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DEVELOPMENTS IN FERROALLOY PRODUCTION AND CONSUMPTION OF TÜRKİYE

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ABSTRACT

In this study, the latest developments in the production and consumption of ferroalloys in Türkiye are given in relation to the raw steel production, the largest consumption area of ferroalloys. Ferrochrome plants of Türkiye and the place of their productions on the world market are also given. There are two plants in Türkiye, producing ferroalloys: Elazığ Ferrochrome Works and Antalya Electrometallurgy Works. The place of the production of these plants on the world market is also given. Ferrochrome produced is mainly exported due to the low domestic consumption, whereas ferrosilicon, ferromanganese ferromanganese-silicon, are imported in great amounts, as they are heavily used in steel production and in steel foundries. Some other types of ferroalloys are imported on a minor scale.

INTRODUCTION

Important steps have been taken in the field of iron and steel manufacturing, during the first years of turkish republic, when foundations of all social, political and economical developments were being constructed as part of the industrialization efforts. Modern style iron and steel production actually began in the nineteen forties when *Karabük* and *Kırıkkale* plants have started production. During the fifties, when the expansion work of *Karabük* was carried out, construction projects of *Erdemir* had already started. Meanwhile, some private enterprises have also started to produce iron and steel. Starting as early as 1963, five-year development plans, aiming to change the model of economical developments from agriculture to industry, have affected the iron and steel sector

and caused its fast progress. Ferroalloy consumption has increased in parallel to the production of iron and steel. A 14.5% of the steel produced in Türkiye is flat products, while the rest being long. Alloyed and quality steels have a share of 2% in this production. Due to these general characteristics of turkish steel products, ferroalloys consumed domestically are: imported ferromanganese, ferromanganese-silicon, and ferrosilicon, some of which are produced locally.

Total ferroalloy production capacity of Türkiye is 171,500 t/y. A capacity of 160,500 t/y is directed towards the production of low-carbon (LC-) and high-carbon (HC-) ferrochrome, domestic consumption of which are very low as the stainless steel production of Türkiye is still on a minor scale. Thus, available capacity is mainly export oriented. The combined share of ferrosilicon and ferrochrome-silicon production is about 11,000 t/y.

DEVELOPMENTS IN STEEL PRODUCTION OF TÜRKİYE

In this century, industrialization has the most permanent effects in the process of rapid economical development of a country. One of the leading sectors in the industrialization is the iron and steel manufacturing.

If we look at the growth rates achieved world wide, it is observed that, except the years of 1988 and 1989, Türkiye's growth rate has been higher than any other EEC countries. For instance, Türkiye's growth rate in 1985 and 1986 were 5.1 and 8.1%, respectively, while that of EEC countries has reached 2.7 and 3.4%, and of Eastern Block countries 2.4 and 2.5% in those years [1]. In 1993, growth rates of higher than 6% were reached in developing countries such as, Argentina, Chile and Türkiye, whereas it declined to 0.2% in Europe and stayed around 2.8% in the United States [2]. One of the most important factors enabling Türkiye to achieve these high growth rates is the enormous developments in iron and steel sector.

Turkish economy showed remarkable development due to the progressive and active policies, followed since the beginning of eighties. As Türkiye is prepared for the full membership to the EEC, it is aimed to have industrial investments realized on a strong basis for increasing the economic activity of the country. The most important sector which allows other sectors to develop is the iron and steel industry. In 1980, Türkiye produced 2.5 million tons of steel, supplying 0.35% of the world production (ranking 33rd in the world) [3]. In 1993, 11.4 million tons of steel production was realized which placed Türkiye 16th in the world, making the 1.57% of the world production of 725 million tons [4].

