ELEMENT

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PAKISTAN FOUNDRY ASSOCIATION
PFA for Development of Foundry Industry

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4th Qtr. 2013

Industrializing Pakistan

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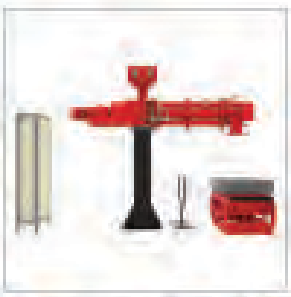

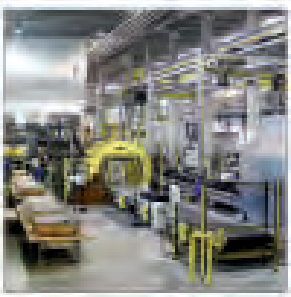

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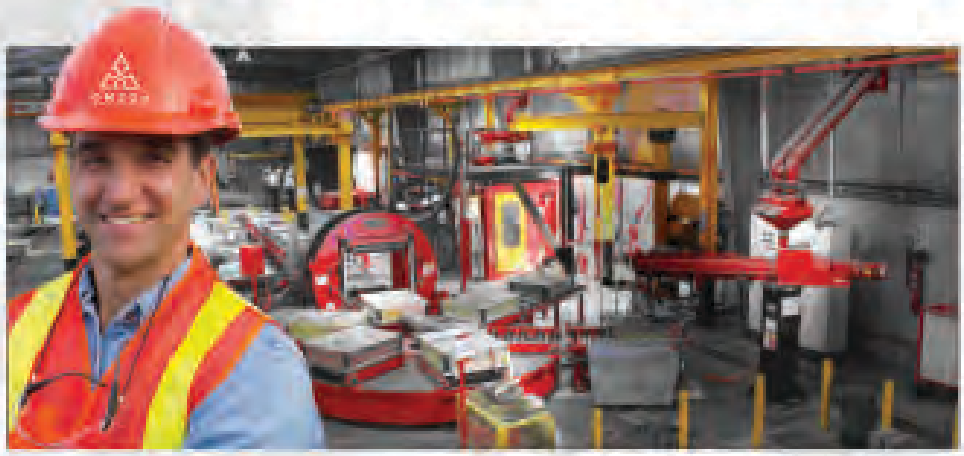

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President Message

With the onset of New Year, the foundry industry must explore all the business opportunities, and come out with the New Year's resolutions. The most important resolution with the greatest emphasis should be the promotion of Exports. For exports we need to focus on technology and quality improvement. One must bear in the mind that the market and especially the International Market is fiercely contested arena. One has to be highly competitive and capable to deliver quality at right time.

Unfortunately amongst us, there are many foundries who do not have access to the modern day foundry practices and quality improvement techniques. It is this area where Pakistan Foundry Association should play its part more vigorously and with devotion. Common Facility Center (CFC) must be equipped and groomed further to support the foundry industry and the desired skill for its growth. In this regard PFA organized a special interactive two day Foundry Workshop on November 7 & 8, 2013 at Foundry Service Center UET, Lahore. The services rendered by Mr. Joop Kikkert, a Senior PUM Foundry expert, must be appreciated. The workshop conducted by Mr. Kikkert was very useful for the participants.

Efficient Energy Management is another area where PFA organized awareness programs. We acknowledge the services of GIZ (German International Technical Cooperation), a team of German Experts and the JICA (Japan International Cooperation Agency) Mission for the assessment of our needs and appropriate advice. We hope the benefits will accrue in the form of energy savings resulting in financial gains.

I hope with our sincere efforts, we will be able to make a breakthrough in Projecting Pakistan as a reliable source for quality castings.

Sikandar Mustafa Khan
President PFA

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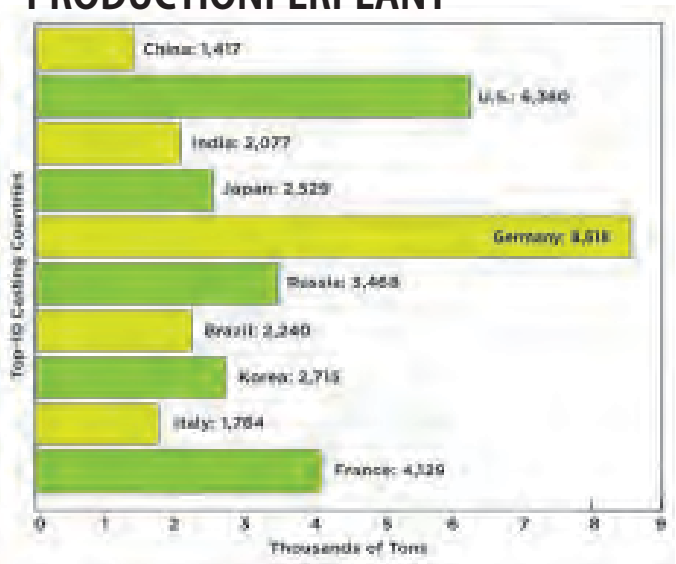
47th Census of World Casting Production

DividingUpThe GlobalMarket

Annual global casting production has shown continued growth since exceeding prerecession levels in 2011.

A MODERN CASTING STAFF REPORT

PRODUCTIONPERPLANT



Only two of the top 10 nations reported growth in production per plant (calculated as total tonnage divided by number of plants) in 2012. The U.S. continued to increase production per plant in 2012, by 28%, with Korea improving 3%.

In 2012, a year after world casting production exceeded pre-2008 levels, global production increased to more than 100 million metric tons, a 2.3% increase from 2011, according to this year's MODERN CASTING Census of World Casting Production. Following a sharp decline in total production in 2009, the industry rebounded over two years to prerecession figures. The 2012 production total represents a continued upward trend.

Of the 37 countries that provided census data, 20 reported a contraction in annual volumes for 2012. Bosnia and Herzegovina, after posting the greatest amount of growth in last year's census, saw its production total fall by 50.1%. Brazil experienced the largest contraction among the top producing countries with a 16.9% drop in overall volume in 2012. Brazil, Finland, Italy, Norway, Pakistan, South Africa, Switzerland and Taiwan reported decreases in the double digits.

While only 11 countries reported growth, the world's two largest casting producers, China and the United States, buoyed global output by increasing production by 1.2 million metric tons and 2.8 million metric tons, respectively. Belgium (63.5%,

an additional 29,200 metric tons) and the Ukraine (53.2%, an increase of 532,000) posted the largest increases in relative production compared to the year prior.

China remained far and away the world's largest producer with a total volume of 42.5 million metric tons, a total of 43% of global production. The U.S., after retaking the second spot in the world's top 10 from India in 2011, strengthened its position by producting 12.8 million metric tons, a 28% increase. Following India's 9.3 million, spots 4 through 8 remained in place, with Japan's 5.3 million, Germany's 5.2 million, Russia's 4.3 million, Brazil's 2.9 million and Korea's 2.4 million metric tons. France remained in the top 10, but its total production dropped by 12%. The top 10 nations produced 88% of the world's castings, the same total as the previous three years.

The U.S. continued to improve in its productivity figures, with an increase of 26% to 6,380 metric tons per facility. Germany, the world leader in per plant production, experienced a decrease of

315 metric tons per plant, a 3.5% decline. China and India, the two countries with the greatest number of facilities, reported a 3% gain and 6.5% decline, respectively. Productivity is calculated as total tonnage divided by the number of plants reported.

Total production of iron increased, with gray iron growing 0.3% and ductile iron 1.6%, while malleable iron fell 7.7%. Steel improved 9.2%, aluminum 6.5% and magnesium 24.6%.

The data reported in the 47th Census of World Casting Production is supplied by each nation's metalcasting association or similar representatives. Countries that did not participate this year were Croatia, Denmark, Mexico, Mongolia, Slovakia and Russia. These countries remain listed according to the last year they participated.

Ukraine has returned to the list, providing results updated from 2009. The country has increased its overall output from 1 million metric tons in 2009 to 1.5 million in 2012.

World Totals (metric tons)

Gray Iron	Ductile Iron	Malleable Iron	Steel	Copper Base	Aluminum	Magnesium	Zinc	Other Nonferrous	Total
45,995,817	25,167,222	1,275,473	11,299,044	1,743,817	14,051,924	226,673	587,947	486,764	100,834,681

The Americas (metric tons)

Country	Gray Iron	Ductile Iron	Malleable Iron	Steel	Copper Base	Aluminum	Magnesium	Zinc	Other Nonferrous	Total
Brazil	1,655,903	685,197	19,580	252,020	14,828	225,276	3,649	3,445	-	2,859,898
Canada	393,530	-	-	95,816	15,142	229,926	-	-	-	734,414
Mexico*	771,700	58,947	-	78,746	140,701	600,469	109	1,007	-	1,651,679
United States	4,296,420	4,479,680[A]	85,280	1,432,530	355,620	1,752,680	110,680	240,400	71,670	12,824,960

* 2011 data A) Includes compacted graphite iron

Europe (metric tons)

Country	Gray Iron	Ductile Iron	Malleable Iron	Steel	Copper Base	Aluminum	Magnesium	Zinc	Other Nonferrous	Total
Austria	39,700	93,000	-	17,258	-	123,865	5,687	12,871	-	292,381
Belgium	36,500	6,400	-	31,474	-	790	-	-	-	75,164
Bosnia and Herzegovina	10,942	2,058	-	4,973	-	6,905	-	-	-	24,878
Croatia**	22,107	17,375	-	1,313	459	11,652	-	230	661	53,797
Czech Republic	179,608	52,911	9,240	94,929	5,367	73,165	-	8,268	870	424,358
Denmark*	31,800	47,400	-	-	1,273	3,172[A]	-	-	290	83,935
Finland	24,553	38,431	-	15,637	3,008	3,619	-	259	-	85,507
France	657,700[B]	675,700	-	102,200	17,688	324,509	-	20,064	2,295	1,800,156
Germany	2,392,654	1,641,528	31,679	217,197	77,330	802,501	16,444	34,772	9	5,214,114
Hungary	49,000	31,000	11	3,535	1,745	96,128	189	4,367	124	186,099
Italy	626,435	416,805[B]	-	72,184	12,727	717,213	6,790	56,846	50,680	1,959,680
Norway	13,400	36,400	-	3,000	-	5,575	-	-	-	58,375
Poland	486,000	141,000	10,000	51,500	5,500	330,500	3,300	8,000	1,000	1,036,800
Portugal	35,043	73,884	-	7,982	9,206	18,940	-	1,027	-	146,082
Romania	31,669	2,910	637	24,853	4,878	45795	5,050	20	6	115,818
Serbia	37,251	15,162	10,328	9,050	2,220	4,958	-	-	7,528	86,497
Slovakia*	2,700	18,200	-	4,100	-	46,000	-	-	-	71,000
Slovenia	100,200	24,900	-	33,900	1,052	30,065	-	2,250	-	192,367
Spain	328,600	580,700	5,900	76,100	11,760	112,384	-	8,639	601	1,124,684
Sweden	153,900	51,100	-	23,400	10,300	37,800	2,600	4,300	-	283,400
Switzerland	16,200	29,700	-	2,000	2,347	17,970	-	1,235	-	69,452
Ukraine	420,000	140,000	40,000	530,000	45,000	260,000	20,000	35,000	42,000	1,532,000
United Kingdom	128,000	191,000	3,300	74,000	10,000	104,500	-	8,500	1,000	520,300

