Die Ovens

This Chapter Sponsored by CASTOOL Tooling Solutions

[***www.Castool.com***](http://www.Castool.com)

Purpose

Extrusion dies and support tooling must be preheated to a suitable temperature before being used in the press, in order to avoid breaking the die and to minimize the time needed to reach steady-state extrusion conditions. Experts agree[1] that tooling temperature is one of the critical parameters that must be tightly controlled to bring consistency and predictability to the extrusion process. Good die heaters are critical to a profitable press operation. Because dies and tooling are precision-made and represent a major investment, it is important to see that they receive careful handling and preparation for use in order to maximize their life. Valuable press time may also be wasted and excess scrap generated if the dies are too hot or too cold when placed in service.

Types of Die Heaters

Air Circulation vs. Still Air. To insure faster heat transfer and improve temperature uniformity, air circulation improves die heater performance, especially in larger heaters. A cartridge- or plug-type high-temperature blower is usually selected to circulate heated air at high velocity over the tooling and the heating source. Direct "line-of-sight" radiation from the heat source to the dies should be avoided, by means of properly located baffles, to prevent spot overheating.

Figure 10-1: Box-type die heaters
(Photo courtesy of Gia)

Box Type. The most common form of die heater, especially in the USA, has long been a basic box with hinged top for access. The box type is cheapest and easiest to build and occupies the least floor space per die stored. However, die temperature is less uniform: all tooling is subjected to thermal shock each time the door is opened, and a cold die placed in the oven may draw heat from adjacent dies. Also, considerable hot air is discharged into the press building each time the door is opened.

Figure 10-2: Single cell die heaters
(Photo courtesy of Castool)

When this type of oven is used, it is especially important to use some system for controlling the heating time of each die. Some extruders use a computerized system to track the time each die is placed into the oven and when it is removed.

---

[1] Jowett, Chris; Johannes, Veikko; Langille, Al; Fraser, Warren; and Yoshimura, Hideki, "The Causes of Variation in Extruded Section Weight," *Proceedings of 7th International Aluminum Extrusion Technology Seminar*, Vol. I, (2000) p.1-16.

Single Cell. An improvement to the box-type oven now gaining popularity is the single cell oven. Multiple small box-type heaters, each sized for one press tool, are arrayed in a row in a convenient location. Heating is by electrical resistance without air circulation (due to the small size of the boxes). Advantages claimed for this type of oven are:

- The box is not opened to put in or take out other tooling.
- There is never any cold tooling nearby to affect the temperature.
- Heat-up time for each is less.
- This arrangement makes it easier to control the heating time for each die and prevent over- or under-heating.

Drawer Type. In this design the box is constructed with side-opening drawers to hold the dies. A typical design may have 3 to 5 drawers, each holding 4 or 5 dies. In many cases each drawer has its own compartment with individual temperature control. Putting in or taking out one die set usually has much less impact on the other dies and discharges less hot air into the room. Drawers are opened and closed by hydraulic cylinder or mechanical drive.

Rotary. This type of oven contains a turntable, which may be rotated to position the desired die slot in line with the access door. This design is more costly to build and requires more floor space. However, temperature uniformity is excellent, and accessing one die has little or no effect on the other dies.

Inert Atmosphere. A new design which is also gaining in popularity heats tooling within an inert atmosphere such as Argon or Nitrogen, in order to reduce the occurrence of oxidation. One design places each die set in an individual drawer, which yields very accurate temperature control while reducing energy costs and shortening the heat-up time.

Gas-Fired. A few gas-fired die ovens are in use, primarily because of the lower cost and better availability of gas fuels as compared to electricity. However, gas firing is less desirable due to poor temperature control (a gas flame is difficult to turn down enough for precise control), and also the damaging effects of combustion gases (including water vapor) on the dies. If gas combustion is used, it must be indirect, that is, fired through a radiant tube, to prevent excess oxidation of the tooling by combustion products.

Electric Resistance. Most die heaters, in all of the configurations above, are heated by electric resistance. Resistance elements are reliable and more easily controlled for a uniform temperature, without creating a harmful atmosphere. If air circulation is not provided, care must be taken in placement of heating elements (or baffles) to avoid spot overheating of dies.

Induction Electrical. These heaters are offered with claims that they can heat dies to operating temperature within a few minutes; because heating is from within, no soak time is required. Advantages are production flexibility and less exposure of dies to high temperatures (longer tooling life and less oxidation and pitting). Investment and operating costs are higher, however.

Infra-Red. The electric infrared heating system heats primarily by infrared radiation. Suppliers claim that this type oven offers fast, precise die heating, resulting in improved die performance at the press.

