Precise Alignment (Physical and Thermal) is Key to Profitable Extrusion

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Extrusion—Art or Science?

The most valuable knowledge an extruder can have is a thorough and accurate understanding of his own extrusion production process. This statement may appear patently obvious, but many extruders still consider both die design and the extrusion production process to be an art as well as a science. This is no longer true.

There was once a time when the extrusion of light metal was almost as much an art as a science. Usually, both the die designer and the press operator learned their trade primarily through their own experience. What worked for them before was likely to work again. The die designer didn't really understand or use the laws of physics that govern the flow of metal through the die. His success depended on his experience, his talent, and on the close cooperation of the extruder's die corrector.

Those days are gone. The die corrector, however, is still a key member of the production team. His job originally was to modify the die to compensate for shortcomings in its design, production, or use. Today, as well as being responsible for measurement and communication with dies that can consistently make good product from the first push, the challenge to the die corrector is to modify the die in such a way as to improve productivity.

Over the years, light metal extrusion technology has improved to the extent that now, with computer-assisted die design and die cutting, the extruder should be able to get good product from every billet every time. If he doesn't, the fault is usually in his alignment. If the alignment, both thermal and physical, proves to be accurate, he may be well advised to look for another die maker.

Alignment in the Extrusion Process

Consider the necessity for exact alignment, both thermal and physical, in all stages of the extrusion process:

- All components of the extrusion press should be physically in precise alignment
- The die should be positioned exactly in the center of the container
- The die should initially be completely and uniformly at the same temperature as the alloy leaving the container
- The temperature of the container liner should remain uniform, bottom to top, to preserve the uniformity of the billet temperature and flow during extrusion

In the extrusion process, absolute alignment, both thermal and physical, is obviously critical. "Almost in alignment" is unacceptable.

Physical Press Alignment

The importance of the absolute physical (mechanical) alignment of the extrusion press cannot be overstated. For example, if the die is not mounted exactly in the center of the container, the flow of alloy into the die will be uneven, and the profile will be distorted.

The ram and the dummy block should pass through the container smooth, straight, and true. For this to happen, the press must be in complete physical alignment.

Uneven wear on the front edge or land of the dummy block is usually the first indication of misalignment that can alter the flow of alloy from the container and distort the profile. Unfortunately, once a press becomes badly worn, absolute alignment is often impossible. It is important, therefore, that wear on bushings and seals, particularly the ways and the main ram bushing, be checked regularly.

Press misalignment is insidious because it can result from so many different factors, such as the press foundation, tie rods, stem, billet loader, die changer, etc. None of these factors alone may appear too significant, but combined they can result in one of the most common problems in extrusion, press misalignment.

The key to maintaining good press alignment is regular, detailed, and diligent inspection (Figure 1). Alignment can, of course, only be accurately measured when the press is at operating temperature. Emphasis must always be on prevention, not correction.

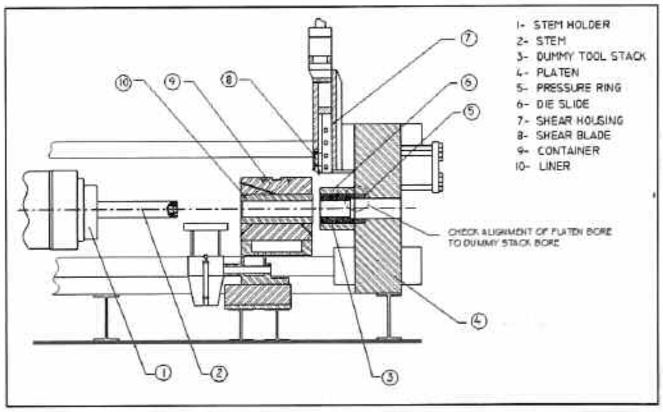

Figure 1. Physical alignment of the extrusion press.

Thermal Alignment of the Die

Maximum productivity is impossible unless the extrusion die is preheated uniformly to the optimum operating temperature. If the temperature is not uniform, the profile will be distorted. If the temperature is too low, increased billet pressure on the die may deflect it. This can result in an inexact profile, as well as increased friction.

Unfortunately, the die designer must assume that if the extruder is using a traditional chest oven, the die may not be sufficiently and uniformly preheated. Accordingly the die must then be made considerably stronger than it theoretically needs to be.

If the die maker can be certain that the die will be properly preheated, he can provide a die that is much easier to push. Because there will be less friction in the die, breakthrough pressure will be reduced and press speed increased before the critical temperature is reached that is necessary to ensure the required physical properties of the extrusion.

Even though most light metal extrusion dies can now be designed and manufactured for use without a die trial, if properly preheated, the average extruder still often wastes valuable press time and reduces his percentage of material recovery while getting new dies to run properly. All too often the first billet, and even the second or third, is wasted simply to bring the die completely to the desired operating temperature. It was never intended that billets would be used to heat the die.

The length of time needed to heat a die in a traditional chest oven is several hours, but incomplete heating is a far greater problem for the extruder than time to temperature.

The solution, in many cases, is a range of single-cell die ovens. In a single-cell oven, each die is individually heated to a completely uniform operating temperature in a fraction of the time taken by a chest oven. With a single-cell die oven ensuring that the die is properly heated, breakthrough pressure may be reduced by 10-15%, press speeds increased, and die deformation or breakage virtually eliminated.

