GREATER ECONOMY IN THE EXTRUSION OF ALUMINIUM SECTIONS

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Key words: Liquid nitrogen, cooling, aluminium profile, die

Abstract. The use of nitrogen for improving output and quality in the extrusion of aluminium has been widely adopted today. There are two different ways of using nitrogen: inerting the extrusion and cooling of the die.
For the majority of extruded products which are produced in small quantities of frequently changing shapes, inerting of the extrusion with nitrogen via an annular nozzle system or similar means enhances the economy and the surface quality of the extrusion.
In many cases however cooling of the die opens the way to an even more significant improvement in output while maintaining a consistently high level of quality. For this process, additional equipment has been developed with which the liquid nitrogen is fed in precisely controlled quantities. This method of operation is particularly efficient when long runs can be extruded and when the peripheral conditions such as the section shapes, dimensional stability, die design and the plant as a whole, permit the extrusion speed to be increased substantially.
The presentation shows the use of liquid nitrogen, the way how it is used in extrusion plants, the development of the temperature in the die and the profile and the benefits which can be achieved by using this system.

Extrusion of aluminium

Extrusion is a forming method used for producing semifinished products (rod, and bar, tube stock, solid and hollow shapes). Such products are produced by pressing a heated billet under high pressure through a die. By virtue of the versatility of the orifice configuration, it is possible to produce extrusions with very complex shapes (see Figure 1).

The diameter and length of the billet can be varied within the limits imposed by the press to suit the desired product specification. Apart from a small remnant piece, the butt, the billet is pressed through the die to form an elongated shape or tube. The container and die assembly (die backer, bolster and pressure ring) are preheated. The higher the billet temperature, the lower the extrusion pressure required. Depending on the alloy concerned, however, one should not exceed a certain temperature, otherwise a host of problems will arise. For instance, surface and dimensional imperfections tearing and cracking will occur in the finished extrusion. In addition to the preheating of the billet, heat is produced through the deformation of the material and through the frictional heat at the bearing surface, all of which add to the exit temperature of the extrusion.

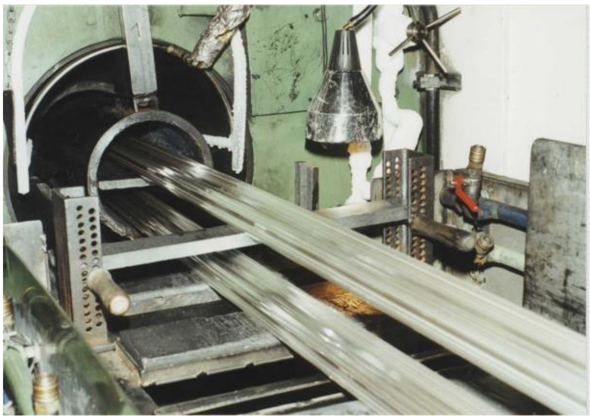

Figure 1: Extrusion

The task of controlling all the temperature factors involved with an extrusion press is extremely complicated and is critical in determining the extrusion speed and the quality of the extruded product.

Extrusion tools

The die must fulfil exacting demands as it is primarily responsible for the dimensional accuracy and clean, unscored surface quality of the extrusion. It is subjected to high pressures as well as a high degree of wear and tear. Nitriding of the die bear surface is used to increasing hardness of the surface and thus increasing resistance to wear and tear of the die. Figure 2 shows a typical die.

Figure 2: Die assembly

Cooling

The production of the extrusion calls for certain temperatures on the one hand. On the other hand, excessively high temperatures will damage the extrusion. One of the objectives is therefore the local use of coolants with the aim of removing the additional heat produced by deformation and friction. The purpose of cooling is to achieve increased output without impairing the quality of the product. In particular there must be no deterioration in the strength of the product and its dimensional accuracy and the surface quality of the extrusion.

A number of patented processes of die cooling are based on the use of water. Other cooling media such as compressed air, carbon dioxide and nitrogen are known. Today however only the use of liquid nitrogen holds any practical significance. Here both, the cooling effect and the inerting properties of liquid nitrogen are used.

Improving the surface technology of the extrusion with nitrogen

On a press which is operated without nitrogen, the extrusion, which has a temperature of more than 500°C, comes into immediate contact with the atmospheric oxygen as soon as it leaves the die. Depending on the alloy concerned, components of the alloy (especially magnesium) may be oxidised on the surface of the extrusion, producing clearly visible surface defects.

