



# CASTING PRODUCTIVITY ANALYSIS OF GLOBAL FOUNDRY INDUSTRY

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## ABSTRACT

Casting manufacture is a value adding process and productivity is the key performance metric for any foundry's efficiency and effectiveness. Every foundry management continuously strives to improve casting productivity. But there are no systematic methods to compute productivity calculations (global, cluster wise, top ten nations, and regional) in terms of tonnes per man-year, tonnes/ foundry site and kg per man-hour. In the present investigation an attempt has been made to develop productivity calculation methods and computing actual productivities for global, top ten, and European Union based on world casting census reports for global foundry industry. Several useful conclusions have been arrived at.

## INTRODUCTION

The paradigm of casting technology<sup>1,2</sup> is undergoing a major evolution globally or universally. With the rapid increase of global population (over 6.3 billions) the primary task of foundry engineering has expanded its horizon beyond satisfying the needs of global industrial societies using the continuously depleting finite natural resources. The diverse distribution of natural resources<sup>3</sup> over the Continents of the world made the metal casting communities to think how to make them available economically to the needy industrial societies, which resulted into the evolution of global casting production systems. India is the fourth largest casting producer in the world as per 41<sup>st</sup> world casting census.

Castings are engineered metal components<sup>4</sup> formed by designing a mould and introducing molten metal into the mould cavity where the molten metal solidifies. Almost any metal that can be melted can also be cast and this flexibility allows the metal casting industry to produce simple or complex shaped components of infinite variety, whether they are produced once as a prototype or thousands of times for use. Metal casting normally involves five basic steps i.e. pattern making, moulding, core making, melting and pouring, and fettling and finishing. These steps collectively or individually determine the quality of the castings produced which is one of the

determinants of productivity. For example, castings with high dimensional accuracies, smooth surface finishes and with good mechanical properties are difficult to manufacture without proper control on total quality.

## METHODS FOR GLOBAL CASTING PRODUCTIVITY CALCULATIONS

The following casting productivities of global foundry industry have been defined.

- **Casting productivity of global foundry industry:** It is the ratio of total annual casting production reported in the world casting production census in metric tonnes and the total number of foundries reported in that year. Its unit is metric tonnes per foundry unit.
- **Casting productivity of global ferrous foundry industry:** It is the ratio of total annual ferrous casting production reported in the world casting production census in metric tonnes and the number of ferrous foundries reported in that year. Its unit is metric tonne per ferrous foundry.
- **Casting productivity of global non-ferrous foundry industry:** It is the ratio of total annual non-ferrous casting production reported in the world casting census and the number of non-ferrous foundries reported in that year in metric tonne per non-ferrous foundry.



- **Casting labour productivity of global foundry industry:** It is the ratio of total annual world casting production reported in the world casting production census in metric tonnes and the total number of workforce. The unit for productivity is in metric tonnes per man-year. It can also be defined in terms of kg per man-hour and number of castings produced per employee.

Average casting production per foundry site of global foundry industry in metric tonnes per foundry site is given by the equation:  $CP_s = [\sum P_i] \div [\sum N_i]$ , metric tonnes/ individual foundry site, .....E1,

where  $P_i$  = Global casting production in metric tonnes; and  $N_i$  = number of global foundries,

where  $i = 1, 2, 3, \dots, 8$  (1 = gray iron, 2 = malleable iron, 3 = ductile iron, 4 = steel, 5 = aluminium, 6 = zinc, 7 = magnesium, 8 = other non-ferrous),

Average foundry industry labour productivity in metric tonnes per man year =  $CP_l = [\sum P_j] \div [\sum E_j]$ , metric tonnes/ man-year, .....E2,

where E is the total number of employees, P is the casting production in metric tonnes; and  $j = 1, 2, 3$  (1 = global, 2 = Cluster, 3= national);

Average foundry industry labour productivity in kgs per man-hour =  $CP_k = [CP_j] \div [H_j]$ , kgs / man-hour, .....E3,

where  $H_j$  = annual working hours per man, where  $j = 1, 2$  and 3 (1 for global, 2 for cluster and 3 for national);

## PRODUCTIVITY ANALYSES OF GLOBAL FOUNDRY INDUSTRY

Global foundry industry<sup>5,6</sup> consists of about 33,537 numbers of foundries manufacturing approximately 68.31 million metric tonnes of metal castings worth \$120 billion employing 2.0 million people directly. It has an average production per foundry of around 2036 metric tonnes per year and labour productivity of around 34.16 metric tonnes per man-year. Its productivity (tonne / man-year, tonne / foundry site and kg / man-hour) based on 36<sup>th</sup> census of world casting production data is presented in Table 1. The results show that Germany has the highest productivity per site followed by France and USA. Considering productivity in metric tonnes / man-year, it is observed that Japan tops the list followed by Russia, and then the United States of America.