* 2011 data ** 2010 data A) Includes magnesium B) Includes malleable iron C) All nonferrous

Asia (metric tons)

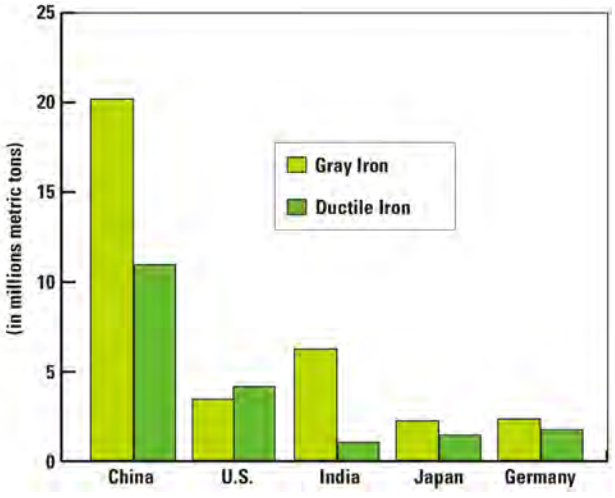
Country	Gray Iron	Ductile Iron	Malleable Iron	Steel	Copper Base	Aluminum	Magnesium	Zinc	Other Nonferrous	Total
China	20,100,000	10,900,000	600,000	5,400,000	750,000	4,450,000[A]	-	-	300,000	42,500,000
India	6,254,000	981,000	60,400	1,158,000	-	891,000[B]	-	-	-	9,344,400
Japan	2,209,307	1,377,385	36,558	213,199	79,571	1,399,053	-	22,981	4,783	5,342,837
Korea	1,062,900	671,500	14,000	160,900	25,800	487,800	12,900[C]	-	-	2,435,800
Mongolia***	2,000	220	-	12,000	60	180	-	-	240	14,700
Pakistan	200,000	20,000	-	30,000	15,000	6,000	-	-	-	271,000
Russia*	1,857,600	897,840	340,560	731,000	56,760	373,670	33,110	9,460	-	4,300,000
Taiwan	597,495	206,889	-	76,248	40,175	279,864	5,865	88,606	3,007	1,298,149
Turkey	610,000	502,000	8,000	140,000	14,000	157,000	-	14,000	-	1,445,000

* 2011 data *** 2009 data A) Includes magnesium B) All nonferrous C) Includes zinc

Africa (metric tons)

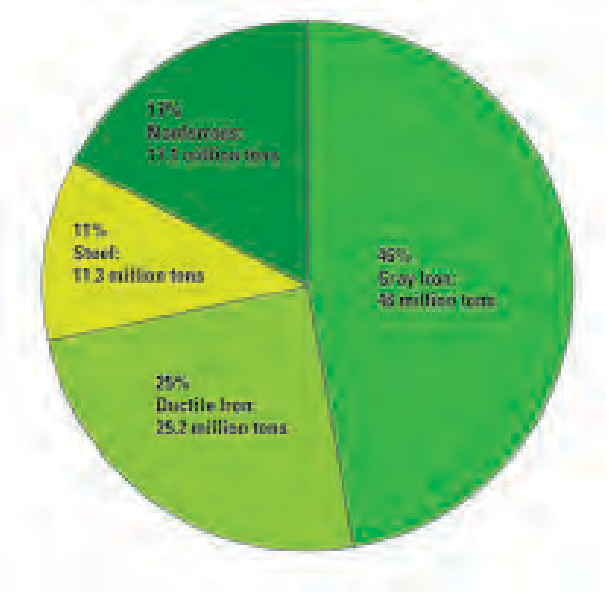
Country	Gray Iron	Ductile Iron	Malleable Iron	Steel	Copper Base	Aluminum	Magnesium	Zinc	Other Nonferrous	Total
South Africa	161,000	59,000	-	118,000	14,300	21,000	300	1,400	-	375,000

GRAY IRON VS. DUCTILE IRON



Top 5 Producers of Iron Castings

Globally, 46% of iron castings produced are in gray iron, compared to 25% produced in ductile iron. But this type of disparity is not present in every country. Austria, Denmark, Finland, France, Norway, Portugal, Slovakia, Spain, Switzerland, the U.K. and the U.S. produce more ductile iron than gray iron.



Gray iron (the calculation includes malleable iron) continues to be the largest contributing material to global production, at 46 million of the 100.8-million-ton total. Ductile iron increased slightly from 2011 levels, remaining at one quarter of total production. Steel and nonferrous castings also increased.

Metalcasting Plants by Nation

Country	Iron	Steel	Nonferrous	Total
Austria	25	4	33	62
Belgium	13	6	7	26
Bosnia and Herzegovina	7	4	4	15
Brazil	521	196	560	1,277
Canada	42	29	111	182
China	17,000	5,000	8,000	30,000
Croatia**	15	3	24	42
Czech Republic	85	34	65	184
Denmark*	9	-	11	20
Finland	16	7	16	39
France	93	36	307	436
Germany	209	53	343	605
Hungary	15	10	90	115
India	-	-	-	4,500
Italy	152	43	916	1,111
Japan	808	78	1,227	2,113
Korea	517	145	235	897
Mexico**	175	167	339	681
Norway	7	3	5	15
Pakistan	1,500	40	100	1,640
Poland	185	48	255	488
Portugal	31	7	30	68
Romania	-	-	-	125
Russia*	-	-	-	1,240
Serbia	12	8	18	38
Slovakia*	12	7	32	51
Slovenia	15[A]	-	50	65
South Africa	63	26	91	180
Spain	49	30	52	131
Sweden	32	13	72	117
Switzerland	18	4	50	72
Turkey	680	98	349	1,127
Ukraine	260	280	265	805
United Kingdom	224[A]	-	208	432
United States	643	362	1,005	2,010
TOTAL	23,433	6,741	14,870	50,909

*2011 data ** 2010 data A) Total Ferrous

While Ukrainian production of gray iron dropped from 640,000 to 420,000 metric tons, the country experienced significant growth in steel (530,000, up from 275,000 metric tons) and ductile iron (140,000, up from 40,000 metric tons).

Economic Rebound

Global casting production grew in 2012, but other than the large gains in the U.S. and China, total tonnage dropped slightly. Economic volatility meant big losses and gains for certain countries. Although France and Brazil reported decreases in the double digits, the majority of the world's largest producers reported only steady growth or slight contraction. Te countries in the top 10 reported a total growth rate of 2.5%, which could be seen as an encouraging sign that the the bulk of worldwide volatility is found in smaller markets. MC

Value & Production Trends

The Value by Nation and Total Production Volume Trend tables are two new elements in this year's survey. In an effort to provide a greater snapshot of the global casting market, we asked national metalcasting associations to provide estimated values for total production in five major categories.

Five of the world's top 10 casting producers were among the 16 countries that provided estimates. The U.S. with $36 million and Germany with $17.6 million topped the list.

Also, considering recent economic history and the effects of the recent worldwide recession, the Total Production Volume Trend provides perspective for each country by comparing present production with data from 2011 and 2008, the year before production totals were significantly impacted by the economic down turn.

Global production continues to exceed prerecession levels. The three largest casting producers in the world provided the most growth in the past four years, with China, the U.S. and India improving output by nearly 14 million metric tons. In Europe, meanwhile, the results continue to be mixed. In the western half of the continent, results tend to remain short of prerecession levels, with Germany, Italy and France still recovering. Eastern Europe, including Poland, Ukraine, Slovakia and Hungary, have recovered lost production and boosted overall tonnage since 2008.

Casting Shipments (value in U.S. dollars)

Country	Gray Iron	Ductile Iron	Malleable Iron	Steel	All Nonferrous	Total
Austria	596,632*	-	-	-	1,215,704	1,812,336
Brazil	-	-	-	-	-	11,400,000
Canada	-	-	-	-	-	3,119,519
Czech Republic	304,175	115,735	27,413	364,855	615,596	1,427,774
Finland	60,248	117,368	-	126,072	87,176	390,864
France	4,360,160*	-	-	-	3,470,720	7,830,880
Germany	5,954,080	4,167,040	-	545,360	6,925,120	17,591,600
Hungary	139,876*	-	-	-	293,760	433,636
Italy	3,590,400*	-	-	-	5,646,720	9,237,120
Norway	69,360	142,800	-	46,240	57,120	315,520
Poland	552,103	296,546	18,729	256,156	1,391,510	2,515,044
Portugal	73,746	148,920	-	65,298	386,194	674,158
Spain	1,924,400	in Gray Iron	-	516,800	1,037,680	3,478,880
Turkey	1,190,000	1,170,000	50,000	600,000	930,000	3,940,000
Ukraine	1,302,000	510,000	155,000	1,910,000	3,780,000	7,657,000
United States	5,544,000	7,348,000	159,000	4,658,000	13,741,000	36,038,000

* All Ferrous

Total Production Volume Trend

Country	2012 Total	2011 Total	+/- vs. 2012	2008 Total	+/- vs. 2012
Austria	292,381	309,892	6%	357,103	22%
Belgium	75,164	45,964	-39%	147,359	96%
Bosnia & Herzegovina	24,878	50,588	103%	-	-
Brazil	2,859,898	3,343,685	17%	3,227,100	13%
Canada	734,414	706,168	-4%	901,385	23%
China	42,500,000	41,260,000	-3%	31,269,630	-26%
Croatia**	53,797	-	-	75,265	40%
Czech Republic	424,358	459,945	8%	541,512	27%
Denmark*	83,935	-	-	84,714	1%
Finland	85,507	99,322	16%	156,181	83%
France	1,800,156	2,046,826	14%	2,471,700	37%
Germany	5,214,114	5,466,696	5%	5,840,022	12%
Hungary	186,099	162,001	-13%	178,884	-4%
India	9,344,400	9,994,000	7%	7,771,100	-17%
Italy	1,959,680	2,213,287	13%	2,742,914	40%
Japan	5,342,837	5,474,008	2.5%	6,960,765	30%
Korea	2,435,800	2,340,200	-4%	2,023,900	-17%
Mexico**	1,651,679	-	-	1,675,212	1%
Norway	58,375	65,130	12%	108,517	86%
Pakistan	271,000	322,000	19%	-	-
Poland	1,036,800	983,751	-5%	921,900	-11%
Portugal	146,082	152,067	4%	155,642	6.5%
Romania	115,818	-	-	142,898	23%
Russia*	4,300,000	-	-	7,800,000	81%
Serbia	86,497	84,423	-2%	-	-
Slovakia*	71,000	-	-	45,445	-36%
Slovenia	192,367	185,978	-3%	197,496	3%
South Africa	375,000	425,000	13%	368,700	-2%
Spain	1,124,684	1,243,756	11%	1,432,996	27%
Sweden	283,400	309,300	9%	361,300	27.5%
Switzerland	69,452	87,189	25.5%	102,164	47%
Taiwan	1,298,149	1,447,582	11.5%	1,627,129	25%
Turkey	1,445,000	1,433,700	-1%	1,316,650	-9%
Ukraine	1,532,000	1,000,000	-35%	974,170	-36%
U.K.	520,300	576,900	11%	718,000	38%
U.S.	12,824,960	10,008,000	-28%	11,686,000	-10%
TOTAL	100,834,681	98,593,122	-2%	94,786,097	-6%

* 2011 Results ** 2010 Results Note: The total production may differ from aggregate of national totals because countries with only one reported year were excluded.

