Exercise : Selecting Materials and Process

Microwave dishes

Background. What do fast food, airline meals, and instant coffee have in common? That they have all been heated by microwaves. To do this they have to be held in a container that must meet certain criteria. It must not absorb microwave strongly – if it does, it will get hot and the contents (where you would like the heat to be generated) will stay cold. It must be stiff and strong enough to allow the food or drink to be carried and consumed. And, if the container is to be disposable, it must be very cheap.

The coupling of microwaves to materials depends on their *dielectric constant* ε; and the degree to which this coupling is dissipative is measured by the *power factor* Z. Thus microwave absorption scales as the product of the two. If the wall of the container is thick it will absorb more than if it is thin so that a second requirement is that the material be stiff and strong enough to carry the contents but also be thin.

The Project is to investigate materials for containers for microwave cooking.

- Collect and examine real containers, identifying materials if possible.
- Formulate a specification for selecting materials for microwave dishes. Clearly we want materials with low values of $Z\varepsilon$. But the dish must be stiff and strong enough to cope with ordinary handling loads. The deflection δ of a flat square plate made of a material of modulus E, of width w and thickness t, held on two opposite edges and carrying a distributed load F, is

$$\delta = \frac{F w^3}{384\, E\, I} \quad with \quad I = \frac{w t^3}{12}$$

and the maximum stress is

$$\sigma = \frac{F\, t\, w}{16\, I} = \frac{3F}{4 t^2}$$

Make sensible estimates for t, w, F and the acceptable δ, and thereby arrive at approximate lower limits for the modulus and strength for the dish. Finally, remember it will get hot – you will need a constraint on service temperature.

- Consider how stiffness and strength could be improved by modifying the shape from a simple flat plate.

• Use CES level 2 to explore the choice of materials for disposable microwave dishes (very cheap) and for reusable dishes (cost less critical) for microwave cooking.

• Present the case for your choice of material and process as a presentation, using data or charts from CES and from any other sources you have used to explain your reasoning.

Hints

The approximate dimensions of the dish shown in the picture are w = 200 mm, t = 2 mm (but note the ribs, increasing I for a given t). A reasonable design load might be F = 10 N (equivalent to a 1kg mass) and a maximum acceptable deflection might be δ = 10 mm. These plus the limit on service temperature and the need for low dielectric loss lead to the following specification:

The Web

The US Food and Safety Inspectorate provides useful information on www.fsis.usda.gov/OA/pubs/meatpack.htmlT

Function	
Constraints	
Objective	
Free variables	

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