INNOVATIONS OF MEDIUM FREQUENCY INDUCTION MELTING

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INDUCTOTHERM CORP
MEDIUM FREQUENCY MELTING
MELT SHOP IN THE NEW MILLENNIUM
WHAT IS INDUCTION FURNACE?

- AN INDUCTION FURNACE IS AN ELECTRICAL FURNACE IN WHICH HEAT IS APPLIED BY INDUCTION HEATING OF A CONDUCTIVE MEDIUM (METAL) IN A CRUCIBLE PLACED IN A WATER COOLED ALTERNATING CURRENT SOLENOID COIL.
TWO TYPES OF INDUCTION MELTING FURNACES

- CORELESS FURNACE
- CHANNEL OR CORE TYPE FURNACE
TWO TYPES OF INDUCTION MELTING FURNACES

- CORELESS
- CHANNEL OR CORE
EARLY CORELESS INDUCTION MELT SYSTEMS IN 1950’S

- WERE POWERED BY HIGH FREQUENCY MOTOR GENERATORS
- WERE POWERED BY 60 HERTZ (MAINS) POWER SUPPLIES
- WERE NOT VERY FLEXIBLE AND REQUIRED A LOT OF OPERATOR ATTENTION
- THE OPERATOR HAD TO BE A OCTUPUS TO KEEP UP WITH THE CHANGES OF CAPACITOR AND TRANSFORMER TAPS
50 KW 3 KC MG SET WITH 75 HP MOTOR 1960
666 KW 1 KC MG SET WITH 1000 HP MOTOR 1950
MAINS FREQUENCY 60 HZ UNIT

POWER FUSES
MAIN CONTACTOR
SOFT START CONTACTOR
AND
SOFT START RESISTOR
PRIMARY TAPPED
POWER TRANSFORMER
PHASE BALANCING
SWITCHABLE CAPACITOR
BANK
FIXED CAPACITOR
BANK
FURNACE COIL

TYPICAL THREE PHASE
POWER CIRCUIT DIAGRAM
60 HERTZ AIR COOLED CAPACITOR RACK
MAINS FREQUENCY CONTROL PANEL
WHAT DOES FREQUENCY MEAN?

- FREQUENCY: THE NUMBER OF PERIODS OF A REPEATED FUNCTION PER UNIT OF TIME
- FURNACE FREQUENCY: THE NUMBER OF TIMES PER SECOND THAT AN ALTERNATING CURRENT CHANGES FROM POSITIVE SIGNAL TO A NEGATIVE SIGNAL.
- CALLED CYCLES PER SECOND OR HERTZ
WHAT IS MEDIUM FREQUENCY?

- OPERATING FREQUENCIES ABOVE 60 HERTZ BUT BELOW 1 KC

- EXAMPLES:
  - 100/150 HERTZ
  - 200/300 HERTZ
  - 300/400 HERTZ
  - 500/700 HERTZ
WHAT DOES KW MEAN?

- KILOWATTS - A UNIT OF POWER OR ELECTRICAL ENERGY
- ONE KW EQUALS 1000 WATTS OF ENERGY
- ONE WATT = ONE AMPERE TIMES ONE VOLT
- INDUCTION FURNACES ARE RATING IN KW OR MEGAWATTS
- ONE KW = ABOUT 1.34 HP
RANGES OF INDUCTION SYSTEMS TO DATE

- 15 KW TO 23,000 KW MELTING
- 15 KW TO 42,000 KW HEATING
- 5 LBS TO 250 TONS CAPACITY
RANGE OF CORELESS INDUCTION COILS
50 POUND HAND POUR FURNACE
70 TON FURNACE POWERED BY 23 MEGAWATTS
INDUCTION COIL

The two purposes of the induction coil:
- To create a concentrated magnetic field
- To contain and rigidly support the refractory lining.
A VARYING MAGNETIC FIELD INDUCES CURRENT IN THE CHARGE

AC Supply To Coil

Magnetic Field Reverses Every Half Cycle

Current In Charge

Current In Coil
EDDY CURRENTS

INDUCED CURRENTS

Secondary currents are induced into the charge.

Point of high resistance causes additional heating.

A current is induced into each separate piece of charge material.
MAGNETIC STIRRING

... IN A CORELESS INDUCTION FURNACE IS CAUSED BY MAGNETIC FORCES ACTING ON THE MOLTEN METAL BATH WHICH RESULT FROM THE INDUCTION ON THE ELECTRICAL CURRENTS FLOWING IN THE INDUCTION COIL AND IN THE MOLTEN BATH ITSELF. THESE FORCES ARE STRONGEST AT THE MID-POINT OF THE COIL. THE METAL IS FORCED TOWARD THE CENTER OF THE BATH, WHERE IT IS DIVERTED UPWARD AND DOWNWARD. THE UPWARD MOVEMENT OF METAL IN THE CENTER CAUSES THE CHARACTERISTIC "KINETICS" OF THE CORELESS FURNACE.

