REAL TEMPERATURE PARAMETERS FOR ISOTHERMAL EXTRUSION

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ABSTRACT --- The main parameters that must be controlled for isothermal extrusion, and to achieve the optimum metallurgical properties in the profile, are the taper heating of the billet, the die exit temperature, and the temperature of the profile during cooling.
This paper discusses different ways to achieve isothermal extrusion, including system requirements and different methods of temperature measurement.

INTRODUCTION

In the last few years, several different closed loop Isothermal extrusion systems have appeared on the market. Systems differ in the hardware used and the algorithms, with user opinions varying regarding the performance of each system.

Many tests have come to the same conclusion. The most important parameter to achieve isothermal extrusion is accurate temperature measurement. The most common reason for failure in many systems was inaccurate pyrometers.

PARAMETER MEASUREMENT

Accuracy problems arise in profile measurements when the profile exhibits temperature variations across complex sections, or differences in temperature between small profiles from multi-cavity dies. This effect occurs most often when the pyrometer used has a large spot size and gives averaged measurements. In order to avoid this, an effort should be made to concentrate on measurements using a small spot size with the possibility of automatic targeting of the pyrometer on the hottest point.

Effective billet taper heating control requires an accuracy of +/- 5° C (10° F) and several measurements along the billet axis.

The best way to achieve the required parameters for billets, is when the remote pyrometer is several meters away, with the billet area free from obstructions. This also avoids the danger of the pyrometer being affected by heat from the billet.

THE DILEMMA OF REPEATABILITY OR ACCURACY

Examination of the performance of some of the isothermal systems and pyrometers used, shows that due to the inadequate accuracy of the pyrometers, manufacturers often promote the theory that repeatable temperature measurement is good enough

Key arguments and recorded experiences that counter this theory are discussed below:

1. When looking on (Figure 1.) one may ask if repeatability is good enough, but if there is always a discrepancy of 15-30 ºC see (Figure 3.) is it possible to reach the peak? Will you always be somewhere below or in the range where quality and metallurgical properties of profile are impaired?

2. When the method is solely based on the repeatability of the system, any changes within the press environment will affect all the saved data, and tests will have to be repeated to ensure the correct process control.

3. Profile positioning (see Figure 4.), This is the most common change that will happen between extrusions from the same die each time it is extruded. Different locations will give different temperature readings. All of the data base will be invalid, as it was based on different temperature readings.
   The profile quality will have to be re verified, as it may be that the measured temperature is now 30º C higher than the last time (see Figure 3.). All the quality process parameters (speed, pressure, billet temperature) must be changed.

4. With multi cavity dies, there is frequently a difference in temperature between profiles coming from the die.

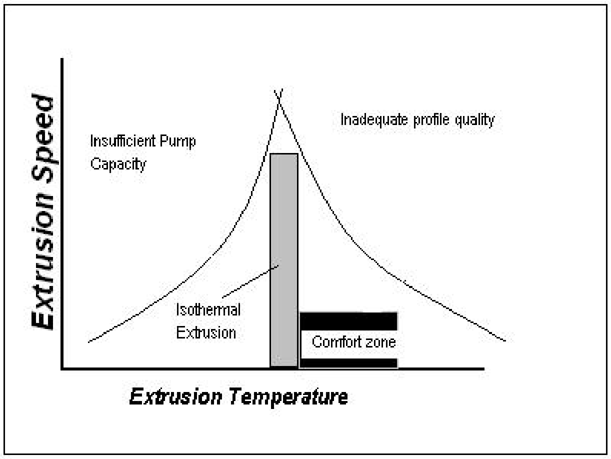

Figure 1

EXTRUDERS TARGET

A number of different methods and equipment are available in the market for temperature measurement in the aluminum extrusion process.
The basic question to be asked is what we are targeting? Are we targeting the 80 % of extruded profiles, which we can already extrude at the optimum parameters, or the 20% more complex ones? We all probably agree that it is a waste of money to invest in something that does not contribute to our aim. We need to focus on the 20% difficult profiles where accurate measurements are needed for maximum production.

PRACTICAL EXPERIENCE, ALUMINUM PROFILE. – AT THE EXIT OF THE PRESS AND DOWNSTREAM.

Two different approaches have been tested in the field, wide and narrow spot measurement.

With wide spot size measurement pyrometers use a 50-90 mm spot size from 1 meter. The camera collects energy from a wide area, therefore the measurement is less affected by profile location The parameters within the processor are set to correctly measure the 80% mentioned above, and probably will have errors of up to 50 ºC.

This occurs because of differences in temperature between different profiles in multi-cavity extrusion (Figure 3.), temperature variations across the profile (Figure 4.), different alloys within the common 6000 series, or, when the profile is smaller than the pyrometer's field of view. (Figure 5.) – in this case there is often a location error.

