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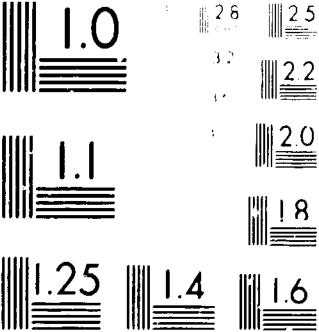
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THE ENERGY SITUATION IN THE IRON AND STEEL INDUSTRY

- CURRENT CONSUMPTION OF ENERGY AND THE OUTLOOK FOR THE FUTURE

Transmitted by UNIDO

(Prepared by Mr. B. R. Nijhawan, Senior Interregional Adviser)

1981

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CONTENTS

TABLES

FIGURES

ENERGY CONSERVATION IN THE IRON AND STEEL INDUSTRY - SOME GLOBAL DATA AND CONSIDERATIONS

Introduction and general development

The steel industry is as capital intensive as it is energy intensive. However, whilst the capital/investment costs per ton crude steel annual capacity have continued to rise during the last decade and more, the energy consumption per ton crude steel output has continued to decline during the same period even though the unit energy costs have multiplied many folds. During the period 1960 to 1973 the energy consumption per ton crude steel dropped by 47% in Japan, 35% in the U.K. and 27% in U.S.A. Since 1974 comprehensive efforts have been launched by most steel producing countries to cut down the energy consumption despite the increased energy demands for environmental/pollution control measures mandatorily required in some steel producing countries including Japan. With judicious selection of energy saving equipment and raw materials controls, the Japanese steel industry has currently brought down the energy consumption per ton of crude steel to 5.5 G cal (million K cal) as compared to the current average consumption of 7, 8 and 12.5 G cal (million K cal) per ton crude steel in the integrated steel industries in West Germany, USA, and India respectively.

During 1978, the energy consumption at Nippon Kokan in Japan, by process gave the following figures:-

a) Total energy consumption = 20.7×10^6 BTU/MT steel (or 5.7 million K cal/MT steel)
divided as follows:

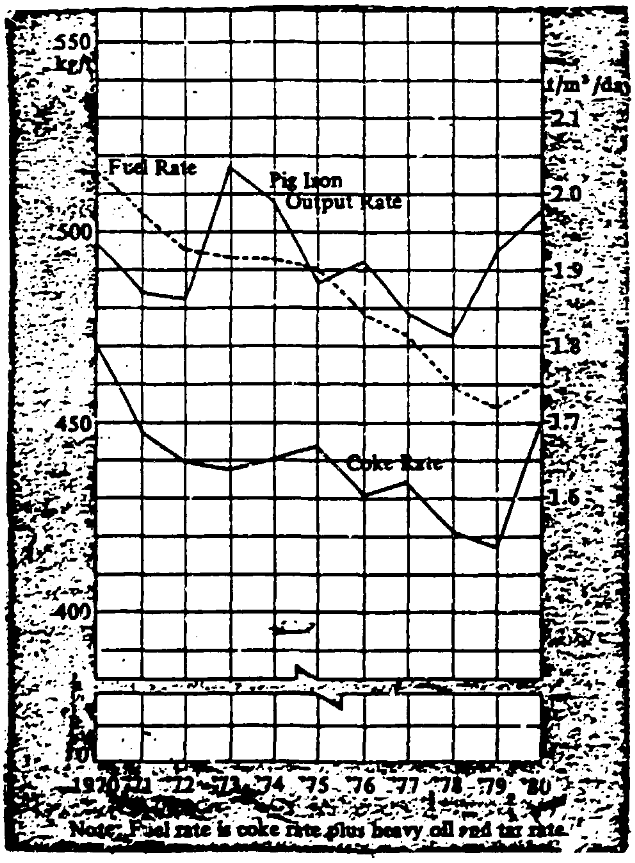
b) Ironmaking - 57%
c) Sintering - 12%
d) Coke & chemicals 9%
e) Others - 8%
f) Steelmaking - 2%
g) Blooming & Slabbing 7%
h) Cold rolling - 5%

Energy savings achieved from 1973 to 1978 amounted to 2.40×10^6 BTU/NT steel or 0.6648 million K cal/MT steel divided as follows:

a)	Ironmaking	- 17%
b)	Sintering	- 15%
c)	Coke & chemicals	- 3%
d)	Others	- 6%
e)	Steelmaking	- 20%
f)	Blooming & slabbing	- 31%
g)	Cold rolling	- 8%

Energy consumption by the Japanese steel industry on an overall basis decreased from 94.08 million tons coal equivalent in fiscal year 1973 to 81.69 million tons coal equivalent in fiscal year 1979 and to about 79 million tons coal equivalent during the fiscal year 1980. With the fiscal year 1973 level taken as the base index 100, real specific energy consumption per ton of crude steel during the fiscal year 1979 and 1980 was 91 and 88 respectively. As for energy related indices, blast furnace fuel rate in the fiscal year 1980 is depicted below:

FIG. 1 - BLAST FURNACE PRODUCTIVITY & COKE RATE, 1970-1980



Note: Fuel rate is coke rate plus heavy oil and tar rate.

