; a tyre safety rate; an amount of electric current generated by the thermogenerator; or a trade-off of two or more thereof, e.g., ensuring that the vehicle reaches its destination safely.
- [0010] According to an advantageous embodiment, the vehicle parameters are at least one of: the vehicle speed, the vehicle load, or the tyre pressure; wherein the environment parameters are at least one of: the type of terrain, meteorology data, localisation data; and wherein the driver parameters are at least one of: the driver profile, the driver ID, the driver personal settings.
- [0011] According to an advantageous embodiment, the system further comprises a pressure regulator for inflating or deflating the tyre of the vehicle under the control of the control unit.
- [0012] According to an advantageous embodiment, the control unit regulates the tyre pressure based on the measured temperature, and on at least one of the target indicators and the vehicle/environment/driver parameters.
- [0013] The invention also relates to a method for training an AI, comprising: collecting data, including vehicle parameters, environment parameters and

driver parameters, and a tyre temperature; assessing a relationship between the parameters, the tyre temperature and an indicator, the indicator being one of: a vehicle consumption; a tyre lifetime; a tyre safety rate; an amount of electric current generated by the thermogenerator; or a trade-off of two or more thereof, e.g., ensuring that the vehicle reaches its destination safely.

- [0014] The invention also relates to a method for regulating the temperature of a vehicle tyre, the method comprising: providing a system with a control unit including an AI trained according to the method mentioned above; and using the control unit to activate a heating actuator and/or a cooling actuator according to the relationships discovered during training of the AI, so as to obtain a target indicator, the target indicator being one of: a vehicle consumption; a tyre lifetime; a tyre safety rate; an amount of electric current generated by the thermogenerator; or a trade-off of two or more thereof, e.g., ensuring that the vehicle reaches its destination safely.
- [0015] The invention focuses on an optimized regulation of the temperature of a vehicle tyre. Alternatively, the component that is regulated can be an IC engine, an electric motor, a gearbox, etc. The system of the invention can optionally regulate simultaneously several of these components. The vehicle may be a car, a truck, a ship, a train, or an airplane.
- [0016] The systems and methods of the invention enable to obtain a multi-factorial optimization for drawing the most out of a vehicle component that produces heat.
- [0017] The invention may also be beneficial for other aspects: it opens the way for a communication system between vehicle components (e.g., tyres) and gas stations' devices (inflators) to optimize the energy efficiency and safety; it enables a new dimension in the personalized experience of the driver through a personalized driving manager; it makes possible to optimize the car consumption based on external parameters (weather, terrain, etc.).

Brief description of the figures

[0018] The advantages of the invention may also appear in the description of the following figures, wherein:

[0019] Figure 1 shows a diagram of the system of the invention;

[0020] Figure 2 shows a tyre that can be used for implementing the invention.

Detailed description of the figures

[0021] Figure 1 shows schematically the main components of the system of the invention.

[0022] The system 1 comprises a control unit 2 which can include adequate software and hardware, e.g., processor, memory, communication buses, etc.

[0023] The control unit 2 is connected to a heating actuator 4 and to a cooling actuator 6. The control unit 2 controls the operations of these actuators 4, 6. For conciseness reasons, only one heating and one cooling actuator are discussed, but the system may comprise several actuators of both kinds, distributed, regularly or irregularly, over/nearby/on/in the component of the vehicle which needs to be warmed up or cooled down.

[0024] The heating actuator 4 is an actuator which provides heat to a vehicle component. It may be a resistor, a heating band or any other actuator transforming an electric current into heat. It may alternatively be a mechanical component opening or closing the heat transfer between a heating source and the vehicle component.

[0025] The cooling actuator 6 is an actuator which refreshes the vehicle component. It may be a cooling band; it may use an AIR/CO or similar technology. It may alternatively be a mechanical component opening or closing a cool source (e.g., air) nearby the vehicle component.

[0026] The control unit 2 is furthermore connected to one or more temperature sensor(s) 8 measuring a temperature (or a temperature distribution/gradient) of the vehicle component.

[0027] For example, if the temperature that is measured is below a pre-determined target, the control unit 2 activates the heating actuator.