There are three integrated iron and steel plants in Türkiye, one of which is manufacturing flat products, and numerous mini steel plants having EAFs producing long products. Table 1 shows the distribution of molten steel production in Türkiye, between 1980 and 1993, according to the methods they are produced. As seen, the share of the integrated plants in the total is decreasing since 1980,

while that of plants with electric arc furnaces is increasing very rapidly. In 1983, while EAFs are producing 63.8% of the total steel in Türkiye, EAFs share is only 30% in the world (Figure 1).

TABLE 1: Steel Production of Türkiye by the Processes (x1000 tons) [2,3].

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
BOF	1312	1295	1566	2032	2375	2617	2929	3285	3590	2945	3902	3652	3493	3409
EAF	658	766	1071	1340	1464	1732	2385	3164	3811	4667	4947	4990	6110	7283
SM	565	558	540	549	501	519	608	595	582	322	605	693	651	722
Total	2535	2619	3177	3921	4340	4868	5922	7044	7983	7934	9454	9335	10254	11414

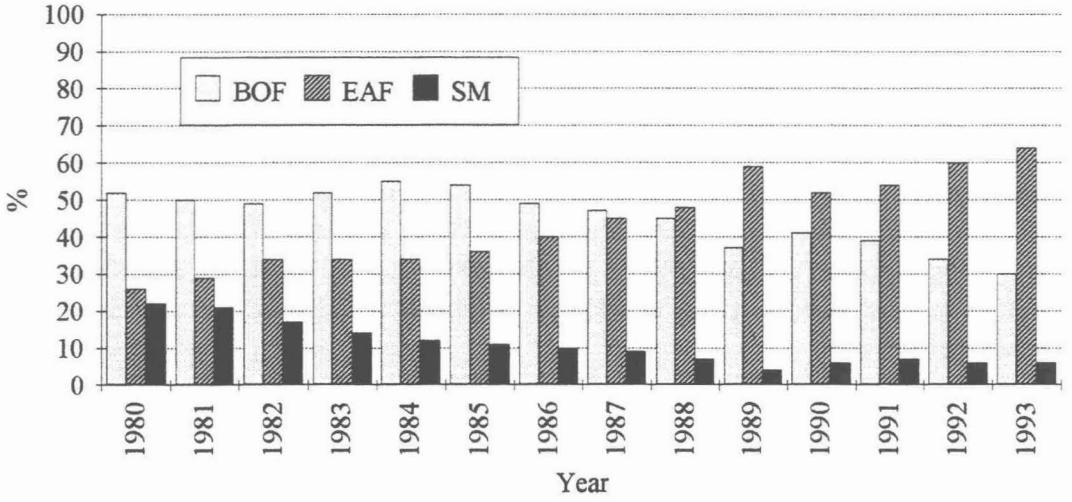

Figure 1 : Crude Steel Production of Türkiye by the Process [2,3].

Figure 2 displays the amounts of various steel products. As seen from the figure, 892,000 tons of flat and 1,643,000 tons of long products were manufactured, in 1980. The share of the flat products in total was therefore around 35% in 1980. However, the products of new plants, built after 1980's, were generally long, thus this share dropped to 14.5%. Flat products of Türkiye are tinplate, cold rolled sheet, hot rolled sheet, galvanized sheet, and welded pipe. Long products, meanwhile, are bar, wire, profile, and quality steel. As the Turkish steel products show these variations, ferroalloys consumed are ferromanganese, ferrosilicon and lately some ferromanganese-silicon. Although some of the ferrosilicon needed is supplied domestically, a great portion of it is imported. Ferromanganese and ferromanganese-silicon are imported since they are not produced in Türkiye. On the other hand, since the domestic consumption of high and low-carbon ferrochrome is very low, almost all the production is exported.