Productivity studies of top ten casting producing

nations have led to the following results: total number of foundries - 26,544, production - 55.99 million metric tonnes, productivity per foundry site - 2109 metric tonnes per year; total workforce - 1.531 million, productivity per man-year - 36.52 metric tonnes, productivity in kg / man-hour - 17.41. Top ten casting producing nations (along with production in million metric tonnes and number of foundries within brackets) are: P.R. China (14.89 million metric tonnes / 12000), United States (13.69 / 2700), Russia (6.2 / 1900), Japan (5.84 / 1789), Germany (4.64 / 702), India (3.16 / 4700), France (2.53 / 461), Italy (2.39 / 1100), S. Korea (1.68 / 754) and United Kingdom (0.968 / 438).

The global average productivity is approximately 15.18 kg / man-hour whereas the same for Japan is 44.24 kg / man-hour. There are a large number of countries in the world for which the productivity values are much lower than the global average. Use of advanced technology could be one of the reasons for maintaining high level of productivity in some of the counties. The comparative productivity figures might be useful for any country in working out strategies for improvement and setting goals.

## PRODUCTIVITY OF GLOBAL FOUNDRY CLUSTERS

Global foundry industry<sup>7,8</sup> can be divided into seven regional foundry clusters. They are Asia Pacific Foundry Cluster (APFC), African Foundry Cluster (AFC), European Union Foundry Cluster (EUFC), Eastern and Central Europe Foundry Cluster (ECEFC), Latin American Foundry Cluster (LAFC), Middle East Foundry Cluster (MEFC) and North American Free Trade Area Foundry Cluster (NAFTAFC). APFC consists of fourteen major casting producing nations i.e., PR China, Japan, India, South Korea, Australia, Singapore, Taiwan, Indonesia, Hong Kong, Malaysia, New Zealand, Pakistan, Philippines and Thailand together producing around 29.46 million metric tonnes annually. The total number of foundries in APFC is 20,577 and direct employment potential is around 1.148 million. The average productivity per foundry site is around 1430 metric tonnes and that of labour productivity is around 25.7 metric tonne / man-year. The results of the analysis are presented in Table 1. APFC has the highest number of foundries but EUFC has the highest labour productivity and the MEFC has the lowest figure in tonne / man-year.

AFC consists of two casting producing nations (South Africa and Zambia) reporting to world foundry casting census. South Africa of AFC is the major



**Table 1 : Productivity of Global Foundry Industry**

S.No.	Name of the nation	No. of foundries as per 36 <sup>th</sup> WCP (1)	Production, MMTs (2)	Productivity per foundry site, MTs (3) = (2) × 10 <sup>6</sup> ÷ (1)	No. of work force (4)	Annual working hours, hours (5)	Productivity, ton / man-year (6) = (2) ÷ (4)	Productivity, kg per man-hour (7) = (6) × 10 <sup>3</sup> ÷ (5)
01	China	12000	14.89	1241	700000	2400	21.27	8.86
02	USA	2700	13.69	5070	225000	2080	60.84	29.25
03	Russia	1900	6.2	3263	100000	2080	62	29.81
04	Japan	1789	5.84	3264	60000	2200	97.33	44.24
05	Germany	702	4.64	6610	80000	1550	58	37.42
06	India	4700	3.16	672	200000	2400	15.8	6.58
07	France	461	2.53	5488	43000	2080	58.84	28.29
08	Italy	1100	2.39	2173	70000	2080	34.14	16.42
09	S. Korea	754	1.68	2228	33000	2080	50.91	24.48
10	UK	438	0.968	2215	20000	2080	48.5	23.32
11	Top Ten	26544	55.99	2109	1531000	2100	36.52	17.41
12	APFC	20,577	29.46	1430	1148000	2350	25.67	10.92
13	AFC	209	0.59	2800	22200	2400	26.58	11.1
14	EUFC	4,500	15.53	3450	269000	2050	57.62	28.11
15	ECEFC	3,343	9.03	2450	186000	2080	48.39	23.26
16	LAFC	1,550	2.15	1390	67200	2400	32	13.33
17	MEFC	1,210	1.74	1440	58000	2400	30	12.5
18	NAFTAFC	4,682	14.63	3125	300000	2080	48.76	23.45
19	Global	33,537	68.31	2036	2000000	2250	34.16	15.18