Thermal Alignment of the Container

People are often unaware of the high level of technological sophistication that is required in a container to allow the extruder to operate his press confidently and consistently at close to maximum speeds. For example, the die designer must be able to assume that the flow of alloy into the die during extrusion is uniform. The sizing of die bearings, pockets and ports is based on this assumption.

The total rate of flow of alloy from the container depends solely on the speed of the ram. The billet, however, is extremely thermoplastic. If the temperature rises, it softens. If the temperature drops, it hardens.

As the billet moves through the container during extrusion, the top of the container usually becomes hotter than the bottom. Although conduction is the principal means of heat transfer within the container, heat lost from the bottom of the container rises inside the container housing, and thus increases the temperature at the top (Figure 2). The rate of flow from the top of the container into the die will therefore increase, and the flow from the bottom will accordingly decrease. This can alter the shape of the profile, but perhaps more importantly, in a large multi-hole die, it will significantly change the length of the runouts. A difference of 5°C in the liner can equal a 1% difference in the length of the runout. This makes it an advantage to have a thermal control system that can heat the lower zone independently from the upper.

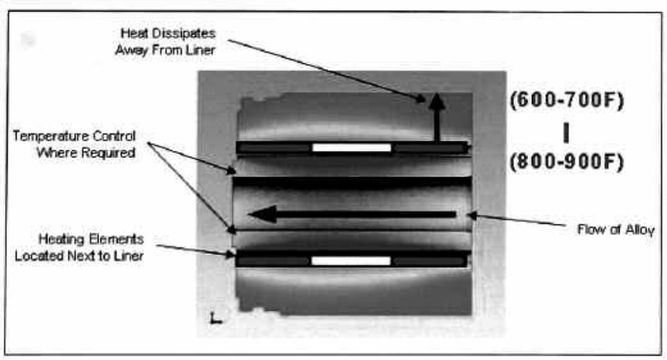

Figure 2. Thermally aligned extrusion container.

Continual uniform billet temperature can only be maintained if the container can immediately correct any change in liner temperature when and where it occurs.

Maintaining a consistent thermal profile in the axial direction usually requires only the addition of relatively small amounts of heat applied near both ends of the container when needed, to offset the heat loss from the exposed faces. For effective temperature control, however, the container should have at least four separate heating zones, top and bottom, as well as front and back.

Profitable Extrusion

In North America, the biggest market for light metal extrusion today is in the automotive sector. Yet this huge and growing market is just now being served by only a comparatively few extruders. Others cannot compete because they are unable to meet the stringent quality and service requirements demanded by automakers. They cannot profitably provide large volumes of perfect product in short runs at low prices. The fact is, however, that many extruders already have the production equipment and the capacity necessary to enable them to share in this market, but they have never yet even approached maximum productivity. This is most often because they are not making best use of the knowledge that they already possess.

If an extruder concentrates on both thermal and physical alignment in his production process, there should be no need for costly die trials. Correctly designed and cut, his die should make good product at near maximum speeds from the first push of the first billet.

Light metal extrusion is a holistic process. It is a complete system whose real value is more than merely the sum of its parts. All parts of the system must work together in a common cause. No part should be considered in isolation, because each part impacts on, and is impacted, other parts. The function of each component is well known to the extruder, but there is a natural inclination to prioritize, and to assume that some parts of the system are much more important than others. Unless every component is considered in the context of the complete system, anything close to maximum productivity is unachievable.

Extrusion is no longer an art, it is a science. By concentrating on thermal as well as physical alignment, and by using dies that are properly designed and manufactured, many more extruders can join the elite group that now serves the automotive industry.

***Paul Robbins**' father was a toolmaker who started his first shop making aluminum extrusion dies fifty years ago in the garage of his home in Toronto. In 1952 he launched the Extrusion Machine Company Ltd. Exco Technologies is the leading provider of light metal extrusion tooling today in North America. Paul is general manager of Castool, one of the original companies in the Exco group. Paul has a postgraduate degree from the Schulich School of Business at York University. He has worked in the extrusion industry for the past twenty years. He holds six U.S. patents that reflect some of the seminal development work he has done in the aluminum extrusion industry. Paul is well-known throughout the industry for his work over the years with trade associations such as the AEC, for many articles he has authored in industry publications, and for technical papers he has presented at both national and international aluminum conferences all over the world.*

Popular Extrusion Die Clinic Returning

One of the Aluminum Extruders Council (AEC)'s most popular educational offerings available to members, the Die Performance Improvement Clinic, is returning March 8-9, 2005, at the Hilton Chicago O'Hare Airport Hotel. The Die Clinic offers practical hands-on training for aluminum extrusion die correctors. The educational program is led by AEC members who are experts in the field of die design, manufacture, and correction. Participants will work with actual cases of problem dies in an interactive workshop environment. Each mini-workshop tackles a different set of problems encountered by die correctors every day, and the workshops are repeated throughout the program so that every attendee can participate in each of the sessions. For more information, contact: AEC. email: mail@aec.org. www.aec.org.