Self-inflating tire technology

for passenger car, truck and bus tires, awarded on the 2008 SAE World Congress in Detroit.

Research into reducing fuel consumption and CO2 emissions as well as improving on the road safety has resulted in the world's first self-inflating tire system to be mass-production feasible.

SIT – the Self Inflating Tire system is an invention of CODA DEVELOPMENT, a company based in Czech Republic. The patented SIT solution offers a major advance in solving tire pressure concerns.

The SIT system was introduced at the 2008 SAE WORLD CONGRESS in Detroit where it received the 2008 Tech Award. The company is now ready to develop and test a pre-production prototype with the aim to bring this technology to the market by 2010.

SIT system description

The SIT system is based on highly reliable and proven peristaltic pump principles. It uses the weight and motion of the vehicle to inflate the tire as needed, sourcing air from the outside atmosphere. The whole system consists of only two components – a tube chamber functioning as a peristaltic pump for the tire and a pressure management device to control the inflation.

The peristaltic tubing is located longitudinally between the rim and the tire wall and copies almost the whole perimeter of the rim. Normal tire deformation caused by the weight of the vehicle creates a closure of the tubing at its lowest point. As the tire moves against the road this closure pushes the air contained inside the tubing into the tire and simultaneously it pulls outside air back into the tubing. As a result, the tire is inflated with the contents of the tubing with each wheel revolution until it reaches its desired pressure.

Tests conducted on a regular passenger car wheel have proven that the forces between the deformed tire wall and the rim are sufficient to generate significantly higher pressure than what is needed for tire inflation.

SIT peristaltic tubing solution

The peristaltic tubing can be implemented into the tire wall in the following way. As there already exists room between a regular tire and rim where the reinforced tire wall is periodically pressed against the rim due to the weight of the vehicle, the tubing can be created as a crevice in the tire side wall. When tire and rim are assembled together, the crevice is sealed by the pressure between them (which is sometimes more than ten times higher than the required tire pressure) and therefore it becomes a sealed tubing inside the tire wall. This could be accomplished by a simple design change in the tire side wall, which, simplified, could be achieved by a modification of the mould in the normal tire production process. The crevice in the tire wall and its sealing during the wheel assembly is shown in figures 3 and 4.

It is also possible to create the tubing outside the tire wall as a separate unit placed between the rim and the tire. In that case the tire would just lean on the tubing and enclose it by its deformation, as shown in figure 2. Such a setup was used during the prototype testing.

Therefore, SIT can be either a part of the tire or a part of the rim. Upcoming road testing of

a pre -production prototype will show which one of the two options will be more suitable for the introduction on the market.

SIT pressure management solution

The above-described inflation system would pump up the tire with every wheel revolution regardless of whether the tire is under-inflated or not. Therefore a managing system has been designed to turn the inflation ON in case the tire is under-pressured, and turn it OFF once the desired pressure inside the tire has been reached.

In case of a properly inflated tire the managing system connects both intake and outlet of the tubing with the inside space of the tire. Therefore the air only circulates between the tubing and the tire with each rotation of the wheel while the pressures remain almost equal. In addition to the intake opening into the tire there is another opening from outside of the tire, equipped with a check valve. This setup of properly inflated tire is shown in figure 5, where the internal air circulation is indicated by the red arrow.

When the tire pressure falls below its optimal level the pressure management device closes the intake from the tire and instantly creates a vacuum at the intake part of the tubing. This vacuum opens the check valve and the tube starts pulling air from the outside atmosphere into the tubing and subsequently into the tire. Once the correct tire pressure is reached, the pressure management device again opens the intake of the tubing from the tire, the tubing and tire pressures equalize and the check valve closes down. This setup of under-inflated tire is shown in figure 6, where the stream of inflation air from the outside atmosphere is indicated by the green arrow.

In summary, the SIT consists of the tubing with a single opening (1) at its one end leading into the tire and two openings at its other end, one of which (2) leads back into the tire and is equipped with the pressure management device, and the other intake opening (3), equipped with the check valve, leads outside the tire.