Codes: APFC- Asia Pacific Foundry Cluster, AFC- African Foundry Cluster, EUFC- European Union Foundry Cluster, ECEFC- Eastern Central European Foundry Cluster, LAFC- Latin America Foundry Cluster, MEFC- Middle East Foundry Cluster, NAFTAFC- North American Free Trade Area Foundry Cluster. Data source: 36<sup>th</sup> census of WCP of Modern Casting Journal

casting-producing nation. This cluster has productivity per foundry site of around 2,800 tonnes and labour productivity in metric tonnes / man-year is around 26.4.

EUFC has 17 nations (Germany, France, Italy, Spain, Greater Britain, Poland, Czech. Republic, Austria, Sweden, Belarus, Belgium, Netherlands, Finlands, Portugal, Hungary, Switzerland, Norway and Denmark) with 4,500 foundries producing castings of around 15.53 million metric tonnes with productivity per foundry site of 3,450 metric tonnes and labour productivity of around 57.7 metric tonne / man-year.

ECEFC (Russia, Croatia, Ukraine, Romania, Slovenia, Slovakia and Yugoslavia) has 3,343 numbers of foundries producing 9.03 million metric tonne / year. Its productivity per foundry site is found to be around 2,450 metric tonnes and labour productivity is 46.6 metric tonne / man-year. LAFC consists of six nations viz. Brazil, Argentina, Chile, Peru, Columbia, and Venezuela. It has around 1,550 number of foundries

producing 2.15 million metric tonnes of castings. The productivity per foundry site and labour productivity of LAFC are 1,390 metric tonnes and 32 metric tonnes per man-year respectively.

MEFC (Turkey, Iran, Egypt, UAE, and Israel) has 1,210 numbers of foundries producing 1.74 million metric tonnes. The labour productivity and productivity per foundry site are found to be around 1,440 metric tonnes and 30 metric tonne / man-year respectively. NAFTAFC is the second largest casting producer (20.2%) among the seven foundry clusters. It consists of nations like United States of America, Mexico and Canada. It has 4,682 numbers of foundries producing metal castings of around 14.63 million metric tonnes per annum. It has labour productivity and productivity per foundry site of 48.8 metric tonne / man-year and 3,125 metric tonnes respectively.

Clusterwise global foundry labour productivity is varying widely from 25.7 to 57.7 tonne / man-year.



EUFC has the highest productivity (57.7) followed by NAFTAFC (48.8). APFC has the lowest labour productivity of around 25.7 metric tonne / man-year. The Cluster average productivity is found to be 38.2 metric tonnes per man-year. The average productivity per foundry site is varying from 1,390 to 3,450 with a cluster average of 2,020 metric tonne per foundry site. EUFC has got the highest productivity per foundry site (3,450) followed by NAFTAFC (3,125). LAFC has got the lowest productivity per foundry site (1,390 metric tonnes). Its percentage share of world casting production is varying from 0.7 to 40.3. APFC has the highest share (40.3) followed by EUFC (21.3). AFC has the lowest percent of global casting production (0.7). Number of foundry units per member countries is varying from 209 to 20,577 with a cluster average of 5,143. APFC has got the highest number of foundries (20,577) followed by NAFTAFC (4,682) and EUFC (4,500). AFC has got the lowest number of foundries (209).

#### PRODUCTIVITY OF GLOBAL TOP-TEN CASTING PRODUCING NATIONS

Global top-ten casting producing nations<sup>9,10</sup> are P.R.China, United States of America, Russia (Commonwealth of Independent States), Japan, Germany, India, France, Italy, Korea and United Kingdom. There are around 26,544 foundries producing approximately 55.99 million metric tonnes with a direct manpower of around 1.531 million. The average productivity is found to be around 36.57 metric tonne / man-year. The average productivity in kg / man-hour is found to be 17.41. The average productivity per foundry site is around 2,109 metric tonnes.