... IS AFFECTED BY THE POWER AND FREQUENCY APPLIED; THE SIZE AND SHAPE OF THE INDUCTION COIL, BURNER, AND MOLTEN BATH; AS WELL AS THE DENSITY AND VISCOITY OF THE MOLTEN METAL. THE EFFECTS ON STIRRING BY THE THREE MOST COMMON VARIABLE FACTORS ARE:

- POWER
- FREQUENCY
- FURNACE SIZE

BB1-0009-C
EFFECTS OF INCREASING FREQUENCY

- 50 Hz
  - 1000 Kw 4 Tonne
  - SMALLER FURNACE
  - INCREASE FREQUENCY

- 100 Hz
  - 1000 Kw 3 Tonne
  - 1000 Kw 2 Tonne
  - 1250 Kw 4 Tonne
  - MORE POWER

- 200 Hz
  - 1000 Kw 4 Tonne
  - 1000 Kw 4 Tonne
  - 2000 Kw 4 Tonne

- 500 Hz
  - 1000 Kw 4 Tonne
  - 1000 Kw 4 Tonne
  - 3000 Kw 4 Tonne

- 1000 Hz
  - 1000 Kw 4 Tonne
  - 1000 Kw 4 Tonne
  - 4000 Kw 4 Tonne
FURNACE SIZE VS FREQUENCY CHART

INDUCTOTHERM
MEDIUM FREQUENCY FURNACES VS MAINS

- Does not require starter blocks as does mains frequency
- Can melt scrap with smaller cross section
- Can be used as batch melters or low heel melters
- Furnace size is smaller for the same KW applied
- Can be emptied at the end of the day or week depending on size
- Requires less refractory because the furnace size is typically smaller
- Can be easily emptied and restarted with different analysis iron in batch melt mode
- Furnace components are smaller thus lower cost
- Lower holding power due to smaller furnace
- Shorter time required to reline
MELTING WITH MEDIUM FREQUENCY IS NOT NEW!

- FIRST 180 HERTZ SYSTEM BUILT IN 1961 USING TOROIDAL TRIPLERS
- FIRST 540 HERTZ SYSTEM BUILT IN 1965 ALSO USING TRIPLERS
- THE LARGEST 180 HERTZ TRIPLER SYSTEM WAS RATED AT 3600 KW WITH 20 TON FURNACE IN 1972 USING TRIPLERS
180 Hertz Melt System 1972
600 KW and 3000 LB Furnace
EARLY SOLID STATE POWER SUPPLIES

- Introduced to the foundry industry in 1967
- Used stud mounted type SCRs
- Used many control boards
- Very complex for units in the 500 kW range
STUD MOUNTED SCR-- SILICON CONTROLLED RECTIFIER IN 1967 RATED 125 AMPS
HOCKEY PUCK SCR TODAY
TYPICAL HOCKEY PUCK RATINGS

- 53 MM SCR  2000 AMPS
- 77 MM SCR  4000 AMPS
- 100 MM SCR  5500 AMPS
HOCKEY PUCK SCRS

- The continued development of more powerful hockey puck SCRS has made it possible to provide melting systems able to apply 1000 KW per metric ton of furnace size in the 100 to 300 Hertz range.
SCR ASSEMBLY
1500 KW 200 HERTZ POWER SUPPLY SCR INVERTER SECTION
1500 KW 200 HERTZ POWER SUPPLY SCR RECTIFIER SECTION
MEDIUM FREQUENCY CAPACITORS

- In 1970, 180 Hz capacitors were rated at 300 kVAR.
- Today, medium frequency capacitors are rated as high as 5500 kVAR or higher.
- Require much less space and less water cooling.
AC WATER COOLED CAPACITORS
1500 KW 200 HZ POWER SUPPLY CAPACITOR SECTION
CONTROL BOARDS REDUCED TO ONE
SIMPLIFIED CONTROLS
BATCH MELTING VS HEEL MELTING
SINGLE POWER SUPPLY WITH SWITCHES
DUAL OUTPUT SYSTEM - 1991
ARTIST CONCEPTUAL LAYOUT

TYPICAL LARGE VIP DUAL-TRAK WITH STEEL SHELL FURNACES.
TRIPLE OUTPUT SYSTEM -1997
20,000 KW TRIPLE OUTPUT SYSTEM

- 10,000KW ACI
- 10,000KW Inverter and P.F. Capacitor Bank
- 10,000KW Inverter and P.F. Capacitor Bank
- 10,000KW Inverter and P.F. Capacitor Bank
- 12.5 MT Steel Shell Furnace
- 12.5 MT Steel Shell Furnace
- 12.5 MT Steel Shell Furnace
FUTURE MULTIPLE OUTPUT SYSTEM FOR 100 TONS/HR
COMPUTER CONTROLS
FURNACE WEIGHING LOAD
CELLS
DIGITAL CONTROLS NETWORKS
CLOSE CAPTURE FUME COLLECTION AND BACK SLAGGING
10 METRIC TON FURNACE AND TRANSVERSE INDEXING CHARGE CAR
AUTOMATED CHARGE CONVEYORS WITH ACOUSTIC ENCLOSURES
PUSHOUT LINING REMOVAL SYSTEM
LINING INSTALLATION UNITS
BOTTOM VIBRATOR
FORM VIBRATOR
SAVEWAY ELECTRODE PANEL
INSTALLATION

- Connecting Wires
- Top Cap Segments
- Coil Grout
- Coil
- Electrode Panel
- Refractory Lining
SAVEWAY OPERATIONAL DISPLAY
ARMS SYSTEM - AUTOMATED ROBOTIC MELT SHOP
ARMS-AUTOMATED ROBOTIC MELT SHOP
WORKING WITH MOLTEN METALS HAS ALWAYS BEEN A DANGEROUS JOB. TODAY'S HIGH EFFICIENCY INDUCTION FURNACES HAVE IMPROVED WORKING CONDITIONS BY MAKING FOUNDRIES COOLER, CLEANER AND GENERALLY LESS HOSTILE FOR THE OPERATORS. THEY HAVE NOT HOWEVER ELIMINATED THE DANGERS INHERENT IN WORKING WITH MOLTEN METALS!
THE INDUCTION FOUNDRY SAFETY TRAINING KIT
THANK YOU!
QUESTIONS ?