- [0028] The control unit 2 is also connected to a thermogenerator. A thermoelectric generator (or thermogenerator) is a device that benefits from the temperature difference between a hot source and a cold source, to generate electric current. The control unit 2 can measure the electric current thereby generated.
- [0029] The system 1 may also contain a battery 12 which may be at least partly charged by the thermogenerator 10.
- [0030] The control unit 2 may control the heating and cooling actuator to amplify or decrease the temperature difference in the vehicle component so as to obtain a target amount of current generated by the thermogenerator.
- [0031] The control unit 2 also receives input from various detectors (A, B, C...N) or from the ECU of the vehicle, i.e., car consumption, driver's settings, throttle position, brake pedal position, gearbox information, etc. The control unit 2 can thus gather vehicle parameters (speed, load, tyre pressure); environment parameters (type of terrain, meteorology, localisation); or driver parameter (ID, profile, personal settings, behaviour).
- [0032] The control unit 2 can comprise an AI module which may be specifically trained to instruct the processor, based on a plurality of inputs, to provide appropriate outputs to the actuators 4, 6, with the purpose of reaching a target indicator.
- [0033] For example, the AI can be trained to identify a relationship between target indicators and the various parameters / measurements / inputs provided to the control unit 2. As a mere example, a target indicator can be the car consumption. The AI can be trained by collecting data from the various parameters and sensors of the car, and by collecting the actuation of the actuators and the temperature of the vehicle component, so as to identify the car consumption resulting from a given setting of the actuators and from the temperature of the vehicle component, as well as under a given set of car parameters (e.g., car load, terrain, throttle position, etc.). By learning a multitude of combination of all these collected data, the control unit 2 is then able to decide how to actuate the cooling and heating

actuators to reach or attempt to reach a given car consumption, when facing a series of parameters.

- [0034] The target indicator may be any of the following (alone or as a trade-off between two or more of them): the car consumption (or km range); the tyre lifetime; the tyre safety; the generation of electricity from the thermogenerator.
- [0035] Hence, various situations may occur. For example, when the target indicator is the safety of a car, the control unit 2 may decide to warm up the tyres of a car rather than to favour the generation of electricity or the tyre lifetime. A tyre that is too cold incurs a performance/safety risk for the vehicle.
- [0036] The collection of data by the AI may also assist the control unit 2 to establish a driver's profile (e.g., dynamic or aggressive drive, or car mainly driven on soft terrain (forest, sand, etc.)). Based on the driver's profile, the heating and cooling actuators may be appropriately controlled to obtain the targeted indicator.
- [0037] The collection of data may be massive and all the variety of drivers or driving conditions may not be anticipated. Hence, the AI enable to constantly update the way the actuators are controlled to continuously improve the overall system. Data can be collected over a given initial duration or constantly through-out the use of the system.
- [0038] Optionally, the system can comprise a tyre pressure regulator. The pressure can be set as an additional actuator, controlled by the control unit 2 in conjunction with the heating or cooling actuators.
- [0039] Figure 2 shows a specific implementation of the concepts of the invention in a tyre 14 of a car.
- [0040] The tyre 14 can be arranged in an IC-engine car, or in a hybrid or electric car. An electric motor 16 can be embedded at least partly within the rim (not shown) of the wheel.
- [0041] Figure 2 also shows schematically the actuators 4, 6 and the thermogenerator 10, as well as the optional tyre inflator/deflator 18.

- [0042] The cooling/heating actuators and thermal sensors can additionally comprise elements distributed over the tyre (angularly and on the various sections of the tyre).
- [0043] For example, cooling/heating actuators can comprise on-rim heating pads 20 and on-rim cooling pads 22.
- [0044] Heating pads 24, 26, 28, and cooling pads and temperature sensors 30, 32, 34, can be respectively arranged at various positions on the inner edge, outer edge, central band of the tyre, and at various angular positions of the tyre.
- [0045] These elements are connected, directly or indirectly, to the control unit 2 via conductors (not shown), as well as connected to the battery 12.
- [0046] Although presented in conjunction with a tyre, the invention is not limited to this implementation. It can be used with an IC engine or an electric motor.
- [0047] Also, a system can combine the heat management upon several components of a given vehicle. For example, electric energy can be retrieved from a hot engine (due to the presence of fresh air around the car, thus creating a temperature difference useful for the thermogenerator) and this electric energy can be used to warm the tyres up, so as to bring the tyres at a temperature where it positively impacts the car consumption.
- [0048] Hence, the system and method of the invention enable a multi-objective optimization-based solution to maximize tyre lifetime, tyre safety and electricity generation for longer ranges, especially for electric vehicles.
- [0049] Additionally, an Internet of Things-based driving behaviour monitoring and recommendation system can be used to obtain a given trade-off between tyre safety and fuel optimization.

