

Evaluation of the production of DRI in the world and Iran in 2021

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Abstract

Direct Reduced Iron (DRI) is one of the charging materials of steel furnaces and its production is increasing in the world and Iran. India and Iran are the main producers of DRI in the world. The production process of DRI based on natural gas forms the main pillar of green steel production. In this method, 2/3 of iron ore is reduced with hydrogen gas and the remaining 1/3 with CO gas. Hot charging (HDRI) of DRI in EAFs brings many advantages, including increased productivity, reduced energy, refractories, and graphite electrode consumption. Last year, 119.16 million tons of DRI were produced worldwide, of which 13.72 million tons were charged as the HDRI charge in EAFs. The Mobarakeh Steel Company Group of Iran is the largest producer of DRI (with 9 million tons) among the world's steel companies. It is expected that in the next 2-3 years, Iran will overtake India and become the first producer of DRI in the world.

Keywords : DRI, Steel, Green Steel, Sponge Iron, HDRI, EAF.

1. Introduction

In 2021, the world's production of DRI products increased by 13.7% to 119.16 million tons. Figure-1 shows the types of DRI products, including HBI, DRI produced from pellets, and lump iron ore. This production has been achieved while the total production capacity of DRI in the world has reached 132 million tons. In 2021, the highest growth of DRI production has been observed in Argentina and India, 1.41 (160%) and 39.11 (18.6%) million tons, respectively. Compared to 2020, the production of DRI in the Islamic Republic of Iran has increased by 1.65 million tons. A slight increase in production can be seen in Qatar compared to the previous year (0.79 million tons). In Saudi Arabia, an increase in the production of

DRI by 940 thousand tons has been reported. The MENA region has obtained 46% of the world's DRI by producing 54.84 million tons of DRI. In the previous year, Russia produced 7.89 million tons of DRI. With two key points of the world, in other words, in India and Iran, there is a large increase in production. The amount of DRI production in India has increased to 39.11 million tons, while in 2010, the amount of DRI production in this country was 23.4 million tons. 50% of India's DRI production is used in induction furnaces. Table-1 shows the trend of DRI production in India. In Venezuela, the amount of DRI production has decreased by 130 thousand tons compared to 2020. In Table-2, the production trend of DRI in the world during the years 2005-2021 can be seen. Islamic countries produce 45.73 percent of the world's DRI equivalent to 52.11 million tons. The share of Arab countries in the production of DRI in the world is 19.4%. Currently, two modules for the production of DRI by the Energron method with a capacity of 1 and 0.6 million tons, respectively, in Bao Steel and HBIS, China, by Tenova HYL are in the engineering phase. In

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2021, the cumulative production of DRI by the Midrex method exceeded 1286.48 million tons. In the 39th year in a ranking list Midrex's direct reduction process was at the top of the world's main s DRI production processes with the production of 70.85 million tons (59.5% of the world's total DRI production). The amount of DRI produced by the Midrex production process, except for Iran, has been recorded at 41.68 million tons. During the previous year, the share of DRI production processes based on gas and coal were 79.9% and 20.1%, respectively. The cumulative production of DRI by different methods from 1970 to now (2021) is estimated to be more than 2001.6 million tons. It is expected that by 2030, the production capacity of DRI iron in the world will exceed 200 million tons.

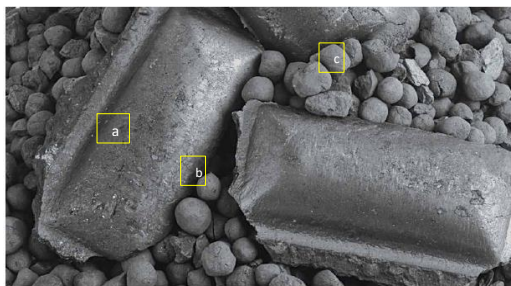


Fig.1. Types of DRI products (a)HBI b) DRI from pellet c) DRI from lump) [1].

Table 1. Production trend of DRI in India (million tons) [2].

Year	MMT	Year	MMT	Year	MMT
2006	14.74	2014	17.31	2018	28.11
2007	19.06	2015	17.68	2019	36.8
2008	21.2	2011	21.97	2020	32.98
2009	22.03	2012	20.05	2021	39.11
2010	23.43	2016	18.47		
2013	17.77	2017	22.34		

Table 2. World production trend of DRI (million tons) [2].

Year	Production	Year	Production
2005	56.87	2014	74.55
2006	59.7	2015	72.57
2007	67.12	2016	72.76
2008	67.95	2017	87.1
2009	64.33	2018	100.73
2010	70.28	2019	108.1
2011	73.21	2020	104.4
2012	73.14	2021	119.16
2013	74.92		