P. R. China has the largest number of foundries (12,000) in the world followed by India 4,700 and United States 2,700. In terms of casting production in million metric tonnes: China has produced 14.89 followed by U.S.A. 13.69 and Russia 6.2. The average labour productivity of top-ten nations is widely varying from 15.8 to 97.33 metric tonne / man-year. Japan has shown the highest labour productivity of 97.33 followed by Russia 62 and USA 60.84 metric tonne / man-year. Average production per foundry site for top-ten nations is varying from 672 to 6,610 metric tonnes. Germany has highest average production per foundry site (6,610) followed by France (5,488 metric tonnes) and USA (5,070). The average productivity in kg / man-hour is varying from 6.58 (India) to 44.24 (Japan). Japan has the highest productivity in kg / man-hour (44.24)

followed by Germany (37.42) and Russia (29.81).

#### PRODUCTIVITY OF EUROPEAN UNION FOR FIVE YEARS

European Union Foundry Cluster (EUFC) is one of the seven world foundry clusters<sup>11</sup>. It consists of the following seventeen nations: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Great Britain (United Kingdom), Hungary, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden and Switzerland. The productivity studies for a period of five years have been carried out. EUFC consists of 4,500 foundries producing 15.53 million metric tonnes of castings, with an employment potential of 0.269 million.

The average productivity of ferrous foundries<sup>12</sup> of EUFC was found to be around 54 metric tonnes / man-year and that of non-ferrous foundries was around 18 metric tonnes / man-year. The maximum productivity in ferrous foundries was around 89 metric tonnes / man-year in France and minimum was 20.1 metric tonnes / man-year in Poland. The average productivity in ferrous foundries has increased by 22.2% during the period. The productivity analysis (both ferrous and non-ferrous) of EUFC is presented in Table 2. Non-ferrous casting productivity of EUFC varies from 34 tonnes / man-year (in Belgium) to minimum productivity 5.6 tonnes / man-year (in Hungary). The increase of productivity during five years is around 13.5%. Belgium has the highest (average) productivity of 30.92 tonnes / man-year whereas Hungary has the lowest (average) of 8.26 tonnes / man-year. Four nations i.e., Germany, France, Italy, and United Kingdom belong to the top ten casting producing nations.

Total ferrous casting production of EUFC varies from 11.1 to 11.8 million tonnes (an increase by 6.3%) whereas non-ferrous casting production was varying from 2.4 to 2.8 million tonnes (an increase by 16.7%) during five years. Total number of ferrous foundries varied from 1,582 to 1,504 (a decrease by 4.9%) whereas the number of non-ferrous foundries varied from 2,797 to 2,876 (an increase by 2.8%). The employment in ferrous foundries was varying from 2,11,004 to 1,77,360 (a decrease by 15.9%) whereas the employment in non-ferrous foundries varied from 82,156 to 77,454 (a decrease by 5.7%). These results show that though there has been some increase in production, the employment figure has shown a decline. The reason possibly lies with adoption of more

**Table 2: European Union Average Productivity of Ferrous and Non-Ferrous Metal Castings (tons/ man-year) during five years**

