PERIODIC ATMOSPHERE FURNACE MAINTENANCE: PART ONE

PREVENTATIVE MAINTENANCE PLANS

To realize the benefits of a planned preventative maintenance program, irrespective of the type of equipment being used, a carefully structured, well-disciplined, and rigorous plan must be created, implemented, and followed.

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How many times have you looked at atmosphere heat treated parts and been amazed by how poor their surface appearance is (Fig. 1), or visited a heat treat shop only to find critical components such as gears coming out of carburizing furnaces scaly with decarburized surfaces, coated with sludge, or blackened by oil stains? Well it doesn't have to be that way. A little furnace maintenance goes a long way toward improving both the image and the quality of heat treated parts and reducing the cost to produce them.

In a well-maintained shop, parts come out of hardening and carburizing furnaces extremely clean, typically being gray-green in the as-quenched condition (Fig. 2). There is no evidence of loose soot, scale, or other contaminants on their surfaces, so a simple post-wash operation will suffice. Badly discolored parts, by contrast, are typically shot blasted, and even then may not clean up.

One of the secrets to success in "clean" heat treating is to perform an atmosphere burn out of the furnace(s) at specific time intervals, being careful not to let the furnace temperature "run away" and cause damage to the interior components. Other basic practices such as filtering or centrifuging quench oil help keep parts bright. Clean parts mean avoiding unwanted stresses and possibly even distortion induced by blasting. The goal is to have parts look as clean as if they had been run in a vacuum furnace.

Wind-energy and mining gears for heat treatment in a batch IQ furnace. Courtesy of Aichelin Heat Treatment Systems, Plymouth, Mich.

Accepting the Inevitable

Maintenance is a fact of life for heat treat equipment. In general, the cost of maintenance increases dramatically as the operating temperature increases and/or the process environment becomes more severe (e.g., carburizing versus hardening). As with all equipment, some styles and designs require more attention than others. However, it is interesting to note that construction of heat treat equipment can often be classified as heavy duty or light duty by the amount of maintenance required. Of course, if any furnace is operated outside its design limitations, it almost always translates to a need for more extensive maintenance.

A great deal of money can be spent (and wasted) if careful thought and a clear understanding of the equipment design, as well as the extent of the repair, are not taken into consideration. Not taking the time to determine the root cause of why a component failed can have disastrous bottom-line consequences.

Proper maintenance maximizes "up-time" productivity, and the use of planned preventative maintenance programs result not only in better equipment reliability but in improved process repeatability and control—essential to producing good parts with consistent metallurgical and mechanical properties.

Once management understands, accepts, and budgets for maintenance expenditures, the operation of all heat treating equipment, especially high temperature furnaces and induction units, becomes far more reliable.

Record Keeping

Good electronic record keeping is an important element of today's planned preventative maintenance

Fig. 1 — Unacceptable part surface appearance; parts after heat treating can include conditions such as blackened quench-oil stains, a coating of sludge, or scaly decarburized surfaces. Courtesy of D. Scott MacKenzie, Houghton International Inc., Valley Forge, Pa.

Fig. 2 — Acceptable part surface appearance; parts coming out of hardening and carburizing furnaces are clean, typically being gray-green in the as-quenched condition, with no evidence no evidence of loose soot, scale, or other contaminants on their surfaces. Courtesy of Specialty Heat Treating, Grand Rapids, Mich.

Heat Treat Checklist

Following is a list of questions that should be asked to determine if your heat treater has his process under control and his equipment properly maintained.

Control of operation

- ☐ Is the overall operation in control?
- ☐ Are written instructions, operating procedures, and all rules and regulations being used on a daily basis, or do they exist only for show?
- ☐ Are all procedures understood by the workforce, or only by management?
- ☐ Are the heat treat practices being used effective?
- ☐ Is maintenance planned (predictive maintenance), or does it occur only when machinery breaks?
- ☐ What types of quality control checks being made on the furnace (daily, weekly, monthly, semi-annually, annually)?

Parts preparation

- ☐ How effective is the precleaning of parts?
- ☐ Are the incoming parts clean?
- ☐ How are they being cleaned?
- ☐ How effective is the cleaning method?
- ☐ How well is it controlled?
- ☐ How often is it monitored?
- ☐ Is a bath chemistry check performed?
- ☐ How often are the washers monitored for proper concentration and pH?
- ☐ How are the washers being cleaned?
- ☐ Are oil skimmers in use and are they properly maintained?

Furnace inspection

- ☐ How often is the furnace inspected?
- ☐ What method(s) is used?
- ☐ What are the criteria for acceptance?
- ☐ How effective are the inspections?
- ☐ Are they frequent enough?
- ☐ Does the atmosphere flow fluctuate or remain steady?
- ☐ What method is being used to check the furnaces for leaks?
- ☐ What type of thermocouple is being used?
- ☐ Are they adequate for the temperature range being run?
- ☐ When maintenance is performed on thermocouples, are their insertion depths per equipment manufacturer's recommendations?
- ☐ Has the insertion depth of the thermocouples changed since the temperature uniformity survey (of the workload area) was performed?
- ☐ Are the protection tubes alloy or ceramic (high-nickel alloys act as catalysts and will cause errors in carbon potential, especially in computer controlled systems)?
- ☐ Are radiant tubes checked frequently for leaks (cracks), and are the seals checked to avoid making atmosphere control more difficult?
- ☐ Have the position of the pilot and flame curtains (flame screens) near exit doors been properly adjusted to ensure they are not under the part trays, where if a tray stopped in this location, the parts could be tempered back?