Currently, the production growth of the Midrex process is very high and it is expected to produce another 75 million tons of DRI this year. Last year, out of 91 modules installed, 82 modules with a capacity of 82.09 million tons were working. Currently, 14 Midrex DRI modules are being built in the countries of Iran (15.22 million tons), Russia (4.16 million tons), and Algeria (2.5 million tons) with a total capacity of 21.88 million tons. Table 3 shows the DRI production units in Iran under construction. In figure-2, the process of increasing the production capacity of Midrex modules can be seen. Following the Midrex process, the coal-based rotary kiln process ranks second with the production of more than 25.4 million tons (30.27% of the world's total production). The amount of production of Process HYL Energiron is reported to be 15.13 million tons (12.7% of the world's total production). In the previous year, Iran's innovative DRI production process known as PERED produced more than 2.622 million tons (2.2% of the world's total production). PERED technology is also known as 'Persian Reduction' technology. It is the direct reduction technology invented and patented by 'Mines and Metals Engineering GmbH' in 2007. The PERED direct reduction process converts iron oxides, in the form of pellets or lump ore, to a highly reduced product for suitable steel making. It is worth mentioning that in Iran DRI units of Miyaneh, Baft, Shadegan, and Neyriz companies produce DRI by the PERED method. The capacity of each of these modules is 800 thousand tons per year. A DRI Module with a capacity of 300 thousand tons per year using the PERED method is being installed in Chinese Jinzhong. During the previous year, 23 DRI modules were installed using the HYL Energiron method, 16 modules with a capacity of 16.63 million tons, are being in operation and another 7 modules (capacity of 4.97 million tons) have been stopped. Currently, 8 Midrex modules (except for Iran), 4 HYL modules, and one PERED module are being built in the world. A typical comparison between PERED and other DRI technology is shown in table- 4. Figure-3 shows the contribution of different processes in the production of DRI in the world in 2021. In addition, figure-4 shows the contribution of different methods in the global DRI gas base process in 2021. Midrex's share in the global DRI gas base process is 79.9%. Iran ranks first in the production of gas-based DRI in the world with a production of 31.85 million tons. Iran's DRI production capacity last year is estimated at 37.18 million tons. In the figure-5, the growth trend of Iran's DRI production and capacity increase is displayed. In fact, the utilization rate of DRI production last year in Iran was recorded at 85.66%. Since the beginning of the operation of Midrex units, the amount of DRI produced by the Midrex method has been reported to be 1235.9 million tons. The Islamic Republic of Iran ranks first in the world in the production of DRI (31.85 million tons) based on gas. The amount of production by the Iranian IMIDRO organization in 2021 was 29.87 million tons. Table-5 shows the produc-

tion process of DRI of the IMIDRO Organization of Iran. The amount of DRI production by the Iranian Mobarakeh Steel Company was 6.322 million tons. The amount of DRI production by these Hormozgan and Saba companies in 2021 was reported as 0.971 and 1.713 million tons, respectively. The Mobarakeh Group Steel Company is the largest DRI producer in the world with a production of over 9 million tons. The DRI production capacity of Mobarakeh Group is more than 11 million tons. The amount of DRI production by the Khuzestan Steel Company was 3.39 million tons in the previous year. It is worth mentioning that the number of pellets produced by this company in the previous year was 5.622 million tons. In 2021, the Iranian Chadormalo company produced more than 1.318 million tons of DRI. In the table-6, the

companies producing DRI in Iran in the year 2021 are given. Among the companies producing DRI in Iran, the Shadegan Steel Company has achieved the highest production growth with 34.98%, amounting to 805,221 tons of HBI. Iran's production of DRI by PERED method in the previous year (1400 Iranian Calendar) was recorded as 2.933 million tons. Table -7 shows the manufacturers of DRI in Iran using the PERED method. The production capacity of DRI in Arab countries has been recorded at 25 million tons. Last year, the production of DRI in Arab countries was 23.1 million.

It is worth mentioning that Cliffs company has greatly helped to increase American production by setting up a DRI /HBI production unit. Figure-6 shows the view of Cliffs company's DRI production unit.

Table 3. DRI production units under construction in Iran.

Nr	Name of Unit	Location	Capacity
1	Ghaenat Steel	South Khorasan- Ghaenat	0.8
2	Iran Ghaltak	Isfahan	0.07
3	Jahan Sirjan Steel – Phase 2	Sirjan- Kerman	0.96
4	Bafaq Iron and Steel Mining and Industry Complex	Bafgh- Yazd	0.8
5	Kavand Nahan Zamin	Kerman	0.5
6	Behnavard Kavir steel complex	Yazd	0.5
7	Bootiyayeh Iranian	Kerman	1.8
8	Biston iron smelting	Kermanshah	0.2
9	Torbat Heydarieh steel complex	Razavi Khorasan	1.8
10	Ehya Makran phase 1	Sistan & Balouchestan	1.6
11	Iron and steel development of Gol Gohar - Tubi plan	Kerman	1.85
12	Bafghe Kasra iron smelting	Yazd	1.7
13	Baft Steel-Phase 2	Kerman	0.8
14	Kurdestan Steel - Bijar	Kurdestan	1.6

Table 4. Typical comparison between PERED & Other DRI technology [3].

Parameter	Unit of Measurement	PERED	Others
Carbon%	%	1.5 -3.0	1.2 – 2.5
Pellet / DRI	Ton / Ton DRI	1.42 less dust	1.45
Gas Consumption	Gcal / Ton DRI	2.4 -2.7	2.5 – 2.8
Power Consumption	Kwh / Ton DRI	100- 120	100 - 130
Water Consumption	M ³ / Ton DRI	9.0 – 1.4	1.0 – 1.5
Furnace Efficiency	Ton / Day - M ³	10 – 10.5	9.5 - 10
Maintenance costs	Euro / Ton DRI	3.9	4.3
Man-Hour	Man-Hour / Ton DRI	0.40	0.45

Table 5. Production trend of DRI in Iran [6].