Country	Ferrous casting productivity					Change + / -	Non-ferrous casting productivity					Change + /-
	Year 1	Year2	Year3	Year4	Year5		Year 1	Year2	Year3	Year4	Year5	
Austria	48.4	54.9	54.9	57.3	65.5	+35.3	21.8	22.4	22.1	24.4	24.7	+13.3
Belgium	56.3	51.2	64.9	46.1	80.9	+75.5	27.3	30.7	29.6	34.0	33.0	+14.5
Czech Rep.	48.3	50.9	39.1	56.4	48.3	+44.3	14.4	16.8	18	19.3	18.2	+34
Denmark	57.5	57.9	58.1	65.1	61.5	+13.9	9.3	4.51	10.6	10.6	12.9	+38.7
Finland	51.5	52.7	53.0	58.0	57.2	+12.6	16.0	14.8	13.4	11.3	13.9	+41.6
France	76.0	85.2	83.5	89.1	86.3	+17.2	17.0	18.9	19.3	21.2	21.5	+26.6
Germany	72.5	78.0	78.7	83.7	84.9	+17.1	21.2	24.5	23.6	25.5	24.4	+20.3
Gr. Britain	39.6	44.9	47.5	53.8	54.9	+38.6	17.1	18	18	18	18	+5.2
Hungary	22.4	22.4	20.9	23.6	23.0	+10	5.6	6.3	8.9	8.1	12.4	+121.4
Italy	69.0	68.4	67.2	68.6	67.0	+3	20	20	20	20	20	0
Netherlands	52.2	57.0	57.0	64.2	64.1	+23	20	20	20	20	20	0
Norway	43.2	35.0	39.7	40.5	41.9	+23.4	18.1	17.5	17.9	17.8	20.7	+18.3
Poland	21.8	20.1	21.4	25.1	25.2	+25.4	15.0	15.0	12.9	13.6	17.5	+35.7
Portugal	35.2	37.2	34.9	36.8	36.0	+6.6	11.3	14.6	17.2	17.7	18.3	+62
Spain	54.2	51	54.1	67.7	86.8	+70.2	26.7	24.9	27.3	21.5	28.2	+31.2
Sweden	73.9	77.7	69.4	73.1	64.4	+20.7	16.6	18.5	15.1	15.8	14.4	+28.5
Switzerland	47.5	51.2	53.0	50	44.0	+20.5	11.1	11.7	11.5	12.0	11.0	+9.1
Average	48.3	52.8	53.6	56.4	59.0	+22.2	17.1	17.4	18.0	18.2	19.4	+13.5
Maximum	76	85.2	83.5	89.1	84.9		27.3	24.5	29.6	34	33	

automation. The annual production, employment and number of foundries have been, however, found to be varying from year to year.

The productivity of EUFC for a period of five years was computed for ferrous castings and non-ferrous castings. The average ferrous casting productivity had been varying from 48.3 to 59 tonnes / man-year during five years whereas the non-ferrous casting productivity was found to be varying from 17.1 to 19.4 tonnes per man-year.

The productivities of EU for ferrous foundries and non-ferrous foundries in kg per man-hour during five years were calculated and are shown in Table 3. Ferrous castings productivities are found to be higher than that of non-ferrous castings during the period under consideration. The number of annual working hours for Germany is 1,550 and the remaining countries have working hours of 2,080. Germany has the highest ferrous casting productivity (54.77 kg / man-hour) followed by France (42.84) and Sweden (37.36). The lowest ferrous casting productivity was found to be in Poland and it is around 9.66 kg / man-hour. Germany has the highest non-ferrous casting productivity (16.45

kg / man-hour) followed by Belgium (16.35) and Spain (13.56 kg / man-hour). Denmark had the lowest non-ferrous casting productivity in the year 2 and it was around 2.17 kg / man-hour. Hungary is found to be the second lowest in non-ferrous casting productivity and it is around 2.69 kg / man-hour.

The average production figures per foundry for EUFC during five years were also computed for ferrous and non-ferrous castings and are presented in Table 4. France has the highest average production per foundry (14,793 tonnes) for ferrous castings followed by Germany (13,199 tonnes) and Denmark (8,033 tonnes). Portugal has the lowest figure per ferrous foundry and its value is around 1,563 tonnes. Norway has the highest production per non-ferrous foundry (3,090 tonnes) followed by Austria (2,888 tonnes) and Belgium (2,380 tonnes). The production per foundry for ferrous foundries is found to be higher than that of non-ferrous.

Total castings production (ferrous and non-ferrous) of EUFC is presented in Table 5. Total numbers of ferrous and non-ferrous foundries are presented in Table 6. and the employment in ferrous