Fig. 1 depicts the blast furnace coke rates country-wise from 1970-1980, whilst Fig. 2 depicts the progress of Japanese blast furnace productivity and coke rate from 1970-1980.

The following particulars are quoted from the 'Iron and Steel Industry of Japan - 1980 - Japanese Iron & Steel Federation'.

The blast furnace operations during 1980 in Japan were based on all coke operation with no oil injection whatsoever; BOF gas recovery improved remarkably approaching an estimated 1.4 million Kl oil equivalent during 1980; the continuous casting ratio touched the 60% mark and together with improvements made in product yields, contributed most significantly to energy savings. The industry made notable progress in installation of BF top pressure power generation. At the end of 1980 and start of 1981, 29 units are in operation with a combined capacity of 320,000 kW.

Advances in BF oil-less operation

The Japanese steel industry has been making the utmost effort to reduce production costs and save raw materials and energy by improving blast furnace (BF) productivity. This is particularly important because the industry depends on overseas sources for most of its iron ore and coking coal needs.

Specifically, measures implemented by the industry to improve BF productivity have included iron ore beneficiation, high-temperature and high-pressure operation, dehumidified and oxygen-enriched blast, and installation of movable armor and bell-less top charging equipment. Most recently, blast furnace operators have been practising all-coke or coke-tar operation - oil-less operation that has been increasingly adopted to offset rising fuel prices. A mixed injection of fuel oil and coal fine also is being experimented with by some companies. As of the end of 1980, 30 of the 44 blast furnaces in operation were oil-less units.

Today, raw materials beneficiation technology is so advanced that the proportion of sintered ore and pellets in the blast furnace burden has reached approximately 90%. To cope with the worldwide shortage of heavy coking coal, blast furnace operators have been making concentrated efforts to reduce coking coal consumption. At the same time, they are making greater use of non-coking coal by expanding coal briquette production facilities. A great deal of effort is also being devoted to R&D work on formed coke production processes.

As of the end of 1980, Japan had a total of 65 blast furnaces, including one blown-out unit. Of these BFs, 39 were large units, each with an inner volume of more than 2,000 m^3. Among these were 15 gigantic BFs, each with an inner volume of more than 4,000 m^3, the largest being 5,070 m^3.

More sophisticated steelmaking processes

Larger, more sophisticated steelmaking facilities have been put into operation, and various rationalization measures have been taken. These include dynamic control of basic oxygen furnaces (BOFs), ultra-high power (UHP) operation of electric furnaces, adoption of oxygen injection equipment, implementation of various kinds of automated systems, installation of ladle refining facilities, and the introduction of vacuum degassing equipment. Consequently, the varieties of steel produced have been increased, and product quality has been improved.

Vigorous conservation efforts

Various resource and energy conservation measures have been introduced in all ironmaking, steelmaking and rolling processes. Energy-recovering equipment includes BF top pressure turbines, coke dry quenching (CDQ) equipment, and various types of boilers for waste heat recovery. Energy-saving technologies, which primarily involve the bypassing of some processes and imrpvement of heat control, include direct rolling of continuously cast slabs, billets and blooms, hot charging (charging of hot slabs, billets and blooms into reheating furnaces), combustion control for various types of reheating furnaces, charging of reheated scrap into electric furnaces, and all coke operation of blast furnaces.

Meanwhile, research is being conducted in nuclear steelmaking - a process that makes use of energy generated by high-temperature gas-cooled reactors.