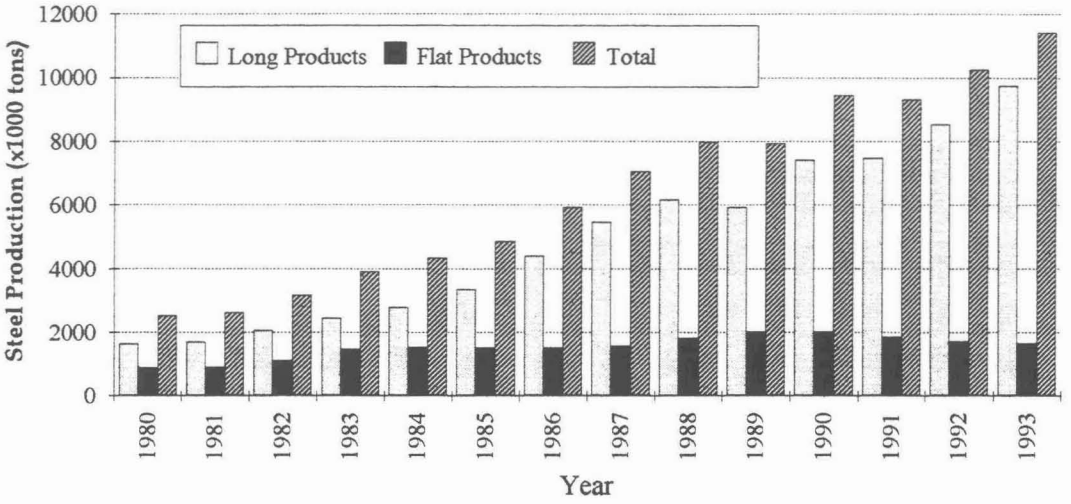

Figure 2 : Crude Steel Production of Türkiye by the Products [2,3].

WORLD FERROCHROME PRODUCTION

Ferrochrome industry of the world, among which Türkiye is one of the biggest producers, have witnessed important changes within the last 20 years. More than 70% of the ferrochrome consumption in the world are used in stainless steel production. Thus, the ferrochrome market is affected primarily by the changes in stainless steel industry.

Some great changes have occurred in ferroalloy industry of the world starting from the early nineteen seventies. In 1970, the United States and Japan were the top two ferrochrome consumers of the western world and they were producing about 45% of the world ferrochrome. Today, their share in world ferrochrome production is below 10%. During the same period, the ferrochrome production of some developing countries, e.g., South Africa, have also increased very sharply. The main reasons of these changes might be listed as follows [5]:

1. Energy consuming and environmentally unsafe technologies are being re-evaluated in developed countries in parallel to the changes observed in their general production structure. Therefore, productions, such as ferrochrome, shifted toward the developing countries where rich raw material sources are easily available, e.g., chromite reserves.
2. Chromite producing countries started producing ferrochrome to boost their iron and steel production and to increase their exports.
3. The difficulties encountered in developed countries are increasing, due to the strong environmental consciousness and related restrictions, and rising labor and energy costs.
4. Low costs of labor and vast raw material sources in developing countries bring the advantage in production.

5. Today, the latest technologies are employed in plants built in developing countries. Developed countries, therefore, are decreasing their production due to the difficulties in competition.

Along with the changes observed in ferrochrome industry of the world, the types of ferrochrome consumed have also changed, within the past 15 years. In this period, the HC-ferrochrome consumption increased very rapidly. Technological advances in stainless steel making are the main factors behind this increase. During this period, new processes such as, AOD (Argon-Oxygen-Decarburization), ASEA and similar techniques found widespread use for the production of stainless steel. The most important feature of these technological advances for the ferrochrome industry is that their capability of oxidizing carbon selectively and thus allowing inexpensive HC-ferrochrome production.

The largest ferrochrome producing countries in the world are South Africa, Russia, Kazakhistan, Japan and India. In 1992, the amount of ferrochrome produced in the world was 3,544,751 tons. In 1988, Türkiye's share in this production amounted 1.44%. However as the world figures declined and Türkiye's production increased, this percentage climbed up to 2.42% in 1992. By reaching to the full capacity in production this figure should be 4% [5].

