Application of Thermal Effusivity as a Non-Destructive Method to Evaluate the Impact of Compression Forces

GARY SACKETT[1], LIRONG LIU[2],TIMOTHY J. SMITH[1], YVES ROY[3], DALE NATOLI[4], RAYMOND QIU[3], NANCY MATHIS[3], PAUL SHESKEY[5]
[1]VECTOR CORPORATION: MARION, IA USA [2]PFIZER INC: MORRIS PLAINS, NJ USA [3]MATHIS INSTRUMENTS LTD: FREDERICTON, NB CANADA [4]NATOLI ENGINEERING: ST. CHARLES, MO USA [5]THE DOW CHEMICAL COMPANY: MIDLAND, MI USA

OBJECTIVE

Use of effusivity as a non-destructive method to determine the effects of compression forces on the thermal property changes in the products from two pharmaceutical compaction processes.

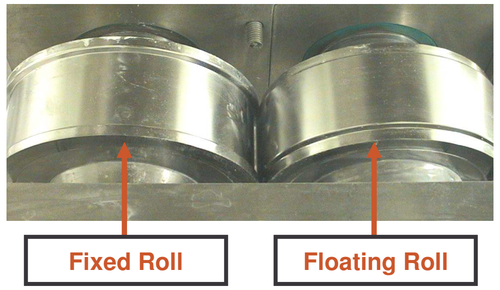
METHODS

Formulation (A) contained 20% hydroxypropyl methylcellulose (METHOCEL® E5P), 79% lactose 316 Fast-Flo®, and 1% magnesium stearate. The mixture was blended in a high-shear mixer and compressed by a hydraulic press (Carver press) at 1,250; 2,500; 3,750; 5,000; 7,500; and 10,000 psi for 10 seconds.

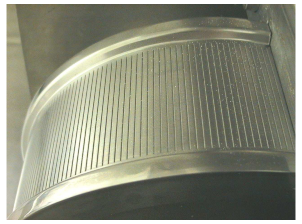
A similar formulation (B) with 0.3% of magnesium stearate was blended in a v-blender and compressed into ribbons using a roller compactor (Vector Model TF-156) equipped with 6 cm wide smooth rolls at 500; 750; 1,000; and 1,500 psi. The ratio of screw speed to roll speed was kept constant for all compression levels. The thermal effusivity of the compacts and ribbons were analyzed using Mathis Instruments Thermal Effusivity Sensor (Model ESP-01) with 314 g of weight applied on the top of the ribbon.

Formulation (B) was used to study the impact of the roll design. Ribbons were manufactured using two different roll types: smooth surface and serrated surface. The thermal effusivity of both sides of the ribbons were analyzed with same effusivity sensor and 500 g of weight applied.

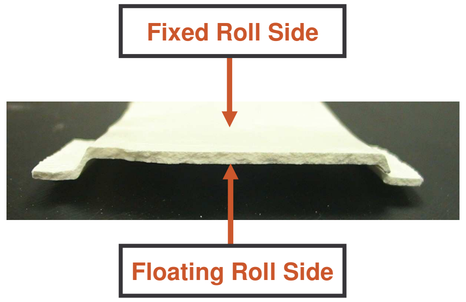
Smooth Rolls



Serrated Rolls



Thermal Effusivity Sensor



$$Effusivity = \sqrt{k\rho c_p}$$

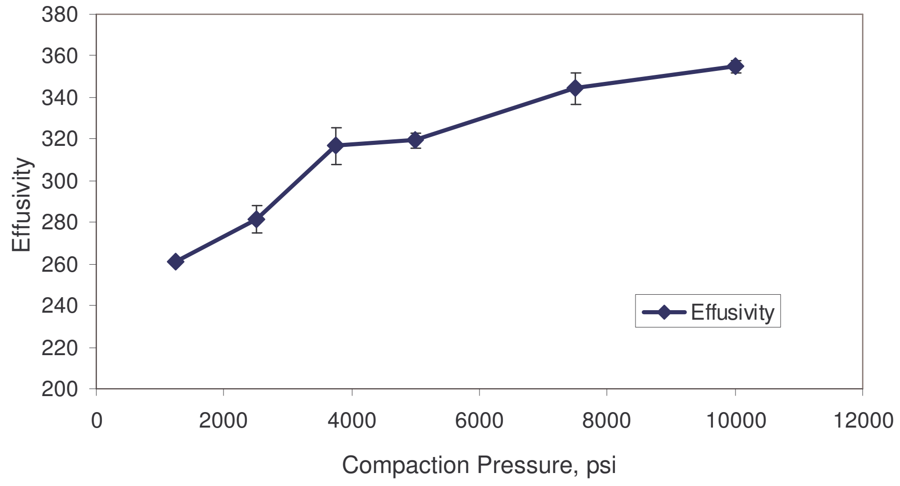
Where:
k = thermal conductivity (W/m·K)
ρ = density (kg/m^3)
c_p = heat capacity (J/kg·K)

RESULTS

EFFECT OF PRESSURE BY HYDRAULIC PRESS PROCESS

The effusivity results of the compacts manufactured with a Carver press at different pressures are shown in Figure 1.