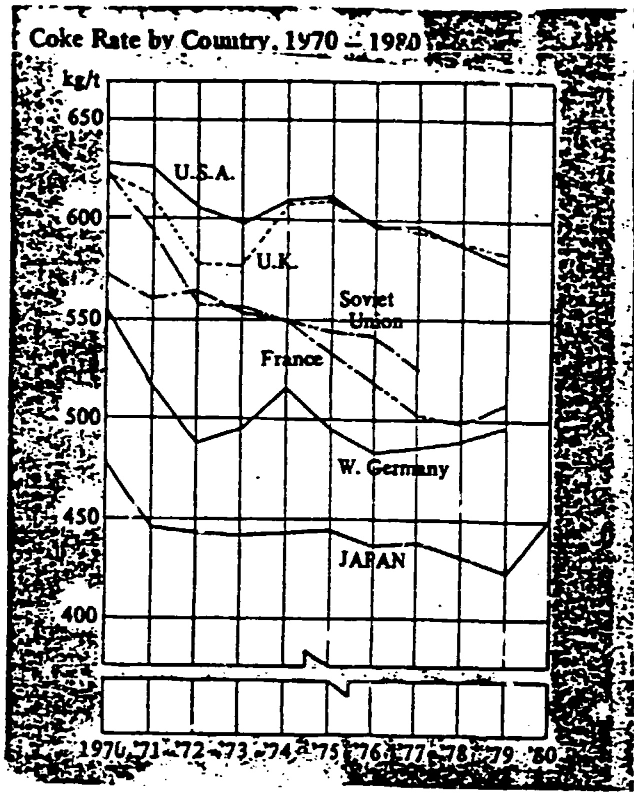


Fig. 2

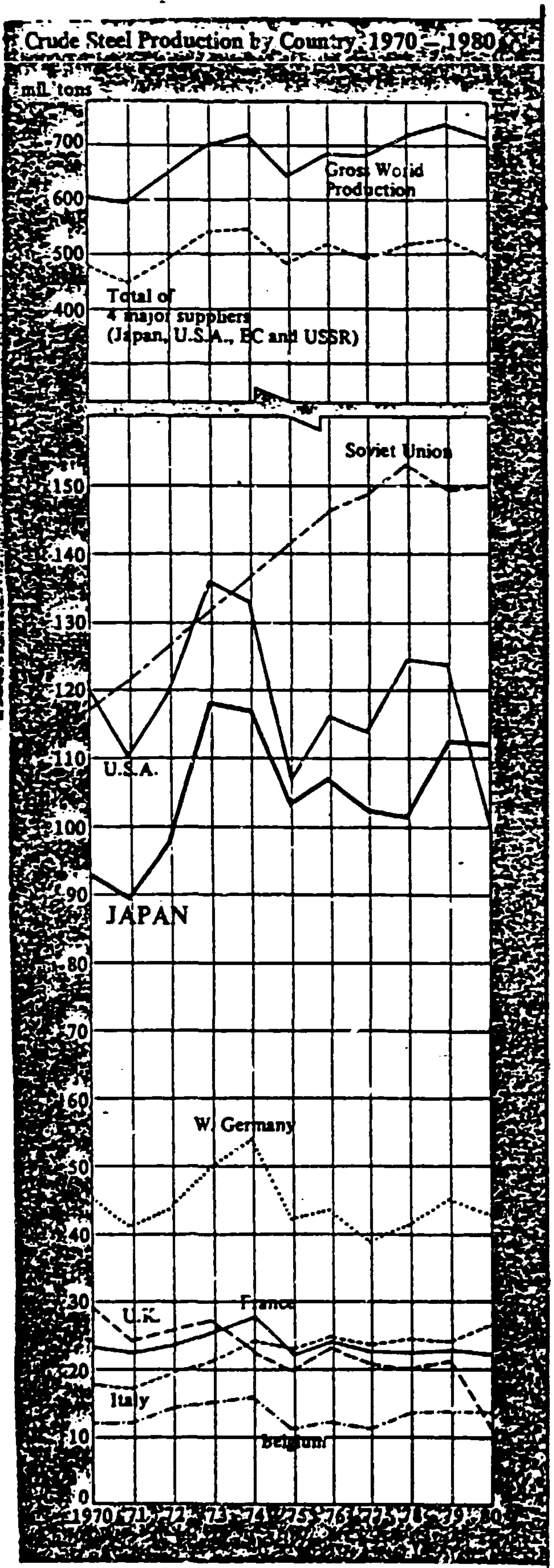


Fig. 3

Fig. 3 depicts the crude steel production country-wise from 1970-1980 for some of the leading steel producging countries of the world.

Fig. 4 depicts the world steel production and consumption during 1980 and percentages of principal countries in world crude steel output from 1970-1980.