Year	MTT	Year	MTT
1384	6815	1393	16701
1385	7165	1394	15764
1386	7353	1395	17444
1387	7920	1396	19880
1388	8288	1397	25254
1389	9649	1398	27876
1390	10402	1399	33462
1391	12685	1400	29871
1392	15475		

Table 6. Companies producing DRI in Iran in 2021[4].

#	Company	Million Tons	#	Company	Million Tons
1	Mobarakeh Steel	6.322	11	Shadegan Steel	0.805
2	Khouzestan Steel	3.39	12	Sefid Dasht	0.802
3	Gol Gohar	2.876	13	Baft	0.8
4	Kaveh Jonoub	1.767	14	Neyriz Steel	0.722
5	Hormozgan Steel	1.713	15	Arfa	0.708
6	Chadormalou	1.464	16	Sabzevar Steel	0.689
7	Khorasan Steel	1.029	17	Miyaneh Steel	0.611
8	Saba Steel	0.982	18	Ghaenat Steel	0.207
9	Saaba Steel	0.822		Total	28.350
10	Sirjan Steel	0.815			

Table 7. Production of DRI by PERED method in Iran in 2021 [4].

Company Name	Production (thousand tons)
Miyane	611
Baft	800
Neyriz	722
Shadegan	800
Total	2933

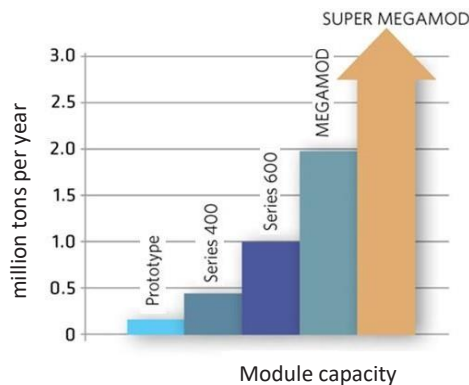


Fig. 2. The process of increasing the production capacity of Midrex DRI modules [5].

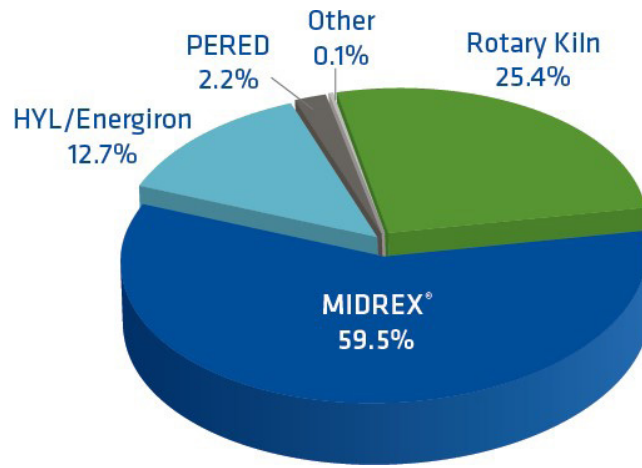


Fig. 3. The contribution of different processes in the production of DRI in the world in 2021[2].

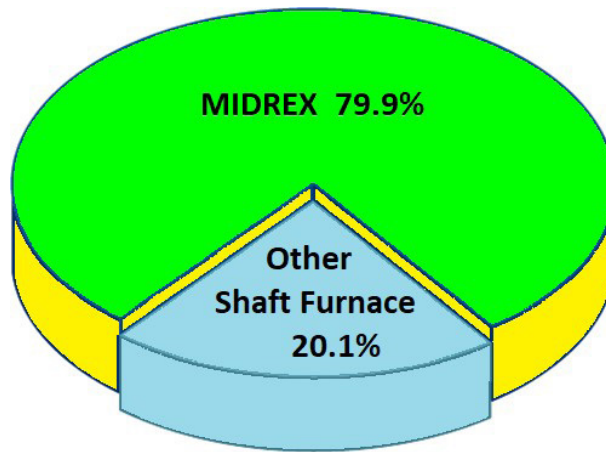


Fig. 4. The contribution of different methods in the global DRI gas base process in 2021[2].

