The profitability of a sintering operation is determined by Energy Efficiency, Throughput, Quality, and Equipment Uptime. The choice of sintering tray material is key to optimizing these performance parameters.

Energy efficiency within a furnace entails optimizing thermal energy delivered to the sintering parts, and sintering trays influence efficiency through:

- **Thermal mass**: the energy required to heat the tray material versus customer parts

Throughput is dependent on cycle time, and sintering trays influence cycle time through:

- **Thermal shock resistance**: the speed at which a material can be taken to temperature without shattering
- **Plate thickness**: the ability to stack more parts vertically in the muffle or furnace

Quality of powdered metal parts with respect to sintering trays is influenced by:

- **Flatness stability**: the ability to provide a flat surface to a sintering part, resulting in consistent part flatness
- **Chemical invariance**: the avoidance of part “footprinting” on trays, as well as carbon pickup

Equipment uptime can be limited by the following sintering tray properties:

- **Thermal shock resistance** and fracture toughness: the avoidance of furnace shutdown to remove broken trays and lost parts, as well as time spent managing a tray replacement inventory
- **Flatness stability**: the ability for automation robotics to interact with predictable geometry, as well as the ability to uniformly provide support to sintering parts
- **Thermal expansion**: the stability of in-plane tray dimensions, which can determine sintered part dimensions
- **Physical mass**: the ability of the motion technology (mesh belts, ceramic links, etc.) to support and move trays and parts without experiencing undue stress leading to mechanical failure

Fracture toughness (MPa-m^1/2) | Thermal shock resistance (W/m) | Thermal mass (J/K) | Initial flatness (inches)
--- | --- | --- | ---
30 | 30 | 30 | 30
20 | 20 | 20 | 20
10 | 10 | 10 | 10
0 | 0 | 0 | 0

An all data is for a 11” x 17” x .25” sintering tray

INTRODUCTION

An evaluation of Carlisle’s carbon/carbon technology was undertaken in two sintering operations:

1. **Automated, mesh belt sintering furnace**
   - Environment: 2650° F, 10% H2, 30% N2
   - Tray: 11” x 17” x .200” (with initial flatness of 0.001” overall)
   - Carrying an array of Fe-based parts
   - Cycled 200x through 4 hour cycle

2. **Stationary pressure sintering furnace**
   - Environment up to 7000 F, 5% H2, 95% N2
   - Replacing graphite separator plates with carbon/carbon at 25% thickness
   - Cycled 300x through 24 hour cycle

RESULTS

1. **Automated, mesh belt sintering furnace**
   - Tray flatness was maintained at 0.0013”
   - Plate lost 6% of initial mass
   - No evidence of footprinting was apparent

2. **Stationary pressure sintering furnace**
   - Additional capacity (36%) was gained through reduced separator plate thickness
   - Ergonomics were improved due to reduced mass (improved operator safety)
   - Part scrap due to thermal uniformity and separator plate breakage was reduced by 25%
   - Separator plate breakage was eliminated (lower maintenance costs)

CONCLUSIONS

Carlisle has developed affordable carbon/carbon (C/C) furnace fixtures that offer significant advantages in the powdered metal industry. The excellent strength-to-weight ratio of C/C means thinner and lighter fixtures that do not crack, warp, or “footprint” the graphite. In addition, the low thermal mass and high thermal shock resistance of C/C makes it better than alumina for energy efficient sintering and reduced cycle times. By moving to C/C fixtures, powdered metal sintering manufacturers demonstrated:

- 36% capacity increase
- 25% scrap reduction
- Faster process times
- Lower maintenance costs
- Improved operator safety
- Reduced labor hours


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