Essential Readings in Light Metals: Cast Shop for Aluminum Production.
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THE HUNTER CONTINUOUS STRIP CASTING PROCESS

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Brief introductory comments are given to substantiate the development of the Hunter Caster and to provide a basis for discussion of the casting process as is successfully being accomplished today.

The scope of the presentation, as augmented by slides, will include a description of the mechanical components necessary in the transformation of pig or scrap aluminum to coiled strip; including furnaces and the various components in the continuous caster line.

Specific attention will be directed to the mechanical and metallurgical functions occurring at the point of metal transfer and solidification.

Further comments will be made on advantages and limitations of continuous cast end product, mentioning typical end uses of cast coil. Brief mention is made of manpower requirements, operating costs, and a discussion, in conclusion, of new development work underway on the Hunter Continuous Casting Machine and application technology.

Introduction

The Hunter Continuous Strip Casting Process

The Hunter Continuous Strip Casting Process for aluminum alloys has now been in commercial operation for approximately 15 years. During this period, many operational, metallurgical and mechanical improvements have been made to the process. The cumulative result of these is a process that is reliable, efficient, with proven production records that verify that cast strip can be processed by cold rolling into good commercial quality sheet and foil products.

Stated in simple terms, the Hunter Continuous Caster is an ingenious shortcut to producing sheet and foil products. It accomplishes in a single system what normally requires ingot casting, scalping, heating or soaking and hot rolling.

The product from the caster line is coiled aluminum in reroll gauge suitable for direct cold rolling. The cast strip is of good quality, having a uniform transverse and longitudinal thickness. It. is of uniform density with low porosity and is reasonably fine grained when properly processed. In actual appearance and physical performance it is basically equivalent to conventional sheet produced by hot rolling of billet with cold mill finishing process.

Equipment Required For The Hunter Continuous Strip Casting Process

Slide #1 (View of Casting Facility)

The line consists of melting and holding furnaces, the caster, pinch roll, shear, bridle and coiler. Utility requirements are fuel for the furnaces, cooling water, electrical power, and plant air.

Slide #2 (Double Hearth Furnace)

The furnace arrangement usually suggested or installed is either a combination melting-holding furnace or a two furnace system consisting of separate melting and holding furnaces. Multiple casting lines may utilize combined melting and metal charging facilities feeding individual holding furnaces, and in turn, the respective casting lines.

Slide #3 (Two Furnace System)

The combination unit operates successfully for casters having an hourly production rate up to about 2500 pounds per hour. For greater production rates, the two-furnace system assures stable conditions of temperature, quantity of metal, and improved metal quality in the holding furnace. We supply the two furnace system, generally, to foil producers. In either case, the furnace charge may vary from 100% pig to 100% scrap depending on alloy requirement and metal availability. When using the combination furnace system, charging is done in small amounts at regular intervals with care being taken to limit the maximum charge at any one time. With the two-furnace system, batch transfers from the melter to the holder are based on about a four hour production cycle and the furnaces sized accordingly. High scrap content in the metal charge may require specialized melting furnace design encorporating a scrap charging well, fume collection hood, and air pollution equipment. In order to produce a high quality product, fluxing and skimming practices must be performed at regular intervals with adjustments made for content of the charge and desired end product.

Grain refinement is made through the addition of powdered or metallic hardener. The latter being added as pellets directly into the holding furnace, or by a Hunter built device to feed grain refiner in wire form into the metal transfer trough between the holding furnace and the caster.

Temperature control of metal from the holding hearth to the caster is extremely critical and should not vary more than ± 10°F from the required setting. Necessary temperature recording equipment is visible to the operator at the control console.

Slide #4 (Schematic of Feed Device)

From the holding furnace, molten metal flows from a tapout box, horizontally through a launder to a caster head box. It then flows through a fibrefrax tube to the tip assembly. The tip assembly distributes the still molten metal uniformly across the width of the casting machines rolls. The molten bath in the caster head box is held at a constant level, approximately even with the center line of the rolls. It enters the freezing zone just below the center line "bite" of the water cooled rolls. The metal is cooled and solidified, and is given approximately a 15% reduction before leaving contact with the caster rolls. The formed sheet - 1/4" thick nominal leaves the roll bite in a vertical loop to the pinch rolls, followed by the shear, bridle and rewind reel, where it is wound in a tight coil with O.D.'s up to 96" and widths up to 66". Coil O.D. and sheet width remain at the user's option.