TOP 10 CASTING PRODUCERS

1. China
42,500,000 metric tons

Gray iron:	20,100,000 tons
Ductile iron:	10,900,000 tons
Steel:	5,400,000 tons
Nonferrous:	5,500,000 tons

2. U.S.
12,824,960 metric tons

Gray iron:	4,296,420 tons
Ductile iron:	4,479,680 tons
Steel:	1,432,530 tons
Nonferrous:	2,531,050 tons

3. India
9,344,400 metric tons

Gray iron:	6,254,000 tons
Ductile iron:	981,000 tons
Steel:	1,158,000 tons
Nonferrous:	891,000 tons

4. Japan
5,342,837 metric tons

Gray iron:	2,209,307 tons
Ductile iron:	1,377,385 tons
Steel:	213,199 tons
Nonferrous:	1,506,388 tons

5. Germany
5,214,114 metric tons

Gray iron:	2,392,654 tons
Ductile iron:	1,641,528 tons
Steel:	217,197 tons
Nonferrous:	931,056 tons

6. Russia
4,300,000 metric tons

Gray iron:	1,857,600 tons
Ductile iron:	897,840 tons
Steel:	731,000 tons
Nonferrous:	473,000 tons

7. Brazil
2,859,898 metric tons

Gray iron:	1,655,903 tons
Ductile iron:	685,197 tons
Steel:	252,020 tons
Nonferrous:	247,198 tons

8. Korea
2,435,800 metric tons

Gray iron:	1,062,900 tons
Ductile iron:	671,500 tons
Steel:	160,900 tons
Nonferrous:	526,500 tons

9. Italy
1,959,680 metric tons

Gray iron:	626,435 tons
Ductile iron:	416,805 tons
Steel:	72,184 tons
Nonferrous:	844,256 tons

10. France
1,800,156 metric tons

Gray iron:	657,700 tons
Ductile iron:	675,700 tons
Steel:	102,200 tons
Nonferrous:	364,556 tons

Europe's total production dropped by half a million metric tons, while North America, boosted by the U.S., is up 1.2 million metric tons from 2011 levels. China also improved, up 3% since 2011.

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Technology Improving Your Meltshop Performance

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INTRODUCTION

Every casting (Fig.1) begins with molten metal and every foundry wants to make a profit. To melt metal, it requires energy and in the case of an induction furnace it means kilowatts.

More efficiently one uses those kilowatts, lower is the costs and the greater is the profit.

Fig. 1: Typical automotive castings.

There are "technologies" and practices out there designed to help, and the basis of this paper is to give a better understanding of what these are and how they can be implemented in an iron foundry.

Once it is established about how much molten metal is required per "batch" the frequency at which a "batch" is required, in conjunction with the "utilisation" would determine the kilowatts are required and the total production would determine the quantity of power supplies required.

The following are the stages one must go through to get a ladle full of metal with a specific analysis at the required temperature:

MELT CYCLE - is the period when maximum power is continuously applied to the furnace and charge is added.

NON-PRODUCTION CYCLE - is when no or reduced power is being applied, such as when the initial charge is being added, when slag is being removed, when a temperature dip or analysis sample is being taken, waiting for an analysis result and pouring the furnace empty.

PRODUCTION CYCLE - is the "melt cycle" and the "non-productive cycle".

UTILISATION - is the "melt cycle" divided by the "production cycle" expressed as a percentage. If the melting cycle is of 45 minutes and the "non-production" cycle is of 45 minutes, then the "production cycle" is 90 minutes. The 45-minute "melt cycle" divided by the 90-minute "production cycle" times 100 gives an "utilisation" of 50%.

If it is a process that requires 10 tonnes of iron poured into moulds per hour and the "production cycle" is such that it can only achieve 50% "utilisation", one will have to buy a power supply capable of melting 20 tonnes per hour.

CHARGE MATERIALS - for producing gray and ductile iron, the charge consists of steel scrap, pig iron, in-house returns and scrap.

CHARGE PREPARATION and **CHARGING -** irrespective of whether the furnace is to be charged manually or mechanically, the charge materials should be weighed and these ought to fit into the furnace. If the scrap sections are long and extend out of the top of the furnace, these, will ultimately melt but will take time, which will influence the "utilisation". The initial charge needs to be as quick as possible and of sufficient density to allow maximum power. The initial charge needs to be added to the furnace as quickly as possible. For optimum performance, the density should not be less than 1,750 kg per cubic metre and the furnace must be filled to a minimum of 30% and maximum of 60% of its rated capacity.

SLAG REMOVAL - an essential but unpleasant job. The slag produced during melting iron is usually viscous and, if not, the addition of a pearlite-based coagulant will create a viscous slag that can be raked or lifted off. For any sized furnace removing the slag manually is possible, but on larger furnaces it is unpleasant and time consuming. The options for larger furnaces are "back tilt slag removal" or a slag grab.

TEMPERATURE DIP AND SAMPLE ANALYSIS - a temperature dip to establish the bath temperature and a molten metal sample has to be taken to establish the chemical composition.

CHEMISTRY ADJUSTMENT AND SUPER-HEATING – as soon as the analysis result is known the "trim" materials should be weighed and charged into the furnace and full power applied to superheat to the pouring temperature.

POURING CYCLE - the time taken to empty the furnace.

To help one to achieve an optimum "production cycle" one needs to understand fully the technologies and practices that are available.

THE CHARGE - Every "melt cycle" starts with a charge (Fig. 2). The charge materials must be weighed before these are put into the furnace. When the charge is fully molten it is easier to calculate any "trim" additions, if the weight of the liquid iron is known.

If "standard" charges for various grades of iron are developed, it is much easier to achieve the target analysis. One will be able to use more lower cost materials, as one will learn the addition and recovery rates for the various materials used for element additions.

The quality of these materials and the charging sequence are important. Rust on steel scrap can influence lining life. Sand on in-house returns has to be melted and then removed as slag. Purchased cast iron scrap may contain unwanted elements and must be purchased with care. To melt slag, energy required is twice as much as that for iron.

Alloying materials also influence performance of the "melt cycle". As a base recarburiser, one can use a lower cost petroleum coke (Fig. 3).

Fig. 3: Petroleum coke.

If this is for gray iron, materials with higher sulphur levels can be used as final sulphur of 0.5 to 0.12%, enhances the performance of ferro silicon-based inoculants. Silicon addition should be made using 75% silicon ferrosilicon as this is an exothermic reaction. An alternative source of silicon is silicon carbide which is 66% Si, 33% C and zero carbon and an important consideration if one is making a ductile or compacted graphite iron.

At the end of the melt, it is often necessary to make small adjustments to "trim" the final analysis.

The charging sequence will influence carbon pick-up. Pig iron is high in carbon and the carbon is already in the iron matrix. It should be charged late in the "melt cycle". In-house foundry returns and scrap are of known analysis

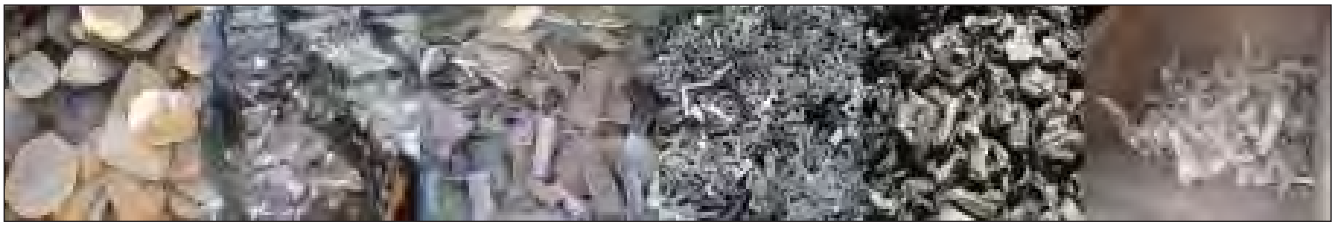

Fig. 2: Typical charge materials.

with the elements in the matrix so they can be added last. Steel is low in carbon and carbon can enter the matrix. The charging sequence should be steel scrap, recarburiser, in-house returns and scrap, pig iron (if required) and ferro alloys.

Any "trim" materials should be added after the slag has been removed and the charge is being superheated.

The furnace should not be overfilled. Any molten metal above the power coil at the end of the "melt cycle" reduces the surface stirring and subsequent surface, when "trim" materials are to be added. Movement caused by thermal convection and carbon boil does not enhance element recovery.

For any high production, a mechanised charging system is essential. The initial step is to weigh the charge. A crane scale can be used to weigh a charge as it is loaded into a feeder. A furnace feeder can be mounted on a track weighing station. A weigh hopper (Fig. 4) can be positioned to discharge into a feeder.

Fig. 4: Feeder and weigh hopper.

The best option is to select a feeder that can hold a full furnace charge. If it is a large furnace, then a feeder that holds half the charge can be used but, in this case, a weigh hopper also capable of holding half the charge is essential to ensure no delays in the charging sequence that could affect the "utilisation".

The size of the scrap is important to ensure the charge does not bridge. On average, each piece should not have a dimension greater than 33 % of the furnace diameter and no dimension should ever exceed 50% of the furnace diameter. The feed rate of the system must be able to deliver the full charge into the furnace within 65 to 70% of the actual "melt cycle".

The equipment must be sized based on the scrap density available (Fig. 5). There is no point in buying a 5-tonne feeder based on 2 tonnes per cubic metre, if the only scrap available is 1 tonne per cubic metre or less.

SCRAP DENSITY – Kg/M³	
Automobile scrap	670
Light Railroad scrap	720
Light bales	810
Crushed turnings	890
Heavy Railroad scrap	1,360
Steel Bails	1,500
Rails	2,000
Foundry gates & risers	2,101
Returns	2,500
Construction steel scrap	2,500
Car motor scrap	2,700
Billet ends	2,880
Pig iron	3,250
Cast iron machine scrap	3,300
Short heavy crop ends	3,800
Large scrap	4,802
Solid steel for comparison	7,700

Fig. 5: Typical scrap densities

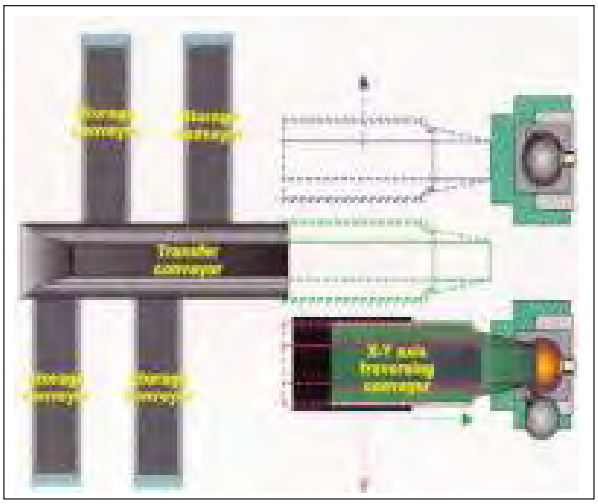

Fig. 6: A possible charging system configuration.