FERROCHROME PRODUCTION OF TÜRKİYE

There are two plants involved in ferroalloy production, in Türkiye; Etibank Elazığ Ferrochrome Works and Antalya Electrometallurgy Works. HC-ferrochrome production is carried out at Etibank Elazığ Ferrochrome Works. The plant started operation in 1977 with a capacity of 50,000 t/y. Additional capacities of 50,000 t/y each were added in 1989 and in 1991. The flowsheet of the new plant is given in Figures 3. The old plant has two open type arc-resistance furnaces with a power of 17,000 kVA and a capacity of 50,000 t/y each, whereas the new plant consists of two closed type furnaces each with 30,000 kVA power and a 100,000 t/y capacity. Technology employed during the expansion of Elazığ Ferrochrome Works contracted mutually to the companies of Elkem (Norway) and Outokumpu (Finland), the founders of ferrochrome production technology. This system is one of the most effective technologies in the world. Having closed type furnaces and preheating system for raw material preparation, decreases the electric energy consumption from 4140 kWh/ton to 3300 kWh/ton [6].

Antalya Electrometallurgy Works produce LC-ferrochrome. The production of LC-ferrochrome is carried out at two steps and in two different furnaces which complement each other (Figure 4). In the first step, Si-reach ferrochrome-silicon alloy is produced in an arc-resistance furnace with a power of 7500 kVA. In the second step, a concentrate with 48% Cr_2O_3 content is melted in a 6,500 kVA furnace and a rich slag containing 29-30% Cr_2O_3 is produced. This rich slag is mixed with ferrochrome-silicon from the first step, in a ladle where chromium and

iron oxides in the rich slag are reduced by the silicothermic reaction, and LC-ferrochrome is produced. Ferrosilicon, containing 75% Si, is also produced in Antalya Electrometallurgy Works at a capacity of 5,000 t/y in a 6,000 kVA arc-resistance furnace. Ferroalloy production of Türkiye, between the years of 1982 and 1992 is given in Table 2 [5,7]. As seen from Table 2, the production of HC-ferrochrome has shown an increase in parallel to the rise in capacity and export. Important declines have taken place in the production of ferrosilicon during 1991 and 1992. The inexpensive ferrosilicon imported from old USSR countries have made the competition difficult.