Slide #5 (Casting Line Components)

The Casting Machine consists of a variable speed drive, a gear reducer pinion stand drive with two output shafts, two mill type drive spindles, a casting machine frame supporting four roll chocks equipped with antifriction bearings and hydraulic load cylinders, two water cooled caster rolls with rotating swivel joints to connect to the customer's cooling water system, a motorized tip elevator with tip, permitting tilting of tip, and a caster roll removing fixture for roll changes.

The Pinch Roll Stand

The Pinch Roll Stand consists of a welded steel base stand supporting two water cooled pinch rolls with rotating swivel joints and air cylinder actuated pinching action, a variable speed drive powering the pinch rolls through a gear train, strip guide aprons, and vertically arranged width adjustable side guide rollers at the entry side.

The Shear

The Shear consists of a base frame supporting a fixed mounted top knife, a reciprocating bottom knife powered by an electric motor gear reducer and crank shaft with top and bottom guide rolls. The shear knives are arranged so that the leading strip edge will be turned down approximately 30° for easy feeding of the strip onto the coil winder mandrel slot.

The Bridle

The Bridle consists of a base frame supporting a series of antifriction bearing mounted water cooled bridle rolls (upper rolls fixed mounted, bottom rolls raised and lowered by hydraulic cylinders) with manual adjustable nestling stops and roller type strip guides.

The Coil Winder

The Coil Winder consists of a variable speed drive, a gear reducer supporting a hydraulically expanding mandrel with gripper slot, and a hydraulically actuated stripper plate for coil removal.

The Coil Car

The coil car consists of a hydraulic cylinder or motor traversed carriage with four antifriction bearing mounted rimmed wheels supporting a hydraulically actuated elevator with idling cradle rolls mounted to the elevator platen.

The Air & Hydraulic Systems & Controls

The Air & Hydraulic Systems & Controls consist of a power unit with tank, strainer, valving, pump and motor, all necessary instruments, auxiliary and control valves for the hydraulic system as well as all required instruments and valves for the plant air system. Total air required is up to 10 CFM @ 90 PSI.

The Water Requirements

The water requirements, in most cases, necessitate the installation of a cooling tower, a cooling water circulating system with provisions for treatment. Cooling water temperature to the caster should be 85°F (maximum). Inlet pressure at the caster can be up to 70 PSI.

Water requirements through the caster rolls, breaker roll, pinch roll and bridle rolls, is generally about 400 GPM for a 66" wide casting line.

The Electric Power

The electric power line is about 50 KVA. This provides power for the drives and hydraulic system.

Fundamentals Of The Caster Process

The success of the Hunter process depends, to a large extent, on the ability to distribute the molten aluminum across the width of the feed tip at a uniform temperature and feed rate. Since the actual distance for the transfer of heat to the metal shell is only about 1-1/4 inches, any variations in either factor will affect the metal viscosity and degree of hot rolling taking place in the bite of the rolls. The rolling pressure created, provides for the necessary high rate of heat transfer rate to complete solidification. Any section that is restricted from metal flow will not provide this pressure, consequently, remelting may take place with a resulting hole in the strip.

Slide #6 (Cross Section of Feed Tip)

Temperature uniformity is required in order to control metal viscosity. The latter affects the bulge of molten metal slightly above the tip orifice. If the metal is too hot, it may flow between the roll shell and tip, freeze and fracture the Marinite in that area. If it is too cold, freezing will occur in the tip from the ends,and consequently, a ragged, narrow edge will appear.

Other critical factors are uniform caster roll speed, metal level control from the furnace to the caster head box, and proper tip height positioning.

Casting speed is primarily affected by alloy content of the processed material. Alloys of narrow freezing range are produced in 1/4" thick gauges at speed from 44" to 50" per minute, and in some cases, slightly higher. Alloys similar to 5005 are produced at about 36" per minute while harder alloys such as 5052 are produced at about 27" per minute. It is necessary to complete solidification before the strip leaves the caster; therefore, alloys with low melting eutectics must be subcooled to a greater degree. This results in an increase in the heat to be removed from a given area of metal as well as separating forces generated by the cast strip at the roll nip. Combined, the casting rates are affected accordingly.

Current usage of the caster on hard alloys produced in large quantities is 5052 having about 2.2% magnesium. This alloy has a solidification range of about 100°F.

The Hunter Caster has been successfully applied to all common 1100 series foil alloys, including 99.99 percent pure aluminum.

Slide #7 (Metallurgical Structure)

The macrostructure of Hunter continuously cast sheet, shown in Slide VII, is characterized by highly oriented dendrites which nucleate at both surfaces and grow inward until they meet at the center of cooling. The dendrites are oriented at an approximate angle of 15° to the transverse axis of the sheet and rotate during caster roll shell reduction to an angle which is approximately 45° to the same axis.

