# HOTSEAT

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Equipment hardware with nitrogen/methanol carburizing atmosphere and the necessary utility configurations.

**IN THE MARCH HOT SEAT COLUMN,** I presented the operating cost for a standard UBQ batch furnace carburizing cell processing 3000 net pounds of parts utilizing generator-produced endo gas with the following equipment configuration:

- Gas fired furnace hot zone with four 8" (203 mm) diameter radiant tubes, with recuperation providing 65% efficiency
- Electrically heated oil quench
- Electrically heated post quench washer
- Direct gas fired temper

This month's column will present equipment hardware with nitrogen/methanol carburizing atmosphere and the following utility configurations:

- Electrically heated furnace hot zone, (12) 6.625" (168) diameter 12 radiant tubes with bayonet elements totaling 144 kW
- Electrically heated oil quench
- Gas fired serpentine radiant tube, post quench washer
- Gas fired temper

You will also note that in each of these scenarios the post quench washer is heated throughout the entire processing time of 10.74 hours and the energy to bring the wash water to temperature is disregarded.

"A few heat treaters have grown up with nitrogen/methanol in the belief that eliminating the maintenance expense of the endo generator is an advantage."

However, when the operating cost is figured in, the difference is surprising. And nitrogen/methanol systems are not without their own maintenance requirements, as flowmeters, valves, and a methanol pump are still required. A detailed breakdown follows. Below is a summarized comparison:

**HEAT/SOAK/DIFFUSE (FURNACE) PER THE RECIPE:**

- Gas fired $30.14
- Electrically heated $42.18

**CARBURIZING/DIFFUSE (FURNACE) PER THE RECIPE:**

- Generator endo gas $16.94
- Nitrogen/methanol $47.57

**PROCESS PARAMETERS:**

- 0.060" (1.52 mm) total case depth
- 7446 operating hours per year
- 3000 Lbs. net

**CYCLE:**

- Load vestibule from charge car, 30 seconds
- Purge vestibule, 10 minutes
- Transfer load to hot zone, 30 seconds
- Heat to 1700°F (926°C) and equalize, 90 minutes
- Carburize with nitrogen/methanol, 5 hours, equivalent to 700 CFH endo gas, reduced flow, 400 CFH after the CP reaches the set point
- Diffuse and equalize one hour at 1550°F (843°C)
- Oil quench, 12 minutes
- Wash, 15 minutes
- Temper at 350°F (177°C) 3.5 hrs.

**BEST AND WORST CASE FURNACE/CELL SCENARIOS PER THE RECIPE ABOVE:**

| BEST CASE | | WORST CASE | |
|---|---|---|---|
| Gas heated furnace & gas for generator | $65.65 | Electrically heated furnace & Nitrogen/methanol | $99.31 |
| Gas fired washer | $8.96 | Electric fired washer | $11.87 |
| Gas fired temper | $3.96 | Electric temper | $8.88 |
| | | | |
| **COST PER RECIPE** | **$78.57** | **COST PER RECIPE** | **$117.22** |
| **COST PER HOUR** | **$7.32** | **COST PER HOUR** | **$10.91** |
| **COST PER NET POUND** | **$0.026** | **COST PER NET POUND** | **$0.039** |

The following examination (continued in subsequent columns) will identify and compare the cost to operate a UBQ integral quench carburizing furnace using nitrogen/methanol with the following configuration:

- 36" W x 48" L x 36" H load size
- 3,500 Lb. (1,588 Kg) capacity
- 3,500 gallons (13,249 L) of quench oil
- Post quench washer
- Temper 800°F (427°C)
- Transfer car