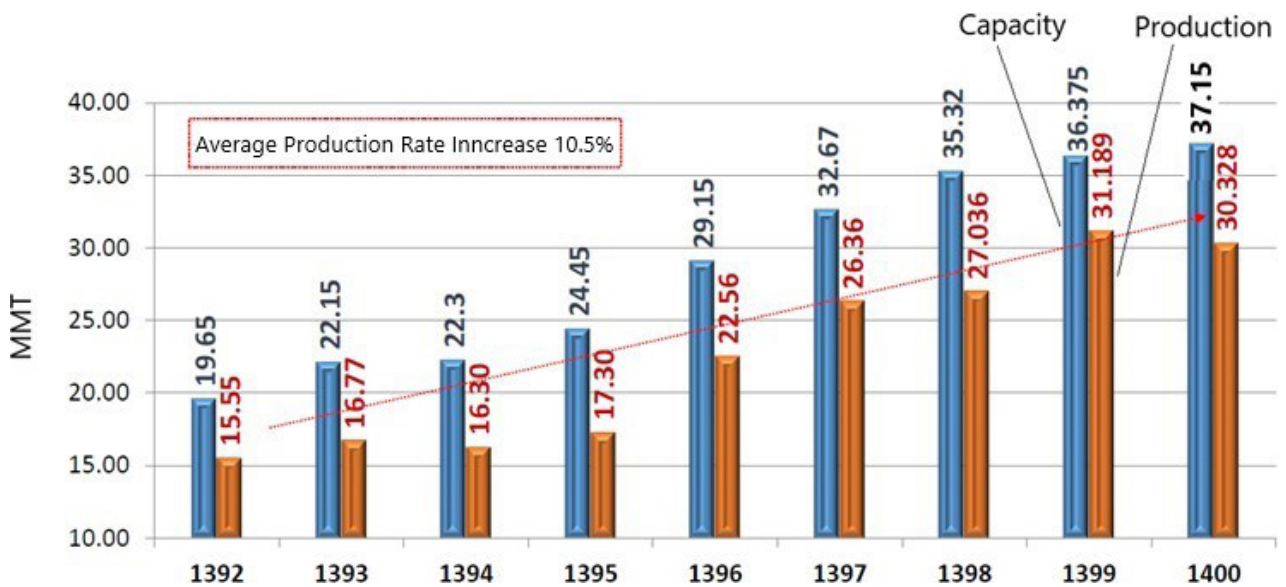


Fig. 5. The growth of the capacity and production trend of DRI in Iran[6].



Fig. 6. A view of the new DRI production unit of the American Cliffs company [7].

With a production of 39.11 million tons, India is at the top of the DRI producers in the world. The process of production of DRI in India based on coal and natural gas can be seen in Table-8. India has exported more than 690 thousand tons of DRI in 2021. It is worth mentioning that nearly 82% of the DRI in this country is obtained in coal-based rotary furnaces. In India, the production capacity of DRI by coal base method in 2010 was 18.1 million tons. The amount of DRI production of AM/NS company (ArcelorMittal/Nippon Steel) of India last year was 5.34 million tons. Last year, the amount of HDRI charged by AM/NS (ArcelorMittal/Nippon Steel) in EAFs was more than 2.9 million tons (equivalent to 89% of total production). More than 80 million tons of DRI have been produced in 6 modules located in this company since the beginning of operation (1990). Tata Steel India's DRI production last year was 839 thousand tons. The amount of DRI sales of the said company last year was reported as 594 thousand tons. With 31.851 million tons (in 1400, 30.3 million tons), Iran has taken the second rank of DRI production in the world. Meanwhile, Iran's production of iron ore concentrates and pellet is estimated at 51.54 and 56.12 million tons, respectively. From the beginning until now, Iran has cumulatively produced more than 316.35 million tons of DRI. In 2021, Iran exported 1.055 million tons of DRI. Iran's consumption of DRI in the previous year was reported to be 29.273 million tons. The amount of DRI production in Venezuela was 0.76 million, and the mentioned country is in the 17th rank of DRI producers in the world. While the production of DRI in this country in 2005 was about 8.9 million tons. The amount of DRI production by the Russian OEMK company in four installed modules is nearly 28.3 million tons. The amount of DRI production by the Russian Metalloinvest company is reported to be 7.7 million tons. Figure 7 shows the

production process of DRI by Metalloinvest company. The amount of DRI sold by Russian company Metalloinvest in the previous year was reported as 4.2 million tons. The amount of DRI production by Acindar company in Argentina is reported to be 1.4 million tons. The cumulative production of DRI of this company in the last 43 years is estimated at 3 million tons. The production rate of DRI modules 1 and 2 of the Saudi DRIC company was 1.011 million tons. During the last year, 68% of the input charge of the direct reduction furnaces of the Saldanha company in South Africa were lump iron ore. The amount of DRI production by the Saldanha company in South Africa is reported to be 200 thousand tons. The Sulb Bahrain company produced 1.4 million tons of DRI in the previous year, 1 million tons of which was charged as HDRI in furnaces. The mentioned company exported 180 thousand tons of DRI by sea last year. This company has produced more than 11.5 million tons of DRI since 2013. During the previous year, 1.2 million tons of DRI were charged hot in EAFs in this company. In addition, Russia, Saudi Arabia, and Mexico are ranked third to fifth in the world with the production of 7.89, 6.13, and 5.83 million tons of DRI, respectively. In the European Union, Germany and Sweden have produced 0.5 and 0.1 million tons of DRI, respectively. Table-9 shows the amount of DRI production in different countries of the world in 2021. Iran ranks first in the production of DRI among Islamic countries and the Middle East and North Africa region (MENA) .5 leading countries (India, Iran, Russia, Saudi Arabia, and Mexico) produced 76.21% of the total DRI in the world. In 2021, ArcelorMittal has produced 6.3 million tons of DRI. ArcelorMittal has 12 DRI production units worldwide with a production capacity of 8.6 million tons. Last year, America imported 1.6 million tons of DRI from Trinidad and Tobago.

Table 8. Production of DRI in India based on gas and coal [8].

