HEAT TREATMENT OF EASILY OXIDIZABLE METALS

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HEAT TREATMENT OF EASILY OXIDIZABLE METALS

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This invention relates to the heat-treatment of the light and easily oxidizable metals and alloys containing substantial or preponderant amounts of these metals.

5 The terms "heat-treating" and "heat-treatment" have both broad and specific meanings. Within the scope of this specification and he appended claims they are taken in their broadest sense as designating the heating of metal to effect therein some structural or physical change; as, for instance, the preheating of a metal ingot prior to working, the annealing of wrought metal to cause recrystallization or softening, the solution heat-treatment of metal to effect a material change in strength or other physical property, the aging of metal for the same purpose, and, in short, any heating designed to produce a definite effect other than fusion in or on the metal.

10 The factors which vary and must be controlled in the fabrication or other treatment of metal are by no means completely understood. Unexpected metal failures, and unexpected property differences among different lots of seemingly similar metals are by no means uncommon. The light and easily oxidizable metals, such as aluminum, magnesium, and the many and various alloys in which either of these metals is present in substantial amount, say 50 per cent or more, are no exception to this general rule. Many developments in the efficient and economic production, fabrication, and commercial use of these light metals have taken place in recent years, and particular emphasis has been laid upon the heat-treatment of such metals. There remains, however, variable factors which must be found and controlled before the heat-treatment used in connection with the light metals will be such as to develop to the fullest possible extent the inherent potentialities of these metals and their alloys.

20 It is upon my discovery of one of these herefore unperceived factors that my invention is predicated. I have found that the moisture content of the atmosphere in the furnace or chamber in which the metal is heated plays a substantial part in the heat-treatment of the light metals and their alloys, and I have further found that the drying or desiccating of the air which surrounds the metal during thermal treatment produces a definite and beneficial result; even, in some instances, where the amount of moisture removed from the air is so small as to be apparently inconsequential. In pursuance of my discovery, I have experimented with the heat-treatment of light metals and their alloys and as a result have determined that the deterioration induced in the metals during the heat-treatment by the presence of moisture in the air is cumulative and insidious, and is the explanation, at least in part, for certain defects and inconsistencies heretofore noticed in the light metals and alloys. Moreover, I have found that the physical properties of the light metals and their alloys may be increased and developed with greater consistency if the moisture in the air surrounding the metals or alloys during heat-treatment be reduced by a preliminary moisture-removing treatment.

25 For instance, the light alloys of aluminum and often the aluminum metal itself, when in thin section, appears to gradually undergo a deterioration in properties as the thermal treatment is extended in duration. My belief, based upon the discovery hereinafore mentioned and the experiments carried on pursuant thereto, is that the deterioration in ordinary furnace atmosphere is due to intercrystalline high temperature oxidation caused by the moisture in the furnace atmosphere. This particular insidious type of defect is often not apparent until an unexpected failure in service brings it to light. It is markedly evident in the case of fine-gauge aluminum alloy wire which, after a heat-treatment of the usual duration under ordinary heat-treating conditions, often becomes so brittle that it breaks apart merely in handling. I have taken wire of this nature and, applying the principles of my invention, I have given it a long time treatment in a furnace containing a dry atmosphere and have thereby secured a product which is strong and ductile. This same result I have obtained in the treatment of sheet of light gauge. In addition I have found that worked metals which have been given a solution treatment in a dry atmosphere are not so susceptible to surface blistering during heat-treatment as are articles heated under the conditions encountered in the usual practice.

35 In heat-treating the light metals and their alloys in ordinary furnace atmosphere the injurious effect of moisture is cumulative and may not make itself evident unless the time of treatment is extended. Nevertheless, the deleterious forces are active from the beginning, and if, as I have reason to believe, intercrystalline oxidation is the primary cause of the deterioration, the areas of incipient or initial oxidation may well serve as foci or centers of further disintegration when the article becomes subjected to corrosive conditions in service. By reason of a reduced thickness or diameter, the injurious effect of ordinary furnace atmosphere becomes
readily apparent when light gauge sheet or wire is being heat-treated, since the depth of penetration is relatively a larger proportion of the total thickness, but it is advantageous to avoid such pernicious results. In 2 articles, whether cast or wrought, of heavy section, although differences in the latter instance may not be so readily detected, I have also found that the effects which I originally noticed in connection with aluminum and its alloys, when heat-treated in ordinary furnaces, are produced in the other well known and widely used light metal, magnesium and its alloys when they are similarly treated.

It is obviously impossible to state any hard and fast upper limit to the amount of moisture which the atmosphere surrounding metal during thermal treatment must not exceed. The ideal state of the furnace atmosphere would be one in which no moisture at all is present. This is, of course, impossible of attainment under feasible manufacturing and operating conditions, but any substantial reduction of the moisture in the air will produce material benefits. I prefer, in the practice of my invention, to maintain in the moisture content of the air below about 3 grains of moisture per cubic foot, since this limit has been found to give good results and with the exercise of reasonable care can be maintained in present commercial apparatus and processes by which the light metals and their alloys are thermally treated.