The degree to which a charging system (Fig. 6) can be mechanised is endless and depends on the degree of automation required. Software to automate the system is available from a number of suppliers (Fig.7). Different materials can be stored in separate weigh hoppers. The analysis of the various materials in the weigh hoppers can be entered in the computer along with the formula of the

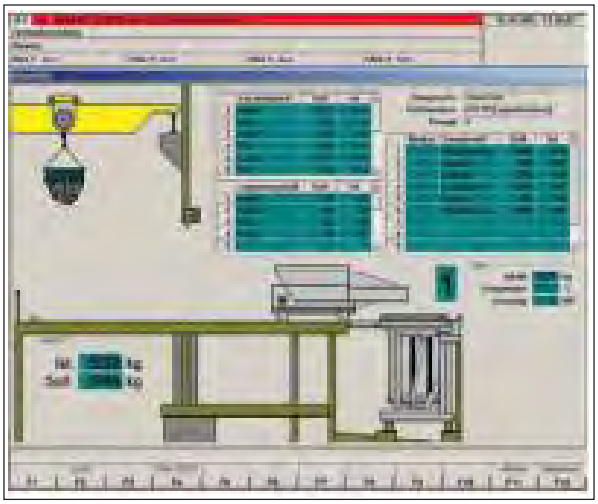

Fig. 7: Charge system computer screen.

grades of iron to be produced and the batch size. The software will select a charge-based on the materials available to ensure one get the maximum use of elements already in the charge. Based on the feedback from a spectrograph and the furnace load cells, the computer will calculate the "trim" materials required. Once all the necessary data has been loaded, a computer system will generally provide the following information:

- Weight and analysis of various materials in storage weigh hoppers with maximum and minimum stock levels.
- Recovery rates for materials used.
- Formulation for grades of iron to be produced.
- The grade of iron currently being produced with weights of the various charge materials required.
- A report to a crane operator to indicate what materials and weights are required.
- The total weight of each charge.
- Printed reports.
- Weight of any trim material required.
- The sequences in which multiple furnaces are to be charged.
- Information available from the computer system can usually be accessed through the internet or a LAN network.

When the weighed charge has been loaded on to the furnace feeder, the feeder will index to a position behind the furnace to be charged.

The only functions not automated are, indexing the feeder forward over the furnace and starting the feeder. This is for safety reasons to ensure the feeder is in the correct position and the area is clear. As the melt progresses, the operator needs to stop, and start the feeder to ensure the furnace is always full but not overfilled.

Fig. 8: Melting at full power.

THE MELT CYCLE - the "melt cycle" starts as soon as sufficient charge material is in the furnace to enable power to be applied (Fig. 8). Modern power supplies automatically control the power being applied to the furnace as the condition in the furnace changes (Fig. 9). The goal is to get the energy into the charge as quickly and efficiently as possible. A power supply able to deliver maximum power throughout the "melt cycle", always achieves the best melt rate. As the charge goes through "Currie", the voltage applied to the coil is allowed to increase. This increase gives two advantages:

Factors that will increase energy usage kW/tonne	
Returns with 25 kg/tonne of sand	12
Rusty charge material	27
Insufficient charge density	20
Recarburising when fully molten 20 kg/tonne	36
Melting with half power	18
Heel Melting	36
Excessive fume extraction	14

Fig. 9: Factors that will influence power usage.

Firstly, it ensures maximum kilowatts are continuously applied to the coil. Secondly, a high coil voltage means that the voltage induced into the charge is higher and

therefore the contact heating in the charge is more efficient. Typically, this results in a ten percent improvement in the melting rate as compared to a power supply where the power draw drops as the charge passes through “Currie”.

Fig.10: Melt cycle screen

Computer systems are available which will help manage the “melt cycle” (Fig. 10). The final pouring temperature is entered into the display. Taking a signal from the furnace load cells and the kilowatts being applied to the furnace, the computer’s algorithm displays a calculated temperature as a vertical bar chart, which has set points for various alarms and functions. As the display temperature increases the operator is prompted to add charge to the furnace. A temperature alarm is set at the temperature the charge will be fully molten. This alarm calls for a temperature dip. However, it is also the point at which power should be turned off and the slag removed. The computer system generally provides the following functions and reports:

- Manages an automated “melt cycle” (Fig. 10).
- Starts the equipment at a predetermined time to preheat the charge.
- Provides an automatic sinter cycle (Fig. 11).
- Provides diagnostics.
- Displays a simulated bath temperature.
- Displays information about the power supply.
- Displays the weight of charge in the furnace.
- Displays drain temperatures and alarms.
- Maintains a record of alarm trips.
- Provides printed reports.
- Communicates via the internet or a LAN network.

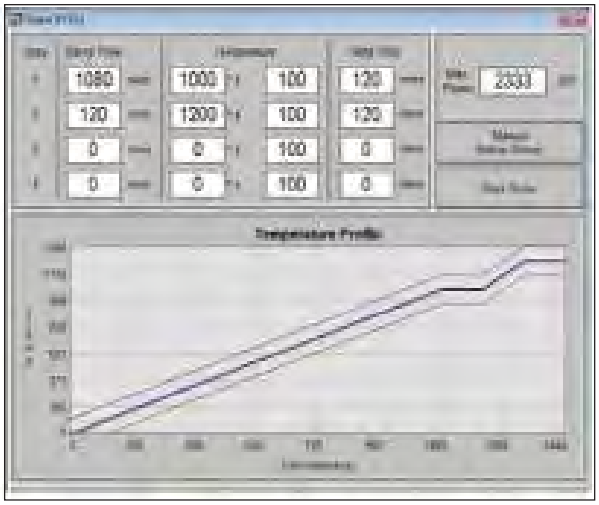

Fig. 11: Sinter cycle screen

SLAG REMOVAL - During the removal of any slag, the power must be off to ensure all the slag floats to the surface and can be removed. The longer the power is off the greater the effect on the overall “Utilisation”.

Manual removal can be enhanced by using a pearlite-based slag coagulant, which will exfoliate to tie the slag pieces together so they can be lifted off. Howeve,r it is a hard and unpleasant job.

Fig. 12: Back slag removal.

If the furnace is larger, a back slag (Fig. 12) feature may be available. In this case, the furnace is constructed with

two stanchions, which allow it to tilt in two directions, and there is a second spout at the back opposite to the pouring spout. When required, the furnace is back tilted and the slag is raked into a slag bugging positioned under the rear spout. The advantage of this system is that the operator has to rake rather than lift, and the process can be completed much quicker but there is a cost involved at the time of purchase.

Another option is to use a slag grab (Fig. 13). This is a pneumatically powered unit, which is suspended from a crane or hoist above the furnace. It comprises of two replaceable steel plate jaws that are opened and closed by a pneumatic cylinder. With the jaws open the unit is lowered into the slag, the jaws are closed and lifted out of the furnace. It is then swung to the side and the jaws are opened to drop the slag.

Fig. 13: A slag grab.

Fig.14: A mechanized slag grab.

A variation of the slag grab is a powered unit, which is mounted on a structural steel frame that forms part of the melter's cabin between the furnaces (Fig. 14). The unit can be swung to either side of the cabin to service two furnaces. The jaw assembly is moved up and down by a power cylinder and the action of the jaws is the same as the crane mounted unit. This type of unit is useful if the slag has a strong crust that needs a force to break through the slag surface.

The key is to remove the slag as quickly and efficiently as possible.

Fig. 15: Carbon, silicon and CE unit

TEMPERATURE DIP AND SAMPLE ANALYSIS - in most iron foundries, a thermal analysis system is used and the metal is poured based on the resulting carbon equivalent reading and a carbon percentage (Fig. 15). If a spectrograph analysis result is required then there will be a delay, which adversely affects the untilisation.

Just after the temperature dip (Fig. 16) and analysis sample are taken, holding power is restored to the furnace.

Fig. 16: Dip temperature unit.

CHEMISTRY ADJUSTMENT AND SUPERHEATING - depending on which analysis system is used,

just as the result is known, the "trim" materials should be weighed and charged into the furnace.

If a spectrograph is to be used, the positioning of the unit and the means by which a sample is delivered to the laboratory and the result transmitted to the furnace operator needs to be carefully thought out to ensure it can be accomplished in the shortest possible time.

The carburiser used to "trim" needs to be small-grained (Fig. 17) to increase its surface area and full-graphitised as this ensures that it goes into solution quickly. The function of carbon entering the iron matrix requires time, temperature and a large contact surface. If a large-grained petroleum coke is used at this point it will take longer to enter the matrix and adversely affect the "utilisation". Silicon additions should be made using a crushed 75% Si material.

Fig. 17 : Correctly sized "trim" graphite.

Immediately after the "trim" materials are in the furnace full power should be able to superheat the charge and create surface movement to increase the contact area. The rate at which a given furnace capacity and power supply will always superheat can be established, during the commissioning. When the required degree of superheat has been established, maximum power can be applied for the required time and further temperature dip is not necessary.

If the "melt cycle" is being managed by a computer a mouse click will restart the power supply and the computer will control the power to ensure only the required amount of energy has been applied. At the conclusion, an alarm will signal to alert the operator and the power will be reduced to holding power.

ROBOTICS - software which allow a robot to carry out a number of the these functions include:

- Slag removal by raking or slag grab (Fig. 18)
- ·Temperature dip
- Taking a liquid sample and pouring it into a thermal analysis cup or chill mould
- Adding pre weighed "trim" materials.

Fig. 18: A robot being used to remove slag.

The robot's advantage is that it cannot be hurt, it does not take rest breaks or holidays and it performs the same way every time.

POURING - at the conclusion of the superheating/trim addition cycle the furnace is ready to be poured empty.

If it is wanted to get the maximum advantage of the contact heating as the charge goes through Currie one must pour the furnace empty.

Very simply, the faster the furnace is emptied the better (Fig. 19). During the pouring cycle, only low power is applied and the time it takes to empty the furnace has the greatest effect on the "utilisation".

SUMMARY – If it is desired to purchase a specific amount of energy from the utility supplier and biggest profit is planned.

The one factor that will have the most effect is the level of "utilisation" that can be achieved. Higher "utilisation"

Fig. 19 : A large capacity crane mounted ladle.

is better. High utilisation means energy efficient production cycles.

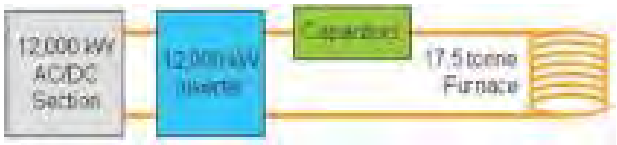

Fig. 20: A simple Power-Trak circuit.

EXAMPLE 1 - A 12,000 kW Power-Trak working with a 17.5-tonne furnace with a hot lining and an empty furnace will melt iron to 1,550°C at a rate of 25.2 tonnes per hour at 100% "utilisation" +/-5% (Figs. 20 & 21).

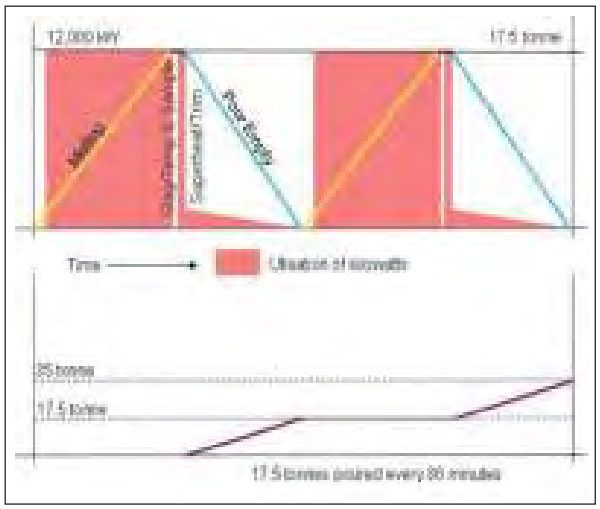

Fig. 21: A typical melt and pour cycle for a Power-Trak delivering batches to the casting plant.

