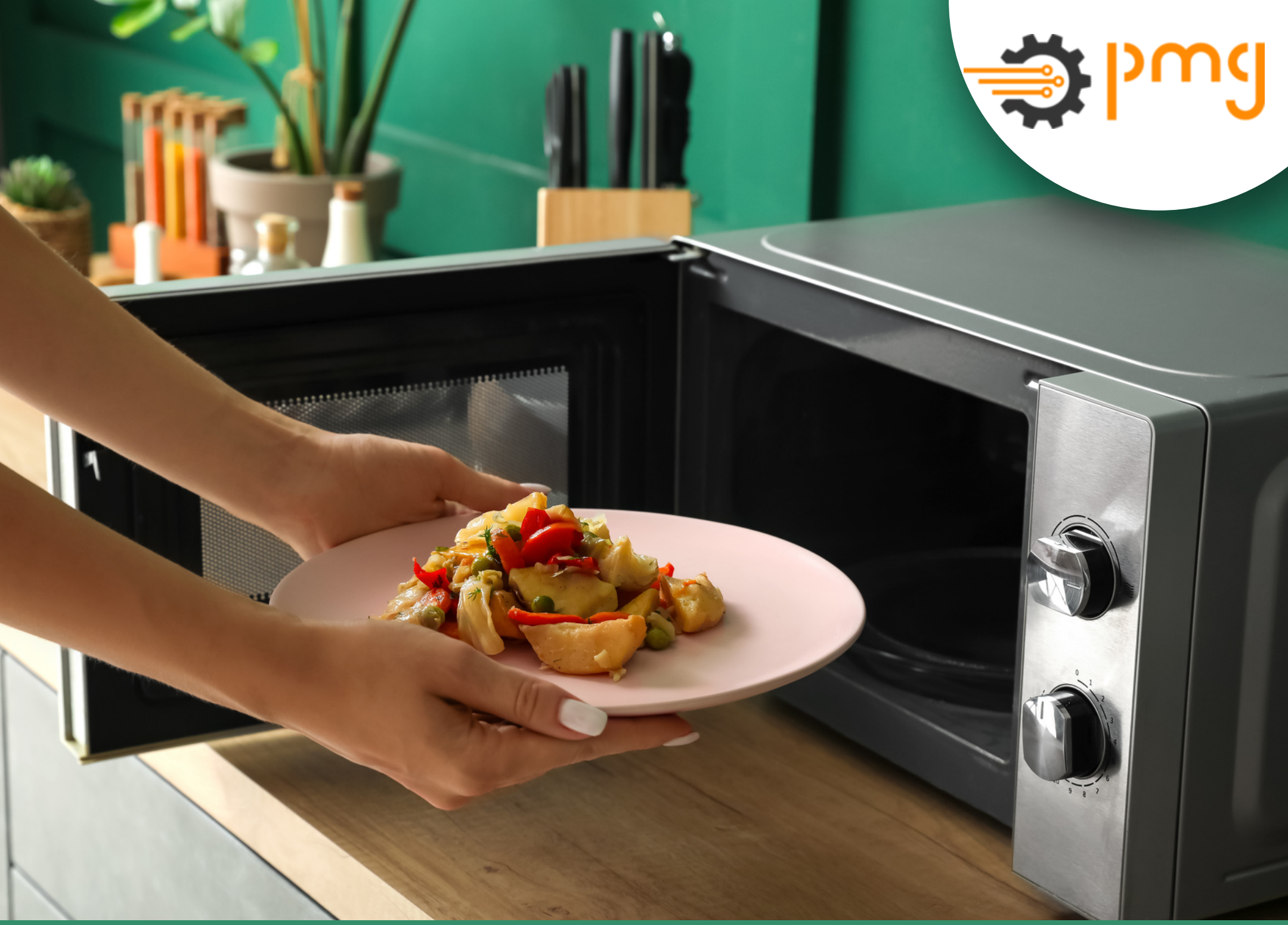


HEAT TRANSFER UNIT OPERATIONS

IN FOOD PROCESSING

- **Evaporation, drying, freezing, refrigeration, heat sterilization, pasteurization, and other food processing operations all involve heat transfer.**

- **Heat transfer is a dynamic process in which heat is transferred from one body to another that is cooler.**

- **Rate of heat transfer is determined by the temperature differences between the bodies; the greater the temperature difference, the greater the rate of heat transfer.**

