Die Management
From the Die Shop to the Press

Introduction

A great deal of information is available on die management techniques inside the die shop. This presentation deals with the often-neglected steps between the die shop and the press. I will explain some of the common problems that occur at this stage of the extrusion process, and present some data on ways to drastically improve die performance through better die management between the die shop and the press.

Treatment of Dies in the Die Shop

A die typically receives a tremendous amount of TLC after it is used at the press, including…

- Carefully cleaned with caustic.
- Carefully sandblasted (more & more with auto blasters).
- Taken into the die shop, checked for signs of excessive ware, i.e. cracks, washed-out bearings, etc.
- Pinned for dimensional conformity.
- Sometimes re-nitrided.
- The bearings are polished to an almost mirror finish.

All of the above, especially the nitriding, are very closely controlled activities.

After all of this TLC, the die is then stored on a rack until it is needed once again for service. It is from here to the extrusion press (not extrusion itself) that the die sees the worst treatment of its life.

Problem Overview

Over 90% of extruders in the US utilize conventional convection ovens to heat their dies.

We are all very familiar with these ovens. They heat the air in the chamber and blow the hot air around the dies to heat them. These ovens typically hold ten to fifteen dies and most presses use two or more of these ovens.

This configuration of oven lends itself to the following three process problems.

1. Uneven heating
2. Slow heating
3. Leaving dies at temp for too long
4. Excessive oxidation on the bearing surface
5. Convection heating of dies is tremendously energy inefficient.

Let's look at each of these in a little more depth.

Problem #1: Uneven Heating

Studies show that the average thermal gradient of a die heated in a convection oven is 100 or more degrees F. At the press, this will cause uneven runnout on multi hole dies Example: We have all seen this, the first billet to go thru a die has 20 foot runnout difference, the second, a 10 foot difference and the third with an even runnout. What is happening here is that the die is becoming EVENLY heated by running billets thru it. In the case of single hole hollows or large solids it can take several billets to properly heat the die to get good dimensions. This thermal gradient also causes tremendous uneven stresses on the die, which causes die breakage. This is why we typically see die breakage on the first or second billet, rarely, after that.

There are many reasons that convection ovens heat dies unevenly.

1. The air being blown around in the die box will travel the path of least resistance. Therefore, only part of any die will get that blast of hot air somewhere on its surface. That area will get hotter than the rest of the die and stay hotter.
2. Because all of the dies in a convection oven are under the same lid, the very medium that is heating the dies escapes every time the lid is opened to get a die for the press or when loading more dies in the box.
3. Finally, the biggest cause of unevenly heated dies is putting a cold die next to a hot die in the oven. It is virtually impossible to avoid this. Obviously the worst case here is when a cold die is placed next to an already hot die, only to have the once hot die brought out 1 or 2 hours later for and put in the press. This once hot die will now have a tremendous thermal gradient across it and is subject to breakage, poor runnout, and non-conformant extrusion dimensions for at least the first three billets.

Problem #2: Slow Heating

Convection heating technology is terribly inefficient. The accepted rule of thumb for heating extrusion dies is 1 hour per inch of thickness. So, an average size tooling stack of 16"x5" will require a minimum of 5 hours to heat. We are all seeing smaller and smaller lot sizes these days and with such long heat times for dies, more of our dies are going to the press under heated. A survey of 31 different extruders (two in South Africa, one in Australia, one in France and the rest in the US & Canada) who use convection ovens shows the following:

1. 22 of the 31 know that their convection ovens don't properly heat their dies. Therefore they have set the oven at 850 to 900 Fahrenheit in hopes to get the dies to at least 800 Fahrenheit.
2. Of the 31 extruders, the average temperature of their dies coming out of the ovens was 660 Fahrenheit.
3. 27 of the 31 extruders admitted that they do not regularly or otherwise monitor die temperature prior to extrusion.

Problem #3: Leaving Dies at Temp for Too Long

Given that the typical extrusion press has two die boxes that hold 10 to 15 dies each we are leaving a lot of dies at temperature way too long. All of us have seen some dies go into an oven Monday morning and come out Thursday afternoon. Goes without saying what this does to dies - Oxides on bearings, annealing, etc.

Problem #4: Oxidized Bearing Surfaces

Especially for you high finish extruders, this is a big problem. Again, convection ovens blown hot air around the dies. This itself promotes oxidation on the bearing surface. And the typical long heat times associated with convection ovens make for poor surface finish of extrusions.

Problem #5: Energy Consumption:

Convection oven technology is the same technology used since extrusion began, some 100 years ago. While we as extruders have embraced new technology in almost all other facets of the extrusion process – Automated everything, from runnout tables, extrusion press control systems, etc. we still use old and inefficient die heating. Convection ovens use about twice the electrical energy to heat a die than does new technology available today. Convection technology is extremely inefficient. It relies on air to heat the steel. Air is a thermal insulator and does not like transferring thermal energy. Then, this heated air is blown around the die box and expected to transfer the thermal energy. The problem here is the fact that air will travel the path of least resistance and will never evenly heat the die. Today's die heating technology does not rely on air to heat the dies; rather a direct transfer of energy from the heat source to the die is used. Much like a microwave oven heats our food. New and efficient die heating technology today will use half the energy to heat dies, as do the old convection die boxes we are all familiar with. With all of the energy concerns today, efficient die heating is more important than ever.

The Solution: Infra-red Die Heating

Heating extrusion dies with infrared energy is the most energy efficient and precise method available today. Infrared, unlike convection, does not rely on air to heat the dies. It is a direct transfer of thermal energy to the die. Because of this, infrared is four to five times faster than convection technology. Today's ovens are capable of heating extrusion dies to +-10 degrees Fahrenheit. This chart was generated with a 16" x 5' inch die and had thermocouples potted throughout it. As you can see, it took just over one and a half hour to heat it to 875F. Notice how precisely it is heated. This will improve your extrusion process tremendously.

Case Study: How Infra-red Heating Improved Die Performance & Productivity

RD Werner in Greenville PA "a large extruder in Pennsylvania shares the following:
Die breakage on their 10 inch press averaged 23 dies per quarter (that's almost eight per month). Since installing one of these state of the art ovens, their die breakage has reduced to 3 per quarter. This is an example of what properly and evenly heated dies will do.

This would a good place to talk about the fact that VERY FEW extruders ever check their die temperature prior to extrusion. We are all very aware how important billet temperature, container temperature, exit temperature, etc, etc. But almost no one knows or even checks their die temperature.

This would also be a good spot to talk about what temperature the die **should** be heated to. You guys have found that 925f is good. Most people (try to) heat their dies to 800 to 850f. It would be interesting to ask them if the even know why this is their target temperature and if they really know what temps they are getting!!!

Conclusion:

Today's die heating technology will heat dies is one forth to one fifth the time of that required for conventional convection ovens. This does tremendous things for you high finish extruders. When a typical die (14" X 4") can be heated in just one hour, there simply is not much time for oxides to build on the bearing surface. Fewer oxides on the bearing means a brighter and cleaner surface finish of the extrusions. Of course, the key here is to get the die heated and out of the oven as soon as possible. So it is important to not fill your die boxes with more dies than you will need in any given shift.