It will melt 17.5 tonnes to 1,450°C in 39 minutes +/-5%.

A 12,000 kW will superheat 17.5 tonnes of iron through 100°C in 3 minutes +/-5%.

The 17.5-tonne furnace with a silica lining holding iron at 1,550°C will require 250 kW per hour to overcome the thermal losses +/-5%.

The following are two charts listing the operations required for a full melt cycle (Fig. 22). In both cases, the kilowatts and furnace size is the same. The time required to melt and to superheat is the same in both.

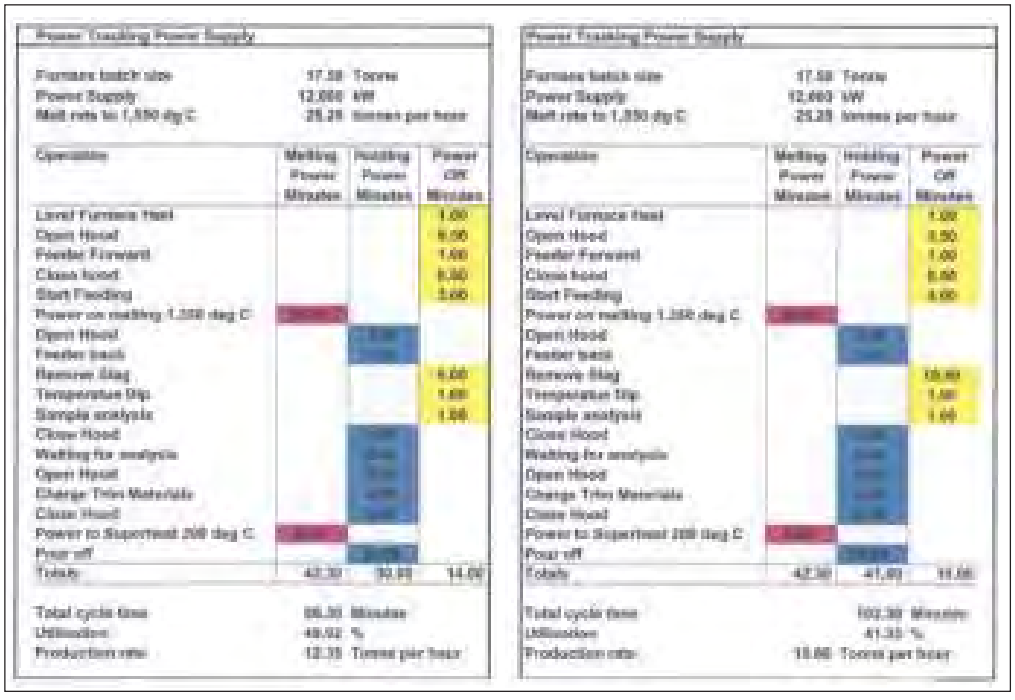

Fig. 22 : Utilisation.

However, in the right-hand chart, (Fig.22) the time taken for various operations is longer.

The calculation at the bottom shows the effect the "utilisation" has on the production rate.

In both cases, one has to purchase a 12,000 kW supply from the utility company. Yet only 40 - 50% of the total production capacity can be achieved.

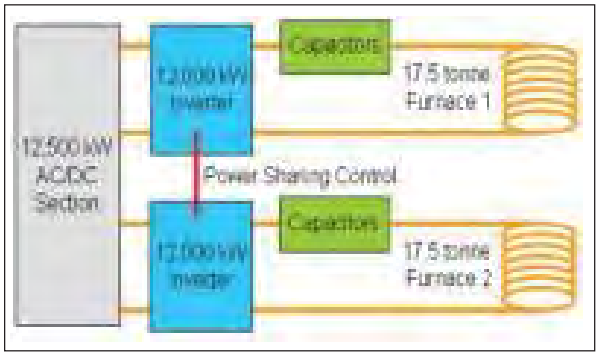

Fig. 23: A simple Dual-Trak circuit.

EXAMPLE 2 - A 12,500 kW Dual-Trak Plus has two 12,000 kW inverters (Fig. 23) working with two 17.5-tonne furnaces and each of these will provide the same performance as a single 12,000 kW Power-Trak. The extra 500 kW in the AC/DC sections allows the unit to simultaneously provide upto 500 kW to a second furnace to maintain temperature.

Each furnace will melt and pour in sequence (Fig. 24). If the "melt cycle" and the "non productive cycle" are equal in duration, then you will achieve close to 100% utilisation.

In practice, the utilisation of a Dual-Trak © power supply is between 85 and 95% and there is a constant supply of metal to the foundry casting process.

EXAMPLE 3 -A Tri-Trak has three inverters each rated at 100% kW and three furnaces (Figs. 25 & Fig. 26). The AC/DC section is rated at 210% of an inverter.

Each furnace will melt and pour in sequence. In this case, to achieve 100% utilisation the "non-productive cycle" must not exceed 50% of the "melt cycle" (Fig. 27).

THE MESSAGE: There is technology out there in practice, materials, hardware and software that will enable to run the equipment more efficiently. The more efficiently one runs the equipment the higher will be the

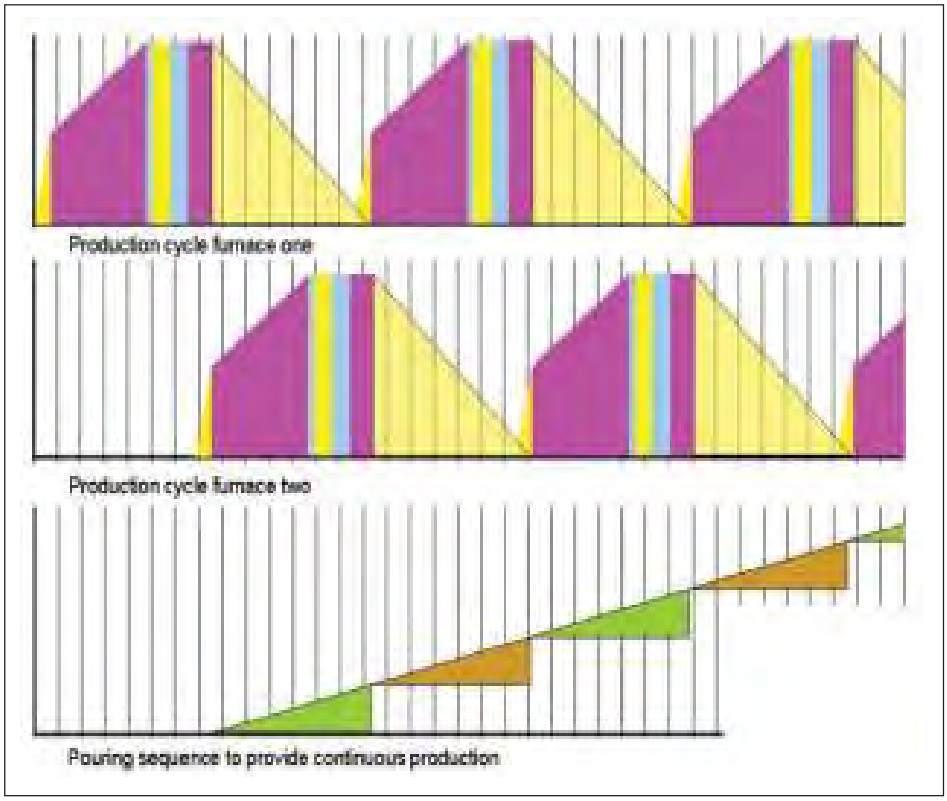

Fig. 24: Typical melt and pour sequence for a Dual-Trak delivering a constant supply of metal to the casting plant.

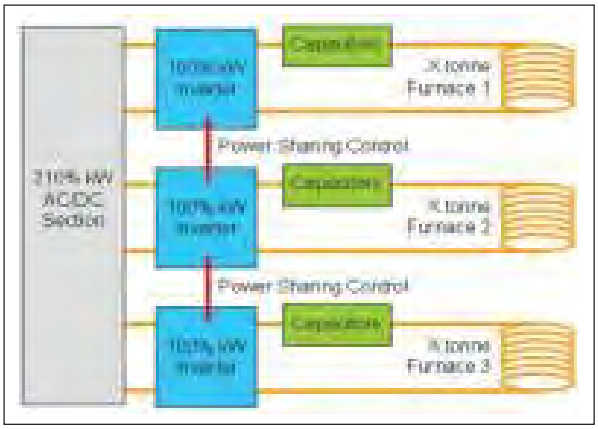

Fig. 25: A simple Tri-Trak circuit.

Fig. 26 : Tri-Trak installation.

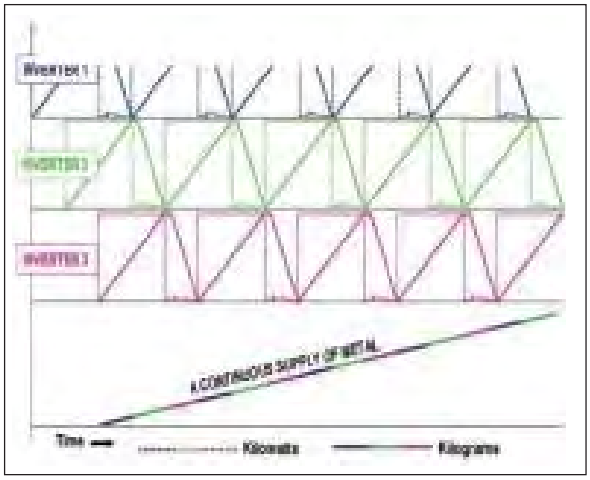

Fig. 27 : A typical melt and pour sequence for a Tri-Trak delivering constant supply of metal to the casting plant.

"utilisation" of the equipment, and the KVA power supply purchased from the utility company.

However, to achieve this, one will need properly trained personnel and a management structure that ensures training is kept upto date and the equipment is properly and timely maintained.

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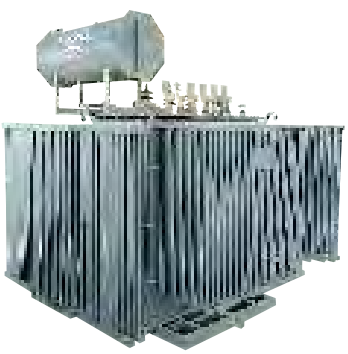

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Millat Tractors to Step in Export Market

Abdul Rashid - Secretary PFA

Millat Tractors Limited (MTL) organized a one day vendors conference '12th Vendor Conference 2013' on 5th December, 2013 at Faletti's Hotel, Lahore. The focal point of discussion at the conference was 'Global Competitiveness', aimed to develop strategy to survive through the current worldwide recession and future state of liberalized trade and tough international competition.

Over 200 vendors throughout Pakistan attended the conference. In welcome address Mr. S.M. Irfan Aqeel – CEO, MTL stated that Millat is proud of its rich heritage of indigenization through technology transfer and development of local vending industry and is producing most reasonably priced tractors in the world. "Millat has once again taken the lead in establishment of first of its kind engine testing laboratory for emission compliance certification according to international standards", he further said.