DRI Production MMT					
Year	2017	2018	2019	2020	2021
Coal Based	23.282	27.161	30.120	27.519	30.606
Gas Based	6.223	7.052	6.699	6.074	8.402
Total	29.505	34.213	36.819	33.593	39.008

Table 9. The amount of DRI production in different countries of the world in 2021 [2].

Rank	Country	MMT	Rank	Country	MMT
1	India	39.11	12	Trinidad Tobago	1.62
2	Iran	31.85	13	Bahrain	1.51
3	Russia	7.89	14	Argentina	1.41
4	S. Arabia	6.13	15	Libya	0.88
5	Mexico	5.83	16	Qatar	0.79
6	Egypt	5.23	17	Venezuela	0.76
7	US	5.01	18	Germany	0.5
8	UAE	3.66	19	Malaysia	0.36
9	Algeria	3.08	20	S. Africa	0.2
10	Oman	1.7	21	Sweden	0.1
11	Canada	1.65		Total	119.16

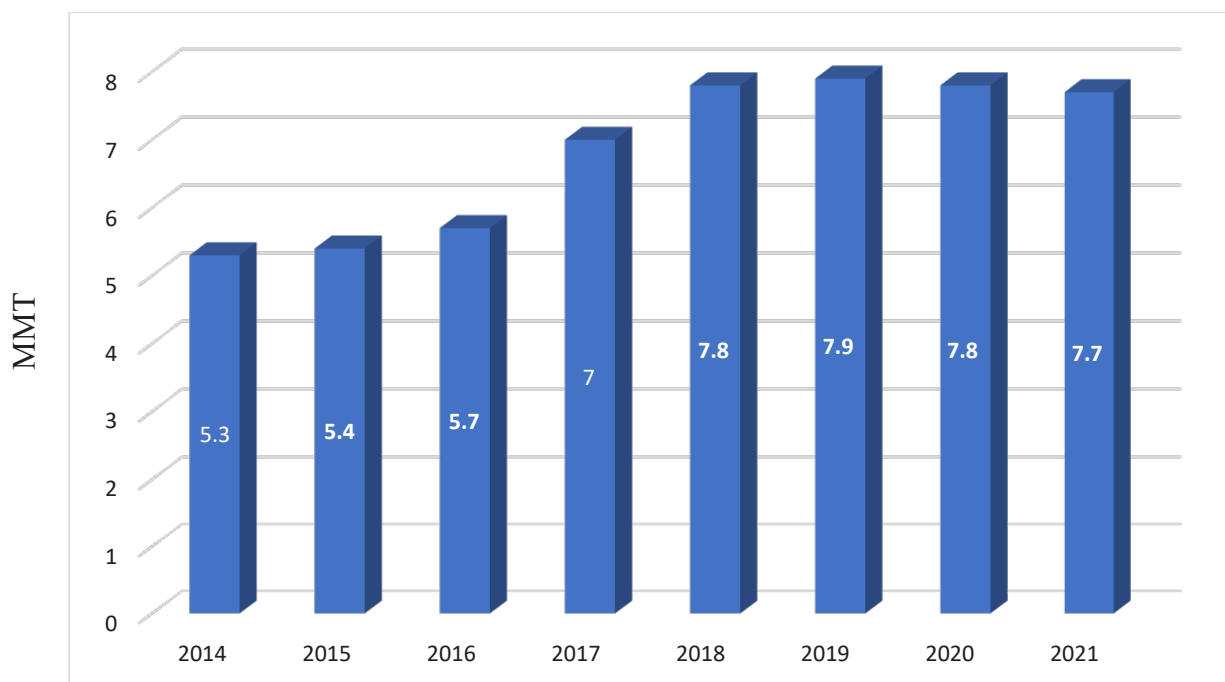


Fig. 7. Production trend of DRI and HBI of Metalloinvest Russian company [9].

According to the planning, in the near future, Iran's DRI production capacity will be increased by 15.22 million tons. The amount of DRI production in the UAE in 2021 was about 3.66 million tons. Oman has been ranked in the world for the sixth consecutive year with the production of 1.7 million tons of DRI. According to the reports, the HDRI produced in Oman is transferred to neighboring companies through insulated bunkers on trucks and charged in EAFs. The EAF of Shadid Oman Company was completed at the end of 2013. The amount of DRI production in Bahrain is 1.51 million tons. The amount of DRI production in the country of Qatar has been recorded at about 0.79 million tons. It is worth mentioning that all DRI in Qatar is produced by Qatar Steel Company. Module No. 1 of Qatar Steel Company has produced more than 28.3 million tons of DRI since 1978. The degree of metallization and carbon content of DRI were 94.08 and 2.58%, respectively.

Currently, in India, more than 300 coal-based direct reduction rotary furnaces with a production capacity of more than 10,000 to 30,000 tons of DRI per year are being operated. Usually, conventional rotary (coal) furnaces have the capacity to produce 50,000 tons of DRI per year. Most of the DRI produced in India is consumed in induction melting furnaces. The production process of DRI in South Africa is also based on coal. In Table-10, the production trend of cold (CBI) and hot briquette iron (HBI) in the world is shown separately. It is worth mentioning that in the previous year, 13.79 million tons of HDRI were charged in the EAFs of the world. In other words, 15.73% of the DRI produced in the world has been charged as HDRI in EAFs.