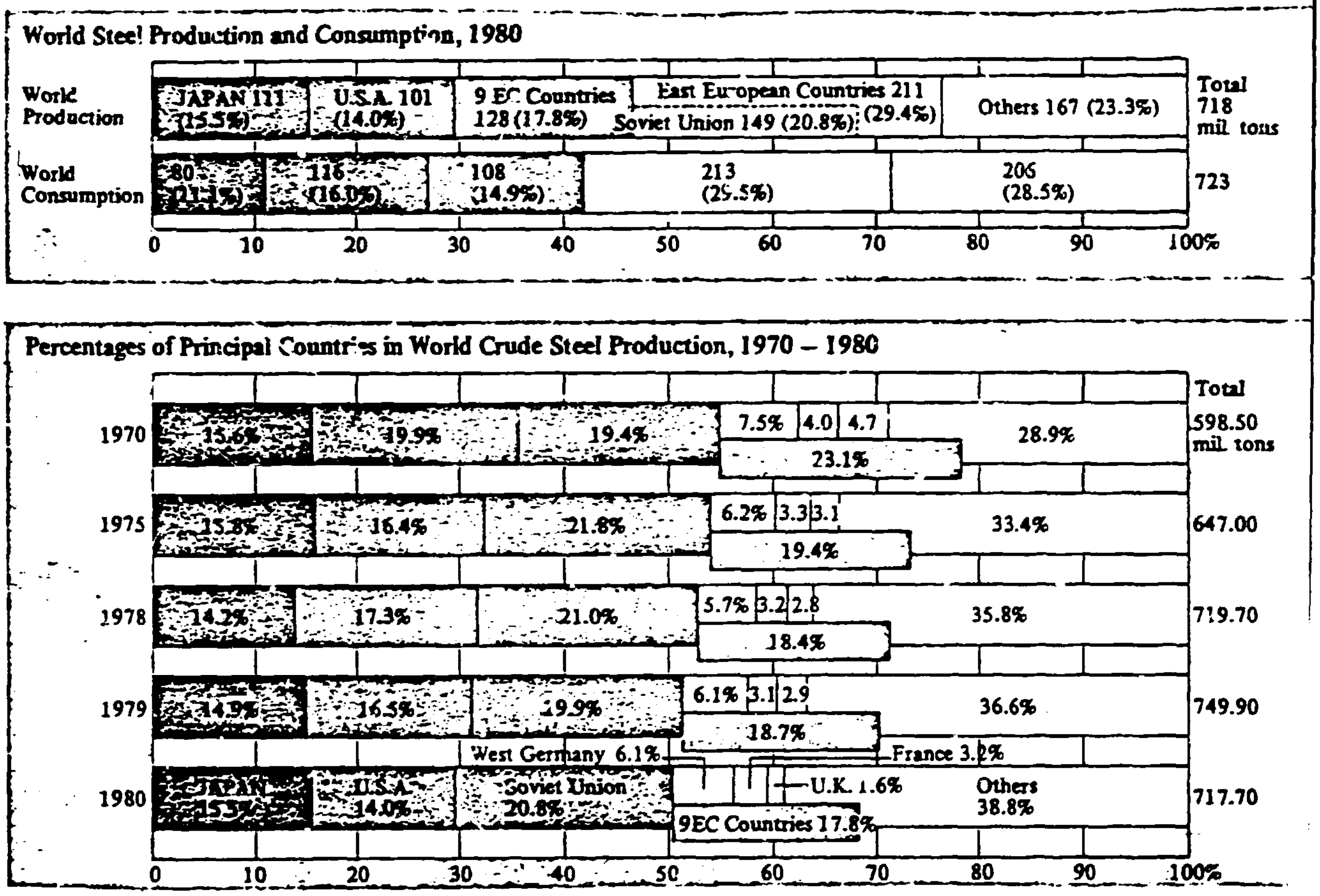


Fig. 4

The following table (Table 1) presents the approximate/pragmatic comparison of practical/actual energy consumption per ton of steel rolled products by various process routes as specified/compiled by the author.

Table 1

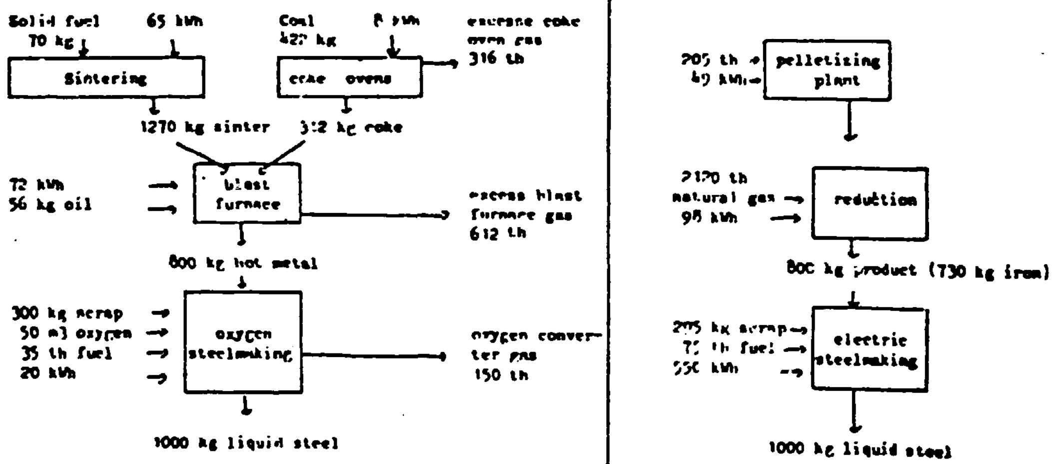
APPROXIMATE/PRAGMATIC COMPARISON OF PRACTICAL/ACTUAL ENERGY CONSUMPTION PER TON OF STEEL ROLLED PRODUCTS BY VARIOUS PROCESS ROUTES AS SPECIFIED