In addition, the atmospheric oxygen leads to oxide deposits on the die which are then picked up by the exiting extrusion, producing an irregular pattern of surface defects. The use of nitrogen avoids these

drawbacks. As a rule, the inerting of the press throat alone is sufficient to solve the problem. In customary practice it was also found that the service life of the die is extended appreciably.
For this kind of application, which is in widespread use today, cooling takes place via an annular nozzle system (see Figure 3).

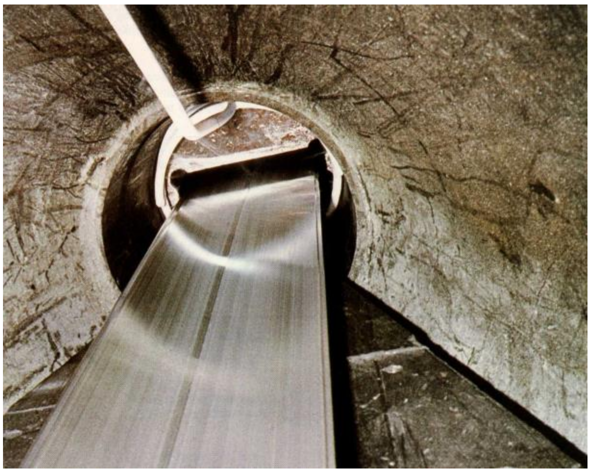

Figure 3.2: Ring nozzle cooling

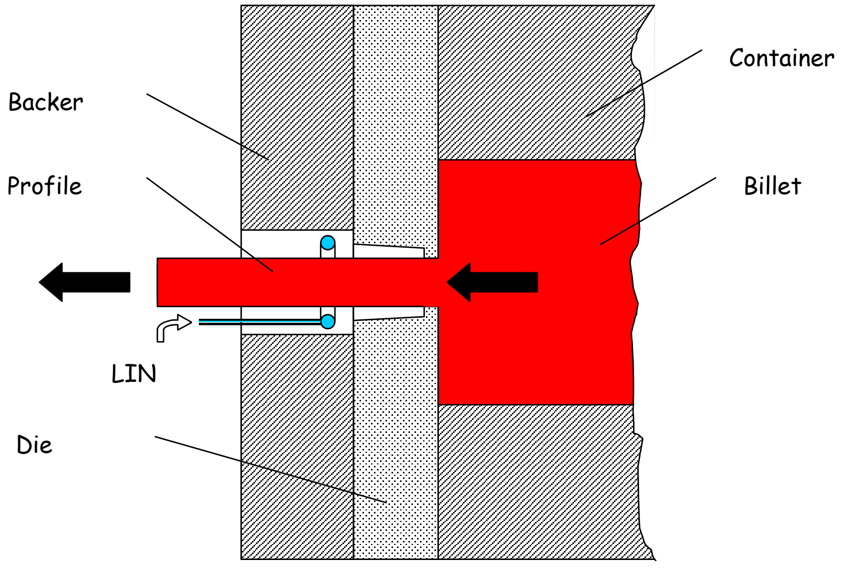

Figure 3.1: Ring nozzle cooling

With this system, the nitrogen is directed to the extrusion in the throat of the extrusion press. Most users employ liquid nitrogen and obtain thereby a certain degree of cooling in addition to the inerting effect. The advantage of the ring nozzle system is its simplicity, low cost of installation and ease of positioning. As a result of the improved surface quality of the extrusion it is possible to increase the press speed also.

Incal® die cooling with liquid nitrogen

In die cooling (see Figure 4), the liquid nitrogen is introduced into the backer, where it provides cooling while vaporising. The resulting nitrogen vapour enters the press throat at the down stream side of the die and protects the extrusion from oxidising.

With this process the bearing surface is cooled, thus compensating for frictional heat build-up. Given optimum heat conduction, it is possible to achieve an increase in output in the order of 20 to 50% depending on the shape of the extrusion, the design of the tool and the aluminium alloy employed (see Figure 5).

Die cooling calls for some special features of the die. For each shape carefully matched cooling ducts need to be provided in the backer. To ensure optimum cooling efficiency, it is essential that the ducts run close to the die bearing surface so that the surplus heat is effectively removed.