Rate of heat transfer = temperature difference/ heat flow resistance of medium

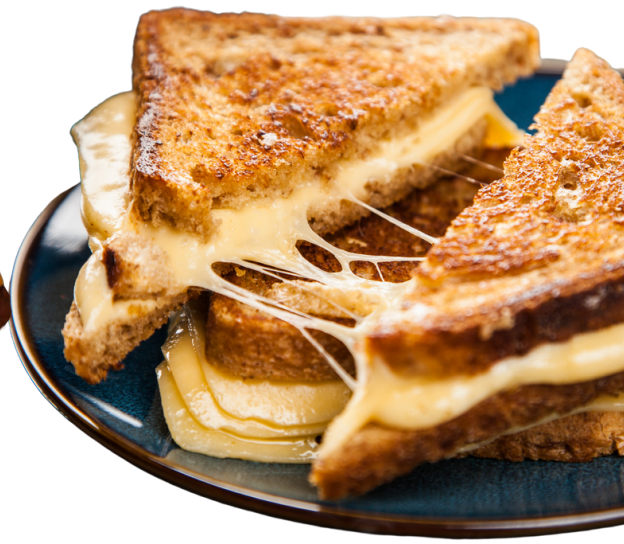
3 ways of Heat Transfer

1. Conduction

- **Heat transfer occurs due to the transfer of vibrational energy from one molecule to adjacent molecules in a solid mass.**
- **Conduction does not involve any physical movement of the body.**
- **Fourier's equation of heat transfer :** $\frac{dQ}{dT} = -\frac{dT/dX}{1/kA}$

where,
dQ/dT is conduction rate of heat transfer
dT/dX is temp. difference/unit legth
1/kA is resistance offered by medium
h is convective heat transfer coefficient
A is area of cross section perpendicular to direction of heat flow
k is thermal conductivity of body

- **Ex; As heat is transferred from the meat to the cheese, cheese melts**



2. Convection

- **Heat tranfer occurs due to the movement of groups of molecules in a fluid.**

- **The groups of molecules can be moved by either density changes or forced fluid motion.**
- **The basic equation for the rate of convection heat transfer is known as Newton's Law of Cooling: $Q_{conv} = hA(T_\infty - T_s)$**

where,
$\dot{Q}_{conv}$ is convective heat transfer rate
h is convective heat transfer coefficient
A is surface area of the object being cooled or heated,
T_∞ is bulk temperature of the surrounding fluid
Ts is surface temperature of the object

- **Ex; Boiling of Water**

3. Radiation

- **Transfer of heat energy by electromagnetic waves.**

- **Radiation operates independently of the medium in which it occurs.**

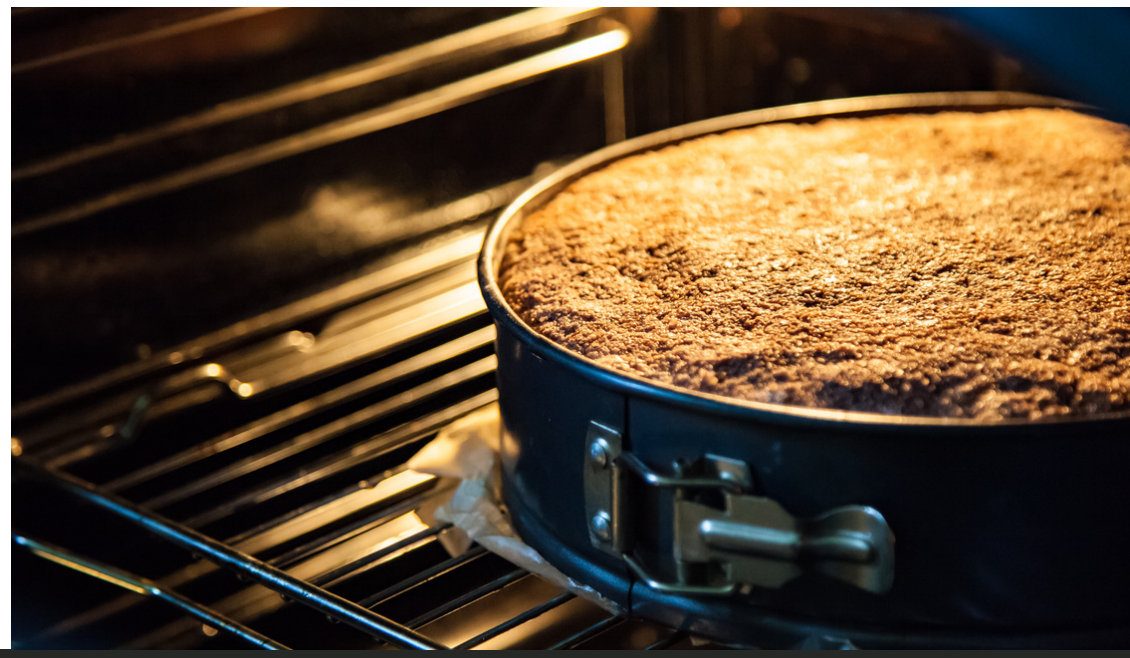
- **It's determined by the relative temperatures, geometric arrangements, and surface structures of the materials emitting or absorbing heat.**

- **Stefan-Boltzmann Law of heat transfer : $q = A \sigma T^4$**

where,
T is absolute temperature
Sigma is stefan-boltzmann constant ($5.670374419 \times 10^{-8}$ watt per square meter per kelvin)

- **Ex; Baking in oven**

Radiation via resistors



Heat Transfer Characteristics of Food

- Type of product
- Agitation of the container
- Shape of the container.
- Size of the container
- Temperature of the retort
- Type of container.

- Heat penetrates faster through metal than glass or plastics due to differences in thermal conductivity.
- Tall containers promote convection currents in convective heating foods.

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