The amount of hot charging of Midrex DRI modules was 9.7 million tons last year. Figure 8 shows the trend of hot charging of DRI in the Midrex process with different charging methods. In the near future, hot charging of DRI in EAF will start with Pasargad and Chadormelou companies in Iran. In 2021, the global production of DRI and HBI has been recorded as 94.97 and 10.39 million tons, respectively. In 2021, DRI and HBIs have been exported to other parts of the world in the amount of 12.92 and 9.86 million tons respectively (a total of 22.78 million tons). The amount of DRI exported in the world is 7.96 and 14.82 million tons by water and land respectively. The largest export of hot briquetted sponge iron (HBI) was made by Russia (mostly by LGOK company) in the amount of 3.5 million tons. Trinidad & Tobago has exported 1.6 million tons of HBI to the USA. The consumption of DRI in the United States last year was estimated at 3.5 million tons. Iran's export of DRI is also recorded as 1.055 million tons. Figure 9 shows the trend of Iran's DRI exports. As can be seen in the map, the origin of the export of DRI products is America, Russia, and Venezuela to European countries, China, and America. The total capacity of HBI installed worldwide is more than 30 million tons. In the Islamic Republic of Iran, Foolad Saba Persian Gulf Steel Company supplies its DRI products in the form of HBI. The amount of production and export of HBI of Persian Gulf Saba Steel Company has been recorded as 822 and 362 thousand tons respectively. In the previous year, the 3 main countries importing DRI/HBI in the world were USA, China, and Italy with 1.7, 1.5, and 0.9 million tons respectively.

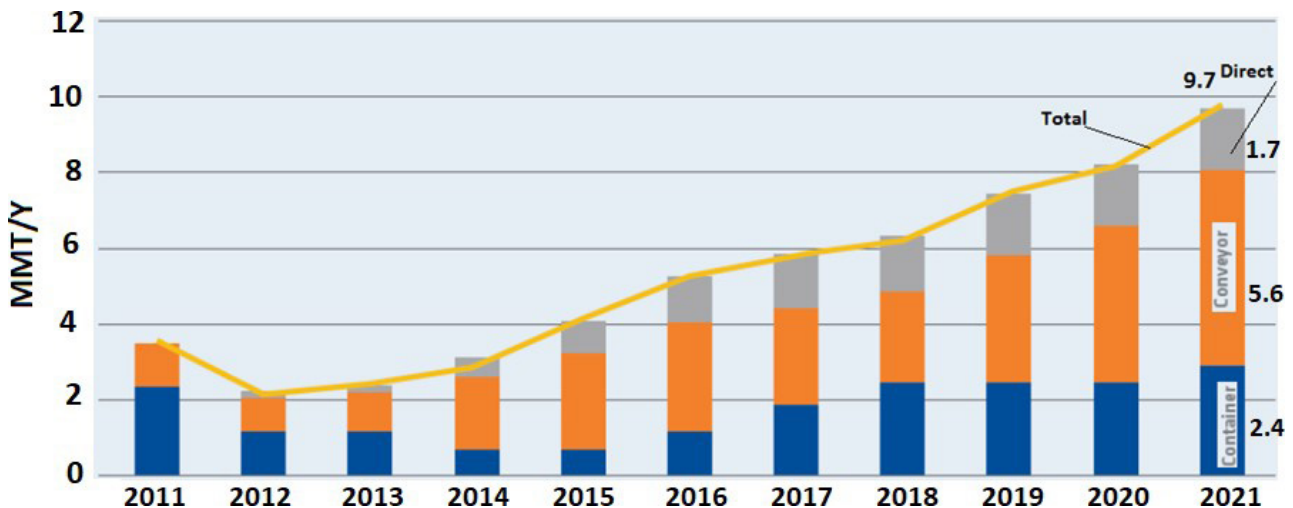


Fig. 8. HDRI charging trend in EAF by Midrex method [7].

Table 10. Global CDRI, HBI, and HDRI production trend [2].

Year	Total	Year	Total	Year	CDRI	HBI	HDRI	Total
1970	0.79	1989	15.63	2008	55.52	8.19	4.24	67.95
1971	0.95	1990	17.68	2009	52.54	6.93	4.86	64.33
1972	1.39	1991	19.32	2010	56.60	7.21	6.47	70.28
1973	1.90	1992	20.51	2011	59.41	7.60	6.20	73.21
1974	2.72	1993	23.65	2012	59.51	7.90	5.73	73.14
1975	2.81	1994	27.37	2013	62.50	6.17	6.25	74.92
1976	3.02	1995	30.67	2014	62.41	5.17	7.01	74.59
1977	3.52	1996	33.30	2015	58.43	5.66	8.55	72.64
1978	5.00	1997	36.19	2016	57.74	5.29	9.73	72.76
1979	6.64	1998	36.96	2017	67.88	8.16	11.06	87.10
1980	7.14	1999	38.60	2018	80.55	9.03	11.16	100.73
1981	7.92	2000	43.78	2019	87.16	9.67	11.27	108.10
1982	7.28	2001	40.32	2020	83.95	9.51	11.38	104.84
1983	7.90	2002	45.08	2021	94.97	10.39	13.79	119.16
1984	9.34	2003	49.45					
1985	11.17	2004	54.60					
1986	12.53	2005	56.87					
1987	13.52	2006	59.70					
1988	14.09	2007	67.12					