Mr. Ahmed Hassan - CEO Chenab Engineering Works & Foundries Pvt. Ltd reported from 46th Census of World Casting Production 2011 that the production of ferrous metal in the world in year 2012 was around 82.2 Million metric tons, from which China produced 35.9 million metric tons, 43.7% of the world manufacturing. India produced 9 million metric tons, 10.9% and Pakistan contributed just 0.29 Million metric tons, which is around 0.35% of the world manufacturing of ferrous metal. We are being the cheapest in the world still struggling for our survival. All we need to do is to plan and access the global market.

Here is a price comparison of our 85 horsepower tractors with Turkish and Indian tractor, they export to European market at a price almost double to our tractor's export price. Their 85 horsepower tractor is around 15,000 Euros in European market while 50 horsepower tractor's price in Europe is around 11,000 Euros as compared to our brands they are at a higher price. I am sure some improvement in quality of our tractor will bring us at par with those from India and Turkey and even then our price will be more economical and attractive. To penetrate into the world market, we have to work hard to achieve the quality of international standards. I feel there is a great vacuum and demand in the world for ferrous casting and we can get a lot of share in international market.

Mr. Sikandar Mustafa Khan – Chairman, Millat Group of Companies expressed his gratitude towards the vendors and Millat's entire team and especially CBA (Combined Bargaining Agent) MTL President Mr. Maqsood-Ur-Rahman who stood by the company in every moment. While explaining the company's next vision, to reach the global market by exporting the products he told the participants that in this regard a company 'TIPEG International' has already been established in Dubai. He further said that Millat and vendors are like a family and both will touch every level of success together.

With strong base of manufacturing quality and economical tractors in Pakistan, MTL is ideally poised to enter in global market. Mr. S. M. Khan said that MTL is particularly geared up now to launch export business in a more formal manner. He added that MTL cannot think of becoming a player in the Global Tractor Market unless we are fully prepared for a fierce and cutthroat competition. He said vendors in Pakistan and especially MTL should enter in international casting market including tractors, agri-parts and engines from the year 2014. At present our locally manufactured tractors are in the exporting process through Messey Furguson, our international partner, and through our own resources. He added we will export tractor engines having a great potential in the world market. There are various proposals and with the collaboration of our vendors we will enter in the export market.

He added we will start with few vendors in the beginning to access certain markets and will expand our exports gradually. He said MTL excelled to an extent due to a team effort and in partnership with vendors who have gained expertise in manufacturing a wide range of quality parts and we are ready to be a global player. He said 'TIPEG international' a subsidiary firm has been established in Dubai to deal with exports.

The conference was part of the process of sensitizing the vendor base for the commencement of export of Massey Ferguson to the international market via their principal i.e. AGCO. The conference was merely a success and the conference ended with healthy deliberations, award giving ceremony and lunch.

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ENVIRONMENT, HEALTH AND SAFETY ISSUES IN IRON FOUNDRIES USING INDUCTION FURNACE

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SYNOPSIS

Production of molten metal is one of the major activities in any foundry. However, this should be done with utmost care so that there is no adverse impact on environment and also health and safety of the personnel is not jeopardized. Focus of this technical paper is iron foundry, using coreless induction furnace as melting unit. The EHS (Environment Health and Safety) issues during a campaign of furnace i.e. from lining making to lining breaking are highlighted and precaution / countermeasures suggested.

INTRODUCTION

In India foundries, producing Iron Castings prefer to use medium frequency core less induction furnace as basic melting unit. The furnace during its campaign undergoes a cycle of lining installation, sintering of lining, melting and dismantling of lining. During all these operations there are activities which make adverse impact on environment and are also hazardous to health and safety of the personnel. The duty of the management, managers, supervisors and workers associated with operation and maintenance is to ensure that all risk associated with hazardous activities are minimized and brought down to acceptable level(1). Similarly, activities impacting environment should be controlled so that its effect become insignificant (2). The foundry should also comply with all applicable central, state and local regulations pertaining to environment, health and safety.

In this paper attempt has been made to highlight EHS issues during iron melting and countermeasures for the same has been suggested. Hazard during treatment of liquid iron for production of S.G. iron is also highlighted.

1. Dust exposure during induction furnace lining

For melting grey iron acidic lining material is most suitable. The material used is commonly known as silica ramming mass which is sieved and graded crushed quartzite rock. The sieve grading of material is done to obtain maximum density on compaction. For this purpose there is a certain percentage of fines (i.e. – 200 mesh size) in the material. The material supplied to foundry is premixed with a binder which is usually boric acid or boron oxide. Care should be taken to ensure that these fines do not fly away during lining process.

1.1 EHS Issues

Dust from silica ramming mass contains respirable crystalline silica (RCS) which is Health Hazard and may cause Silicosis which is scarring disease of lungs. A long period of exposure is required for development of disease.

1.2 Precaution / Countermeasures

1.2.1 During lining operation batches of ramming mass are filled between former and furnace coil. To minimize dust formations ensure that ramming mass is charged through a funnel and the drop of material is minimum.

1.2.2 Ensure that all workers use nose mask during lining of furnace

2. Safety during sintering of lining

Before start of sintering operation ensure that ground leak detection (GLD) system is properly connected and is operational. More detail regarding GLD is described elsewhere in this paper.

3. Furnace charge materials, charging and melting operation

3.1 EHS Issues

Molten metal splash is high risk incident which may result in serious burn injuries to personnel working in and around melt shop. Molten metal is splashed out of the furnace in case some charged material containing water goes under the surface of molten metal resulting in sudden formation and expansion of steam. Splash

may also happen if combustible materials like oil, grease etc. enclosed in containers enter into furnace having molten metal.

Dust and smoke from furnace may pollute air and also affect personnel working in melt shop.

3.2 Precaution / Countermeasures

3.2.1 Charge Material

The charge material for producing grey/iron castings consist of mild steel scrap, foundry return (gating system, risers and rejected castings.) and pig iron. Mild steel (MS) scrap may be heavy melting scrap (HMS) or light melting scrap (LMS) or in the form of bundles/bales made from steel sheet. Some foundries also use turnings and borings, in lose or in compacted form. Precautions during use of these materials are as given below:-

i) Heavy Melting Scrap

This is an ideal melting scrap for induction furnace. But precaution must be taken that a single piece should not weigh more than 10 Kg as this would result in heavy splash if added directly to the liquid metal.

ii) Light Melting Scrap

The size i.e. length and thickness is important from bulk density point of view of the scrap. If bulk density is very low then one may not be able to feed the furnace to match the melting rate. The low bulk density may also result in bridging of the crucible as the material may not descend down with melt rate.

iii) Baled Scrap

To improve bulk density of scrap sheet metal is hydraulically pressed to form bales. The important factor is the size of the bale. The vendors/traders who are in the business try to make the size as big as possible, using unsorted scrap. The ideal size of the bale for induction furnace melting point of view is 300×300×300 mm. One must develop trust and educate vendors/traders to sort out and remove bad material such as galvanised steel, lead coated and painted scrap before making bales.

Foundries producing S.G. iron castings use bales produced from CRCA sheets because of its low manganese, sulphur and phosphorus content. However, due caution should be taken to ensure that these bales do not contain undesirables materials inside.

iv) Cast Iron/Steel Turnings and Borings

Many foundries use this material to keep the cost under control. To keep the chemistry under control, precaution must be taken that the material is from known source. If the material is highly oxidized it may result in casting defects. The cutting oil and water makes this material highly susceptible to splashing. If charging is not done properly it may also cause bridging. Training of workmen working on furnace platform is of utmost importance for use of this material.

v) Hazardous Materials

i. Explosives and scrap from artillery

ii. Closed Containers

iii. Armatures

iv. Oil filled shock absorbers and oil filters.

Any charge material should be free from liquids and should not contain sealed containers, closed tubes and pipes. Examples of such material are oil filters and shock absorbers etc. Explosion can occur if sealed containers containing water are charged into an empty but hot furnace (6). In such a case force of explosion may damage the furnace lining and throw charge material out of the furnace, injuring personnel. Scrap material should be inspected to ensure that there is no moisture or material covered with oil and grease. If bundle scrap is used, it is good practice to open few bundles from every consignment and check for any suspect or undesirable material inside.

It should also be ensured that scrap do not contain spent military ammunition, spent bomb shell, hand grenade etc. Such materials find its way to foundries when scrap imported from war affected countries is supplied to foundries. Occasionally such scrap also comes from domestic sources when the scrap dealer

supplies the materials which have been purchased from scrap pickers who may have picked up such material from nearby areas of army practice/firing range. Authors of this paper had the misfortune of undergoing harrowing experience when some explosive material had gone into 8 tons induction furnace resulting in metal splash and the ammunition itself shooting vertically out of the furnace and going through the roof of 25 meter high shed. Luckily, no one was injured.

Scrap should also be inspected to look for any containers with radiation hazard marking (Photograph-1). Radioactive materials like cobalt – 60 are used for industrial radiography.

Careless disposition of such material may find its way to foundry. Although such material will not cause any explosion or molten metal splash but emanating radiation will affect the personnel. The castings produced from scrap containing any radioactive materials will also be emitting radiation and will be affecting all persons handling and using such castings. Instruments are available to detect radiation. These instruments can be used to check suspect scrap pieces or the whole truck or individual castings. In this context a news item as it appeared in a foreign newspaper dated 9 April, 2009 is reproduced below: -

" Rajender ,35 ,was one of seven people hospitalized after being exposed to radioactive materials at scrap metal shops in an industrial area known as Mayapuri, located barely 10 mile from India's Parliament ……

Police cordoned off a large section of Mayapuri while scientists removed 11 samples of material contaminated with Co-60. …"

3.2.2 Material Storage

Material storage should be under shed to avoid rain water falling over it. Roof and sky light of the shed above furnace should be kept in good condition to avoid rain water falling on or near by furnace

3.2.3 Melting Tools

Tools for removing slag should be free from moisture and rust to avoid splashing when put into contact with metal bath. Ladle should be dry before taking metal into it.

3.2.4 Ferro Alloys

All Ferro alloys should be inspected to check that it is free from moisture. Silicon Carbide (SiC), if used, should not be added on liquid bath but with solid charge because dissolution of SiC is highly exothermic and intense heat forms pockets in the lining.

3.3 Precaution / Countermeasures during furnace charging, melting and tapping

3.3.1 Furnace Charging

Furnace charging is a hazardous activity and the risk may be minimized by using appropriate PPE (Personal Protective Equipment)

Furnace charging may be done manually, by using bottom opening baskets or by vibratory chargers. Vibratory chargers are safest as it can be operated from a safe distance. However, large pieces should not be dropped into furnace containing liquid metal to avoid splash.

3.3.2 Bridging

It is imperative that furnace is fed continuously to get the maximum or rated output. Over feeding the crucible leads to bridging as the material in contact with molten metal melts faster than the material on top. The cardinal principle for melter is that he should be able to see the liquid metal all the time throughout the melting cycle to avoid bridging.

Bridging can cause superheating of the molten metal resulting in fast erosion of lining and ultimately furnace coil puncture due to liquid metal. Operator should use correct size of material to avoid bridging. As a thumb rule, length of any charge material should not be more than one third of the diameter of furnace. If bridging occurs, furnace power must be turned off or reduced and bridging should be broken, by adding molten metal of low temperature into the furnace till the bridge comes in contact with molten

metal. Then remove slag. If molten metal is not available, make opening in the solid crust and add pig iron or small pieces of return, till liquid metal in furnace comes in contact with bridge to melt the bridge.