## DETAILED COST BREAKDOWN:

| VESTIBULE & QUENCH TANK | UTILITY | TIME ON (HR.) | COST/UNIT | $ COST PER RECIPE |
|---|---|---|---|---|
| Oil pump (1.48 kw) | Electric | 10.74 | 0.07 | 0.001 |
| Agitators low speed (2) [5.55 kw] | Electric | 10.74 | 0.07 | 4.17 |
| Agitators high speed (2) [11.1 kw] | Electric | 0.2 | 0.07 | 0.16 |
| Flame screen [175 cfh] | Natural gas | 0.01 | 0.006 | 0.01 |
| Quench oil heat [4 kw] loss at 180°F (82°C) | Electric | 10.74 | 0.07 | 3.01 |
| **TOTAL** | | | | **7.35** |

| HEAT CHAMBER | UTILITY | TIME ON (HR.) | COST/UNIT | $ COST PER RECIPE |
|---|---|---|---|---|
| Rear handler [1.48 kw] | Electric | 0.01 | 0.07 | 0.001 |
| Heat parts [780 cfh] recuperated | Electric | 1.5 | 0.07 | 15.12 |
| Steady state heat loss [195 cfh] | Electric | 10.74 | 0.07 | 27.06 |
| Recirculation fan [2.22 kw] | Electric | 10.74 | 0.07 | 1.66 |
| Controls [0.74 kw] | Electric | 10.74 | 0.07 | 0.55 |
| Methanol to make high flow process gas, [420 cfh] (11.9 $M^3$) | Methanol [$ft^3$] | 1.98 | 0.017 | 14.13 |
| Nitrogen to make high flow process gas, [280 cfh] (7.2 $M^3$) | Nitrogen [$ft^3$] | 1.98 | 0.004 | 2.21 |
| Methanol to make low flow process gas [240 cfh] (6.80 $M^3$) | Methanol [$ft^3$] | 6.50 | 0.017 | 26.52 |
| Nitrogen to make low flow process gas, [160 cfh] (4.5 $M^3$) | Nitrogen [$ft^3$] | 6.50 | 0.004 | 4.16 |
| Methanol pump [0.74 kw] | Electric | 10.74 | 0.07 | 0.55 |
| **TOTAL** | | | | **91.96** |

| WASHER | UTILITY | TIME ON (HR.) | COST/UNIT | $ COST PER RECIPE |
|---|---|---|---|---|
| Spray pump [3.7 kw] | Electric | 0.25 | 0.07 | 0.064 |
| Holding losses [138] CFH] | Natural Gas [$ft^3$] | 10.74 | 0.006 | 8.96 |
| **TOTAL** | | | | **9.02** |

| TEMPER (800°F, 427°C) | UTILITY | TIME ON (HR.) | COST/UNIT | $ COST PER RECIPE |
|---|---|---|---|---|
| Heat to 350°F (177°F) (48 kw) | Electric | 1.50 | 0.07 | 5.04 |
| Recirculating fan [3.7 kw] | Electric | 3.50 | 0.07 | 0.90 |
| Holding losses [12 kw] | Electric | 3.50 | 0.07 | 2.94 |
| **TOTAL** | | | | **8.88** |

| | |
|---|---|
| **GRAND TOTAL COST FOR THE RECIPE** | **$117.21** |
| **OPERATING COST PER HOUR** | **$10.91** |
| **COST PER NET POUND** | **$0.039** |

For this discussion, I've taken the detailed cost as explained on a spreadsheet that breaks down every drive and fan motor, gas function, and heating element used per equipment type. The data is presented in cost per recipe, per hour, and cost per net pound processed, and is based on the following utility rates:

- Natural gas, $0.60/therm, [100,000 BTU](105,505 kilojoule), $0.006/CF
- Electricity, $0.07/kW
- Nitrogen, $0.40/100 CF (2.831 M3), $0.004/ CF
- Methanol, $4.00/gallon (3.78 L), 1 gallon = 230 CF = $0.017/CF

When a heat treat manager (or anyone responsible for purchasing heat treating equipment) makes a buy decision, they must first consider the process required, then spreadsheet items such as capital and operating cost. However, I'd venture to say the manager often pays little to no attention to the maintenance required, labor expertise, material handling and their associated cost.


## ABOUT THE AUTHOR:

Hot Seat columnist Jack Titus has an additional column in *Thermal Processing for Gear Solutions*, in which he discusses scheduled maintenance of furnaces, distortion control, and low-pressure carburizing.

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