Country-wise	I (Coke+sinter) Blast furnace + LD Oxygen steelmaking + rolled billet produc.	II Gaseous direct reduction process/ sponge + electric arc steelmaking + rolled billet product	III Solid reductant based direct reduction process/sponge + electric arc steelmaking + rolled billet product	IV 100% scrap melting in electric arc furnace	V 50% scrap + 50% sponge - (solid reductant based DR process) + electric arc fce
Japanese	5.5 million K cal (C cal)	2.6 million K cal (C Cal) for 90% Fe metallized sponge + 650 kWH x 1.1 to allow for liquid steel 96-98% Fe = (650 kWH x 350 K cal per kWH x 1.1) = 0.61 C cal To allow for 30% electric power generation efficiency, the figure of 0.61 C cal would be 0.61/0.30 = 2.036 C cal. Thus the total would be 2.6 + 2.036 C cal = 4.636 C cal per ton. For continuous cast and rolled billet product, corresponding figure would be 90% of 2.036 C cal + 2.6 C cal, totalling thereby 1.8324+ 2.6 C cal = 4.4324 C cal	4.6 C cal per ton of 90% Fe metallized sponge + 2.036 C cal vide II column = 6.636 C cal per ton. For continuous cast and rolled billet product, corresponding figure would be 90% of 2.036 C cal + 4.6 C cal, totalling thereby 1.8324 + 4.6 C cal = 6.4324 C cal	550 kWH x 850 = 0.47 C cal. To allow for 30% power efficiency ratio, 0.47 C cal would become 0.47/0.30 = 1.55 C cal. If intrinsic energy input to produce steel scrap is also taken into account which would be of the same order as for the rolled product, the corresponding figures contained in column 1 would need to be added to the figure of 1.55 C cal	4.6 C cal vide col III divided by twc 2.33 = 1.55 C cal/ = 0.77 vide colum Total = 3.07 C cal for rolled product If intrinsic energ input to produce steel scrap is tal also into account then about half of the corresponding figures contained in column 1, would need to be added c to the figure of 3.07 C cal.
U.S.A	8.5 " " "				
W. Germany	7.5 " " "				
India	12 " " "				
	For continuous cast and rolled billet, corresponding figures would be 90% of the above figures.				

NOTE: The above Tabulation is a kind of "ready reckoner" to figure out various combinations of melting stock and the corresponding energy figures expected in practical operations; these figures are not theoretical figures which are much lower than the figures attained in practical operations and practice. The theoretical figures elaborated later on in this paper correspond to 2 to 3 C cal/ton compared to the 5.5 C cal/ton contained in column 1 above vide the Japanese figures; the corresponding figures in million BTU per ton are:
a) for theoretical value 8 million BTU and b) 24 to 30 million BTU depending upon the efficiency of operations of the respetive country concerned, per ton of steel made. (Source - Author's)

Fig. 5 indicates the differences between the projected/ ideal figures of energy consumption between a) the classical route based on blast furnace and b) the Direct Reduction route; whilst a) uses more energy than b) Direct reduction route, this difference is offset by energy contained in the by-product gases and if this energy is recovered, the energy consumption by both the routes is about the same.

FIG. 5 - COMPARISON OF ENERGY REQUIREMENTS FOR THE TWO SOURCES



Blast furnace + Oxygen steelmaking

fuels	kg	th or 10^3 kcal/ t liquid steel	remarks
Coal	462	3 444	
Oil	56	560	
Various fuels	35 th	35	
Electrical energy	(165 kWh	142	860 kcal/kWh
	(	380	2300 kcal/kWh
Total	(	4 181	860 kcal/kWh
		4 419	2300 kcal/kWh
recovery of gases		1 078	
Total net	(	3 103	860 kcal/kWh
	(	3 341	2300 kcal/kWh

Direct reduction + Electric Arc furnace

fuels	quantity	th or 10^3 kcal/ t liquid steel	remarks
natural gas	2400 th	2 400	
electrical energy	(697 kWh	599	860 kcal/kWh
	(	1603	2300 kcal/kWh
Total	(	2 999	860 kcal/kWh
	(	4 003	2300 kcal/kWh

(After J. Astier - M.B. Iron Ore Symposium, March 1981)

The Direct Redutction route using electric arc furnace for steelmaking, is based on electric energy plus other energy derived from natural gas or coal. The blast furnace gas route is based on coking coal principally. The Direct Reduction route is more flexible as the steel melting feed stock can be steel scrap and directly reduced sponge.

If one uses more scrap than DRI sponge, the total energy requirement of the DR/electric arc furnace steelmaking route will decrease. In mini steel plants, using only steel scrap, the kWH per ton of steel will be of the order of 550 kWH corresponding to:

a) 473 K cal (0.473 G cal) based on 860 K cal/kWH

b) 1265 K cal (1.265 G cal) based on 2300 K cal/kWH

when about 30% efficiency of (KWH) electric energy generation is taken into account.

<u>Energy content of scrap and energy consumption for production of steel for various process routes:</u>

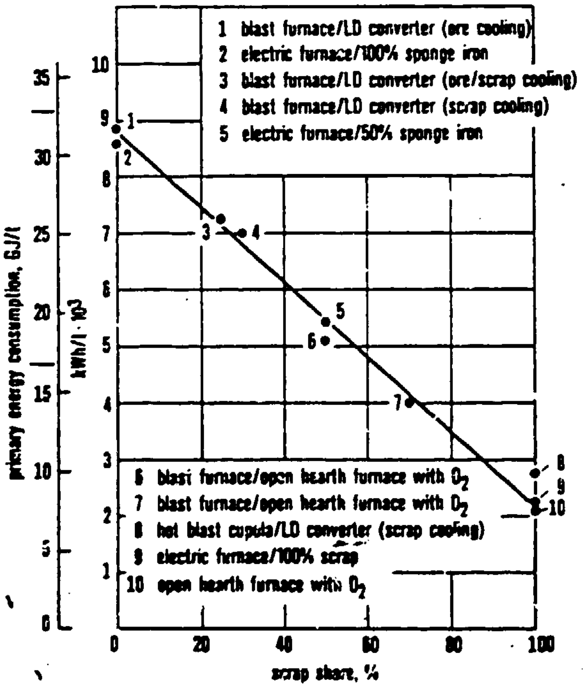


Figure 6 Primary energy consumption for the various steelmaking routes

The following data and particulars are quoted from MPT-ISSN 0171-4511 (p. 22-23) - Dr Ing Hans Graf, Dr Ing R Baum and Dr G. Kronche.