3.3.3 Furnace Pit Area

Furnace pit area should be kept clean and dry. Water and hydraulic oil should not be allowed to accumulate.

3.3.4 Furnace Lining Maintenance

Furnace lining should be maintained to correct thickness to avoid coil rupture due to liquid metal.

Ground/Earth Leakage Detector helps in monitoring condition of furnace lining (4). This safety equipment is provided by the furnace manufacturer and has different electronic circuits depending on the make of the furnace. This essentially monitors the potential between current carrying coil and liquid metal which is earthed through antenna. It gives a signal in the event of:

i) Liquid metal film which has penetrated the lining and solidified near the coil

ii) Liquid metal has penetrated though the lining and touching the oil

iii) Metal Streak or metallic dust on coil from outside getting earth through physical contact between coil and yoke.

iv) Sweating of the coil during sintering of the crucible and/or water leakage through the coil

All the four eventualities are to be taken seriously and attended to. Many a times shop floor personnel tend to bypass the system and operate the furnace which leads to bigger disaster. Authors have experienced that it is told many times that GLD alarm was false. It is the tendency of the shop floor managers to doubt the electrical circuits and push their own agenda of lining health under production pressure. Authors would like to emphasize that GLD/ELR system must be in working condition all the time and never doubt the system. It has been noticed that many times furnaces are devoid of this safety measure, although provided by the furnace manufacturer. It is recommended that Chief Executive of the plant must ensure that this vital safety measure is always healthy and functional.

3.3.5 Induction Furnace Splash

I) During Slag Off

The slag pan must be dried before it is used for deslagging. The cold pan can result in metal splash, due to sudden formation of steam, endangering the operators.

ii) Due to wet furnace launder

When the crucible is being charged particularly with vibro feeder, sometimes the furnace launder gets damaged due to impact of charge material. There is no quick setting refractory available to repair the damaged launder. Sometimes launder is repaired with castables or ramming mass mixed with sodium silicate. During tapping liquid metal splashes from repaired launder which may damage gear box and lock of the ladle apart from injury to operator. The other major problem encountered from incorrectly repaired launder is run down of liquid metal on coil through the corners or gap between launder and furnace lining. The metal streak depending on size can create havoc with coil. When metal is trapped in between yoke and coil can give ground/earth leakage alarm (many a times it is bypassed by maintenance staff in collusion with melters). This undetected metal certainly leads to water leakage through the coil. It is very important to make the launder with correct material (as suggested by refractory manufacturer) and maintain it in healthy condition.

To prevent injuries due to metal splash foundry person/ workers/ operators should avoid standing in the hazardous zone. As per ASTM (American Society for Testing and Materials) standard 2349-12, hazardous zone is from the edge of the furnace to five times the furnace diameter or 20 feet, whichever of the two is greater (3). Hazardous area should be clearly marked, by paint on furnace platform and in front of furnace.

3.3.6 Fume, smoke and dust during charging and melting

When an induction furnace with liquid metal heel or empty furnace with hot lining is charged, there is

sudden formation of dust, fume and smoke. The amount of dust and smoke formation depends on the cleanliness of charge material. Foundry returns with a layer of sand sticking on its surface will form more dust as compared to shot blasted returns. Similarly, rusted scrap generates more dust as compared to clean scrap. Galvanised scrap generates lot of white fumes due to formation of Zinc Oxide (ZnO). Excessive inhalation of this fume irritates respiratory system and may cause fever (8). For avoiding air pollution and for protecting health of personnel, this dust and smoke need to be captured and passed through a dust extraction system consisting of filter, suction blower and stack. The hood above the furnace is either of swing type or close capture fume hood incorporated in furnace top cover (lid).In both the designs there is some fugitive smoke and dust because the device is not on top of furnace at that time when maximum smoke and dust is generated i.e. during charging. It is therefore, suggested that shed above the furnace platform should be high with monitor roof and exhaust fan. Roof extractor which works with wind velocity also helps.

The dust collecting equipment could be of bag filter type or wet scrubber. In authors' opinion wet scrubber is more effective and easily meets the Indian standard of clean air from induction furnace. Bag filters can also meet the pollution control board norm but requires more maintenance because of short life of filter bags caused by high temperature of smoke/fume. The sludge collected in wet scrubber is easy to dry and dispose as it mainly consists of sand and rusted metallic particles.

3.3.7 Splash due to wet ladle lining

Ladle lining, new or repaired, should be thoroughly dried under burner before taking liquid iron into it. Liquid metal taken into improperly dried ladle may be thrown out resulting in serious burn injury to workers. It has been observed that melt shop operators heat the ladle by repeatedly taking liquid metal into ladle and pouring back into furnace. This is a highly risky practice and should not be allowed.

3.3.8 Furnace Platform Working Condition

Working on furnace platform and around it is a hazardous occupation .Workers should protect themselves from dehydration by frequent in take of water. Hot molten metal produces radiation that can damage eyes. Workers should be asked to wear protective glasses.

Workers should also wear only cotton garments, under the overalls, as synthetic fibers may melt or catch fire.

4. Hazard during S.G. Iron treatment

There is several methods for treatment of liquid iron for producing S.G.iron .However most popular method in Indians foundries is sandwich process using ferro-silicon-magnesium alloy. As the name suggest there is a sandwich layer of steel sheet punching between spherodising alloy and liquid metal in the treatment ladle. The treatment can be done in open ladle, specially designed with height to diameter ratio of at least 2 : 1 and with a pocket at the bottom for keeping spherodising alloy. Treatment by sandwich process can also be done in ladle with tundish cover. Tundish cover not only improves magnesium recovery but is also much better with respect to EHS issues.

When liquid metal comes in contact with Fe-Si-Mg, there is formation of flash, fume and splash. Flash is formation of bright light due to combustion of magnesium, fume is due to formation of magnesium oxide and splash is due to violence of reaction which tries to throw liquid metal out of ladle. A tundish cover is much better for containment of all the above.

For safety of workmen following should be ensured:-

i. Use of correct height to diameter ratio ladle.

ii. Use of large enough pocket to accommodate spherodising alloy.

iii. Use of correct size of Fe-Si-Mg alloy which should be properly compacted in the pocket

iv. Cover material of correct size and quantity which should be spread evenly over the spherodising alloy.

v. Tundish cover should be properly aligned to ensure that liquid metal stream falls away from the pocket.

All workers engaged in treatment should use PPE for eye protection and all other protective gears against liquid metal splash.

5. Hazard during breaking of induction furnace and ladle lining

Induction furnace lining may be broken manually using pneumatic chipper. It may also be removed with the help of lining push out arrangement.

5.1 EHS issues

Dust formation affecting personnel and polluting air. Pneumatic tools also cause noise pollution and its vibration may cause health problems.

5.2 Precaution / Countermeasures

5.2.1 Provide and use following PPE:-

- For Noise – Ear muffs
- For Dust – Nose mask

When lining is dismantled with the help of lining push out arrangement, there is a sudden dust formation when complete lining falls at the end of hydraulic push out piston stroke. It is good practice to park a trolley so that complete lining falls into it. Water jet may be used for dust suppression.

5.2.2 To minimize effect of vibrating tools on Hand/Arm, workers should work by rotation. There are foundries with many induction furnaces where breaking and relining of furnace is done almost every day. This work is generally performed by the same group of workers. In such cases special care should be taken to protect workers from "hand arm vibration syndrome (HAVS) (7)". This is caused by excessive exposure of fingers, hands and arms to vibration. The symptoms of HAVS are:-

- Blood circulation effect , evidenced by white fingers
- Tingling and numbness caused by nerve damage.
- Pain and stiffness in the hand and joint of wrist, elbow and shoulders.

6. Emergency Procedures In Melt Shop

6.1. In Case of Lining Failure

6.1.1 EHS issues

Water coming out at high pressure from punctured coil may travel towards lining and may enter into furnace which may lead to molten metal explosion. This may result in serious burn injuries to personnel working in and around melt shop. It is therefore, of utmost importance to take care of furnace coil and protect it from damage by maintaining lining in healthy condition through out the campaign. This is to be done by monitoring lining life via daily key readings e.g. KW drawn at constant metal level and visual condition of lining in hot condition , daily and in cold condition , on week ends. Coil insulation should also be changed at fixed intervals as preventive maintenance activity and not waiting till it fails.

6.1.2 Precaution / Countermeasures

i. Make sure that the furnace is switched off.

ii. Empty out the molten metal in a ladle, preferably big enough to accommodate all molten metal in furnace. This metal may be transferred into other running furnace or may be suitably pigged.

iii. If metal is in semi molten stage and furnace under charging, keep furnace in tilted condition and remove unmelted scrap. When furnace is in tilted condition, ensure that no one is standing in front of furnace.

iv. Furnace pit is to be kept clean from water, oil etc. all the time. Leaked metal falling on water, oil etc. is potentially very dangerous condition, as fast expanding steam will throw metal with great force causing injury to the personnel.

v. Reduce water pressure and remove water from furnace basement

vi. Continue flow of water till all metal in the furnace becomes solid and cools down to 200 to 300°C. Thereafter, lining should be further cooled by water/air and broken.

vii. When the metal is still liquid or semi solid, try to insert an inverted "U" shaped hook, made from 20 mm diameter round bar, into bath and allow liquid metal to solidify around it. This hook will be of great help in removing the solidified slug during lining dismantling.

6.2 **Emergency In Case Of Metal Spillage**

6.2.1 EHS Issues Metal spillage while transporting liquid metal in ladle by forklift may cause serious burn injuries to the personnel working in an around the above area.

6.2.2 Precaution / Countermeasures

i) Make sure that Forklift is in good working condition, with respect to horn, light, brakes and weight lifting mechanism

ii) Check lining of ladle which should be in good condition without crack or erosion

iii) Avoid over filling of liquid metal in ladle.

iv) Warn all persons around not to come in the affected area.

v) Throw dry sand on the spilled metal, allow metal to cool and then clean the floor.

vi) Ensure that there is no water on the floor in the area of liquid metal transport.

7. Conclusions

7.1 Suggested PPES for melt shop are –

Safety glasses with side protection , Leather safety shoes with metallic toe protection , Helmet , Nose mask , Leather aprons , Hand gloves(Heat resistant type), Ear plug (during lining breaking by pneumatic tools)

Appropriate PPE may vary from foundry to foundry.

7.2 It is management responsibility to provide personal protective equipments to all persons working in melt shop, train them in correct use of PPE and enforce use of provided PPE. Any PPE is designed to be effective when worn properly (5).

7.3 Melt shop operator should be trained to recognize and remove hazardous materials in scrap like shock absorbers, closed containers and spent ammunition etc. They should also be trained in emergency preparedness and use of fire fighting equipments. In every shift there should be one or two persons trained in providing first aid.

7.4 Management should list all aspects of melt shop activities which impact environment and make a program to minimize the same to an insignificant level. Similarly, Hazard Identification and Risk Analysis should be done to reduce risk to acceptable level.

7.5 Visitors or any other person not associated with melt shop activities should not be allowed in hazardous zone. Any person with metal implant in their body should not be allowed to go near furnace or preferably in hazardous zone.