With a narrow spot size sensor, accurate measurements result only if the profile is in the field of view. Data collected during a Benchmark test last year demonstrate the error of using wide spot size pyrometers (Figure 3).

Thermocouple	Narrow	Wide # 1	Wide # 2
537	541	547	562
551	552	562	568
547	551	561	573
541	544	558	576
549	548	564	572
511	516	545	529
549	548	564	572
546	549	559	574

Figure 3. Comparison test

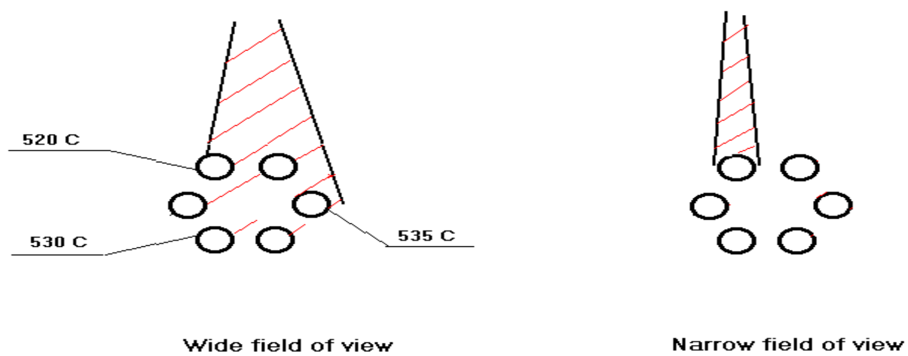

Figure 3

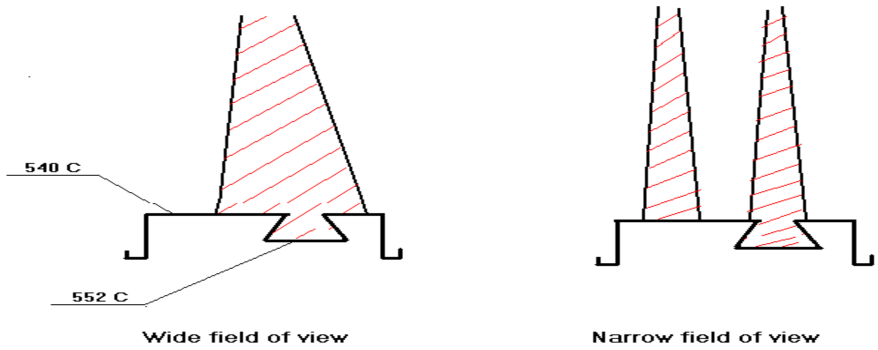

Figure 4.

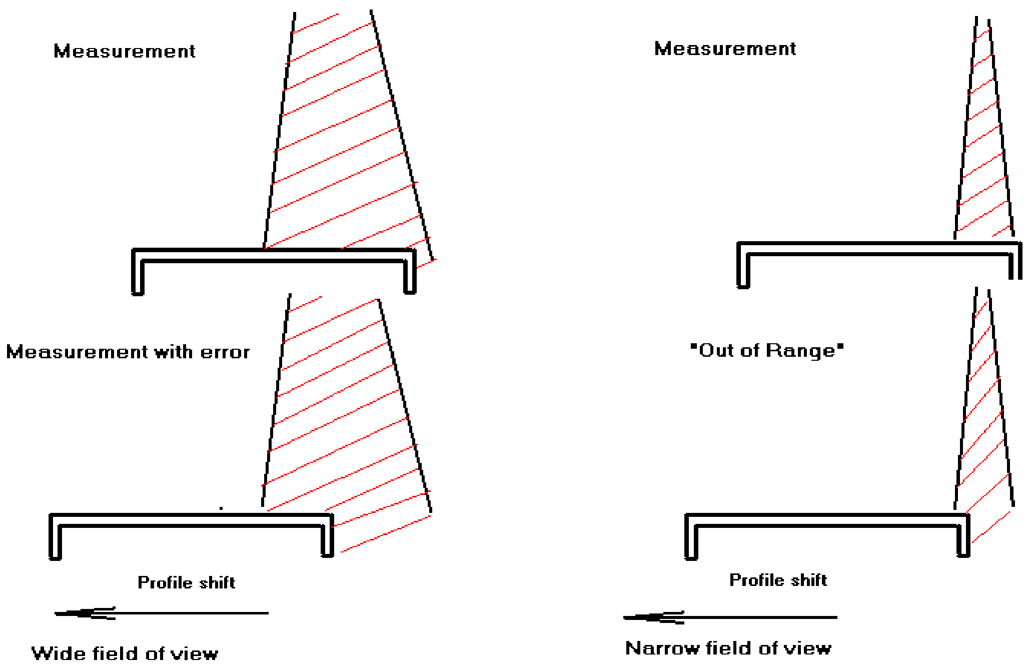

Figure 5

In recent years most customers reported that even today when level of accuracy of measured temperature has jumped, the main obstacle to having their system running well is the accuracy and repeatability of pyrometers.