Steel produced by the melting of scrap in an arc or induction furnace contains the energy needed for this process and also the very energy that was initially needed to make steel from ore and that is bound up in the scrap. It is difficult to make a uniform valuation of this bound up energy. Bought trade scrap, for example, has already passed the cycle via consumer goods several times, whereas home scrap produced in the iron and steel industry would for internal energy balance reasons have to be rated to possess a zero energy content.

The primary energy consumption for various steelmaking routes was calculated as a function of the scrap charge in a more recent publication (Fig.6). All energies needed for production of raw materials, fluxes and additions, as well as for operating materials and consumables such as water, electrodes and refractories, have been considered in determining the primary energy demand. To achieve a real basis for comparison, all electrical energy used has been additionally converted to the amount of primary energy consumed via power station efficiency and transmission losses. In the case of electrode graphite, for instance, not only the calorific value of graphite as such, but also the primary energy needed for calcination, annealing and graphitization have been accounted for. The primary energy demand for the refractory construction materials used, for ferro alloys and for lime has been likewise calcualted, while scrap has been rated to have a zero energy content. The electrical energy required for cooling water recirculation or dust removal has also been converted to primary energy via the power station efficiency. Yet it was impossible to consider all energies; the energies needed to construct and erect the production facilities were thus left unconsidered.

Zero energy content has been allocated to scrap. Fig.6 shows scrap to have a theoretical energy content by way of comparison between the process varieties without scrap and with 100% scrap.

R.S. Barnes assumed an energy content of 7 400 MJ, corresponding to approx. 2 000 kWh, per ton of scrap for calculation of the energy consumption involved in producing 1 ton of liquid steel via various steelmaking routes. (RS Barnes Stahl u Eisen 94 (1974) p. 1077/84).

Rational use of energy in electric steel production

As earlier pointed out, it is the arc furnace that consumes most of the electric heat in the steel industry, so that new methods should have their total energy consumption (primary energy) compared with the conventional mode of operation of an arc furnace. Table 2 therefore compares the consumption figures from a study of the Battelle Institute - which are based on operational parameters for US arc furnaces in 1973 - with the values of a modern UHP arc furnace with watercooled sidewalls and roof elements. The production programme taken as a basis is identical in both cases. As our own results show, the primary energy consumption of the present day UHP arc furnace is 10% lower than the average values of the Battelle Study. This is so because the forced furnace operating mode and its concomitantly shorter melting times reduces the relative heat losses, even though the refractory lining is substantially replaced by water-pass boxes. This water cooling approach also enables the system to be operated with longer arcs and lower current loads imposed on the electrodes to thereby achieve a one-third reduction in electrode consumption. This saving is having a parcicularly strong impact in case of the primary energy content of approx. 51 kWh/kg graphite. Computer control of the entire process also makes a decisive contribution to minimizing energy consumption.

Energy flow sheet

The Committee on Technology of the International Iron and Steel Institute in Brussels carried out a study in 1977 and as a part thereof compiled an energy flow sheet on steelmaking in the arc furnace (Fig. 7). A power station efficiency of 35% was assumed for a fossil fuel operated power plant. Thermal efficiency - excluding slags and reaction heat - when using fossil primary energy in the power plant is only 26% of that of electric steel production using water power as primary energy. This means that, for the upper Italian, Swedish and a number of French arc furnaces within the concerned Euroepan area, water power as a secure domestic energy source offering high energy efficiency can be expected to bring about an even greater competitive benefit in the medium and/or long run.

The energy flow sheet as per figure 7 applies to a 150 t model type UHP arc furnace with an installed specific capacity of 450 kVA/t and a daily production of 1 500 tons of steel. The figures refer to 1 ton of liquid steel at 1 570°C tapping temperature. The specified 460 kWh/t power consumption would increase in practice by 40 to 90 kWh/t to the more standard values of 500 to 550 kWh/t liquid when accounting for the 5 to 6% melting loss and the necessary heat-up beyond 1 570°C. No closer consideration is given here to further influenceing parameters of power consumption such as scrap quality, amount of additions, thermal state of furnace and design of dust removal system.

Fig. 7 indicates how further energy savings can be achieved for the arc furnace.