Figure 10-3: Drawer-type die heater
(Photo courtesy of Belco Industries)

Figure 10-4: Rotary-type die heater
(Photo courtesy of Mechatherm)

Figure 10-5: Inert Atmosphere-type die heater *(Photo courtesy of OMAV)*

Operation and Procedures

Properly used, the die oven should heat the tooling to the desired temperature without regard to where each tool is placed in the oven. The tool's time in the heater should be carefully managed: if not heated long enough the die may break; if heated too long the hardness will be lost (also resulting in breakage), and oxidation or pitting of the surfaces may occur.

Recommended tooling preheat temperatures will vary according to the extruder, particularly with regard to preheating of support tooling (backers and sub-backers or bolsters). In informal surveys, we have found that as many as half of all extruders do not preheat support tooling. However, some experts[2] strongly recommend preheating the support tooling in order to increase predictability in the process, since it also affects the die temperature during the initial stabilization of the process for each new die.

[2] Ibid.

The following are generally accepted rules for preheating of die tooling[3]:

- **Solid Shape Dies -** The preheat temperature is best determined by experience for each die; otherwise, 800 to 850°F (425 to 455°C) is recommended. Dies with critical tongue sections should be heated to higher temperatures.
- **Hollow Dies - Porthole and Spider -** Preheat to approximately 850 to 950°F (455 to 510°C).
- **Bridge Dies -** Temperature may be as much as 100 to 200°F (55 to 110°C) less than billet temperature, depending on the die ratio and shape.
- **Bolsters for Solid Dies -** Should be heated to the same temperature as the die and backer, or a minimum temperature of 400°F (200°C).
- **Bolsters for Hollow Dies -** Should be heated to the same temperature as the die assembly, and the bolster is to be transferred to the press with the die in the minimum length of time to retain the temperature required for extrusion.
- **Soak time -** After reaching temperature on the surface, tooling must soak for ¾ hour per inch of thickness for the entire tool to reach uniformity, in an oven with air circulation. (In a still-air oven, allow 1 hour soak per inch of thickness.)

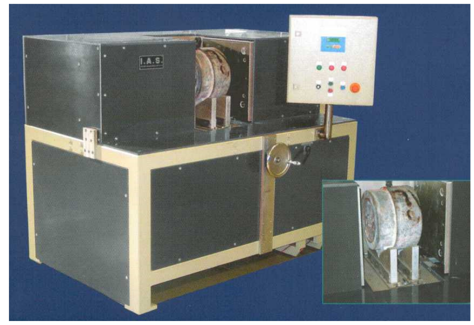


Figure 10-6: Induction die heater
(Photo courtesy of IAS GmbH)

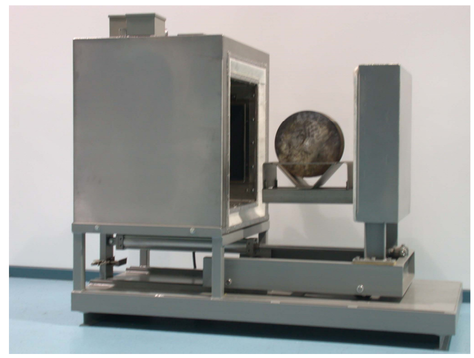


Figure 10-7: Drawer-type infrared die heater *(Photo courtesy of Novatec)*

Temperature Uniformity Throughout the Die Heater. Uniformity should be within ±25°F (14°C) throughout the oven. Temperature may be surveyed by using the same methods and equipment described in *Chapter 9 - Ageing Ovens*. Hot and cold spots in the oven may be adjusted somewhat by the addition of baffles to change the flow of circulated air. Still-air ovens may require conversion to air circulation to attain the desired uniformity.

