

IMPROVE MEASUREMENT IMPROVE PRODUCTIVITY

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Introduction

Anything that can be measured can be improved.

This old platitude is as true for the process of light metal extrusion as it is for any other process. In fact, the mere act of regularly and accurately measuring, recording, and displaying the results can be almost guaranteed to ensure some improvement in productivity, because close attention is being focused on the critical factors that affect the measured results, and the extent of their affect is being quantified

Few extruders really know with much accuracy how their performance compares with that of other extruders. The following estimated figures reflect information gained from a large number of extruders in several countries over a number of years.

Assuming 8 in. (20.3 cm) billet and 6063 alloy.

	<u>AVERAGE EXTRUDER</u>	<u>GOOD EXTRUDER</u>	<u>SUPER EXTRUDER</u>
Net Product Produced per manned hour	3000 lbs/hr (1587 kg/hr)	4500 lbs/hr (2404 kg/hr)	5300 lbs/hr (2404 kg/hr)
Ram Speed	23 in./min. (58.4 cm/min.)	26 in./min. (66 cm/min)	29 in./min. (73.7 cm/min.)
Contact Efficiency	60%	62%	65%
Net Recovery	80%	81.5%	83%

In considering the real worth of any component of the production process, it is important to estimate its affect on ram speed, contact efficiency, and net recovery. If the extruder doesn't clearly measure results in this way, it is virtually impossible for the press operator to improve productivity.

The Market

Just now, auto makers throughout the world are preparing to produce smaller, lighter cars in order to reduce fuel consumption. For almost all components, they are evaluating the comparative strength-to-weight ratio of steel, plastic and aluminum. As a result, a vastly increased market is anticipated for aluminum extrusion. In the past, relatively few superextruders participated in the automotive market, because its demands are so exacting and the price level so low. In North America, however, the recent financial meltdown has reset our market in such a way that the product quality, service and prices of the past will be inadequate in the future. This is not a temporary situation. This reset is undoubtedly permanent. For many extruders, improving productivity is no longer simply a means

of increasing profit; it has already become necessary for survival. Yesterday's automotive standard is today's norm.

The Moment of Extrusion

The moment of extrusion is in fact the essence of the entire production process.

Extruding aluminum alloy appears deceptively simple. A billet is heated until it becomes soft, and then is pushed through a die which determines the resulting profile. In this very brief moment of extrusion, as the alloy passes through the die, hardens, and the shape is set, most of the added value on which the extruder depends is generated.

The die is, of course, the heart of the extrusion process. Over the years, however, too much emphasis has perhaps been placed on the die as the prime source of improving productivity. It is fairly recently that breakthroughs in the technology of accurately measuring temperatures and speeds have revealed the real importance of the effective interaction of all components in the production system.

If the die is well designed and well made, the shape that leaves it should meet all required dimensional tolerances, have a good surface finish, and be moving at a profitable speed from the first billet to the last. This can only happen, however, if three specific conditions are met: First, the alloy must enter the die uniformly at or near its optimum operating temperature. Second, the die itself must be completely and uniformly at the operating temperature of the alloy being used. Third, the temperature of the die and the exit temperature of the extrusion should remain virtually unchanged from the beginning to the end of each cycle.

To satisfy these conditions, all parts of the extrusion production process must act and interact together as a system, and the temperature of the die must be effectively controlled from start to finish.

Premise

Every extrusion production system can be improved.

There are no exceptions. For example maximum ram speed is actually limited only by the mechanical properties of the alloy being extruded.

Better extrusion is done by better extruders, not just better equipment. They are daunted, however, by the number of constantly changing variables in the extrusion production system. Because light metal extrusion is a process in which components interact closely, and temperatures and speed continually changes, the number of combinations and permutations that can occur at any point in time is virtually infinite.

If, however, the press operator can know the temperatures at several critical areas during the extrusion cycle, plus the ram speed, he can positively control the process while the press is running. He will then have a much better opportunity to operate closer to optimum productivity. This is now possible.

Recent advances in the technology of ultra-accurate remote temperature measurement, plus the introduction of computer-controlled smart containers, has made possible the development of a visual optimizer, the best tool yet devised to assist the extruder in improving his productivity.

The Visual Optimizer

The operator is given the press, the profile, the die and the type of alloy. From this information, plus his experience and talent, he can prepare an initial production recipe. This will contain all necessary temperatures, ram speed, dead cycle time etc. that he can instantly and positively control, and that will safely produce saleable product.

