TANKER FOR HOT DE-ICING OF ROADS AND HIGHWAYS

ITALY, THE LAND OF SUN, PROVIDES AN INNOVATION
FOR RAPID MELTING OF SNOW AND ICE

A. Zavitteri
AIPCR, Rome, Italy
zavitteri@iol.it

ABSTRACT

Patented fast-acting road de-icer which spreads hot solutions of $CaCl_2$.
The process is based on the intrinsic properties of calcium chloride, which develops an exothermic reaction when dissolved in water, producing heat that combined with the strong chemical de-icing effect of calcium chloride, greatly increases the efficacy of road de-icing treatments. The technique employs a tanker that spreads hot solutions of $CaCl_2$ (temperature circa 50°C), which self-produces the de-icer in approx. 5 minutes even while the tanker is travelling to destination. This is possible through the use of special mixing nozzles employing the Venturi principle. These nozzles, accurately positioned in the tanker, are able to move by means of self-suction a quantity of liquid 5 to 8 times greater than the fluid dispensed by the nozzle itself.

The advantages of this important innovation are immediately evident and result in operating, economic and ecological benefits for users.

1. Objectives

To prevent the formation of ice on roads and highways, in addition to the removal of snow and ice that has formed over them, today the standard method is to use liquid brine solutions at ambient temperature, a process that exploits only the chemical properties of these de-icers. The technical objectives of this project were to maximize the intrinsic properties of calcium chloride, which upon being dissolved in water, develops an exothermic reaction (it gives off heat when becoming a solution). This innovative method allows the hot solution to be spread onto the road and as a result greatly increases the efficacy of the treatment.

To meet these objectives, a system was developed and patented that consisted of a tanker with the dual function of quickly self-producing the calcium chloride solution and spreading it while still hot onto snowy or icy roads.

2. Technical Level

The technique currently used for de-icing involves the following: the Maintenance Centres situated along roads and highways in Italy are normally equipped with brine solution storage facilities or facilities for their self-preparation.

In the first case, the storage facilities are filled with calcium chloride solution before the start of winter. This type of solution, which is factory-produced (the primary producer is the Solvay Co. based in Rosignano Solvay near Livorno) and shipped throughout Italy to

storage points, loses all of its “thermal power” during the long transport. When maintenance operations require it, the solution is available at ambient temperature.

In the second case, the calcium chloride solution is autonomously produced on site in special facilities. The procedure is slow (approximately one hour for the production of 10,000 litres of solution), making it essential to perform production beforehand, then store the solution in large tanks. Again, the thermal effect is completely lost.

In both cases, when the situation requires, the calcium chloride is loaded onto the tanker spreaders by means of pumping systems and spread at “ambient temperature,” i.e., cold, onto the road surface.

The innovation of the project lies in providing road and highway maintenance staff with a tanker spreader that has the dual function of rapidly self-producing the calcium chloride solution at the concentration of 26-27% and at a temperature of circa 50 °C (= 122 °F) and spreading it onto the road while the solution is still hot.

Figure 1 – Field comparison between tankers containing solutions of hot and cold $CaCl_2$. The difference in the de-icing effect of the hot solution (at left) is significant.

The reason for studying the project was to give a concrete response to the emergency situations experienced over the last few years on Italian road and highway networks, as well as on roads in other European countries, which have produced serious traffic stoppages during snowfalls.

These problems are often due to the following:

- An exponential rise in traffic levels which has not been matched with improvements in road networks.

- The widespread use of draining asphalt, especially in Italy, a material excellent in rainy conditions but less efficient during snowfalls, especially over bridges and viaducts where winter weather have a more severe impact and the formation of ice can be more sudden and uncontrollable than elsewhere.

- The lack of skill and experience of some drivers of heavy vehicles who are insufficiently equipped to travel stretches of road in adverse weather conditions. The classic case is when one of these vehicles causes a blockage of the road network (even in a light snowfall and with minimum sloping of the road) by slipping sideways across the road and creating long backups and preventing the salt spreaders and snow ploughs to perform road maintenance. Certainly in these cases even the most efficient and careful organisation may be futile and the formation of packed ice and/or snow turns into a problem without an easy solution.

