HOTSEAT

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An accurate comparison between LPC/HPGQ and endo atmosphere carburizing cell.

TYPICALLY, LPC/HPGQ SYSTEMS have evolved into individual batch carburizing chambers with continuous prewash, pre-oxidizing, and continuous tempers. Atmosphere carburizing cells retain a complete batch material handling arrangement, making an accurate comparison a little challenging.

In the March and April columns, I presented operating cost for one 36" x 48" x 36" (900 x 1200 x 900) UBQ batch furnace cell with a 3,000-lb. load processing 279 lb./hr over 10.74 hours using endo gas and nitrogen methanol. The following is the summary for the UBQ with endothermic gas:

Cost for the 10.74-hour recipe, (carburize/oil quench/wash/temper): $78.57
Cost per hour: $7.32
Cost per net pound: $0.026

Instead of a 3,000-lb. (1361 kg) UBQ net load I've opted for a smaller load—maybe not so fair for the UBQ.

LPC capacity for the 600 mm- (24"-) wide x 700 mm- (27"-) high x 1000 mm- (39"-) long load is 2200 lb. (1000 kg) x 80% of the maximum = 1760 lbs. (798 kg), and 80% of the UBQ 3,500 lb- (1588 kg-) load, 2,800 lbs. (1,270 kg).

The recipe for the endo gas UBQ above is five hours carburizing at 1700°F (926°C) plus one hour at 1550°F (843°C) resulting in an ECD effective case depth at 0.40% carbon of 0.037" (0.93 mm) followed by a 12 minute oil quench, 15 minute wash, and two hour 350°F (176°C) temper. The LPC/Endo comparison will use production based on 4,800,000 pounds per 7466 operating hours per year = 642 pounds (291 kg) per hour. This requires two UBQ's and two LPC chambers.

I sized the comparison this way because of the LPC process, due to the faster carburizing time at 5.42 hours to heat, carburize, and diffuse, and the UBQ, with endo at 8.29 hours. Two furnaces are required, not including the ancillary equipment, of which impact will be included. Also affecting the operating cost is the energy to heat the loads for carburizing. LPC employs 180 KW graphite elements vs. the UBQ's six gas fired radiant tubes.

One of the advantages of LPC is the minimal acetylene carburizing gas required. For the load in question I've

One continuous prewash, one continuous pre-ox, two LPC carburizing chambers, one HPGQ supporting the two carb chambers, one continuous temper		Two UBQ, one batch wash and one temper, one endothermic generator	
Vacuum pumps [7.53 hrs]	$7.90	Endothermic generator [10.74 hrs]	$17.20
Continuous Pre-wash, gas fired [7.53 hrs]	$9.85		
Continuous Pre-Ox. [7.53 hrs]	$13.75		
Two LPC ea. 45 min. convection heat + 45 min. vac. heat + 150 min pulse carb./diff + 85 min. final diff. = [5.42 hrs each]	$102.70	Two UBQ, boost carb. 5 hrs. + 1hr. diff. + 30 min. equalize at 1550°F (843°C) = [8.19 hrs]	$63.28
HPGQ [0.5 hours for each LPC]	$26.84	Two oil quench ea.[0.20] hrs]	$27.30
		Post washer, gas fired [10.74 hrs]	$8.24
Continuous Temper, Electric [7.53 hrs]	$34.11	Temper, gas fired [10.74 hrs]	$8.25
(a) Cost per recipe includes two LPC's	$195.15	(a) Cost per recipe includes 2 UBQ's	$124.27
(b) Cost per hour, total equipment time = 13.86 hrs.	$14.08	(b) Cost per hour, total equipment time = 19 hrs.	$6.54
(c) Loads produced in a five day week 24 hours/day	8.66	(c) Loads produced in a five day week 24 hours/day	6.32
(d) Cost per week = (a) x (c)	$1689.61	(d) Cost per week = (a) x (c)	$784.86
(e) Pounds per week = 1,780 x (c)	15,238	(e) Pounds per week = 2,800 x (c)	17,684
(f) Cost per pound = cost/week ÷ pounds / week	$0.11	(f) Cost per pound = cost/week ÷ pounds / week	$0.04

assigned a surface area of 25 M2 (269 ft2) not a huge load for the UBQ maybe about average. LPC required 59 CF of acetylene when the cycle is modeled with simulation software. However, this volume has been verified empirically. The acetylene cost will depend on the total facility consumption, but $0.50 per CF is used for this comparison resulting in a cost of $29.50 for each LPC.

To make 700 CFH initial and 400 CFH reduced endo flow per hour for each UBQ for 10.74 hours, the process natural gas plus the gas cost to heat the generator is $17.20 including the pump motors. Keeping both UBQ's hot for the 10.74 hours is $63.29. Natural gas is priced at $6.00 per 1000 CF or $0.006 per CF in Ohio and $0.07 per kWh.

Prior to vacuum processing parts are washed and pre-oxidized; in some instances with certain steels applying a thin oxide can enhance carbon diffusion. In addition, this LPC arrangement includes a continuously running vacuum system that evacuates both LPC chambers and provides the pressure control for the acetylene/nitrogen pulse process.

For this comparison, the steel used can be hardened with 10 bar nitrogen for 20 minutes. Nitrogen is not recycled. The same utility rates apply for both furnace systems. However, the utility cost for the recirculated water system required for the HPGQ (350 to 450 gallons per minute when quenching) is not included in this comparison and is not insignificant.

Left is the operating cost summary for the two LPC's and one HPGQ, servicing both chambers plus the continuous pre-wash, pre-oxidation, and temper and two UBQ's and batch washer and temper based on the production above:

I've made some assumptions, such as cost of acetylene for a particular total plant usage, based on 300 cubic foot daisy-chained tanks, and I've estimated the energy for the continuous washer, pre-oxidation, and temper. The quantity of energy I used for the continuous systems is adjusted to the production from actual equipment of higher production. The overall processing times are empirically accurate for the case depth indicated.

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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