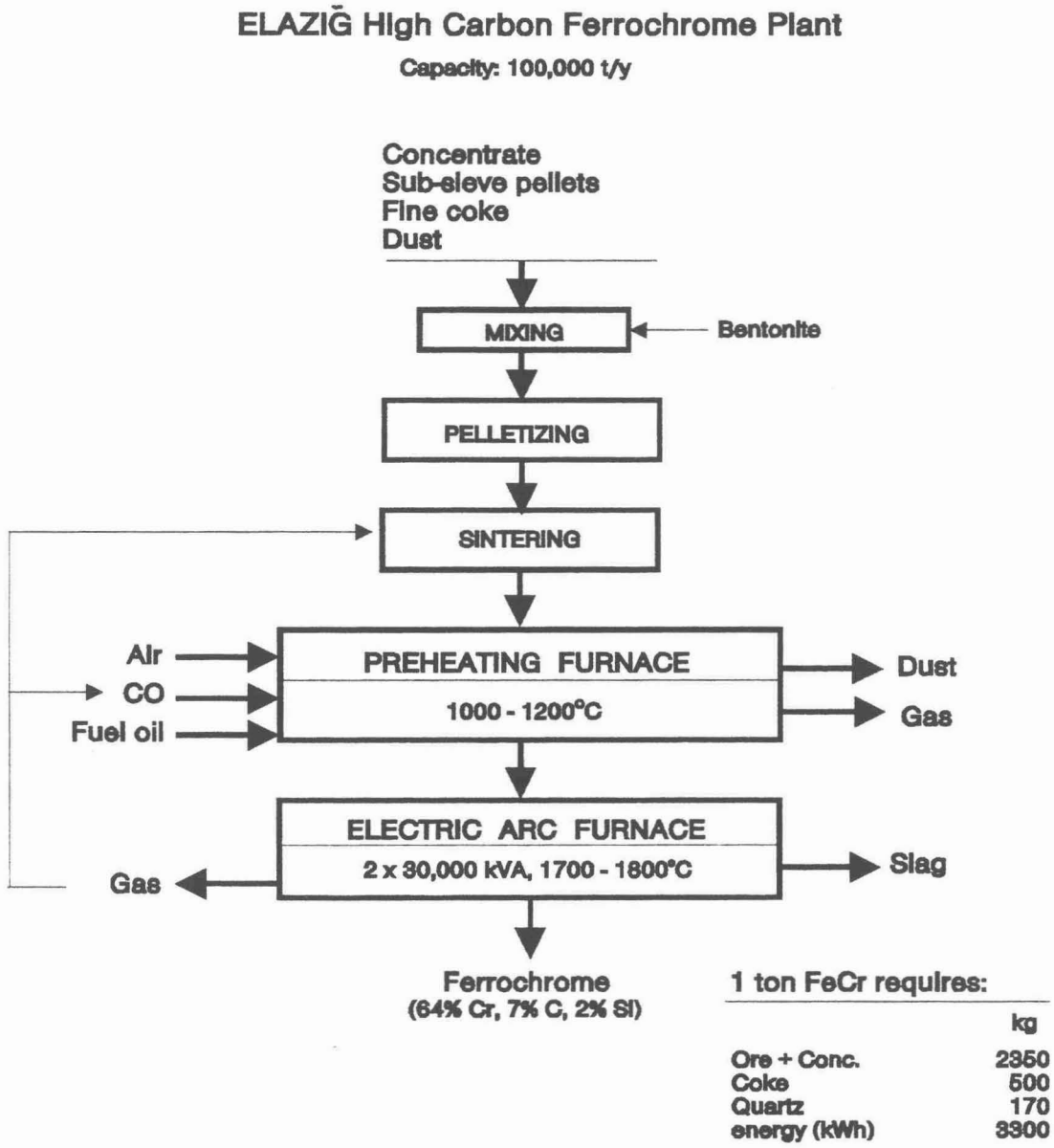

Figure.3 : The Process Flowsheet of Elazığ Ferrochrome Plant [6].