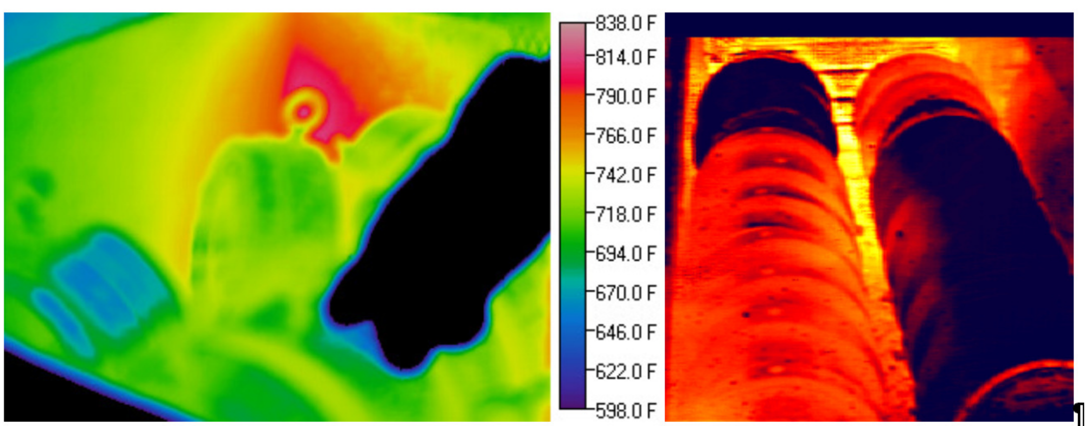


Figure 10-8:Infrared thermal scans show the non-uniformity of temperatures in a multi-die oven

[3] Mason, Bill, and Molitor, Mel, Session on Die Correction at 1989 Die Workshop, Aluminum Extruders Council, October 1989, Chicago.

Temperature Accuracy. The accuracy of the actual oven temperature as compared to the control set point should be checked monthly with an accurate reference thermocouple and potentiometer or recorder. A second, high-limit controller is also recommended to protect against overheating in case the primary controller fails.

Maximum Time at Temperature. The grain structure of press tooling tends to deteriorate when exposed to high temperatures for extended periods. The recommended temperature-time tables vary slightly according to the steel supplier and grade of steel used but are approximately as follows:

500ºF .... Unlimited

600ºF .... 30 hours

700ºF .... 10 hours

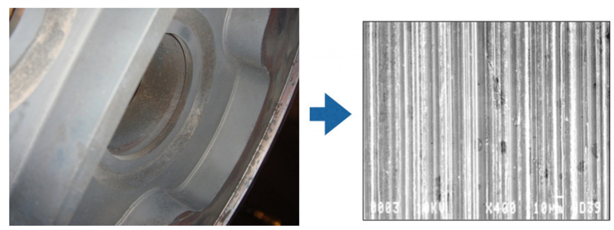
800ºF .... 6 hours

900ºF .... 2 hours

It is recommended to have in place a good management system for controlling this important variable --- for example a computerized record at the press, or a single-cell type system. Otherwise this control must be the responsibility of a press crew and die technicians who are well trained in the importance of tooling temperature; and even so they must be equipped with an effective manual record-keeping procedure.

Dies that are too hot create oxide build-up on bearings, causing die lines on profiles.

Dies that are too cold are at risk for breaking or failure to extrude.



Die Lines

Figure10-9: Extended time at temperature creates oxide build-up on bearings, resulting in die lines

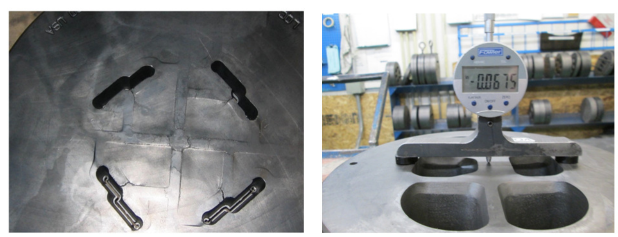


Figure 10-10: Cold Dies m,ay result in broken die and/or wasted billets

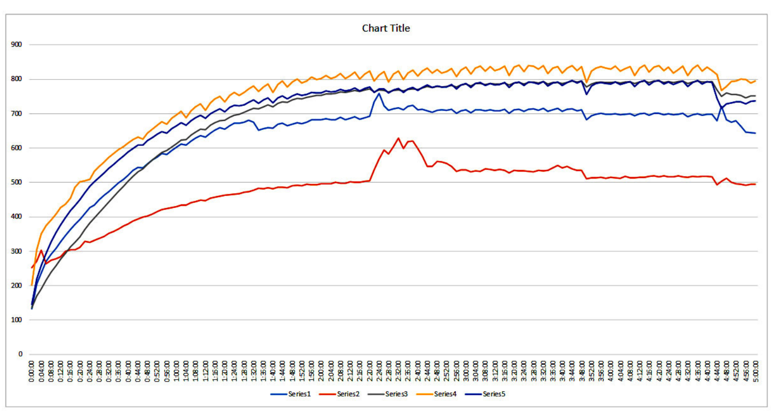


Figure 10-11: One-year old chest-type oven. Set/target temp 860F. In 288 minutes the core never reached more than 550F. Result is 310F too cold, with an increase of 31% flow stress. Increased oxidization on die bearing, negatively effecting extrusion surface finish.