At the operators post, above the press a large back-lit monitor screen shows the actual temperature or speed at each point being monitored, plus the target from a previously prepared recipe. If the actual is equal or greater than the target, it will appear in green. If not, it will be shown in red. The operator will then be able to tell at a glance how close he is to target at each point being monitored, and take whatever action is required to bring the system back on track.

The visual optimizer will be customized to fit each user's needs and budget, but it will typically include ram speed, dead cycle time, billet temperature, container liner temperature top and bottom at both entrance and exit, die temperature, profile exit temperature, quench rate, and also graphically, the temperature status of the die in each single cell die oven, i.e. time to temperature, and time at temperature.

Whenever the combination of temperatures and speeds that is being used produces a new level of productivity for the die, a freeze-frame automatically records all the information being monitored at that precise instant. This then becomes the new recipe for the next repeat run.

Once the die has been optimized, leaner alloys can be tried. This can dramatically increase ram speed, and increase productivity. The world's best extruders today consistently use extremely lean alloys, i.e. minimal magnesium and silicon.

Eventually every die will be accompanied by a current recipe.

The goal of the extruder using a visual optimizer is to determinedly and knowledgeably eliminate any barriers to improved productivity.

A Closed Loop?

The reason that a visual optimizer is preferable to a PLC or computer driven closed loop system at the present time, is that the die has not been optimized for a completely thermally controlled process. If the loop is closed with a die that is designed for an imperfect production process, ram speed cannot be optimized.

Only by manually controlling temperatures and speeds, while using a visual optimizer, then updating both the die and the recipe for its use, can the operator continually improve productivity. When the loop is closed, the door is closed on better productivity which could result from ongoing improvement in technology.

The Single Cell Die Oven

A properly designed and made die oven will heat each die safely, accurately and quickly to the required operating temperature, thereby allowing increased ram speeds, increased recovery and reduced dead time.

- Eliminates the need to use at least the first billet in nearly every run to bring the die uniformly to operating temperature. (Improves recovery.) For an extruder using, say, 100 dies per day, the immediate reduction in operating costs is considerable.

- The incidence of cold dies going to the press is eliminated. Broken dies are reduced. (Improves recovery, reduces downtime)
- Breakthrough pressures are relative to die temperature. When dies are delivered to the press at the expected temperature, breakthrough pressures are consistently lower. When the die designer is confident that dies will be used at the required temperature, more efficient dies can be designed and made. (Increases ram speed)
- Dies tend to work better. The occurrences of dies being pulled from the press prior to completing the planned production (knock-offs) are reduced. (Improves recovery, reduces downtime)
- Dies remain at temperature for shorter periods of time. The amount of oxidation on die bearings is reduced and profile surface finish is better. (Improves recovery.)

Single cell die ovens very quickly increase productivity. Most extruders understand the technology of the single cell die oven, but their use is not universal. In today's market, any extruder not using single cell ovens is unlikely to survive.

The Quick Response Container

A properly designed and operated container will keep the die at a uniform temperature during the extrusion process. The flow of alloy through the die is therefore as planned by the die designer.

- The incidence of uneven run-outs is reduced. (Improves recovery, reduces downtime)
- Profile shape and dimensional tolerances are improved. (Improves recovery)
- Dies remain in the press until completing the planned amount of profiles. Knock offs are reduced. (Reduces downtime)
- Dies requiring correction to slow the flow of alloy through the top ports or aperture are eliminated. (Reduces downtime)
- Dies can be designed and made knowing that the flow of aluminum through the die will be as planned. More efficient and repeatable dies that allow faster ram speeds can be used. (Increases ram speeds)

The concept of a container managing die temperature is relatively new and may require some explanation.

The thermal mass of the container is much greater than that of the die. Accordingly, as soon as the die is firmly sealed to the end of the liner, heat transfer begins by conduction, and continues so rapidly that a thermal equilibrium is soon reached between the container liner and the die.

In developing an improved container, therefore, the goal was to control the temperature of the liner as effectively and efficiently as possible, so that the die would remain at optimum temperature, and taper heated billets could optimize exit speed. This would require almost absolute temperature control at all times. The Quick Response Container approaches this ideal.