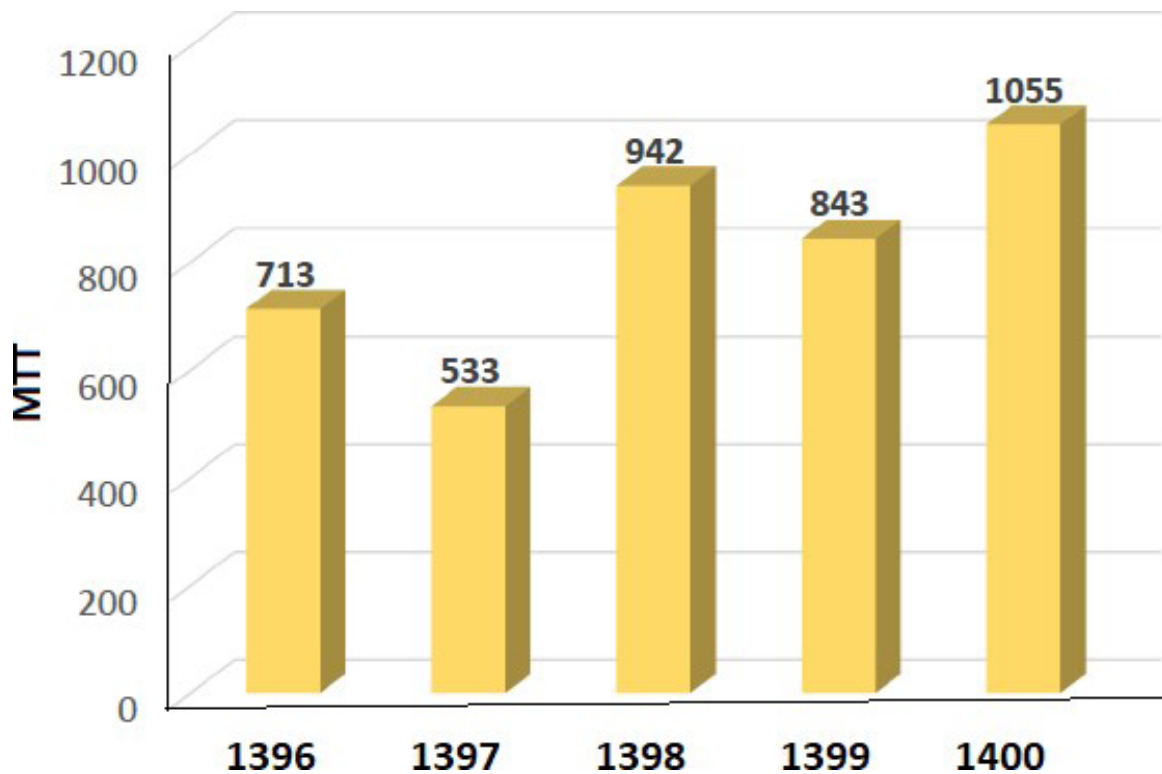


Fig. 9. Iran's DRI export trend [4].

In addition, in Table-11, the trend of export of DRI (including HBI) through the land (14.82 million tons) and water (7.96 million tons) to different regions of the world last year can be seen (total 22.78 million tons). The export amount of HBI in the world was 9.86 mil-

lion tons in the previous year. In table-12, the trend of export of CDRI and HBI in the world is displayed. 25% of the DRI produced in India is transferred to the steel smelting workshops located 5-10 km away from the direct reduction plants.

Table 11. The export trend of DRI through water and land routes of the world (million tons) [2].

Year	Water	Land	Year	Water	Land	Year	Water	Land
1971	-	0.04	1989	1.08	1.23	2005	7.02	6.86
1972	0.01	0.07	1989	1.34	0.87	2006	6.80	7.75
1973	0.02	0.12	1990	1.79	1.38	2007	8.19	8.87
1974	0.03	0.23	1991	2.25	1.71	2008	6.41	7.59
1975	0.06	0.28	1992	2.24	1.93	2009	5.39	8.48
1976	0.10	0.26	1993	2.90	2.11	2010	6.61	7.42
1977	0.04	0.27	1994	3.46	2.91	2011	6.49	7.55
1978	0.12	0.57	1995	3.76	3.92	2012	8.48	6.27
1979	0.33	0.45	1996	3.40	3.50	2013	7.79	6.39
1980	0.54	0.52	1997	3.81	3.80	2014	7.23	5.64
1981	0.53	0.55	1998	4.22	3.11	2015	7.28	6.04
1982	0.65	0.33	1999	5.45	3.00	2016	7.48	6.01
1983	0.67	0.28	2000	6.66	2.90	2017	10.30	5.83
1984	0.69	0.53	2001	7.59	1.82	2018	10.22	11.30
1985	0.81	0.51	2002	6.74	4.56	2019	8.61	11.00
1986	0.99	0.63	2003	8.31	3.94	2020	7.30	14.20
1987	0.95	0.67	2004	6.57	4.51	2021	7.96	14.82

Table 12. Export trends of CDRI and HBI in the world [2].