The pressure management device in its simplest form is a container of compressed air equipped with a membrane. This device is located inside the tire and is therefore surrounded by the air pressure of the tire. The pressure inside this container is pre-set to any desired tire pressure depending on the type of the vehicle the tire is intended for. The membrane is located against the intake opening (3) of the tubing from the tire. As the tire pressure falls below its desired level (the pre-set pressure of the container), the air inside the pressure management device will expand and push the membrane towards the opening (3) and close it. Resulting vacuum in the tubing starts pulling air from the outside atmosphere and the tire gets inflated. Once the tire pressure reaches its optimal level equal to the pressure of the management device, the membrane is drawn out of the opening (3) and the inflation stops. As the pressure management device is always surrounded by the pressure of the tire, there is no big demand on its robustness – due to its design, the pressures inside it and outside it will be most of its lifetime equal, and occasionally slightly lower in its surrounding (the inside of the tire) when the tire is under-pressured until it gets properly inflated again.

Beside its simplicity, where the whole system consists of only the tubing, check valve and pressure management device, there is another great advantage of this setup. Statistics show, that in order to solve under-inflation caused purely by regular tire leakages, the SIT has to inflate the tire only in every 3000^{th} revolution; or in other words, it would be in operation for 3km out of every 10,000km drive. It means that it would not inflate the tire for the remaining 9,997km. Therefore, most of the time there would be only inside air circulation between the tubing and the tire back and forth with equal pressures between them, which further increases the durability of the system.

The pressure management device has yet another advantage. Due to the influence of the temperature on the tire pressure, it is recommended to inflate tires only when they are cold. However, with SIT, the air inside the sealed pressure management device is getting warm together with the tire and therefore it ”recognizes“ the under-inflation of the tire regardless of whether the tire is cold or warmed-up. On the other hand, in order to prevent lowering of the predetermined inflation pressure in cold outside temperatures, the bottom limit for the predetermined inflation has to be built-in in some cases, which can be accomplished easily.

The pressure management device can be replaced by a calibrated spring or an electronically managed valve. If it was electronically managed, it could be easily connected with the mandatory Tire Pressure Monitoring system. In such a case, the TPMS in conjunction with SIT would not only inform the driver about under-inflated tires but also start the inflation immediately and solve the problem as soon as it appears.

In the above section the SIT system is described, which lets the air circulate between the tire and tubing; when the tire is under-inflated, the tubing pulls air from the outside atmosphere.

An inverse solution is also possible. It lets the air circulate from the outside atmosphere into the tubing and pushes it back to the atmosphere in case the tire doesn’t require further inflation. Only in case of under-inflated tire the pressure management device closes the output from the tubing into the outside atmosphere and therefore over-pressure occurs at that end of the tubing. This overpressure is then released into the tire through the check valve. So, the reversed system consists again of the tubing but it has one intake freely open to the outside atmosphere, one output opening into the outside atmosphere equipped with the pressure management device and another output opening directed into the tire and equipped with a check valve.

Peristaltic pumps are dirt or garbage resistant by their design. They function even when something gets stuck inside them and they are naturally self-cleaning. However, both in case of the internal circulation and in case of inverse-external circulation the intake can be equipped with a filter or constructed in such way that centrifugal forces would keep it clean not only from the garbage but also from water and dust. (* Detailed technical description has not been released for public yet).

Both, the internal air circulation and the inverse-external circulation are being evaluated further as it seems that one of them will be more suitable for SIT implemented as a part of the tire and another one for SIT being a part of the rim.

Spare wheel / RunFlat tires replacement by SIT

Statistics say that 87% of all flat tires have a history of under-inflation. For more than 90% of flat tires, it takes more than one hour since the puncture to get completely flat. Considering that SIT can prevent significant amount of flat tires, and for majority of the remaining flat tires it can still keep inflating the tire while the vehicle can be driven to a garage safely, it seems that in almost 100% cases the spare wheel would not be needed anymore. This could result in significant savings in vehicle space and weight as well as in related costs. Furthermore, the SIT system can remove the need for RunFlat tires as it provides for improved driving safety while bringing additional benefits in terms of costs and convenience.

SUMMARY

Main features:

- ●SIT consists of:
  - ●Peristaltic tubing
    - ●created by a change in the tire design or as a separate tube between the tire and the rim
  - ●Check valve
  - ●Pressure management device
    - ●container of compressed air with a membrane
    - ●it can be simply adjustable to use the same device for various pressures or to change the required pressure on the road as needed
- ●SIT will be a part of the tire or the rim
- ●SIT will have either internal or inverse-external air circulation
- ●SIT rests for 99.97% of the tire lifetime in case that there is no puncture
- ●SIT prevents almost 100% needs for solving flats on the road
- ●The ”ready for production“ status of SIT is expected within 12 months since the start of the next R&D stage. This estimation comes from 3rd party experts from the industry (2008 SAE World Congress, Detroit, USA).