Quench system control

- ☐ How is the quench oil being monitored?
- ☐ How is the quench oil being controlled?
- ☐ Is the degree of agitation sufficient for the quenching operation being performed?
- ☐ How often is the quench media analyzed (in-house or outside)?
- ☐ How is the quench media checked for particulates?
- ☐ Is the motion of the elevator (batch furnaces) smooth and quick (2-3 s being typical)?
- ☐ How often is the quench tank serviced?
- ☐ How much drag out (removal) of quench media occurs?
- ☐ What is the transfer time of the workload to the quench?
- ☐ What type of quench tank maintenance is performed and how often?
- ☐ Are trays, baskets, screens, and other fixtures/racks being inspected?
- ☐ Is proper inspection and maintenance of tray sensors and "flippers" (if trays are pushed) being performed (if they are cracked or sticking, trays will be pushed from only one side causing "pile ups" in the furnace)?

programs. An operational logbook as well as a detailed maintenance log should be kept and every action noted. A key aspect of these logs is that they should be reviewed periodically to look for trends, identify problem areas, and used to gain a better understanding of the types of maintenance (and personnel skills) that are required. Having the correct spare parts, detailed construction drawings, and the right tools on hand is essential to minimizing downtime. Support by the plant engineering staff, the original equipment manufacturer (OEM), or a third party is often necessary. Remember, successful planned maintenance is a team effort.

Evaluating Used Equipment

What happens if you buy a used furnace or inherit a piece of equipment from another location? First, try to gather as many facts as possible about its history. For example, find out when it was built, for whom, and for what application it was originally intended. Ask the OEM to look at its spare parts records to identify both the type and frequency of parts sales. This is a good first indictor of places to look for problems. Obtain a copy of the instruction manual and obtain as many detailed prints as possible (there is often a fee for such items).

Next, completely inspect the unit, inside and out. Look for the obvious, and ask yourself the reason for everything you see (and don't see). Last, don't rush the equipment into service. Measure and record such items as transfer times, speed of moving components such as doors or load transfer mechanisms and elevators. Once operational, record gas use, electric current draws, incoming voltage and power, and install hour meters, energy monitors, and other reporting devices. In other words, learn as much about the normal operation of the equipment as possible before putting it in service so you can monitor changes and quantify degradation that occurs over time. HTP

Establishing a Preventative Maintenance Plan

To create a suitable preventative maintenance plan, divide and conquer. Begin by understanding the heat treat process(es) you will be requiring of the unit and compare these to the design ratings/limitations of the equipment. Factors to consider include:

Temperature rating
- Normal and maximum operating temperatures
- Cyclic operating conditions
- Idling conditions

Loading
- Load size including volume or weight limitations
- Load distribution and the necessity for load ballast
- Maximum and minimum gross load weight as a function of temperature

Atmosphere requirements
- Type and function of gas(es); process and heating
- Gas flow rate, pressures, etc.

Quench requirements
- Type of quenchant
- Volume of quenchant (in relation to gross load weight)
- Quenchant temperature
- Flow characteristics of the quenchant around the part

Special requirements
- Baskets and fixturing
- Quench restrictions
- Access and site ports
- Water systems

Design specific features
- Type of furnace (batch, continuous, pit, rotary retort, etc.)
- Support items (heat exchangers, water circulating systems, etc.)

Next, understand the external constraints being placed on the equipment (use, budget, etc.). These factors are important in tailoring your plan to meet expectations. Identify critical spare parts and have them in stock. Understand which spare parts must come from the OEM manufacturer and which ones can be purchased through alternative suppliers.

Now take the time to divide the equipment into logical sections so the maintenance on each of these areas focuses on those components or assemblies that are critical to their functionality (and ultimately that of the entire machine). Then walk around the exterior and inspect the interior. (*Note: confined entry training/permits may be required.*) Observe how all components interact. This takes a surprisingly short amount of time and yields a significant amount of information.

Finally, put this information into a useable form (such as a spreadsheet), review with management, and implement your planned preventative maintenance program. Remember that feedback and refinements to the plan will occur continually. Make sure that the reasons for the changes are captured in the documentation for later use, and make the system independent of changes that will inevitably occur in either the maintenance department, the heat treat department, or in management.

Establish a mean-time-between-failure (MTBF) for critical components, and be sure to conduct a cause-and-effect analysis whenever a part fails prematurely.

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References

1. D.H. Herring, Setting Up a Planned Preventative Maintenance Program, *Industrial Heating,* April, 2004.
2. Mr. Bill Flower, Specialty Heat Treating (www.specialtyheat.com), private correspondence.

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