Year	CDRI	HBI	Year	CDRI	HBI	Year	CDRI	HBI
1971	0.04	-	1988	1.48	0.83	2005	6.76	7.12
1972	0.08	-	1989	1.27	0.94	2006	7.81	6.75
1973	0.13	-	1990	1.46	1.71	2007	10.82	6.24
1974	0.26	-	1991	1.29	2.67	2008	8.01	5.99
1975	0.34	-	1992	1.45	2.71	2009	8.50	5.38
1976	0.37	-	1993	1.45	3.56	2010	8.42	5.60
1977	0.32	-	1994	2.44	3.93	2011	7.97	6.06
1978	0.28	0.11	1995	3.69	3.98	2012	8.17	6.58
1979	0.66	0.12	1996	3.58	3.20	2013	8.56	5.62
1980	0.81	0.25	1997	3.99	3.51	2014	7.70	5.17
1981	0.83	0.25	1998	4.24	3.00	2015	8.35	4.97
1982	0.80	0.18	1999	4.01	4.41	2016	8.79	4.70
1983	0.59	0.36	2000	4.54	5.02	2017	8.00	8.13
1984	0.83	0.39	2001	2.83	6.58	2018	12.49	9.03
1985	0.71	0.61	2002	4.85	6.45	2019	11.27	8.33
1986	0.89	0.73	2003	4.63	7.63	2020	12.39	9.11
1987	0.85	0.77	2004	4.26	6.82	2021	12.92	9.86

The use of HDRI in EAFs, in comparison with HBI, leads to a reduction in electricity consumption by 140 kilowatt hours per ton of steel (for every 100 degrees Celsius, 20 kilowatt hours per ton of steel). In addition, the consumption of graphite electrodes and refractories of EAFs is reduced by 0.55 and 1.9 kg per ton of molten steel, respectively. On the other hand, the efficiency of the EAF increases by 15-20 percent. In table-13, the trend of increasing the charge of HDRI in the EAFs of the world is considered. The countries of India, Malaysia, Saudi Arabia, Mexico, UAE, Oman, Bahrain, Algeria, and Egypt benefit from the HDRI technology of EAFs. The largest DRI module in the world with a capacity of 2.5 million tons is being operated by the Medrex method in the Tosyali company in Algeria. The amount of DRI production rate of Tosyali company in Algeria last year was reported to be 2.28 million tons. This amount of DRI production in a single module is considered a world record. 69% of the DRI product of this company is loaded in EAF as an HDRI. The Voestalpine TEXAS DRI production was 2 million tons in the previous year. On April 22 of this year, 80% of the shares of this company were bought by ArcelorMittal. The amount of DRI production by Jindal Oman Company has

been recorded at 1.7 million tons. In the previous year, 1.6 million tons of DRI produced by this company were loaded as HDRI in the nearby steel factories. Pasargad company has launched charging of HDRI in EAF with a capacity of 1.8 million tons per year. An HDRI charging unit in EAFs of Iran is going to be built in Gol Gohar with a capacity of 1.8 million tons per year. On the other hand, Ardakan Steel Company (Chadormelou Company) has set up a DRI unit with a capacity of 1.55 million tons by the HDRI method of sponge iron in an EAF. Considering that the share of DRI in ferrous materials of Iranian steelworks is 83% (Table-14). The use of HDRI technology in EAFs will save more than 50% of electric energy. The share of s DRI, steel scrap, and molten iron in the ferrous materials of the world's steel mills is 5.73, 29.7 and 64.57 %, respectively (the total weight of the input ferrous materials is 2085.4 million tons) [10]. Therefore, the variety of input ferrous materials in the world's and Iran's steel mills is completely different, and as a result, the specific energy consumption of steel production in Iran is higher than the average energy consumption of steel production in the world. In table-15, the amount of ferrous material consumption in the world's steel mills is presented.

Table 13. HDRI charging trend in EAFs of the world [2].

Year	Pro. MMT	Year	Pro. MMT
2003	1.83	2013	6.27
2004	2.43	2014	7.01
2005	2.6	2015	8.55
2006	2.69	2016	9.73
2007	2.99	2017	11.06
2008	4.24	2018	11.16
2009	4.86	2019	11.27
2010	6.47	2020	11.38
2011	6.22	2021	13.79
2012	5.73		

Table 14. The share of DRI in the ferrous materials of Iran's steel mills in 2021 (calculated by Authors).

Material	(MMT)	%
Hot Metal	3.3	8.9
Scrap	3	8.1
DRI	30.85	83
Total	37.15	100

Table 15. The consumption of ferrous materials in the world's steel mills in 2021(calculated by Authors).

Material	(MMT)	%
Hot Metal	1346	64.57
Scrap	620	29.7
DRI	119.2	5.73
Total	2085.4	100

Conclusions:

- One of the green steel production processes is the steel production process in EAFs with sponge iron charging, especially hot charging of DRI.
- Iran's steel production is based on iron ore, and for this reason, the impurities in its steel are very low and the strength of the produced steel is high.
- The share of DRI in the steel production of Iran and the world is 85% and 4%, respectively.
- More than 75% of DRI in India is based on coal, while in Iran, the production of DRI is 100% based on natural gas, and for this reason, Iran is the largest producer of DRI in the world based on natural gas.

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