CASTOOL
TOOLING SYSTEMS

NITROGEN IN DIE OVENS

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Introduction

For an extrusion die to run properly, the press must be mechanically aligned, and the billet, container, die and support tooling must be heated to the correct operating temperatures, with the variation in the radial temperature gradient of each component minimized. Improper "thermal alignment" of the extrusion process is a major cause of lost production, poor recovery and die failure.

The traditional chest type die oven often with a single heat source, a large door, and holding numerous pieces of press tooling, is an inherent source of temperature variations in the extrusion die. In addition to the problems caused by uneven temperature distribution, traditional chest ovens, multiple die drawer ovens, or for that matter rotary ovens, are often misused and abused. Dies are left in the ovens for eight, twelve, twenty-four or more hours at temperature, causing oxides to build up on the surface of the die bearings with predictable damage to the finish of the extrusions and the life of the extrusion dies.

The inherent problems of type and age of the die oven can be overcome to some extent by the way it's managed by the die shop and press crew. A die oven can be kept perfectly clean and in good working condition, and dies can be loaded, heated and moved to the press in strict sequence. But, ovens holding a number of dies don't lend themselves to one-by-one sequencing and the "visible management" of dies.

In an attempt to reduce or prevent oxidation of the die bearing, there has been some interest in using an inert atmosphere to prevent or slow the rate of oxidation in the oven. This note discusses the significance of research work into the oxidation of nitrided and non-nitrided H13 die steel.

The Oxidation of H13 Die Steel

The oxidation of the H13 or nitrided H13 die bearing in atmospheric air is progressive. The thickness or weight of the oxide formed being a function of the temperature and the time the die bearing is exposed to that temperature. The data complied from that reported by Caule et al, Figure 1 is typical. At the lower temperature of 500°F (260°C), iron samples exposed to atmospheric air gained little weight whether exposed to 8 hours or 120 hours. At the higher temperature of 850°F (470°C) iron exposed to atmospheric air for 2 hours gained measurable weight of oxide, and those exposed for 30 hours (not uncommon in the conventional chest oven), gained over 300 ug per cm^2.

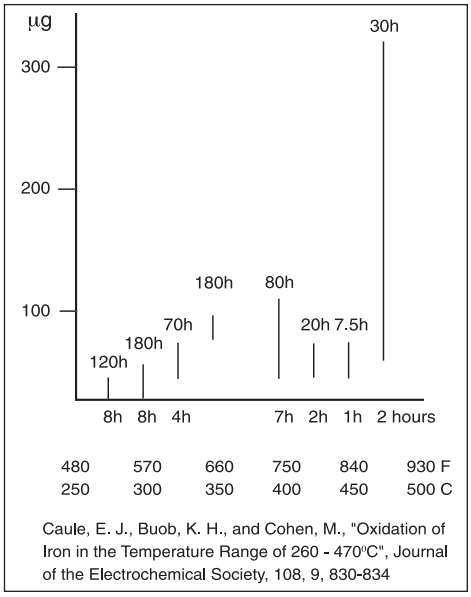

Figure 1: The Effect of Time at Temperature on the Oxidation of Iron. Prepared from data presented by Caule et al. (2)

Aware of the importance of this issue to the aluminum extruder, Castool, supported a series of trials at the Institute for Microstructural Sciences at Canada's National Research Council, Ottawa to measure the growth of oxide on nitrided and un-nitrided H13 die bearings, and specifically to measure the effect on oxide growth of heating 2 hours in an inert atmosphere before exposing the samples to air. The work was performed by Drs. R. J. Hussey and M. J. Graham who have done extensive research into the oxidation of steels. Oxidation of samples at 450°C was performed in flowing air or nitrogen in a Pyrex container placed inside a Lindberg Blue M furnace (thus preventing possible contamination from oxygen adsorbed onto the furnace walls). Scanning electron microscope (SEM) micrographs were acquired before and after oxidation using a JEOL 840A SEM.