What the international patent has achieved, therefore, is to provide the means for spreading the hot solution in those icy areas and obtain the immediate chemical de-icing reaction of the calcium chloride, further increased due to the combined thermal effect.

Of course, the thermal solution can be distributed with excellent results (reduced consumption and greater efficacy) also on less critical sections of road.

The main advantages allow the user to:

- obtain the highest efficacy and rapidity in melting ice and chunks of compressed snow on the road;

- perform both procedures (production and distribution of de-icing solution on the road), with only one tanker equipped with one motor-driven pump.

- use one motor-driven pump with a reduced power with respect to the recognized requirements for melting processes using current systems;

- this is because the new technologies allow, through the use of special “Venturi” mixers, to move 5-8 times the volume of liquid inside the tank compared to other systems in use;

- these features make it possible to dissolve approx. 4000 kg of calcium chloride in about 5 – 8 minutes to obtain a 26-27% solution at a temperature of circa 50°C (= 122 °F);

- in addition to facilitating de-icing operations, the advantages above are determining factors in emergency situations, such as:

    - maintenance on bridges and viaducts where the rapid formation of ice due to the reduced thermal inertia of these structures makes melting the ice immediately absolutely essential;

    - the elimination as quickly as possible of chunks of iced-over snow caused by the packing down effect of vehicles in transit. This situation causes critical problems, such as the vehicle going off the road or more seriously, when maintenance vehicles are trying to de-ice roads and are prevented from performing operations because of stoppages. One example would be a tractor-trailer that has slid sideways across the road and blocked traffic. The resulting scenario is a long stretch of road or highway heavily snowed over with the most dramatic consequences imaginable;

    - the patented system enables the blocked vehicles (often trucks) to resume travel by means of spraying “hot solution” using special nozzles fitted onto the tanker;

- this system replaces costly permanent automatic spray systems containing brine solutions used in critical areas such as bridges and viaducts.

The combination of these advantages, in terms of operation and performance, can be added to the other economic and ecological benefits, such as:

- a reduction in the labour cost for minor road maintenance;
- a reduction in mileage costs of the maintenance vehicles;
- a substantial reduction in the cost of salt;
- a reduction in the cost of maintenance of road and highways structures;
- a reduction in damages due to corrosion to maintenance vehicles and vehicles in transit;
- a reduction in towed vehicles;
- a notable reduction in harmful exhaust emissions produced by maintenance vehicles;
- a significant reduction in pollution caused by the distributed salt.

The only disadvantage, which is easily solved, is to outfit those Maintenance Centres considered strategic with storage facilities of calcium chloride packed in big bags each containing 1000 kg (easily available on the market and produced by the same supplier as the liquid solution) and provide a small lift for loading the calcium chloride into the dissolution tank on the truck.

3. Proposals and Technical Solutions

The project's features can be summarized as follows: the tanker/spreader must have the possibility for example of producing 10,000 litres of calcium chloride solution as quickly as possible at a concentration of 26- 27% in order to spread it while still hot (circa 50 °C).

Figure 2 – Thermal effect (steam) with half-full tank after approx. 1 hour of work

To accomplish this, the project required a fibreglass tank with an approx. 11,000 litre capacity fitted with two loading portholes on the top. Two pumps perform uniform distribution of the calcium chloride inside the tank. With the tank previously filled with 8,000

litres of water, loading then commences by using big bags (1,000 kg each), or better, by means of automated silos filled with 4,000 kg of calcium chloride. The chloride not yet dissolved is deposited on a perforated grate, where the first dissolution process is performed by the mixing nozzles. The part that has been totally or partially dissolved will fall onto the bottom of the tank and by means of suction nozzles and the motor-driven pump reactivated for a rapid and total dissolution. After a pre-set time, the circuit of the mixing nozzles will be closed and the circuit of the nozzles under the grate will be opened to guarantee the dissolution of any material deposited on the bottom of the tank.