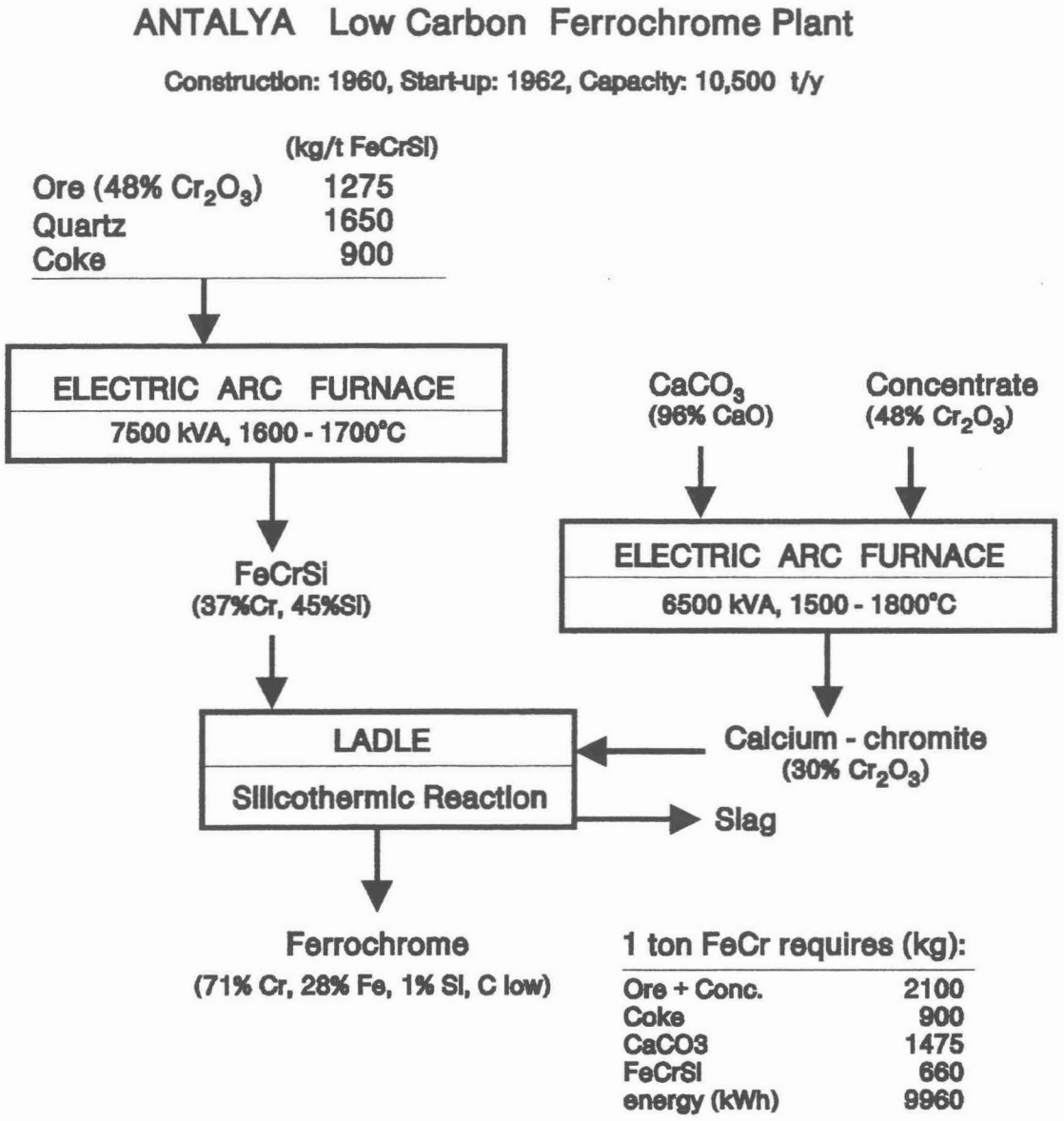

Figure. 4: The Process Flowsheet of Antalya Ferrochrome Plant [6].

TABLE 2: Ferroalloy production of Türkiye (tons) [5,7].

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FeSi	4300	4552	4650	5170	5263	4400	5200	4970	5225	1736	1250	4680
HC-FeCr	29516	22200	38800	42000	38000	43200	43500	48300	51240	72500	73500	82000
LC-FeCr	10350	7975	10280	11330	9502	8330	11530	11415	10600	12150	12300	8030
FeCr-Si	6450	4834	6902	6841	6124	5750	7300	7280	6790	7700	7820	5116

FERROALLOY CONSUMPTION OF TÜRKİYE

Ferroalloy consumption of Türkiye is tabulated in Table 3. As seen from this table, the most heavily consumed ferroalloys in our country are manganese and silicon based alloys, depending on the production structure of iron and steel sector. Ferrochrome is mostly used in iron and steel casting, while it also finds some minor applications in alloyed steel production sector. In 1982, 3.177 milion tons of steel was produced while total ferroalloy consumption has reached over 51,000 tons. A 34.6% of this consumption was ferrosilicon, while 62.2% ferromanganese, and 3.2% both low and high carbon ferrochrome. In 1992, steel production has reached over 10 million tons, whereas ferroalloy consumption realized to be 97057 tons, 20.5% of which was ferrosilicon, 31.4% ferro manganese, and 42% ferromanganese-silicon (included in "other" in Table 3). Consumption of ferroalloys (except ferromanganese-silicon) declined starting from 1988, especially that of ferromanganese, however, ferromanganese-silicon started to be used as an inexpensive substitute.