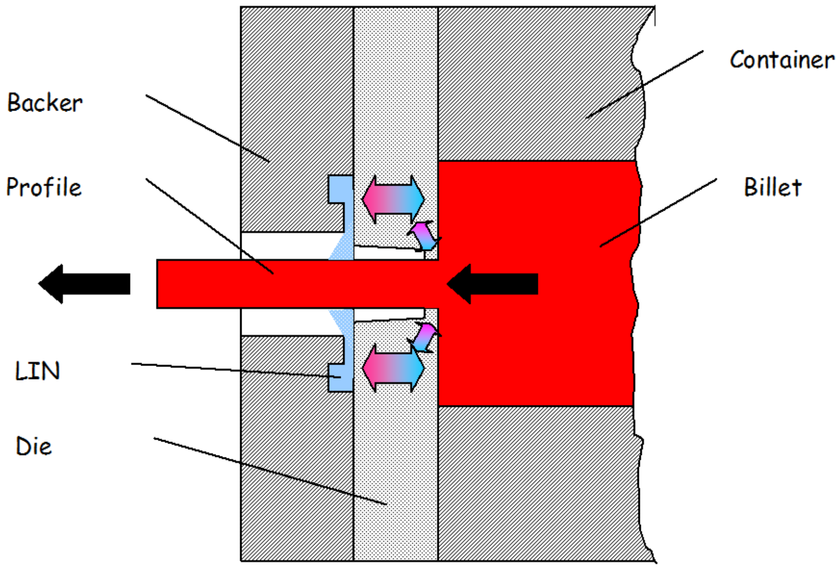

Figure 4: Die cooling

Coolant supply

Accurately controlled feeding of the coolant is of extreme importance in terms of both process safety and efficiency.

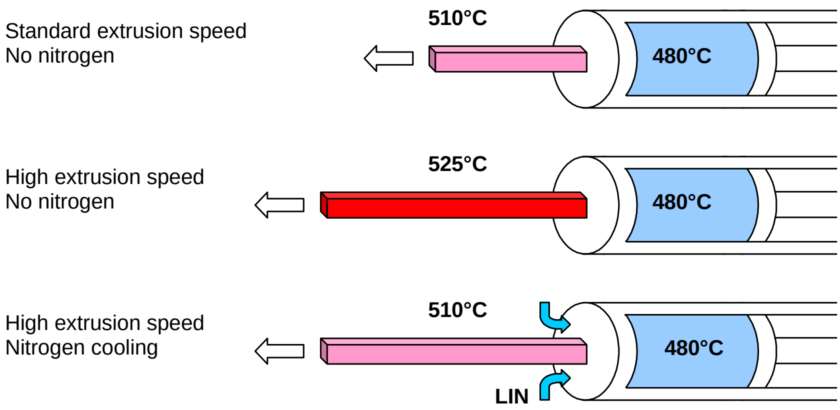

Figure 5 increased extrusion speed

With the ring nozzle cooling system, the nitrogen supply poses no problems. Simple and satisfactory feeding is possible with virtually constant inlet pressure by varying the inflow cross section. The inevitable partial vaporisation of the liquid nitrogen, and hence the fluctuating amount of refrigeration, is of no consequence.

For die cooling one must avoid supplying too much refrigeration, otherwise the die will become “subcooled”. A die which is too cold would call for excessive ram pressure and could in the extreme bring about solidification of the aluminium in the die. However, if insufficient refrigeration is supplied, higher press speeds would cause surface damages due to over-heating.

The coolant supply should therefore be controlled via the ram pressure. Furthermore, the coolant supply line should only be open during the actual production time as a rule. By means of a fine adjustment valve, the amount of coolant admitted to individual extrusion zones can be varied.

Laminar restrictor valves are available for precision-controlled feeding of liquid nitrogen. These valves have been specially developed for precise regulation of cryogenic liquids.

To assure instant availability of gas free liquid nitrogen at the die, a phase separator and a subcooler is employed very near to the point of use.

The function of the gas phase separator is to vent the gaseous portion of nitrogen produced in the nitrogen feed line through heat influx, so that only liquid nitrogen remains. A temperature will establish itself corresponding to the boiling point at line pressure. For example, the boiling temperature of liquid nitrogen is app. –182°C at 3 bar compared with app. –196°C at ambient pressure.