Claims

1. System (1) for regulating the temperature of a vehicle tyre (14), the system comprising:
 - a heating actuator (4) configured to heat the vehicle tyre (14);
 - a cooling actuator (6) configured to cool down the vehicle tyre (14);
 - a temperature sensor (8) configured to measure the temperature of the vehicle tyre (14);
 - a thermogenerator (10) configured to collect electric energy from the vehicle tyre (14); and
 - a control unit (2) connected to the heating actuator (4), to the cooling actuator (6) to the temperature sensor (8) and to the thermogenerator (10), wherein the control unit (2) is configured to control the heating actuator (4) and the cooling actuator (6) as a function of the measured temperature and at least one of:
 - one or more target indicators;
 - one or more vehicle parameters;
 - one or more environment parameters; and
 - one or more driver parameters.
2. System (1) according to claim 1, wherein the one or more target indicators are automatically or manually selected and comprises at least one of: a vehicle consumption; a tyre lifetime; a tyre safety rate; an amount of electric current generated by the thermogenerator; or a trade-off of two or more thereof, e.g., ensuring that the vehicle reaches its destination safely.
3. System (1) according to any of the preceding claims, wherein the vehicle parameters are at least one of: the vehicle speed, the vehicle load, or the tyre pressure; wherein the environment parameters are at least one of: the type of terrain, meteorology data, localisation data; and wherein the driver parameters are at least one of: the driver profile, the driver ID, the driver personal settings.

4. System (1) according to any of the preceding claims, further comprising a pressure regulator (18) for inflating or deflating the tyre (14) of the vehicle under the control of the control unit (2).
5. System (1) according to the preceding claim, wherein the control unit (2) regulates the tyre pressure based on the measured temperature, and on at least one of the target indicators and the vehicle/environment/driver parameters.
6. Method for training an AI, comprising:

collecting data, including vehicle parameters, environment parameters and driver parameters, and a tyre temperature;

assessing a relationship between the parameters, the tyre temperature and an indicator, the indicator being one of: a vehicle consumption; a tyre lifetime; a tyre safety rate; an amount of electric current generated by the thermogenerator; or a trade-off of two or more thereof, e.g., ensuring that the vehicle reaches its destination safely.
7. Method for regulating the temperature of a vehicle tyre (14), the method comprising:

providing a system with a control unit (2) including an AI trained according to the method of claim 6; and

using the control unit (2) to activate a heating actuator (4) and/or a cooling actuator (6) according to the relationships discovered during training of the AI, so as to obtain a target indicator, the target indicator being one of: a vehicle consumption; a tyre lifetime; a tyre safety rate; an amount of electric current generated by the thermogenerator; or a trade-off of two or more thereof, e.g., ensuring that the vehicle reaches its destination safely.