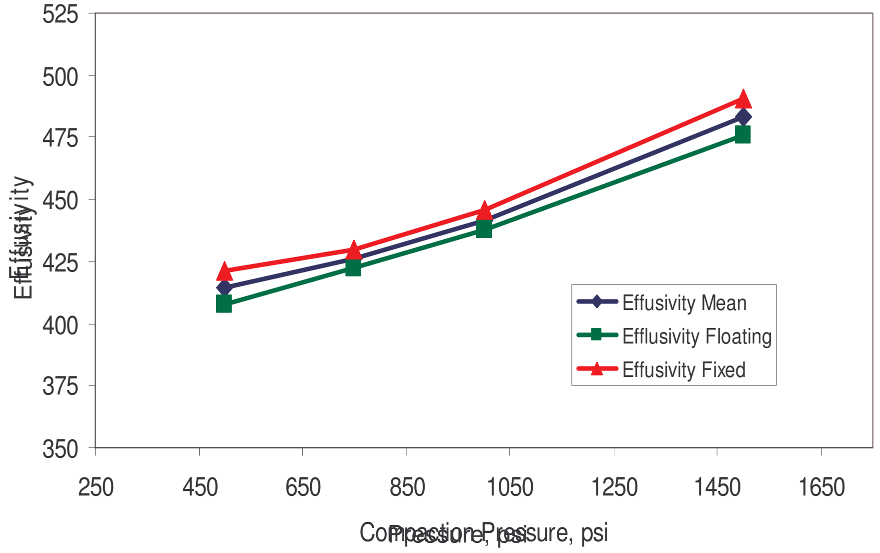
Figure 1.



EFFECT OF PRESSURE BY ROLLER COMPACTOR PROCESS

The effusivity results of ribbons manufactured with the roller compactor (smooth rolls) at different pressures with 314 g of weight applied to the sample against the sensor are shown in Figure 2.

Figure 2.



EFFECT OF DIFFERENT ROLL SURFACE DESIGN

The effusivity results from ribbons manufactured using smooth and serrated rolls at different pressures with 500 g of weight applied to the sample against the sensor are shown in Figures 3 and 4.

Figure 3. Impact of smooth roll vs. serrated roll measured on floating roll side of the ribbon

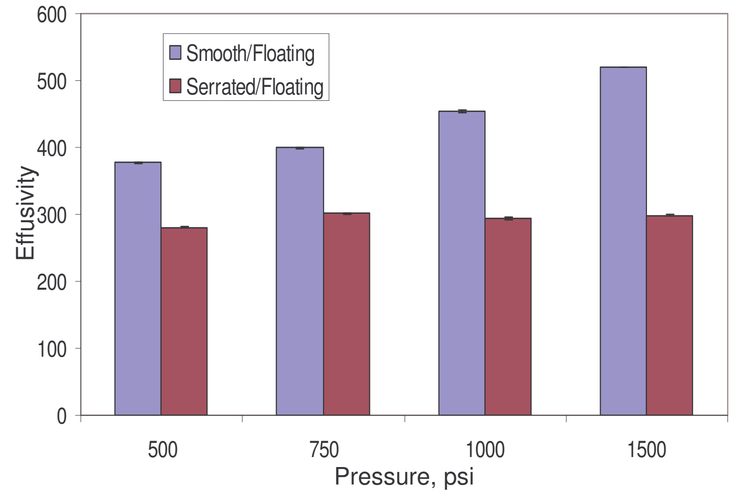
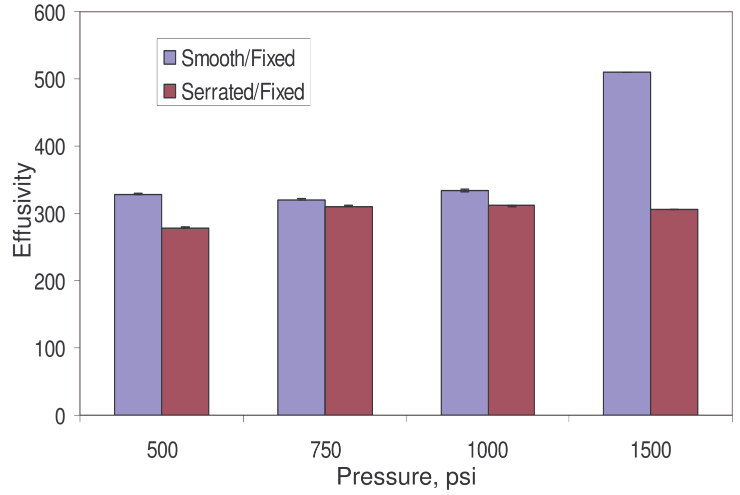


Figure 4. Impact of smooth roll vs. serrated roll measured on fixed roll side of the ribbon



CONCLUSIONS

As the compaction pressure increases, a general trend of increase in thermal effusivity is observed. This is due to the change in density and/or porosity of the compacted tablet or ribbon. However, the increase in effusivity is not as significant with the use of the serrated rolls. This may be due to less slippage at the roll/powder interface using the serrated rolls and thus no substantial change in ribbon density as the pressure increases.

Differences in thermal effusivity measurements from the floating to fixed roll side may be due to variability in the pressure/density distribution or curvature of the compacted ribbon effecting the contact with the effusivity sensor.