Grain size of the cast strip is of particular concern for metal forming quality. Since the percentage of reduction from 1/4" to a finished gauge of .016 to .060 is much less than for a hot rolled billet, grain size in strip casting must be closely controlled. The usual practice is to take sample cuts between each coil and immediately etch for grain size evaluation. Furnace grain refining practices are then adjusted accordingly.

Slide VIII - Production

Slide #8 shows the total number and size of Hunter Strip Casters in operation from 1956 through today.

Table I. Sheet Casters

	Customer		Caster Size	Startup
1.	AMAX Aluminum	U.S.A.	1 - 1/4" x 24"	1956
2.	Cerro Aluminum	U.S.A.	1 - 1/4" x 30"	1956
3.	AMAX Aluminum	U.S.A.	1 - 1/4" x 38"	1957
4.	AMAX Aluminum	U.S.A.	1 - 1/4" x 38"	1958
5.	Nichols Wire & Alum.	U.S.A.	1 - 1/4" x 38"	1958
6.	Alumex S.A. de C.V.	Mexico	1 - 1/4" x 30"	1958
7.	RJR Archer, Inc.	U.S.A.	1 - 1/4" x 58"	1959
8.	AMAX Aluminum	U.S.A.	1 - 1/4" x 38"	1960
9.	AMAX Aluminum	U.S.A.	1 - 1/4" x 38"	1960
10.	Security Aluminum	U.S.A.	1 - 1/4" x 58"	1961
11.	American Zinc Prod.	U.S.A.	1 - 1/4" x 38"	1961
12.	AMAX Aluminum	U.S.A.	1 - 1/4" x 58"	1961
13.	RJR Archer, Inc.	U.S.A.	1 - 1/4" x 58"	1962
14.	Decatur Aluminum	U.S.A.	1 - 1/4" x 58"	1962
15.	Decatur Aluminum	U.S.A.	1 - 1/4" x 58"	1962
16.	Consolidated Alum.	U.S.A.	1 - 1/4" x 58"	1962
17.	Security Aluminum	U.S.A.	1 - 1/4" x 50"	1963
18.	Decatur Aluminum	U.S.A.	1 - 1/4" x 58"	1964
19.	Decatur Aluminum	U.S.A.	1 - 1/4" x 58"	1964
20.	AMAX Aluminum	U.S.A.	1 - 1/4" x 58"	1964
21.	Republic Foil, Inc.	U.S.A.	1 - 1/4" x 66"	1965
22.	Svenska Metallverken	Sweden	1 - 1/4" x 66"	1966
23.	AMAX Foil Products	U.S.A.	1 - 1/4" x 38"(Lead)	1967
24.	Alcan Aluminum	Canada	1 - 1/4" x 58"	1968
25.	Alcan Aluminum	Canada	1 - 1/4" x 58"	1968

Table I. Sheet Casters

	Customer		Caster Size	Startup
26.	Nippon Light Metals	Japan	1 - 1/4" x 66"	1968
27.	Nichols Wire & Alum.	U.S.A.	1 - 1/4" x 38"	1968
28.	Svenska Metallverken	Sweden	1 - 1/4" x 66"	1969
29.	RJR Archer, Inc.	U.S.A.	1 - 1/4" x 66"	1970
30.	National Aluminum	U.S.A.	1 - 1/4" x 66"	1970
31.	National Aluminum	U.S.A.	1 - 1/4" x 66"	1970
32.	Volco Brass	U.S.A.	1 - 1/4" x 38"	1970
33.	Alumex S.A. de C.V.	Mexico	1 - 1/4" x 66"	1970
34.	Volco Brass	U.S.A.	1 - 1/4" x 24"	1970
35.	Svenska Metallverken	Sweden	1 - 1/4" x 66"	1970
36.	Slatina	Romania	1 - 1/4" x 66"	1971
37.	Slatina	Romania	1 - 1/4" x 66"	1971
38.	Slatina	Romania	1 - 1/4" x 66"	1971
39.	NASAS	Turkey	1 - 1/4" x 66"	1972
40.	NASAS	Turkey	1 - 1/4" x 66"	1972

It may be said from exact records that over two and one-half (2-1/2) billion pounds of aluminum foil and building sheet has been produced and sold from Hunter Strip Casters. Approximately one-half or one billion pounds of foil has been produced.