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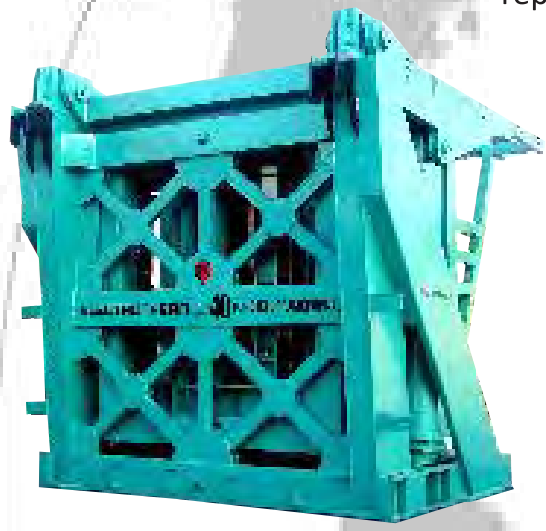

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Special Interactive Foundry Workshop by PFA

Abdul Rashid - Secretary PFA

Pakistan Foundry Association (PFA) is engaged for the development of foundry sector in Pakistan for technological up-gradation and skills development. To help foundry industry and provide them skilled man power PFA organized a very special interactive two days foundry workshop on 7-8 November, 2013 in Foundry Service Center U.E.T Lahore, conducted by Mr. Joop Kikkert - Senior foundry expert PUM, Netherlands.

This workshop was intended to coach the foundry engineers who are responsible for the Method Engineering (designing of Gating / Running Systems in molds) / Charge Calculations for Cupola / Induction Furnace, Green Sand Preparation and dealing with Defect Analysis of various castings. It was largely attended by the foundry engineers of different industries.

Topic included in workshop were . . .

- CV JK,
- Shrinkage in nodular iron,
- Feeder design and calculation,
- Modulus calculation, Gating design and Calculation,
- Pattern plate layout,
- Casting imperfections,
- Casting imperfections ,
- Possible causes and cures, - Charge calculation,
- Melting,
- Inoculation,
- Green sand,

The inauguration ceremony was graced by Mr. Sikandar Mustafa Khan - President PFA, Lt. Gen. Ret. Muhammad Akram Khan - Vice Chancellor UET, Mr. Muhammad Alamgir Chaudhry - G.M. Outreach SMEDA, Mr. Masud Akhtar - Vice President and Mr. Asim Qadri - General Secretary PFA.

In the opening remarks Mr. S. M. Khan - President PFA said that Foundry Service Center is of its kind one and only in Pakistan and has been developed to train young engineers with the latest foundry technologies. He thanked Mr. Joop Kikkert - Senior foundry expert PUM, Netherlands for his interest and time to conduct this interactive workshop and traveled all the way from his home town. I am sure his experience will benefit the participants who may perform better after this training. He pointed out to organize such training courses for engineers to upgrade their technical knowledge for better productivity to meet international standards.

Lt. Gen. (Ret) Muhammad Akram Khan - Vice Chancellor UET was kind enough to spare his precious time to participate in the opening session of interactive workshop. He appreciated the efforts of PFA to organize first technical workshop in Foundry Service Center. He said an engineer can learn a lot by participating in such technical trainings to improve their practical knowledge. He said to me an engineer is a technical person and his

skills can help in developing machinery in Pakistan and a lot of foreign exchange can be saved. He suggested Foundry Service Center can play a vital role in the development of young engineers for practical training by attending short courses.

Mr. Muhammad Alamgir Chaudhry - G.M. Outreach SMEDA thanked PFA for organizing such an interactive workshop in Foundry Service Center and arranged a very senior foundry expert Mr. Joop Kikkert to train our foundry engineers. He said before the establishment of Foundry Service Center, SMEDA conducted a survey of about 25 foundries in Lahore and around and found the common problems of foundries was high rejection rate. It caused a lot of wastage of resources like electricity, man power, raw material and time mainly due to unskilled labor force. There was no research & development of new products in most of the foundries to fulfill the demand of local & international foundry products.

SMEDA authorities realized that there is an urgent need of a training institute for the foundry workers and henceforth Foundry Service Center was ultimately developed.

He said this interactive workshop will play great role in skills development of different engineers who are present today. I advise to all the participants to get the maximum benefit out of this unique opportunity, ask as many questions as you can and use the two way communication. He emphasized to learn at the maximum by Mr. Joop Kikkert who is especially here to transfer his experience for your own benefit. I suggest whatever you learn here try to disseminate this knowledge to your peers and colleagues.

Mr. Joop Kikkert said I am satisfied by the active participation and learning abilities of young engineers and found their aptitude positive. I believe this interactive workshop will play a vital role in the development while going back to their job. Their suggestion has been taken positive to organize such workshops on regular basis in future. Keeping in view their need more attention will be paid to the calculation of the casting modulus and each participating foundry will be invited to bring two different castings with imperfections. He suggested similar workshops to be planned at least twice in a year in future. Mr. Joop Kikkert said that I am obliged and thankful to Mr. Abdul Rashid – secretary, PFA, for a very well organized workshop including location, lunches, tea breaks, beamer etc.

On day two at the end of the training, certificates were awarded to all participants in recognition to their active participation. Vice President PFA - Mr. Masud Akhtar and General Secretary PFA - Mr. Asim Qadri distributed certificates among the participants and thanked Mr. Joop Kikkert for his interest to make this workshop happen and successful.

Opinion of the participants was that the training was very informative. The interactive workshops for pattern plate layout/design and calculation of feeding; gating system and casting imperfections were very well explained. The live demonstration is an effective method as compared to presentations and it was very helpful. It was interesting to work in one group with representatives from other foundries (peers) and exchange of opinion opened doors for future collaboration. All the participants anonymously suggested to organize similar workshops at least 2, 3 times in a year. Future participants may be included from nearby towns having rich potential for foundry production or a workshop can be organized in Gujranwala, Multan etc.

Pakistan Foundry Association welcome you to participate in 5th International Foundry Congress & Exhibition (IFCE) to be held on December 02-03, 2014.

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For Further Information Please Contact:

Abdul Rashid - Secretary

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Report on CBI's proceedings in Pakistan by PFA

CBI (Centre for the Promotion of Imports from developing countries) is an Agency of the Netherlands Ministry of Foreign Affairs, supporting 48 developing countries in 27 sectors, providing them sustainable strengthening of the competitive capacity of SME exporters and producers, focusing primarily on European markets. CBI's project for Pakistan is one of the four projects of the program for the Metalworking Sector Asia.

The common objective is to develop Pakistan through export boost of engineering goods from Pakistan can only be met through mutual cooperation, support to each other and coordinated efforts to achieve efficiency, effectiveness and synergy . In this regard EDB, TDAP, NPO, PFA, PAAPAM and SMEDA are the six Business Support Organizations (BSOs) which have agreed to join hands. It is worth appreciating that PFA has been selected for Export Coaching Program (ECP) by CBI along with four government organizations and PAAPAM.

In Pakistan, CBI's project duration is 4 years (from Nov. 2012 till the end of 2016). This project aims to achieve increased export turnover of participant selected 20 companies up to € 10 million through the Export Coaching Program (ECP), directly supported by CBI. And increased export turnover of another 15 companies up to € 7.5 million through parallel ECP, supported by selected Business Support Organizations (BSO). This whole Export Coaching Program is divided in 12 activities out of which 3 activities have been completed.

1st Activity

"Process Control Workshop for Manufacturing Companies" was conducted on 25-27 June, 2013 at PAAPAM office, Lahore. The purpose of this three day training workshop was to build capacity within the participants. The persons trained can further impart training to others.

Topics included in training:

- Importance of Process Control in the factory
- Implement Operational Process Control
- Process Flow mapping
- Process flow in-efficiencies, quality disturbances, priorities

Mr. Robert Dresen, First Secretary Economic Department, Embassy of the Netherlands inaugurated that workshop in which CBI consultants Mr. Staf Henderieckx and Mr. Wouter Put delivered the subject matter in detail.

2nd Activity

- "EXPRO Training Seminar was conducted on 10-17 November, 2013 at Hague, Netherlands" Topics included in training:

- **4 step Export Marketing Plan.**

1- Situation analysis, own company (Strengths & Weaknesses)

2- Opportunities & Market research (Opportunities & Threats)

3- PMC (Product Market Combination) & Market entry strategy

4- Action plan and budget

- **EU Market trends and developments**

Social market driven trends

Aging, Congestion in Some urban areas, Income disparity, Understanding customer needs, Owning a car becomes less important, Focus on sustainable and environmentally-friendly products, Global growing population.

- **EU technical standards, norms and quality**

Increasing innovation, Pressure on carbon-free vehicles, Increasing IT integration, Innovative lightweight and sustainable materials.

- Introduction of Process Control, Quality Definitions, specifications, testing and certification, overall quality
- Cultural differences
- Segmentation/ Product-Market combination /Distribution Channels

Product Market Combinations (PMC) is the concept of matching products with markets: What, Where and to whom you want to sell your product.

Distribution could be done via Sales agent, Importer or Distributor, direct export to OEMs.

- Request for quotation Offers / contracts / General Terms and Conditions
- Risk management Packing & Logistic
- Communication plan, Promotional tools Value Proposition
- Company visit in Hengelo Hanover
- Travel to Hannover, All Company Visit
- Visit to Agritechnica

While visiting Hanover according to my observation European companies are willing to source finished and semi-finished products & components because of green environment and price hike of production in many respects but most of them do not want to visit Pakistan for business purposes due to security issues and willing to conduct meetings in UAE.

3rd Activity

"CBI's BSOD - EXPRO Training Workshop was conducted on 16-19 December, 2013 at Pearl Continental Hotel, Lahore".

The purpose of this training was to offer added value to the client SMEs by extracting Export Marketing Plan (EMP) on company level from the Sector Export Marketing Plan (SEMP) on sector level.

How to provide knowledge, skills and tools that can be directly applied by BSO staff?

By coaching in development and institutional embedding of export services portfolio in BSO strategy? How?

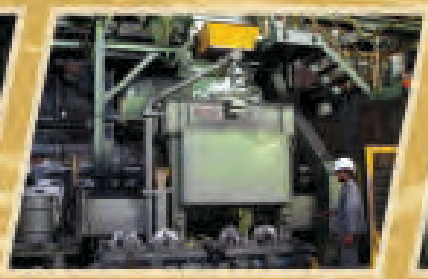
By development of Sector Export Marketing Planning competences at BSO level? How?

Topics included in training:

- Capacity building versus stake holder's added value and involvement
- Basic information about the European Union
- Market research techniques and web-based market research on CBI's MI-platform
- Work on your own market research targets, -questions and –plan for the EU
- Market access requirements for products in the European market, in particular in the field of consumer health and safety, environment and social issues
- Building your service portfolio and value chain mapping and analysis
- Image building, project proposals and implementation
- Export Marketing Plan template

PFA looks forward to expand manufacturing capacity of foundry industry and to promote trade, commerce and manufacture foundry products for the local and global markets particularly auto and agricultural tractor markets.

PFA understands there are many obstacles for the development of export of foundry products. If these are removed by the CBI coaching program our foundry industry will be able to compete with our neighbor countries to export in Europe etc.



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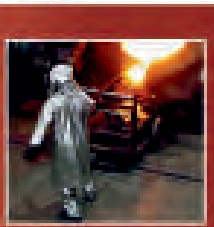

Personal Protective Equipment (PPE) must be worn by anyone in proximity to molten metal.