The time for loading and dissolution time is very fast, verified at a max. of 5-8 minutes, with the process being performed also while the tanker/spreader is travelling to destination so that the calcium chloride solution can be spread at the maximum temperature possible.

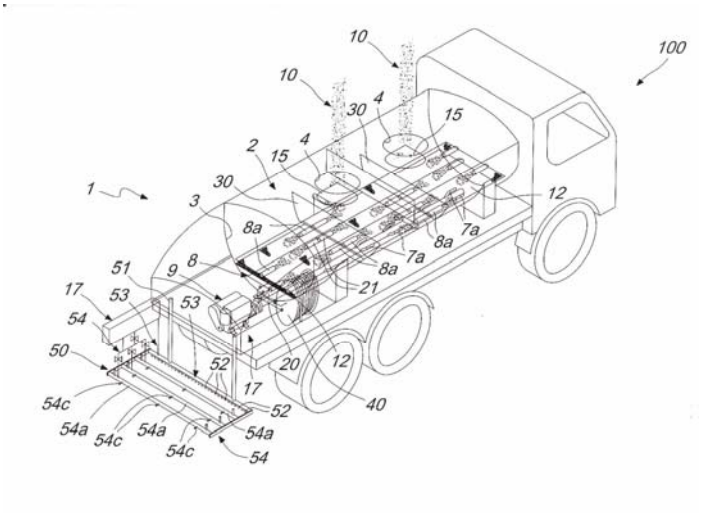


Figure 3 – Diagram of the tanker for the automatic production and distribution of hot brine solution (taken from international patent).

The hot brine solution produced can be automatically spread on the road using a set of sprinkling bars at rear fitted with nozzles, or else manually by using a lateral nozzle in very serious emergencies.

The automatic sprinkling system at rear consists of three or more sprinkling bars (see Figure 4) which can be activated separately or simultaneously according to necessity.

Two of these sprinkling bars are fitted with fan spray nozzles and lateral nozzles at right and left, which perform even distribution of the calcium chloride on the road, based on ending on the speed of the vehicle and the quantity (g/sq m) pre-set by the operator. As a result, this spreading system can be used in less critical situations, e.g., for preventive treatments, with a spreading width up to 11 m, which is equivalent to a 3-lane highway.

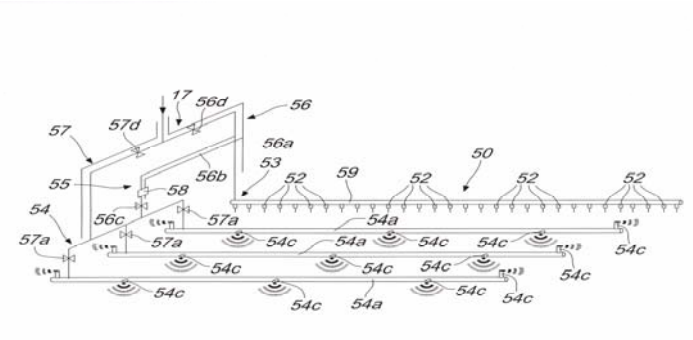


Figure 4 – Diagram of automatic rear sprinkling system (taken from international patent)

The third bar is equipped with special rectilinear jet nozzles and is usually activated in emergency situations (road surface covered with ice and/or compressed snow). Positioned in front of the other two standard bars, it performs the function of a plough thanks to the triple de-icing action (chemical, thermal and mechanical). The special shape of these nozzles (rectilinear with a 1.4 mm section) and the high pressure of the spray (5-15 bar) have a cutting-plough effect on the compressed snow. This factor enables a quick penetration down to the pavement, also of the de-icer spread by the other two bars with the fan jet, helping to break the bond between the pavement and the snow and ice.

The snow and ice can then be easily removed by snow ploughs and optimum traffic and safety conditions can be promptly restored.