Maintenance

Heating System (Electrical). A monthly check should be made for any burned out elements; it is recommended to also check amperage on all elements. At the same time check the elements' electrical terminals to insure that the connections are tight.

Heating System (Gas-fired). Check the combustion system monthly for: correct fuel-air ratio and high/low fire settings; check for proper functioning of pilots, flame detectors, and safety devices in the gas train; and clean or change the combustion air filter.

Air Circulation. A monthly check of the air circulation blower's operation is recommended. Lubricate the fan bearings with the appropriate high-temperature grease. On a quarterly schedule, check the fan blades, motor and drive belts, and check air baffles in the oven for damage.

Controls. Electrical contactors should be checked on a monthly basis. Check thermocouples for damage from tooling. Temperature control instruments should be checked at least monthly for calibration, to verify that temperatures are controlled at the set points. Maintenance and calibration of temperature control instruments is difficult and is usually best contracted to firms which specialize in instrument repair and maintenance.

Oven Structure and Insulation. Check the door or drawer seals monthly and replace as needed. Check the oven shell for hot spots -- block insulation tends to deteriorate with time and vibration, and it may be necessary to re-insulate the walls periodically with ceramic fiber insulation to eliminate heat losses.

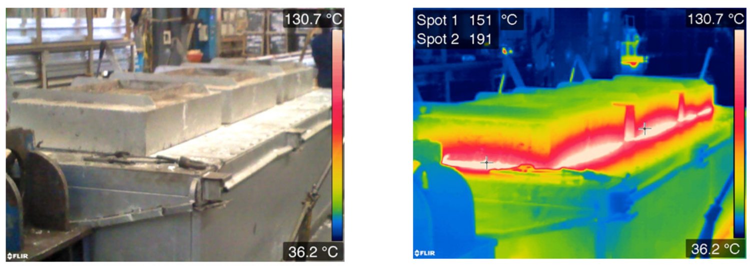


Figure 10-12: Infrared scan shows bad insulation and seals, causing energy loss and non-uniform temperature

Safety Shut-off Devices.
The oven heat and air circulation should be switched off whenever a drawer or oven door is opened. A monthly check is recommended to insure that the limit switch and interlocks operate properly. Check limit switches for loose mountings, loose wires, loose arms, etc.; check for proper tripping.

Door or Drawer Actuators. Each month, check the proper functioning of the air or hydraulic cylinders used to actuate the door or drawers of the oven. If air (ovens with top doors), check the cylinder's air seals, and check/clean the air filter/regulator. If hydraulic, check for fluid leaks, level, and temperature, and clean fluid filters. (General maintenance and trouble-shooting tips for hydraulic systems are also described in *Chapter 5 - Hydraulic Equipment*.)

For drawer or rotary-type die ovens, drive mechanisms (other than cylinder actuated) will usually include gearbox and sprocket/chain drives. Monthly checks include checking the gearbox oil level, lubricating drive chains, and checking for smooth operation. Check the drawer support wheels for wear, and clean the guide tracks with compressed air.

Temperature Tolerances of Standard Data Logging Equipment

Data loggers: Data loggers are typically built with the tolerance of ±0.15% of reading + 0.7°C

At 460deg C the reading can be +/- 1.39 deg C

Thermocouples: Thermocouples built with American Limits of Error ASTM E230-ANSI MC 96.1 have the tolerance of 2.2°C or 0.75% (which ever value is greater).

At 460 Deg C the reading can be +/- 3.45 deg C.

Thermocouples built with IEC Tolerance Class EN 60584-2; JIS C 1602 are built with the tolerance of 0.4%. At 460 Deg C the reading can be +/- 1.84 deg C***.***

Thermocouple Drift: A change of a reading or set point value over long periods due to several factors including change in ambient temperature, time, and line voltage.

New Thermocouple < 1 ohm

Drifting Thermocouple > 90 ohm

Close to Failure Thermocouple > 170ohm

Thermocouple extension wire: K Type TC are built with the tolerance of +/- 2.2°C.

Cumulatively the data log Temperature readings can be out by +/- 7.04 deg C.

Additional info:

PLC Thermocouple Input Card Type K TC: CJC Accuracy ±1.3°C (±2.34°F).

Thermocouple K (-230°C to +1370°C (-382°F to +2498°F) ±1°C (± 1.8°).

The module uses the National Institute of Standards and Technology (NIST) ITS-90 standard for thermocouple linearization

At 460 Deg C the reading can be +/- 2.3 deg C with Auto calibration Enabled