**Table 3 : European Union Productivity of Ferrous and Non-Ferrous Castings during Five Years (in kg / man-hour)**

Country	Non-ferrous castings productivity					Ferrous castings productivity				
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
Austria	10.47	10.77	10.63	11.73	11.88	23.27	26.39	26.39	27.55	31.49
Belgium	13.13	14.76	14.23	16.35	15.87	27.07	24.62	31.2	22.16	38.89
Czech Rep.	6.92	8.08	8.65	9.28	8.75	23.22	24.47	18.8	27.12	23.22
Denmark	4.47	2.17	5.10	5.10	6.20	27.64	27.84	27.93	31.30	29.57
Finland	7.69	7.12	6.44	5.43	6.68	24.76	25.34	25.48	27.88	27.5
France	8.17	9.09	9.28	10.19	10.34	36.54	40.96	40.14	42.84	41.49
Germany	13.68	15.81	15.23	16.45	15.74	46.77	50.32	50.77	54.0	54.77
Great Britain	8.22	8.65	8.65	8.65	8.65	19.04	21.59	22.84	25.87	26.39
Hungary	2.69	3.03	4.28	3.89	5.96	10.77	10.77	10.05	11.35	11.06
Italy	9.62	9.62	9.62	9.62	9.62	33.17	32.88	32.31	32.98	32.21
Netherlands	9.62	9.62	9.62	9.62	9.62	25.1	27.4	27.4	30.87	30.82
Norway	8.7	8.41	8.61	8.56	9.95	20.77	16.83	19.09	19.47	20.14
Poland	7.21	7.21	6.20	6.54	8.41	10.48	9.66	10.29	12.07	12.12
Portugal	5.43	7.02	8.27	8.51	8.8	16.92	17.89	16.78	17.69	17.31
Spain	12.84	11.97	13.13	10.34	13.56	26.06	24.52	26.0	32.51	41.73
Sweden	7.98	8.65	7.26	7.6	6.92	35.52	37.36	33.37	35.14	30.96
Switzerland	5.34	5.63	5.29	5.77	5.28	22.83	24.62	25.48	24.04	21.15
Average	8.36	8.68	8.85	9.04	9.54	25.29	26.09	26.14	27.93	28.87

**Table 4: European Union Average Production of Ferrous and Non-Ferrous Foundries during Five Years (in tons / foundry site)**

Country	Non-ferrous foundry productivity					Ferrous foundry productivity				
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
Austria	2515	2739	2888	1795	1798	6071	6789	6989	7656	8017
Belgium	496	460	2380	2092	2200	2086	3610	5972	6242	7119
Czech Rep.	589	689	739	1030	968	3366	3547	2727	2849	2966
Denmark	389	170	400	364	600	7092	7800	7818	8033	7142
Finland	667	700	588	370	455	6505	6453	4739	5880	6290
France	1026	1113	1154	1255	1275	12271	14793	12854	13671	13174
Germany	1903	1921	1900	2059	2035	10050	11305	11468	12569	13199
Gr. Britain	498	218	372	824	824	4403	4721	4403	4890	4821
Hungary	456	605	636	582	749	2519	2297	2021	2338	1903
Italy	904	1040	1040	1199	1187	4814	4866	4862	5175	4925
Netherlands	1113	1113	1978	1978	1978	6246	6391	4172	4690	4562
Norway	584	1110	1200	1886	3090	5217	5442	5642	5842	6582
Poland	216	216	273	273	249	3591	2885	2653	2916	3059
Portugal	216	278	307	328	378	1563	1590	1602	1677	1639
Spain	1805	1466	1688	1331	2584	4060	3155	3436	4169	4192
Sweden	549	609	688	696	635	5235	5284	5167	5443	4994
Switzerland	409	496	509	474	492	4952	5339	5304	5213	4796
Average	849	879	1102	1090	1265	5297	5663	5402	5838	5846

**Table 5: European Union Total Casting Production during Five Years**

Country	Non-ferrous castings in (1000 ton)					Ferrous castings in (1000 ton)				
	Year1	Year 2	Year 3	Year4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
Austria	83.0	90.4	92.4	105.9	113.3	170.0	190.1	181.7	191.4	192.4
Belgium	27.3	25.3	23.8	27.2	26.4	169.0	144.4	149.3	149.8	149.5
Czech Rep.	38.3	44.8	48.0	57.7	58.1	467.8	493.0	379.1	390.3	415.3
Denmark	3.5	1.7	4.0	4.0	4.8	85.1	85.8	86.0	96.4	85.7
Finland	10.0	10.5	10.0	10.0	10.0	123.6	122.6	109.0	117.6	119.5
France	312.0	338.2	343.8	373.9	379.8	2,122.8	2,500.	2,146.6	2,283.1	2,147.4
Germany	704.1	783.9	777.0	842.1	842.4	3,417.1	3,662.9	3,555.2	3,758.2	3,801.4
Gr. Britain	199.3	121.0	206.1	206.1	206.1	1,202.0	1,076.3	942.2	968.2	906.3
Hungary	17.8	24.8	35.0	44.8	58.4	78.1	78.1	68.7	74.8	62.8
Italy	722.8	832.3	832.1	959.1	960.0	1,521.2	1,508.4	1492.6	1,516.4	1,433.3
Netherlands	17.8	17.8	17.8	17.8	17.8	137.4	140.6	121.0	136.0	132.3
Norway	11.1	22.2	25.2	26.4	30.9	62.6	65.3	67.7	70.1	72.4
Poland	66.5	66.5	84.0	84.0	72.2	732.5	675.0	610.2	671.2	673.0
Portugal	13.6	17.5	21.2	22.6	25.3	96.9	98.6	97.7	102.3	100.0
Spain	153.4	140.7	153.6	121.1	142.1	751.0	706.6	759.3	950.5	955.7
Sweden	46.5	51.8	55.7	58.5	53.3	251.3	264.2	253.2	266.7	244.7
Switzerland	18.8	22.3	22.9	25.1	24.1	113.9	122.8	122.0	119.9	105.5
Total	2,427.9	2,593.8	2,528.7	2,7623	2,421.3	11,502.1	11,685.6	11,148.6	11,862.9	11,598.2