Key benefits to consumers:

SAFETY

- •In the United States, 660 persons die and 33,000 are injured every year.
- •87% of all flat tires have a history of under-inflation
- •Properly inflated tires increase car stability and reduce the danger of blowouts.
- •They also ensure the car's proper braking distance.

FUEL ECONOMY

- •Correct tire pressure leads to lower rolling resistance, thus significantly improving fuel efficiency.
- •In the United States alone, 1.24 billion gallons of fuel per year can be saved by proper tire pressure.
- •Poor tire pressure costs extra $3.7 billion in fuel in the US annually.

TIRE LONGEVITY

- •Every year, 4.5 million tires need to be replaced before their designed lifespan in the US.

ENVIRONMENTAL FRIENDLINESS

- •Less carbon dioxide is released into the atmosphere.
- •Less tire debris litters the roadways.
- •Fewer scrap tires are generated.

CONVENIENCE

- •Drivers have confidence in knowing that their tires always operate at optimal

pressure.

- Eliminates inflating tires at gas stations, using an obviously easier and cleaner solution.

Key benefits to manufacturers:

DIFFERENTIATION

- SIT offers a significant added value to end consumers.
- Its benefits are easy to communicate and relevant to today's market.

LOW VARIABLE COSTS

- The SIT system is easy to integrate into the current tire manufacturing process.
- Production of SIT tires will be only marginally more expensive than the production of today's regular tires.

REGULATORY COMPLIANCE

- Tire pressure monitoring systems (TPMS) notify the driver when a tire is under-inflated. TPMS are already required in the USA and soon will be required in other countries too.
- SIT addresses the core problem of tire under-inflation directly. It works independently, but also in combination with TPMS.

SPARE WHEEL / RUN FLAT TIRES

- Potential for full elimination

Statistics:

Research studies show that under-inflated tires are a major issue today. In the USA, 27% of passenger cars and 32% of light trucks and SUVs have at least one tire under-pressured by more than 25%. This results in 660 fatalities and 1.24 billion gallons of wasted fuel per year (costing 3.7 billion USD).

Similarly, 38% of cars in the EU drive on under-inflated tires. This results in 5.3 billon liters of wasted fuel worth of 7 billion EUR, and an extra 12.3 million tons of CO_2 released into the atmosphere. These figures can be estimated to be similar in emerging populous countries. A simple inflation system that is easy and inexpensive to produce would bring enormous savings in fuel, pollution, and human lives when implemented on a large scale.

Figures:

Figure 1 shows a cross-section through the regular tire. Circles show locations of details A and B described in figures 2 and 3. Detail A depicts an un-loaded part of the tire while detail B depicts a loaded – bottom part of the tire. Figure 2 shows the position of the SIT tubing between the tire and the rim, while it is a part of the rim. At the upper part of the wheel, the tubing is open, while at the bottom – loaded part of the wheel, the tubing is closed by normal tire deformation. Figure 3 shows the SIT tubing as a part of the tire wall. One of the ways how to create such tubing is to make a crevice in the tire wall as shown in figure 4. When the tire and the rim are assembled together, the crevice then seals itself and forms the tubing in the tire wall.

Figure 5 shows the tire, the rim and the tubing in between them forming the SIT system with the internal air circulation. The wheel rotation indicated by an arrow squeezes the SIT tubing at the bottom part, thus forcing air through the tubing as indicated by the dotted arrow. The membrane of the pressure management device is not closing the intake opening of the SIT tubing from the tire

and therefore air keeps circulating between the tire and the tubing as shown by the red dotted arrow.
Figure 6 shows an under-inflated tire where the membrane of the pressure management device closes the intake opening from the tire, and created vacuum then opens the check valve. This pulls air from the outside atmosphere into the tire as indicated by the green dotted line. When the tire gets properly inflated the pressure management device again opens the intake opening of SIT tubing from the tire, thus allowing for internal air circulation again.

More information, including explanatory animations and a prototype testing video, are available at www.selfinflatingtire.com.