The liner temperature is best controlled by correcting any variations as soon as possible. The time taken to respond to a demand for heat is in direct proportion to the distance between the temperature sensor and the heat source. In the QR container, cartridge heaters are located very close to the liner. Their purpose is to immediately summon heat to the liner when needed, not to the container mantle. Specially designed double thermocouples are used to monitor the temperatures of both the liner and the mantle simultaneously.

Heating elements are positioned very close to the sensors. As a result, the quick response keeps the temperature of the liner and thus the alloy fairly constant.

The energy required to control the temperature of the alloy is, of course, a function of the extent of the temperature variations. The QR container is therefore unusually cost effective. Think of smoothing ripples rather than waves. This is evidenced by the fact that when replacing conventional containers with QR containers, energy savings of as much as 75% are not uncommon. In addition, the risk of overheating, tempering and softening the mantle is practically eliminated. The viscosity of the alloy being extruded is extremely temperature-sensitive. The die designer must, however, assume that the die will remain completely and uniformly at optimum operating temperature at all times during extrusion.

Primarily, the QR container differs from other smart temperature controlling containers in that its function is not to control the temperature of the container mantle, but the liner. The real purpose of the QR Container therefore is to manage the temperature of the die during extrusion. The logic of this is irrefutable. Here follows a good example of this theorem.

Unless closely controlled, heat lost from the bottom of the container mantle rises inside the housing, and considerably increases the temperature at the top. With conventional containers, the vertical temperature difference at the liner exit is typically 55-110°C (100-200°F).

Thermal measurements have proven that during extrusion the difference in temperature between the top and bottom of the die is approximately the same as between the top and bottom of the liner exit. Experience has also shown that for every 5°C or 10°F of vertical temperature variance, the runout length from the top apertures of a multi-hole die will exceed that of the bottom openings by approximately 1%. This presents a serious problem for both pullers, and cutting to length. It also makes it difficult to maintain required tolerances on a profile.

The problem of the vertical temperature difference which, if uncontrolled, will occur at the die end of the container liner, is further compounded by another vertical temperature difference in the die itself.

The die slide in which the die sits has enough mass to act as a heat sink and leech heat from the lower half of the die. Equalizing the temperature at the top and bottom of the end of the liner will therefore not completely eliminate unequal runouts. The liner temperature must therefore be made slightly hotter at the bottom than the top to completely eliminate any vertical temperature difference in the die.

Properly designed temperature controlled containers solve the problem of vertical temperature variance in the liner, and thus in the die, by having vertical as well as horizontal temperature control zones. The velocity of the product leaving the top or bottom of the die will therefore be the same.

The Quench

A component that contributes to the mechanical properties of the product, but is often simply taken for granted, is the quench. A new and unique PLC controlled cooling quench is now in the final stages of development and field trials, and will shortly be on the market.

Each cooling zone will use the latest technology in nozzles, allowing air, mist, and flooding, from top, bottom or each side, depending on the requirements of the profile. This will include shape, weight per foot, surface area, type of alloy, speed, and function of the product. The function will determine the mechanical properties required.

The extruder will be able to control the air pressure and water flow going to each manifold. He can therefore control the precise rate of cooling.

The Future

Now we finally can have the die on the press uniformly at the right temperature, a container that maintains the temperature of the die, an effective visual optimizer, and a PLC-driven cooling quench, what's next in the evolution of light metal extrusion?

The next logical step is to automatically control an accurately calculated tapered billet temperature within +/- 5°C at all times, from when it enters the container until it exits the die, because varying ram speed is no longer an option. The longtime goal of isothermal extrusion can only be achieved with a constant ram speed. As soon as the die exit speed varies, the dimensional integrity of the section profile is compromised.

Then optimize die design, and use leaner alloys to allow increased speeds. Most extruders have no idea of the immediate and dramatic increase in productivity that usually occurs when operating temperatures are controlled closely enough to permit leaner alloys to be used.

When this has been done, light metal extrusion will enter new markets with a superior, repeatable, and cheaper product that can be produced quickly and sold profitably. Light metal extrusion will then have been reset to prosper in a permanently reset market.

And in Conclusion . . .

We are just now entering a period of unprecedented and virtually unlimited opportunity for the extrusion industry. The competition for share of the available market, however, has understandably become intense. Yesterday the choice was better or cheaper. There is no longer a choice. Today the product must be better and cheaper. The market will never return to the standards of quality, service and price that were acceptable in the past, but the available technology is rapidly improving to meet this challenge.

The opportunity is there. The tools are available. The challenge is clear.