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The effect of the time the nitrided and non-nitrided samples of die bearings were exposed to the furnace atmosphere at 840°F (450°C) is illustrated in Figures 2 and 3. With the exception of the sample of nitrided H13 steel which spalled after 4 hours heating in air, all measurements follow parabolic curves, with oxidation proceeding rapidly in the first hour, and the nitrided samples gaining marginally more weight than the non-nitrided samples. Note that samples heated 2 hours in commercial grade nitrogen containing less than 5ppm oxygen, followed by exposure to air for 10 minutes throughout the heating cycle. Showed the same weight gain as those exposed to air throughout the heating cycle. This data supports the conclusions that the die heating time should be kept as short as possible. And, there is no advantage to heating the die in an atmosphere of commercially pure nitrogen.

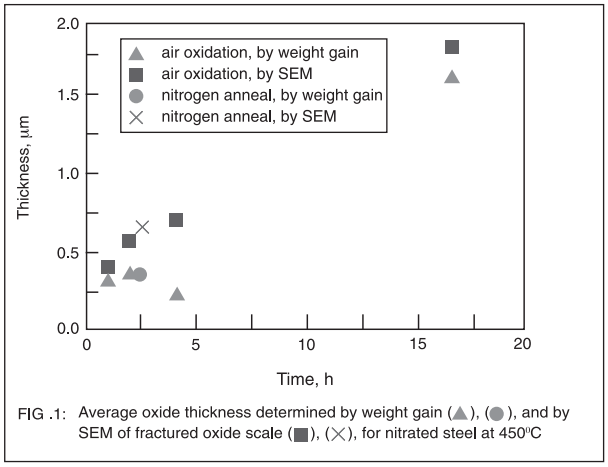

FIG .1: Average oxide thickness determined by weight gain (▲), (●), and by SEM of fractured oxide scale (■), (×), for nitrated steel at 450°C

Figure 2: The Oxidation of Nitrided H13 at 840°F (450°C) Showing the Ineffectiveness of the Nitrogen Atmosphere

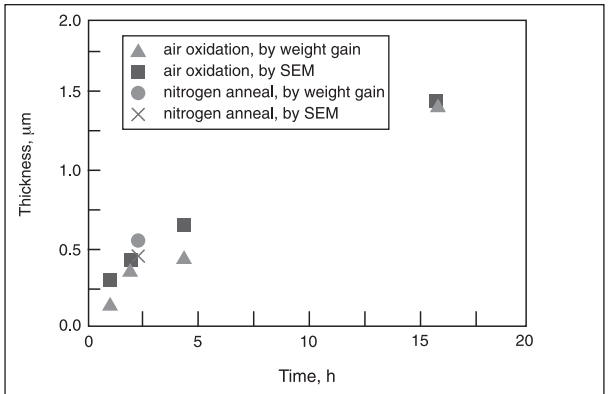

FIG .2: Average oxide thickness determined by weight gain (▲), (●), and by SEM of fractured oxide scale (■), (×), for non-nitrated steel at 450°C

Figure 3: The Oxidation of Non-Nitrided H13 at 840°F (450°C)

One manufacturer of die ovens claims to overcome the problem of oxygen contained in commercial grade nitrogen or adsorbed onto the walls of the die oven by heating the die in a vacuum(3). The system is made up of a number separate, electrically heated chambers. Each chamber, is arranged with an air operated drawer to carry one die assembly, the temperature of each chamber is controlled independently. The die assembly is loaded into and unloaded from an open drawer. Because the system is dependent on evacuating the die cavity prior to purging with inert gas, particular attention is paid to the door seals. It is claimed that dies can be rapidly heated to operating temperature or left for long periods at a lower temperature. But, the oxidation rate of H13 steels is dependent on temperature, and the rate of oxidation is fastest during the first few minutes of exposure to oxygen. Oxide formation can't be prevented during transfer from die oven to extrusion press. Because of the complexity of this system, the extruder is better advised to manage his die ovens to minimize the time in the oven at temperature.