TABLE 3: Ferroalloy Consumption of Türkiye (tons) [5,7].

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
FeSi	17688	18964	20314	22324	25624	28876	20490	18512	20037	18565	19901
FeMn	31763	34243	38464	42590	53308	64594	31947	27334	31418	32506	30519
HC-FeCr	950	1271	1912	1714	2203	2687	1779	2162	1556	1264	1495
LC-FeCr	688	747	773	770	1086	1208	647	597	374	375	442
Other							30024	21955	32048	31991	44700
Total Ferroalloy	51089	52225	61463	67398	82221	97365	84887	70560	85433	84701	97057
Crude Steel production (x1000 tons)	3177	3921	4340	4868	5922	7044	7983	7934	9454	9335	10254

EXPORT AND IMPORT OF FERROALLOYS

Almost all ferrochrome, produced at two state-owned plants, are exported as domestic consumption is very low. Ferrosilicon production is insufficient to supply domestic needs, thus it not exported. The United States is the major importing country of Turkish ferrochrome. Türkiye also exports to Japan and some EEC countries. About 63,000 tons of HC-ferrochrome was exported in 1992, while it was around 22,000 tons in 1982 (Table 4). Ferroalloy imports of Türkiye are listed in Table 5. Imports of ferrosilicon have been carried out from eastern block countries, instead of western block, especially during the past few years.

TABLE 4: Ferroalloy Exports of Türkiye (tons) [5,7].

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
HC-FeCr	22321	20930	49050	35990	24061	46823	37320	99000	54557	62848	63213
LC-FeCr	14140	4450	11750	9555	6350	11534	9488	6766	13188	10768	11064

TABLE 5: Ferroalloy Imports of Türkiye (tons) [5,7].

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
FeSi	6028	12636	11379	12099	14481	26653	24788	29277	32408	26950	20566
FeMn	29640	20905	25625	25647	21006	23363	35964	51081	32047	30099	40186
FeMn-Si	--	--	--	--	--	--	31892	27975	48830	49750	61041

The level of domestic ferrosilicon production capacity supplied the 25% of the demand in 1992. However, due to the low prices of imported ferrosilicon from eastern block countries, actual domestic production supplied only 6.3% of the demand.

All of the ferromanganese demand is supplied by imports, especially from South Africa, which constitutes 32% of the total imports. Ferromanganese-silicon imports are also carried out from South Africa, although in 1992, great portions of it are imported from Russia and Ukraine. There is also a small amount of ferrochome imported.

CONCLUSION

Ferroalloy consumption of Türkiye has shown an increasing trend, especially since early 1980's, in close relation with the speedy developments observed in steel production. Ferroalloys that are consumed most, depending on the types of steel products manufactured, are imported. About 97,000 tons of ferroalloys are consumed in 1992, 96.7% of which is imported. Although, ferroalloy consumptions are expected to reach 144,000 tons by the 1999, a major portion of that will still be imported. This situation is an important drawback for our country which is targeting to be one of the top 10 steel producing countries.

Scientific investigations are being carried out, in Türkiye to evaluate our manganese ores for the production of Mn alloys, thus easing the strong dependency on imports in this crucially important sector. Chromite ore and concentrates produced in Türkiye had been exported for long time, until ferrochrome producing plants have started operation. Fast technological developments are observed in Türkiye and the consumption of alloyed and quality steel will increase in the forthcoming years. Therefore, the added value of ferrochrome sector will considerably increase when stainless steel materials (rather

produced as cast products, today) are produced in larger capacities and in integrated plants as rolled products, in coming years. Some planning works and technological investigations are carried out on the production of ferromanganese, ferrosilicon and ferromanganese-silicon according to the demands shaped by the variations in steel products. Both laboratory and pilot-scale researches also conducted in the laboratories of our school, about the production of ferroboron and ferrovanadium.

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