**Table 6: European Union Number of Foundries (Ferrous and Non-ferrous) during Five Years**

Country	Non-ferrous foundries					Ferrous foundries				
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
Austria	33	33	32	59	63	28	28	26	25	24
Belgium	55	55	10	13	12	81	40	25	24	21
Czech Rep.	65	65	65	56	60	139	139	139	137	140
Denmark	9	10	10	11	8	12	11	11	12	12
Finland	15	15	17	27	22	19	19	23	20	19
France	304	304	298	298	298	173	169	167	167	163
Germany	370	408	409	409	414	340	324	310	299	288
Great Britain	400	554	554	250	250	273	228	214	198	188
Hungary	39	41	55	77	78	31	34	34	32	33
Italy	100	100	800	18	809	316	310	307	293	291
Netherlands	16	16	9	9	9	22	22	29	29	29
Norway	19	20	21	14	10	12	12	12	12	11
Poland	308	308	308	308	290	204	234	230	230	220
Portugal	63	63	69	69	67	62	62	61	61	61
Spain	85	96	91	91	55	185	224	221	228	102
Sweden	85	85	81	84	84	48	50	49	49	49
Switzerland	46	45	45	53	49	23	23	23	23	22
Total	2,797	2,918	2,874	2,629	2,876	1,582	1,729	1,702	1,445	1,504



**Table 7: European Union Employment in Foundry Industry during Five Years**

Country	Non-ferrous foundries					Ferrous foundries				
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
Austria	3,811	4,029	4,179	4,349	4,585	3,513	3,465	3,314	3,342	2,936
Belgium	1,000	1,824	803	800	800	3,000	2,823	2,299	3,260	1,847
Czech Rep.	2,666	2,666	2,666	2,995	3,192	9,686	9,686	9,686	6,919	8,598
Denmark	377	377	377	377	372	1,481	1,481	1,481	1,481	1,393
Finland	627	708	744	884	718	2,400	2326	2058	2027	2090
France	18,372	17,296	17,821	17,651	17,651	27,817	26,407	25,714	25,613	24,871
Germany	33,161	32,000	33,000	33,000	34,500	47,142	46,944	45,157	44,896	44,796
Gr. Britain	11,655	6,722	11,450	11,450	11,450	30,334	24,000	20,000	18,000	16,500
Hungary	3,208	3,208	3,941	5,503	4,702	3,485	3,485	3,285	3,175	2,734
Italy	36,140	41,615	41,615	47,955	48,000	22,050	22,050	22,200	22,100	21,400
Netherlands	890	890	890	890	890	2,633	2,462	2,122	2,119	2,085
Norway	614	1,271	1,411	1,483	1,491	1,448	1,864	1,706	1,703	1,754
Poland	4,433	4,433	6,500	6,200	4,130	33,600	33,600	28,500	26,800	26,370
Portugal	1,200	1,200	1,230	1,280	1,380	2,755	2,649	2,800	2,782	2,780
Spain	5,750	5,650	5,620	5,620	5,034	13,860	13,860	14,040	14,040	11,006
Sweden	2,800	2,800	3,700	3,700	3,700	3,400	3,400	3,650	3,650	3,800
Switzerland	1,700	1,900	2,000	2,100	2,200	2,400	2,400	2,300	2,400	2,400
Total	82,156	83,537	95,065	91,772	77,454	2,11,004	1,98,021	1,88,831	1,70,294	1,77,360