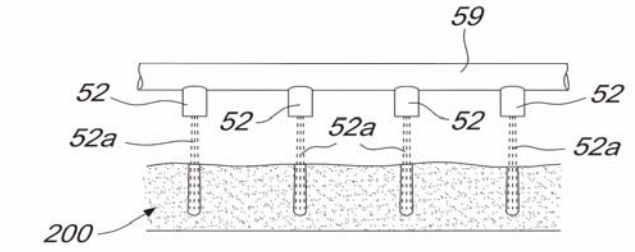


Figure 5 – Diagram of third sprinkling bar with rectilinear jet nozzles highlighting the cutting/ploughing effect on the snow-covered surface (taken from international patent).

4. Technical Problems

The technical difficulties to deal with involved:

- the high melting speed necessary for the prompt and efficient road maintenance using hot solution without the need for a high-powered motor-driven pump unit;

- the thermal shocks generated by the powerful exothermal reaction produced during the dissolution of the calcium chloride in water;

- the maintenance of the high temperature of the brine solution produced.

Special mixing nozzles were used to meet the first objective. These nozzles, through application of the Venturi principle, have the ability to move by means of self-suction a quantity of liquid 5-8 times higher than that discharged by the nozzle itself.

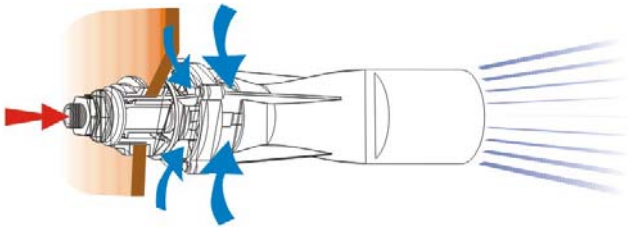
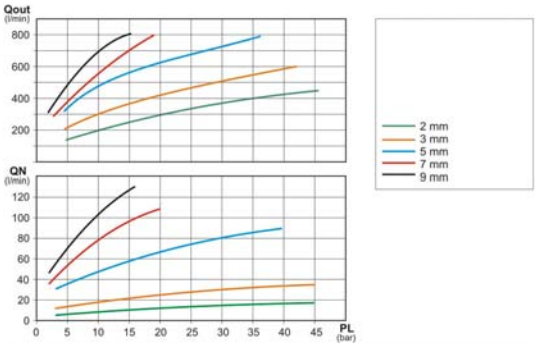


Figure 6 – Mixing nozzle with Venturi effect

Table 1 – Capacity of the nozzle at inlet and outlet at various pressures



The figure above shows the mixing nozzle (Figure 6) with the Venturi effect. Table 1 shows the capacity of the nozzle, demonstrating how for a 5 mm nozzle (blue line), which we consider sufficient, with a pressure of 5 bar, handling a quantity of inlet liquid (QN) of approx. 38 litres/min, a quantity of outlet (discharged) liquid (QOUT) thanks to the Venturi effect of approx. 320 litres/min. This enables large quantities of liquid to be in movement (mixing and rapid dissolution of the calcium chloride) resulting in the advantage of using a low-powered, compact-sized motor-driven pump.

The second objective was met by having all components in contact with the hot brine solution (tank, pipes, valves, nozzles, etc.) in special materials resistant to thermal shocks, with rapid variation of temperature within a range of – 20 ° C (air) to + 50 ° C (brine solution).

The third objective was attained with the use of a fibreglass tank with chemical barrier in vinylester resin, mechanical structure in isophthalic resin and paraffin resin outer top coat with anti-UV additive.

This structure has an insulating power 10 times greater than steel and guarantees the calcium chloride solution to be maintained at approx. 50* C, from its production until the moment it is spread on the road.

However, in zones with very heavy weather conditions, it is possible to use a tank built in insulated fibreglass (composed of a layer of internal insulation sandwiched between two outer layers in fibreglass) with an insulating power 100 times greater than that of steel.