(See Page #7 & #8; Table II. For "Aluminum Products Made From Hunter Cast Sheet")

	Alloys	Gauge	Hardness
Sheet Products			
Siding & Roofing Industr.	3004,5050 5010	.019-.032	H26, H28
Siding & Shingles Resident.	5010,3003	.019	H26, H28
Awnings & Patio Covers	5010,5005	.019-.024	H24, H26
Roof Ventilators	3003,5010	.024	H24, H26
Gutters, Downspouts	5010,3003	.019-.024	H22, H24
Window & Door Frames	5010,5005	.024-.040	H24, H26
Grills & Louvers	3003,5016	.019-.024	H14, H24
Heating & Air Cond. Ducts	5010,5005	.019-.025	H24, H26
Fume Exhaust Ducts	1100,5005	.012-.024	0, H14
Truck Trailer Panels	5050,5034	.024-.050	H24, H26
Fences, Parasols	3004,5010	.025-.032	H24, H34,
Pleasure Boats	5010,5050	.020-.036	H11, H24,
Furniture Tubing Welded	5050,3004	.030	H34, H36
Irrigation Tubing Welded	5050	.032-.040	H34, H36
Cabinets (switch gear)	5010,5005	.030-.040	H24, H25
Refrig. Liners & Evaporators	5010	.032	H22
Radio & TV Chassis	3003,5005	.030-.040	H14, H24
Evaporators Fins	1100,3003	.005-.012	H25, H18,
Fan Blades	5010,3003	.030-.050	H24, H14
Electr. Cable Sheating	1145	.030-.040	0, H12
Shielding Cans	1100,3003	.025-.040	0
Condensers	1100,3003	.020	H14, H16
Oil & Fruit Juice Cans	3004,3003	.014-.020	0, H22
Automotive Trim	1100,5005 3003	.020-.030	H14, H25
Insulation Jacketing	5010,3003 5005	.006-.032	H16
Stamped Parts	1100,3003	.019-.050	H24, H26,
Kitchen Utensils	1100,3003 5010	.025-.040	0, H22
Wash Basins	1100,5010 5005,3003	.020-.040	0, H22
Shower Enclosures	5010,5005	.030	H24, H26
TV Folding Tables	5010,5050	.030-.040	H24, H26
Flashlight Casings	1100,3003	.020	0
Lamp Bases	5050,3004	.010-.018	0
Kitchen Pots & Pans	1100,3003	.020-.036	0
Foil Products			
Can, Carton, Package Labels	1230,1145	.00035	0
Canister & Package Liners	1230,1145	.00035	0
Rigid Foil Containers	1230,1145	.001	0
Medical Supply Wraps	1230,1145	.001	0
Food Wraps	1230,1145	.00065	0
Soap & Toilet Articles Wraps	1230,1145	.000350	0
Cigarette Foil	1230,1145	.00025	0

Table II. Aluminum Products Made From Hunter Cast Sheet

	Alloys	Gauge	Hardness
Foil Products			
Food & Tobacco Pouches	1230,1145	.00028	0
Bottle & Container Caps	1230,1145	.0010	0
Electrical & Mech. Parts Wraps	1230,1145	.0010	0
Freezer & Baking Foil	1230,1145	.0010	0
Household Foil	1230,1145	.00065	0
Gift & Christmas Wrap	1230,1145	.0003	0
Novelty & Florist Foil	1230,1145	.00065	0
Condenser Foil	99.88,99.99	.0028 .00017	0
Transformer Coils	99.60,99.88	.0012	0
Cable Wraps & Shielding	1230,1100	.001	0
Reflective Insulation	1230	.00025	0
Moisture Barriers	1230	.00025	0
Wall Paper Foil	1230	.00025	0
Litho Printing Foil	1230	.001	0

As you will note, the basic condition to practical and economic usage of continuous cast material, is alloys with a relatively wide freezing range.

We suggest that 20 inches per minute be the minimum casting speed for reasons of economic practicality.

The standard caster drive arrangement provides for casting speeds up to 60 inches per minute. Hunter caster users are currently approaching this upper limit on foil alloys.

Economics

1. Fabrication from Hunter cast coil allows in-plant scrap regeneration, and integration of the facility back to ingot and/or purchased scrap.

2. Minimal costs are involved to increase the standard cast coil O.D. from 60", to as much as 96", or whatever custom sizes are required by the owner.

3. Cast strip width changes are easily accomplished and are infinitely variable to suit end product requirements.

4. Compared to conventional hot rolling, low capital investment is required for the Hunter casting process to produce equivalent re-roll material. Hot rolling on "Four High" equipment may be more attractive for high volume production.

5. Increases in freight and labor costs make the integrated facility,based on the Hunter Caster, financially attractive with plant site selection on the basis of markets for the end product. The "Mini-Plant" concept is effective.

6. In-plant quality control practices can be applied to processing from molten metal through finished product.

7. There are fewer quality, scheduling and delivery problems with the Hunter Caster than reliance on outside re-roll suppliers.