In the practice of my invention the metal to be treated is surrounded by an atmosphere of reduced moisture content, say, in a furnace or some similar means. It is not usually necessary that the fitting of the door or other opening in the heating chamber be air-tight. A good mechanical closure will ordinarily be sufficient but I prefer, in designing equipment in which to heat-treat articles made of the light metals and their alloys according to my invention, that the equipment be so constructed as to be as nearly air-tight as is practicable, having in mind the fabrication processes in which my invention may be a step. Under conditions where the furnace or other container or chamber in which the metal is heated is substantially air-tight, it is only necessary, after having charged the article into the furnace, to remove the moisture of the air contained therein, after which no further air treatment need ordinarily be undertaken until such time as the door of the furnace is opened to remove the metal and place therein a further charge.

The drying of the air in the chamber may be easily effected by withdrawing air through a suitable duct and returning the air after it has been deprived of the desired amount of moisture, or by passing a current of dry air through the furnace, thereby expelling more or less air of greater moisture content and bringing the net amount of moisture down to a safe point. My broad improvement is not, however, limited to any particular way of providing a dry atmosphere around the metal,—any way of insuring the presence of such an atmosphere being sufficient inasmuch as the invention in its broader aspects resides in heating the metal in an air-tight chamber regardless of how dry the atmosphere is obtained. Under commercial conditions where air-tight containers or furnaces are not readily available or practical and where doors or openings may be frequently opened and closed, it is preferable to supply the chamber a continual stream of dried air, preheated if desired.

Referring to the drawing is illustrated one form of apparatus by which my method may be carried out:

Fig. 1 is a plan view of the apparatus.

Fig. 2 is a cross section on line 2—2 of Fig. 3, looking in the direction of the arrows.

Fig. 3 is a longitudinal section on line 3—3 of Fig. 1.

The furnace 16, constructed of refractory brick or blocks, is provided with a removable 10 closure 11 and is equipped inside with electrical heating resistors 12, the heating effect of which may be regulated by any suitable current regulating means, not shown. The furnace charge which is to be heat-treated is shown as several 15 I-beams 13.

At its rear the furnace is connected to a dry air supply system comprising a pair of upright drums 14 containing any suitable desiccating material, say calcium chloride, activated carbon, silica gel, or preferably, activated alumina, connected at the top by valved ducts 15 and duct 16 to the furnace bus 17 and at the bottom by ducts 18 to blowers 19 driven by separately controlled motors 20. Between ducts 18 and the drums 14 is placed filter 15, one of which is shown at 21, for reactivating the activated alumina or drying the desiccants used in the drums, and I may provide duct 16 with an air-preheater 22. The air-inlets 23 of the blowers 19 may be provided with regulating valves controlled or actuated by the pressure in the furnace by means of pressure-actuated devices 24 of any suitable type, connected to the valves by means of pipes 25, so that a substantially constant pressure of any desired value can be maintained in the furnace.

In operation the furnace door is open and the charge is introduced. While the door is still open a current of dry air from one of the drums 14 is forced through the furnace, which displaces some or all of the moist air (which entered during charging) thereby decreasing the amount of moisture in the furnace atmosphere. While the stream of dry air is still flowing the door is closed and the pressure in the furnace is allowed to build up. This pressure need only be slightly above atmospheric so as to insure that any leakage which can take place is outward, thus insuring dry air operation. As the point of maximum leakage is usually near the door the pressure control devices 24 are preferably located near that point.

When the desiccant in the drum in use becomes charged with moisture the other is put in operation and the desiccant in the first is dried or re-activated. This may be done by opening the valve 25 in the top of the drum and blowing through the drum a sufficient volume of air which has been raised to a suitable temperature by passing it through the stove 21, heated in any convenient way. Thus one drum is in use while the desiccating material in the other is being treated to restore its moisture-removing power.

It is to be understood that the invention is not limited to the specific apparatus or procedure herein described but can be carried out in other ways without departing from its spirit.

I claim:

1. Method of preventing intercrystalline oxidation of aluminum, magnesium and their alloys in heat treatment thereof, which comprises effecting the heat treatment in air in which the
moisture content does not exceed about 3 grains per cubic foot.

2. Method of preventing intercrystalline oxidation of aluminum, magnesium and their alloys in heat treatment thereof, which comprises effecting the heat treatment in a closed chamber containing a dry atmosphere surrounding the metal.

3. Method of preventing intercrystalline oxidation of aluminum, magnesium and their alloys in heat treatment thereof, which comprises placing the metal in a heating chamber, decreasing the moisture content of the atmosphere therein to an amount less than that of the air outside of the furnace, and heating the metal in such atmosphere of decreased moisture content.

4. Method of preventing intercrystalline oxidation of aluminum, magnesium and their alloys in heat treatment thereof, which comprises placing the metal in a heating chamber, passing dry air into the chamber to expel moist air therefrom, and heating the metal in the resulting relatively dry atmosphere in said chamber.

5. Method of preventing intercrystalline oxidation of aluminum, magnesium and their alloys in heat treatment thereof, which comprises placing the metal in a heating chamber, passing dry air into the chamber to expel moist air therefrom, heating the metal in the chamber, and passing dry air into the chamber at a rate sufficient to maintain therein a pressure adapted to prevent leakage of moist air into the chamber.