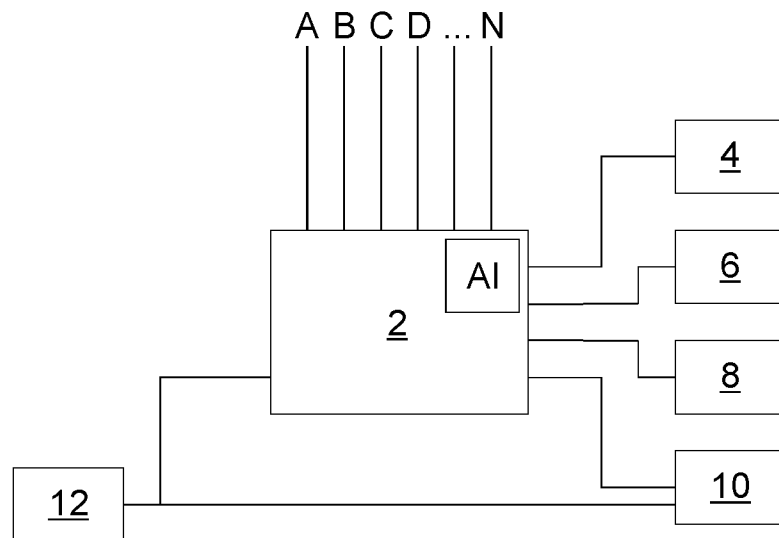
Revendications

1. Système (1) pour réguler la température d'un pneu de véhicule (14), le système comprenant :
 - un actionneur de chauffage (4) configuré pour chauffer le pneu de véhicule (14) ;
 - un actionneur de refroidissement (6) configuré pour refroidir le pneu de véhicule (14) ;
 - un capteur de température (8) configuré pour mesurer la température du pneu du véhicule (14) ;
 - un thermogénérateur (10) configuré pour collecter l'énergie électrique du pneu du véhicule (14) ; et
 - une unité de commande (2) connectée à l'actionneur de chauffage (4), à l'actionneur de refroidissement (6), au capteur de température (8) et au thermogénérateur (10),système dans lequel l'unité de commande (2) est configurée pour commander l'actionneur de chauffage (4) et l'actionneur de refroidissement (6) en fonction de la température mesurée et d'au moins l'un des éléments suivants :
 - un ou plusieurs indicateurs de cible ;
 - un ou plusieurs paramètres du véhicule ;
 - un ou plusieurs paramètres d'environnement ; et
 - un ou plusieurs paramètres du conducteur.
2. Système (1) selon la revendication 1, dans lequel le ou les indicateurs cibles sont sélectionnés automatiquement ou manuellement et comprennent au moins l'un des éléments suivants : une consommation du véhicule ; une durée de vie du pneu ; un taux de sécurité du pneu ; une quantité de courant électrique généré par le thermogénérateur ; ou un compromis entre deux ou plusieurs de ces éléments, par exemple, garantir que le véhicule atteint sa destination en toute sécurité.
3. Système (1) selon l'une quelconque des revendications précédentes, dans lequel les paramètres du véhicule sont au moins un parmi : la vitesse du véhicule, la charge du véhicule, ou la pression des pneus ; dans lequel les

paramètres de l'environnement sont au moins un parmi : le type de terrain, les données météorologiques, les données de localisation ; et dans lequel les paramètres du conducteur sont au moins un parmi : le profil du conducteur, l'identifiant du conducteur, les paramètres personnels du conducteur.

4. Système (1) selon l'une quelconque des revendications précédentes, comprenant en outre un régulateur de pression (18) pour gonfler ou dégonfler le pneu (14) du véhicule sous le contrôle de l'unité de commande (2).
5. Système (1) selon la revendication précédente, dans lequel l'unité de commande (2) régule la pression des pneumatiques en fonction de la température mesurée, et d'au moins un des indicateurs cibles et des paramètres véhicule/environnement/conducteur.
6. Procédé d'apprentissage d'une IA, comprenant :
la collecte de données, y compris des paramètres du véhicule, des paramètres de l'environnement et des paramètres du conducteur, et une température de pneu ;
la détermination d'une relation entre les paramètres, la température du pneu et un indicateur, l'indicateur étant l'un des éléments suivants : une consommation du véhicule ; une durée de vie du pneu ; un taux de sécurité du pneu ; une quantité de courant électrique généré par le thermogénérateur ; ou un compromis entre deux ou plusieurs de ces éléments, par exemple, garantir que le véhicule atteint sa destination en toute sécurité.
7. Procédé de régulation de la température d'un pneu de véhicule (14), le procédé comprenant :
la fourniture d'un système avec une unité de commande (2) comprenant une IA formée selon le procédé de la revendication 6 ; et
l'utilisation de l'unité de commande (2) pour activer un actionneur de chauffage (4) et/ou un actionneur de refroidissement (6) selon les relations découvertes pendant l'apprentissage de l'IA, de manière à obtenir un indicateur cible, l'indicateur cible étant l'un des suivants : une consommation du véhicule ; une durée de vie du pneu ; un taux de sécurité du pneu ; une quantité de courant

électrique généré par le thermogénérateur ; ou un compromis entre deux ou plusieurs de ces éléments, par exemple, garantir que le véhicule atteint sa destination en toute sécurité.

Fig. 1**Fig. 2**