and non-ferrous casting foundries is presented in Table 7. The ferrous casting production in million tonnes in Germany is the highest (3.8) followed by France (2.2) and Italy (1.4) and Hungary had the lowest ferrous casting production and it is around 62,800 metric tonnes in the year 5. The total non-ferrous casting production in metric tonnes in Italy was the highest (9,60,000) followed by Germany (8,42,400) and France (3,79,800). Denmark had the lowest non-ferrous casting production of around 4,800 metric tonnes. Non-ferrous casting production in Italy has been increasing steadily from 722.8 to 960 thousand metric tonnes (32.8% increase) during five years. Italy had the largest number (291) of ferrous foundries followed by Germany (288) and Poland (220) in the year 4. The number of ferrous foundries in Germany had decreased from 340 to 288 (a decrease by 15.3%) over a period of five years. Italy had also shown a decline in the number of ferrous foundries from 316 to 291 (a decrease by 7.9%). The non-ferrous foundries of Germany had increased from 370 to 414 (an increase by 10.6%) during five years. Belgium had shown a constant decline in number of non-ferrous foundries from 55 to 12 (a decrease by 78.2%) during 1997-2001. For

the remaining countries the number of foundries is more or less static.

The employment in the ferrous and non-ferrous foundry industry in EU during five years is presented in Table 7. The employment in ferrous foundries during five years varied from 2,11,004 to 1,77,360 and the employment in non-ferrous foundries varied from 82,156 to 77,454. The highest employment in ferrous foundries is found to be in Germany (47,142) followed by Poland (33,600) and Great Britain (30,334). Great Britain has shown a constant decline in employment from 30,334 to 16,500 (a decrease by 50.5%) during five years. Most of the countries are showing a decline in employment except Sweden, Portugal and Norway. However the variations are in an oscillating manner. The total employment in ferrous foundries decreased from 2,11,004 to 1,77,360 during year 1 to year 5. On the other hand, employment in non-ferrous foundries was increasing continuously during five years. Italy had the highest employment in non-ferrous foundries (48,000) followed by Germany (34,500) and France (17,651) in the year 5.



The average productivity of ferrous castings on EUFC is found to be around 54 tonnes per man-year during five years. France had the highest ferrous casting productivity (around 89.1 tonne / man-year) during year 2. The increase in ferrous casting productivity is varying from +3 (Italy) to +70% (Spain) during five years and the average is found to be around +22.2% during the same period. The increase in non-ferrous casting productivity is varying from 5.6 (Hungary, year 1) to 34 metric tonnes / man-year (Belgium, year 4). The increase or decrease over a five-year period is varying from 5.2% (G.Britain) to 121.4 % (Hungary). The average productivity increase for non-ferrous castings of EU is found to be around +13.5%.

## CONCLUSIONS

In the present research work productivity analyses of global foundry industry, top ten casting producing nations, clusterwise global foundry and European Union (17 nations) for a period of five years have been done. The major conclusions drawn over a given period of time are listed below:

- Productivity of global foundry industry was found to be around 34.16 metric tonnes per man-year, and 2036 metric tonnes per foundry-site. Productivity values of seven major global foundry clusters were found to be varying from 25.67 to 57.62 metric tonnes per man-year and the average is around 38.2 metric tonnes per man-year. European Union Foundry Cluster (EUFC) has the highest labour productivity and Asia Pacific Foundry Cluster (APFC) has the lowest labour productivity.
  - Top ten casting producing nations are identified and their productivities were computed.
  - Global foundries were classified into seven clusters and their productivities were computed.
  - The average global productivity per foundry site (clusterwise) had been varying from 1390 to 3450 metric tonnes and the cluster average productivity per foundry site was found to be around 2020 metric tonnes.
  - Cluster wise contribution to total global casting production was varying from 0.7 (African Foundry Cluster) to 40.3 % (Asia Pacific Foundry Cluster).
- The average productivities of ferrous as well as non-ferrous castings of EUFC were computed and analysed. The increase in productivity was found to be around 22.2% during a five year period.
  - The maximum productivity of ferrous as well as non-ferrous castings in European Union was computed and analysed. The increase in non-ferrous productivity was around 13.5% during the five year period.
  - The average ferrous casting productivity of European Union during year 1 to year 5 had been varying from 25.29 to 28.87 kg per man-hour whereas the average non-ferrous casting productivity was found to be varying from 8.36 to 9.54 kg per man-hour.

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