8. Hunter casters and associated equipment are based on proven standards that allow short equipment delivery and commissioning.

9. Two and one-half billion pounds of cast coil know-how are behind every caster installation.

Manpower

Manpower required to staff a complete casting operation is as follows. Assuming an around the clock (720 hour per month) operation, the caster is run on a four shift basis. The shifts alternate according to shift schedule from "day" to "second" to "third" shift with days off according to the labor laws, which requires a fourth shift.

Control functions on the Hunter Caster are sufficiently automated to require only 4 men per furnace and casting line per shift.

The personnel shown is based on one caster only. For more casters, some functions can be doubled up, thereby reducing the overall total of personnel. Combined melting furnace, and automated pig and scrap charging equipment can also reduce direct labor costs with multiple casting lines.

Laboratory

The laboratory requires (1) metallurgist. This is possible if the leadman of each shift is trained to extract and test the metal samples himself so that the metallurgist fulfills all other functions during his day shift.

Melting & Casting

Melting & Casting requires for each shift (1) leadman supervising the operation and being responsible for his entire crew. (1) furnace operator, (1) caster operator, and (1) helper handling the material to and from the line.

Marinite Shop

Marinite Shop requires (1) man for 8 hours, 5 working days per week to keep pace with the casting operation.

Roll Shell Grinding

Roll shell grinding does not require more than approximately 24 hours each month, so that the expense for a roll grinder and an operator in the case of one casting line, is not justified unless the plant is in a remote area where outside grinding work is not available.

Maintenance Man

One maintenance man would not be fully occupied at the caster, but would primarily take care of other equipment in the plant, such as rolling mills and other processing lines. He would be placed on the overall plant maintenance roster.

Table III. Total Manpower Required Based on a 4 Shift Basis and the Foregoing Explanations. (Show Slide IX).

Job	Number Of Casters 1	2	3	4	Payroll
Superintendent	1	1	1	1	(Salaried Employee)
Metallurgist	1	1	2	2	(Salaried Employee)
Cast & Melt Leadman	4	4	4	4	(Salaried Employee)
Clerk	1	2	2	3	(Salaried Employee)
Maintenance Man	1	1	2	3	(Indirect Labor)
Janitor	1	1	1	1	(Indirect Labor)
Roll Grinder	1	1	1	1	(Indirect Labor)
Furnace Operator	4	8	12	12	(Direct Labor)
Caster Operator	4	4	8	8	(Direct Labor)
Helpers	4	4	8	8	(Direct Labor)
Marinite Operator	1	1	2	2	(Direct Labor)
Total Required	23	28	43	45	

Costs

The general costs related to producing cast coil are contingent on the number of casters, percent and quality of scrap used and resultant melt loss in the furnace, alloys cast and resultant casting speed.

A typical caster operation with 3 or 4 casters, and a single sheet mill to reduce 0.250" gauge to .010" can be set up for about 8 to 10 million dollars, including land and building, casters, furnaces, mill and all auxiliary finishing equipment. Disregarding any rolling mills or other finishing equipment, 1/4" x 66" wide cast strip can be produced, including all costs for about 2.5¢/lb. or less, depending on typical operating efficiencies. This figure is based on average casting speeds and production from a normal mix of sheet and foil alloys.

We invite anyone requiring a detailed facility study to contact the Hunter Engineering Sales Department.

Conclusion

New Developments

Much of the development work on the casting process during the past few years has been directed toward increasing operational efficiency and recovery of metal, as well as expanding the use of continuous cast coil.

This work has led to improvements in caster mechanical design with resultant lower maintenance costs, improved controls for maintaining accurate metal head levels and very close metal temperature, increased caster roll shell life and improvements in the caster feed tip design which has doubled the average marinite feed tip life.

Development work now in process holds promise of further increase in caster feed tip life and increase in casting speeds.

In addition to the process development work, substantial work has been done in improving the metallurgical quality of the as-cast sheet by the continuous regulated addition of grain refiner in the caster launder system.

Other Materials Being Cast

Some development work has been done on adapting the process to metals and their alloys, other than aluminum. The results of this work are commercial operations, located in the United States which use the process to cast zinc and zinc alloys, lead and lead alloys.

At this time, there is research and investigation for the possibility of casting brass and copper strip. This work, however, is in its infancy and will require extensive machine and component development.

Experiments and New Designs

Experiments are now being made to increase the effective caster speed to twice its present rate. These experiments encompass the caster shells, tip arrangement and other media for cooling assistance. Effective casting width increases to meet end use demands are in process. Designs are in process for machines up to 80".