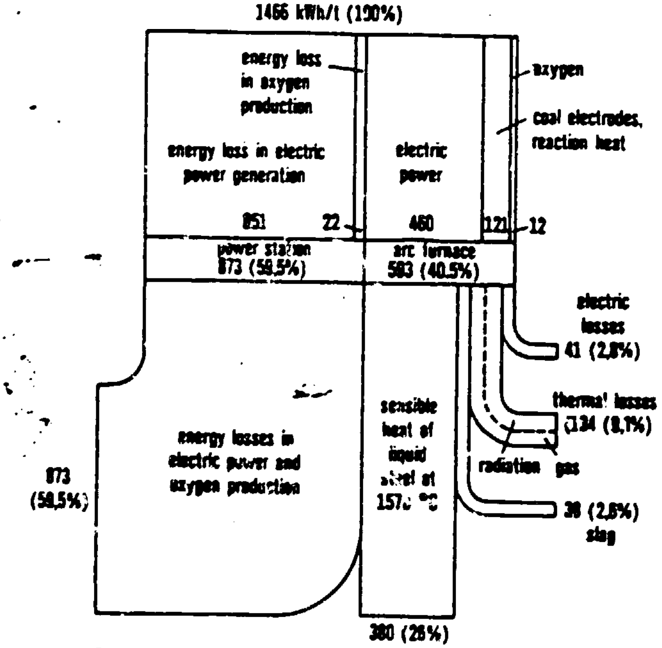


Figure 7 Energy flow for steelmaking in the arc furnace (IISI study 1977): data in kWh/t liquid

Table 3. Total energy consumption (primary energy) for the manufacture of 1 t of crude steel (liquid) in the arc furnace

		USA 1973			UHP 1979		
		Consumption	Energy demand kWh	%	Consumption	Energy demand kWh	%
Charge materials (excluding scrap)			241.2	8.46		239.2	8.39
Alloys			257.0	9.01		257.0	9.01
Refractories	kg	13	104.7		6.0	48.3	
Water	kWh		1.0		10.0	31.2	
Total			105.7	3.71		79.5	2.79
Electrical energy (melting process)	kWh				500	1 562.5	
Electrical energy (dust removal)	kWh	—			50	156.3	
Total		605	1 890.6	66.30	550	1 718.8	60.28
Oxygen	m^3	7.8	14.7		15	28.4	
Natural gas	m^3	3.1	32.2		5	52.0	
Electrodes	kg	6	310.2		4	206.8	
Total			357.1	12.53		287.2	10.07
Total energy consumption			2 851.6	100		2 581.7	90.54
Credit for waste heat						40.0	
Grand total energy consumption						2 541.7	89.13

Possibilities of further energy savings

The total direct energy input from electrical ene[illegible] xygen, coal, electrode burnoff and reaction heat in the example [illegible] 7 is 593 kWh/t. Dissipations are 64% as liquid steel sensible heat, 23% as heat losses due to radiation and flue gases, 7% as electric losses and 6% due to slag heat capacity.

The sensible heat of steel is most effectively utilized where hot shaping to intermediate or end sizes follows or is performed in the absence of chilling or reheating after casting and solidification. Other than in the case of ingot casting, the arc furnace/continuous casting plant process route already results in a primary energy saving of approx. 20%, corresponding to approx. 900 kWh/t of semi-finished products, which is due to increased yield and omission of the semis rolling stage . How can the sensible heat of continuously cast and solidified steel be further utilized? Efforts to achieve this goal in the case of continuous billet casting machines by "in line" arrangement of shaping stands have met with little success, but attempts are being made in many plants to charge the CC materials into the heating furnaces of downstream shaping processes whilst they still carry their casting heat which, besides other benefits, results in a reduction of the energy needed for reheating. These efforts certainly will be intensified over the next few years. In the production of hot rolled wide strip from basic oxygen steel in Japan, for instance, the use of CC slabs in the rolling mill with omission of the reheating furnace stage (process referred to as HDR = hot direct rolling) already has grown to a noticeable extent and is playing a major role in the energy saving comapaigns that the iron and steel plants are carrying out with considerable success.

Another approach for utilization of the sensible heat is presently being tried in practice with a first prototype in a Californian electric steel plant : waste heat from cooling piles of CC billets is used for scrap preheating . It has been reported that scrap temperatures around 750°C and an average energy saving of 90 kWh/t could be achieved this way.

A reduction of heat losses due to recuperation of waste heat is technically feasible for the arc furnace since the introduction of water-cooled walls and roofs. It is also economically interesting provided an adequately sized distribution system is available and sufficient acceptance is ensured.

The cooling water circuit for the water-cooled sidewalls and roofs, as well as the water-cooled dust removal section, operates on the high-pressure water or the evaporation cooling principle at pressures of 10 or 25 bar and temperatures of 130 or 220°C. A first system of this type was commissioned on a 100 t arc furnace in a Danish electric steel plant and is said to achieve a recuperation of about 40 kWh/t from the waste heat of the water-cooled furnace lining. The extent of technical equipment is of course considerable because the cooling water supply connections must be adapted to follow the tilting movement of the furnace and the swivel movement of the roof. If the bottom tap type stationery arc furnace - a prototype of which is already in operation - should make its way in the future, the structural conditions for heat recovery would be essentially more favourable.