Figure 6. shows field data of a simple profile at the press exit. Temperature was measured by small spot size pyrometer. This provided excellent accuracy. A sensor was connected to a scanning system.

On Figure 6 data difference in temperature between highest temperature and lowest temperature exceeds 20°C (68F).

Data may explain why in some closed loop systems installed in Europe, extruders noted that on 10-15% of profiles they couldn't run the system due to pyrometer inaccuracy.

Figure 6 Profile temperature at the press exit

PRACTICAL EXPERIENCE ALUMINUM BILLET

For this application it is impossible to achieve good results using simple pyrometers because of large variations in emissivity and surface spectral properties between billets.

Two different approaches have been introduced to the market. The first uses an emissivity transformer and therefore the sensor is located a few millimeters from the hot billet. The second locates the sensor 1-4 meter from the billet – similar to profile measurement.

With the first method we have again the 20%-80% question. If the billet is scalped and very shiny, the accuracy drops immediately with up to 40-ºC deviations. This is just the application where accuracy is needed for our high quality and expensive product!.

With the second method, its big advantage is the location – far away from hazards. Simple to install, easy to maintain. It covers the full range of billet surfaces (emissivity) from dark black to shiny scalped billet – covering the full 100% and particularly the most important 20% of production.
All existing optical measurements give the result of billet heating after the procedure has been completed, on the exit from the furnace, and in the best case this information is available for modifying the next heating cycle. Control of the heating by the pyrometer allows direct involvement in the heating process without having to take into consideration the reliability of the measurements, as is the case with contact thermocouples.

Billet test field figure 7 and 8, explains the need for accurate measurements of billet temperature.

Measurement of temperature along the billet helps the extruder in two ways – first to monitor billet furnace performance and control it, second and most important, data may be transmitted to a closed loop system, and will immediately correct pressure and speed for the current billet.

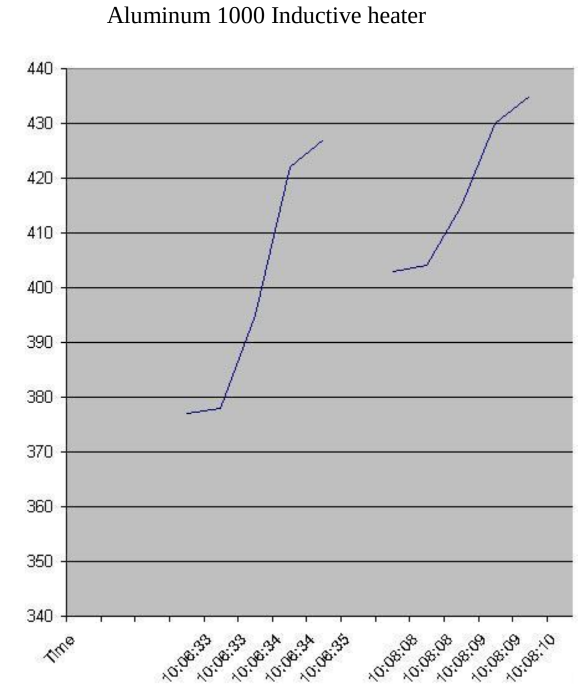

Figure 7. Billet temperature measurements

Measurement	Time	State	3T	Emissiv.
05/03/01	14:48:41	m	515.06	0.39
05/03/01	14:48:42	m	507.83	0.36
05/03/01	14:48:42	m	491.65	0.35
05/03/01	14:48:43	m	476.89	0.34
05/03/01	14:48:43	m	449.52	0.39
05/03/01	14:48:44	m	423.85	0.42
05/03/01	14:48:44	m	415.42	0.39
05/03/01	14:48:45	m	413.56	0.35

Figure 8. Billet temperature

CONCLUSION

Isothermal extrusion systems must use an accurate pyrometer, the method of repeatable sensors is not always repeatable in practice nor applicable in practice for the most important profiles.

Comment from extruders that are using these systems are usually, “Yes it working, but . . . “ Analyzing the “but” shows that it ranges on 10-20 % of production.

Achieving accurate temperature measurements is a hard task. Some of the companies in the field, have chosen to make a detour.

At the very end there are no detours. One may manipulate numbers, explain in detail why repeatability is best, you may see improvement of productivity, but it may be that quality as been reduced – at the end of day, your production and quality are on the table.

The choice is between compromising with the 80% or become one of the 20% market leaders.

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Accurate Temperature measurement
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