The many facets of microwaves

From cooking food to gluing paper

A group in NRC's Division of Electrical Engineering is exploring industrial applications for microwaves.

A new technology is on the horizon. Microwaves, once the sole domain of the military and the communications field, are being applied more and more to a variety of industrial uses. In the last few years we have become quite familiar with the domestic microwave oven, capable of cooking foods in a fraction of the time required by ordinary methods. At the same time, industry has been exploiting microwaves for manufacturing purposes.

In Canada, the National Research Council's Division of Electrical Engineering provides the only major facility for investigating the use of microwaves by industry. A small group in the Division has explored a variety of applications and, in many cases, assisted industry in implementing these innovations.

But what are microwaves? What is it about this invisible energy that allows us to cook a roast in 15 minutes when the same task takes three hours in a standard oven?

Microwaves are, simply, electromagnetic radiation consisting of oscillating electric and magnetic fields, as are visible light, ultraviolet, infrared, and radiowaves. Like light, microwaves travel exceedingly fast (at the speed of light, taking only 1/10 of a second to circumnavigate the earth); they can be reflected, refracted and can pass through certain barriers such as glass. Most important, microwaves contain energy, that entity which allows us to do work.

What happens when an object is exposed to microwaves? Take the example of a roast in a microwave oven. When the microwave generating equipment (such as a magnetron) is turned on, rapidly oscillating electric and magnetic fields are established. At the usual frequency of 2 450 MHz (megahertz), the electric field oscillates or reverses polarity almost 5 billion times every second. As this field surrounds and penetrates the roast, polar molecules in the meat (molecules such as water which do not have a uniform distribution of positive and negative charges) attempt to align themselves in the field – the positive part facing the negative pole and the negative part towards the positive pole. When the polarity of the field reverses the polar molecules immediately rotate and try to realign themselves. This whole process is repeated over and over again so rapidly that the vibration of the molecule produces heat. In short order, the temperature rises evenly throughout the meat, cooking it. In the case of a standard oven, meat is gradually cooked by heat conduction from the

Mr. W. Wyslouzil investigates the performance of a microwave drying apparatus for continuous sheet materials (paper, in this case). In the background is the laboratory's 30 kW, 2450 MHz microwave source. The test apparatus includes a transport mechanism, and a special system for applying the microwaves to the paper, called a serpentine applicator. *(Photo: DEE/NRC)*

M. W. Wyslouzil mesure le rendement d'un dispositif de séchage à micro-ondes pour matériaux en feuilles débitées en continu (ici, du papier). On aperçoit à l'arrière-plan la source de micro-ondes émises à la fréquence de 2450 MHz sous une puissance de 30 kW. L'appareillage d'essai comporte un mécanisme de transport et un système spécial pour l'application des micro-ondes au papier, appelée applicateur en serpentin. *(Photo: DGÉ/CNRC)*