

Numerical solution of heat equation with phase transition and moving source

Ramiro dell'Erba

ENEA - UTTEI-ROB, Centro Ricerche Casaccia, Via Anguillarese 3001, Roma 00123

AREA: RICERCA

DISCIPLINA: A

The reference frame of this work was a FIRB project called MIAO (Microtecnologies for Hostile Environment). It was dealing with the application of technologies and the development of miniaturized products, microscopic sensors for extreme environmental with optimized characteristics.

One of the Workpackage previewed the realization of a tethered robot called Pandora (Program for ANtartic Drilling explORAtor for subglacial lakes) for the exploration of subglacial lakes in Antarctica. The scope is not the realization of the final prototype but the planning and the verification of the wire-guided robotic feasibility of a carrier able to penetrate the ice. Pandora is a robot of cylindrical shape and is able to melt the ice and to come down in vertical driven from the gravity force. The robot will be lost in the meaning that once that the ice is closed behind of it cannot more be recovered; however a cable is unrolled owing to transmit the data on the surface. A prototype was tested on the ice of the Tonale. The NASA is working on a similar robot for the exploration of Europa.

One of the questions we asked was if the ice would be able to lock the robot frozen the water on the lateral surface; the best way to answer is to try directly but, for our knowledge, a nice attempt to solve the heat equation was carried out. Therefore I will present here a numerical solution of the non stationary heat equation with phase transition and moving source. The motion equation of Pandora and the temperature distribution in the ice, as function of space and time, will be the final product of this job.

Mathematica was used, as usual, principally for the calculation of the heat distribution both in explicit and in implicit form. The solution was obtained by discretization of the space and the time and to add a "heat credit swap" matrix to take in account the phase transition of the cells, where the temperature is locked to zero. The motion is allowed only when the all the cell in front of the Pandora's head is melted. Moreover all the graphic representation and also the report was carried out by Mathematica.

Key words: Heat equation Robotic, Hostile environment.