講演番号 120 文献番号 20226120

Heater Power Reduction Effect and Millimeter-wave Transmittance of Snow Melting Radome with Foamed Resin

Ryuho Ikemasu [1)] Tatsuo Tanaka [2)] Mikio Takada [2)]

Tatsuaki Kasai [2)] Hiroyuki Kobayashi [1)]

1) Sankei Giken Kogyo Co., LTD.
2-5-1 Akabane Minami, Kita-ku, Tokyo, 115-8555, Japan (E-mail: g-ikemasu@sankei-gk.co.jp)
2) Asahi Kasei Corp.
Hibiya Mitsui Tower (TOKYO MIDTOWN HIBIYA) 1-1-2 Yurakucyo, Chiyoda-ku, Tokyo 100-0006, Japan

KEY WORDS: **Safety, Pre-crash, Millimeter-wave radar,** Radome, Power conservation (C1)

Millimeter-wave (MMW) radar, which can detect objects even in poor visibility conditions, is an indispensable sensor for realizing the autonomous operation of a vehicle. However, the MMW transmittance can be interrupted by depositing snow on a radome during winter or in cold regions. To address this issue, an approach to remove snow from the radome has been put into practical use by placing a heater element in the radome.

It is important to give directionality to the heat transfer and help increase the temperature of the front of the radome as much as possible to realize a radome with a more efficient snow-melting capability than the current radome. We developed a structure in which insulation material is placed behind the radome to give the directionality of heat in the radome. Furthermore, by employing foamed resin as the insulation material, since foamed resin contains air, the impedance between the insulation material and the air is matched, and higher MMW transmittance can be expected than with solid resin.

This study clarifies the effect of the enhancement of thermal efficiency obtained by giving directionality to the heat by placing the foamed resin on the back of the radome and the relationship between the foaming ratio, i.e., density, of the foamed resin and MMW transmittance.

The heat directionality was confirmed by comparing the power needed to maintain the surface temperature at 15°C in a −5°C environment using heat transfer simulations. This radome model is composed of 2.4 mm thick solid acrylonitrile butadiene styrene (ABS) with 3.0 modified-polyphenylene ether (m-PPE) 10 times foamed resin on the back. At a vehicle velocity of 0, 50, and 100 km/h, simulations are performed. Table 1 shows the heater power consumption required to maintain the surface temperature under steady state conditions with and without the foamed resin. This simulation shows a 30 % reduction in power consumption due to the effect of attaching the foamed resin. This reduction in power consumption increased with vehicle speed, reaching 58 % at 100 km/h.

Table 1 Heat transfer calculation results for the power consumption to maintain the surface temperature at 15°C in a −5°C environment.

Vehicle Speed [km/h]	Power consumption		
	w/o foamed resin [W]	w/ foamed resin [W]	Reduction ratio [%]
0	6.72	4.72	30
50	32.84	15.62	52
100	51.56	21.49	58

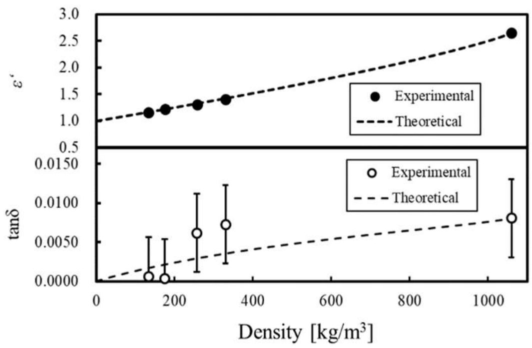

Fig. 1 Real part of the complex relative permittivity (ε') and loss tangent (tan δ) measured at 76.5 GHz of m-PPE foams as a function of the density of the foamed resin. The theoretical plots indicated by the dashed line were calculated from Knott's formula[(1)].

The complex relative permittivity of the molded m-PPE foam, prepared foaming ratio were 3.2, 4.1, 6.1, and 7.9 times, were measured to clarify the relationship between the foaming ratio of the foamed resin and MMW transmittance at 76.5 GHz. Fig. 1 shows the results of the measurement of the complex relative permittivity of the foamed resin and the calculation results using Knott's formula [(1)]. The measurement value of the complex relative permittivity was discovered to be a good approximation of the calculated value. Thus, the complex relative permittivity can be derived at an arbitrary foaming ratio using the Knott's formula, and the MMW transmittance can be predicted.

Expanding the driving range of electric vehicles will result in greater convenience for electric vehicles. Thus, the demand for power-saving technologies related to electric vehicles is expected to increase in the future. The structure proposed in this study, which enables the reduction of power consumption of snow-melting radome employing foamed resin, helps enhance the convenience of electric vehicles.

(1) E.F.Knott.: Dielectric constant of plastic foams., IEEE transactions on antennas and propagation Vol41, no.8, p1167-1171 (1993).