



IMPROVED METHODS OF LOG COOLING

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Introduction

Log cooling after homogenization has begun to play a more important role than ever before. Production demands are requiring both faster and more uniform cooling of the logs. As experience is gained, increased evidence shows that the resulting grain structure and workability properties of the billets are a result of the cooling medium utilized after homogenization. As in the past, today's cast houses use various methods of log cooling to achieve the final desired metallurgical results. Those methods will be discussed, along with an improved method to increase both the cooling rate and temperature uniformity throughout the entire load.

Forced Air Cooling

In the past, and in many facilities still today, the aluminum logs are placed directly outside the furnace and cooled by stationary man-fans. Although an effective means of cooling, this method offers very little uniformity and is generally slower than other means available.

Approximately thirty years ago, various cooler designs began penetrating the market place. The design SECO/WARWICK offered at that time incorporated tubeaxial fans, located above the work in an enclosed chamber. With this arrangement, the load car supporting the aluminum logs would be removed from the furnace and placed directly into the enclosed air cooler. This design utilized two or three tubeaxial fans that pulled ambient air through the work and up the fans.

By using an enclosed cooler, faster cooling rates are achieved than with man-fans. However, the temperature gradient across the load is increased, resulting in as much as 150-200° F difference from side to side. By monitoring the load temperature in the upstream, or air inlet side, and the downstream or air exit side, better control over the gradient can be obtained.

Forced Air and Water Mist Cooling

Several years ago, SECO/WARWICK designed a log cooler that utilized a water mist system. With this arrangement, the cooler is similar fashion to the previous units with the addition of two spray headers located along the length of the cooler of the upstream air side. The water spray nozzles were located on equal centers that were determined by the impingement area of the

nozzle. The spray pattern of the nozzles was a cone-shaped fog, which encompassed an angle of approximately 90°.

The water mist system cooled the logs much faster, and that the temperature gradient across the load was somewhat less than the coolers that utilized air only. The importance of turning the water off at the right time was learned, so as to limit distortion of the logs.

Improved Forced Air Cooling

Reversing Damper Design

SECO/WARWICK has preliminary design at this time that will uniformly cool the logs after homogenization. Because of the shortcomings observed with the previously described cooling units, it was decided to attempt to design a cooler that will reduce the load temperature uniformly throughout the load while retaining log straightness.

With this new design, ambient air is pulled in through the outside wall into the main cooler body, through the work and up through the induced draft fan, where it is then exhausted through the roof. Movable dampers located on each side of the load move the air from one side of the load to the other.

Preliminary calculations indicate that a cooling uniformity of 10-20° F throughout the load can be achieved. The cooling time required will be determined by the temperature of the available ambient air. Another idea that has yet to be considered is the possibility of incorporating the spray mist system with this new style cooler, with nozzles on both sides of the load.

Reversing Axial Flow Fan Design

The steel structure of the cooler includes an open wall on the side of cooler opposite from the fan location similar to the initial axial flow design. The ambient air enters or exits the cooler through the open wall, depending on the rotational direction of the fans. The cooler employs two or three tube axial type fan assemblies to generate the required air movement. The axial fan wheel for

this unit uses fan blades with an elliptical cross section so that the fan direction can be reversed to produce nearly equal volumes of airflow in both directions. Each fan motor is controlled by an adjustable frequency, variable speed, reversing, AC drive. The drive includes ramped acceleration, ramped deceleration, and dynamic braking. These features allow the direction of the airflow to be reversed very quickly and frequently, without building up excessive heat in the motors. The reversing drives allow reversing airflow to be utilized without the need for large mechanical dampers as have been used in the previous reversing design. The variable speed feature provides controlled cooling capabilities, as well as maximizing the fast cooling rate, based on the temperature of the ambient air and the temperature of the billets.

The mechanical design and construction of the cooler is purposely kept simple. It is the software and electrical controls that significantly enhance the performance of this unit. Air thermocouples are utilized on either side of the cooler and load thermocouples are embedded on either side of the load of billets, to provide instantaneous feedback of the cooler performance. A PLC utilizes these inputs to control the speed and reversing frequency of the fans, to accomplish the setpoint profile dictated by the selected recipe, while maintaining optimum load temperature uniformity.

The cooling recipes are developed by the plant metallurgist, according to the aluminum alloy and customer requirements. The recipe parameters include cooling rate for each segment of the cooling cycle, end temperature for each segment, final load temperature, fan reversing frequency and recipe number.

After the cooler door has been closed, the person operating the equipment selects the appropriate recipe using the human-machine-interface panel (HMI), and starts the cycle. The operator then connects the load thermocouples to terminals provided beside the door of the cooler. The remainder of the cycle is fully automatic. An alarm horn will sound when all load thermocouples have reached the final load temperature set by the recipe.

When a recipe segment requires the cooler to cool as fast as possible (plunge cooling), the fan drives receive a signal to run the motors as fast as possible, within the limitations of maximum allowable fan wheel speed and motor horsepower capability. When a slower cooling rate is required (controlled cooling), the motor speed is controlled by a proportional control loop (PID),

with the load thermocouples providing the feedback data. Should a recipe segment specify an extremely slow cooling rate or a hold period at a given temperature, the fan speed will be very slow or may even be stopped to achieve the desired cooling or holding action. Manual controls are provided for fan speed and direction, for testing and maintenance purposes.

Conclusion

Not so long ago, fast cooling of aluminum billets after homogenization was not a widely used process. In fact, if forced cooling was used at all, it was done to get the billets down to a safe handling temperature more so than for any metallurgical improvement. The technology has evolved over the years to the point where not only is forced cooling the standard in the industry, but sophisticated cooling strategies are utilized consisting of several different cooling rates being incorporated into one cooling cycle, specifically tailored to the alloy. The cooling equipment described above keeps pace with the demands of the industry, allowing the logs to be cooled according to a pre-defined temperature profile.