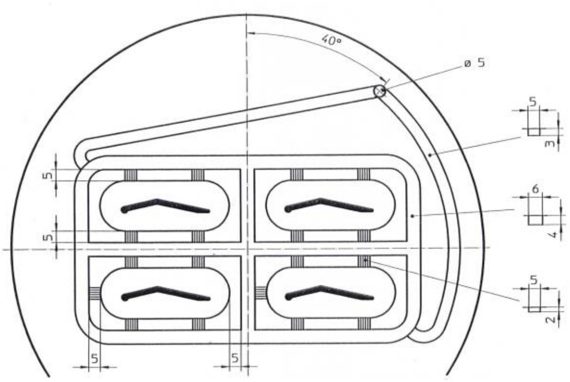

Figure 6: Cooling channels

The subcooler (see Figure 7) serves to reduce the temperature of the nitrogen below the boiling point. In practice, nitrogen feed temperatures of around –192°C are obtained with a line pressure of app. 3 bar, equivalent to a subcooling of 10K. This degree of subcooling prevents the undesired premature gasification of the coolant in the die feed line and thereby ensures uniform and accurately controllable coolant supply in the die.

Nitrogen feed line

Foamed polymer or vacuum insulated nitrogen feed pipes for the press are typically employed. These two types of transfer lines differ significantly in terms of insulation qualities and purchase costs. A 14mm i.d. feed line with foamed polymer insulation has an evaporating rate of app. 0.3 kg liquid nitrogen per hour and per meter of length, whereas the much more expensive vacuum-insulated line has a rate of only app. 0.015 kg nitrogen /h m.

For ring nozzle cooling this amount of gas is not a problem, providing the line is not too long. In die cooling, the portion of gas is separated in the gas phase separator. For die cooling it is generally economical to use a vacuum insulated line.

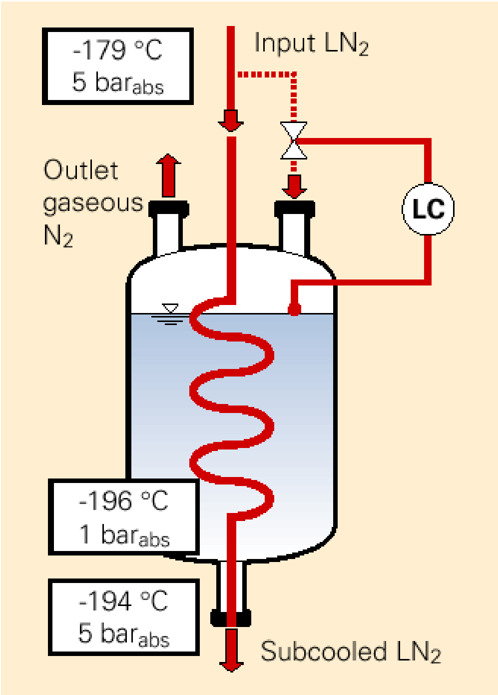

Figure 7: Subcooler

Losses of nitrogen due to evaporation In relation to the length of the supply line are shown in Figure 8. Basis is a two shift operation using a 14 mm diameter pipe.

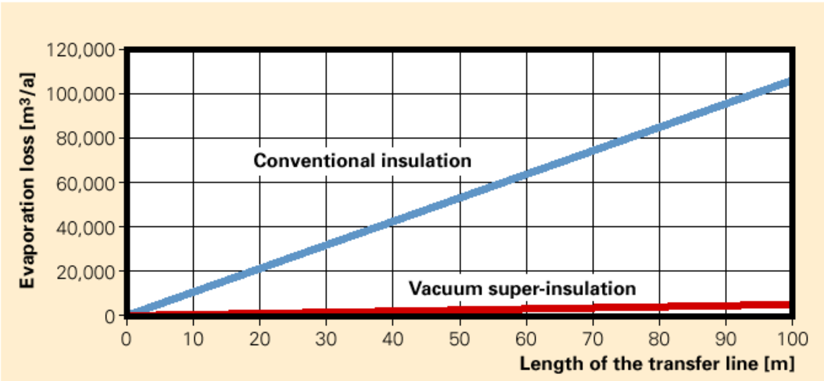

Figure 8: Evaporation in supply line

Summary

The positive effect of nitrogen use in aluminium extrusion is well known. In this abstract today's technology was presented. Three major advantages of INCAL® are:

- Higher press speed
- Fewer surface defects
- Less wear of die (cost approx.$ 2000 to 5000)

In co-operation with the customers requirement an optimised concept will be designed by Messer.

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