The electric losses which, as previously mentioned are only 7% of direct energy input, would also be reduced by construction of stationery arc furnaces, since shorter power conductors would reduce the electric transmission losses, even though restrictions are imposed by potential system reactions, unless the hardly reasonable approach of providing extensive compensation arrangements for suppression of such reverse-effects is adopted.

A research project on a 38 t UHP furnace with an installed capacity of 475 kVA/T, which is implemented under the auspices of the German Federal Ministry of Research and Technology (BMFT), includes investigations into the use of natural gas-oxygen burners during the meltdown phase. Due to faster heat-up and ionization of the furnace atmosphere, an essentially more stable arc behavior can be expected than in the case of operation without burners. An objective of these investigations is to ascertain whether this procedure will permit the reduction of the electric losses and an improvement in energy efficiency.

As earlier mentioned, the energy loss due to slag sensible heat is about 6% of the direct energy input and theoretically could be influenced by reducing the slag volume, but there is no due cause for such reduction in practice because a certain amount of slagforming constituents must be introduced into the meltdown process for metallurgical reasons. Minimum slag amounts must also be present to satisfy the requirement that, after meltdown of the scrap in a shallow bath configuration, an arc must be used which is burning within the slag to thereby give off maximum energy to the bath and minimum radiation heat to the furnace lining.

In the case of British Steel Corporation, there has been an overall improvement in the total energy consumption/ton of crude steel output during 1978-79 at 24.77 GJ compared to 27.47 GJ during the preceding year.

Table 3 gives the fuel and energy required for 1 ton of finished steel product (coil) at successive stages of steel production.

Fuel injection through the tuyeres

The injection of fuel oil in the blast furnace results in increase in production rate as the hydrogen so produced reduces the iron oxide faster than the carbon monoxide. As indicated earlier, the injection of either natural gas or oil lowers the coke rate and increases furnace productivity. The application of either of these in the blast furnaces is not likely to find larger use on account of their increasing costs.

Another alternative to the hydrocarbon injection is coal and some of the plants in France, UK and USA and USSR have adopted to coal injection. The only drawback is that coal grinding and injection system need elaborate arrangement.

Through the injection of hydrocarbon or coal through the tuyeres does result in lowering the coke rate, but the actual energy saving should only be determined by taking into account the energy of the injected fuel. The energy savings for the injection of the optimum amount of a given injectant are given in Table 4. It is noted that though all the injections do lower the energy that is required to produce a ton of hot metal, the most notable saving is obtained with coal.

Table 3 Fuel and energy required for 1 ton of finished product (coil)

	Material consumed, tons		Material consumed, tons		FUEL AND POWER CONSUMED										FUEL AND POWER PRODUCED										Net fuel and power consumption, Therms
					STEAM		ELECTRICITY								STEAM		ELECTRICITY								
					High press, Therms	Med. press, Therms	kWh	Therms	Coal Therms	Coke & breeze, Therms	Oil, Therms	BF gas, Therms	CO gas, Therms	Total Therms	High press, Therms	Med. press, Therms	kWh	Therms	Coke & breeze, Therms	BF gas, Therms	CO gas, Therms	Tar, Therms	Benzole, Therms	Total, Therms	
Coke Oven Plant	Coal	0.764	Coke Breeze	0.590 0.015		3.2	11.7	0.4	238.2			14.7	4.3	260.8					176.2		40.1	8.2	2.4	226.9	33.9
Ore Preparation and Sinter Plant	Ore Breeze	1.184 0.081	Sinter	1.237			26.4	0.9		19.8		2.1	0.7	23.5										-	23.5
Blast Furnace Plant	Coke Sinter Ore	0.554 1.257 0.367	Hot metal	1.007	10.7	1.3	14.6	0.5		156.4		23.4		192.3						61.5				61.5	130.8
L.D. Converters	Hot metal Scrap	1.007 0.367	Ingot Skull & butt.	1.159 0.045		1.9	46.9	1.6			5.7		3.2	15.9	16.7									16.7	−0.8
Steelmaking Ancillaries (inc. Ladles, Launders and Hot Metal Mixers)				1.189		0.1						1.8	3.3	5.2										-	5.2
Soaking Pits	Hot ingot Cold ingot	1.079 0.089	Soaked ingot Scale	1.161 0.021			2.9	0.1				8.5	3.0	11.6										-	11.6
Primary Mill	Soaked ingot	1.161	Slab Crop	1.039 0.122			23.5	0.8						0.8										-	0.8
Reheating Furnaces	Slab after Scarfing	1.039	Rollable slab Scale	1.018 0.021		1.0	2.9	0.1			21.3		4.7	27.1	7.8									7.8	19.3
Finishing Mills	Rollable slab	1.018	Finished product Crop & cobble	1.000 0.018		0.2	67.4	2.3						2.5										-	2.5
Boiler Plant											6.9	9.1	19.8	35.8	30.5									30.5	5.3
Oxygen Plant						0.2	99.6	3.4						3.6										-	3.6
Power Generation					44.3	6.9								51.2		26.9	237.4	8.1						35.0	16.2
Miscellaneous						1.7	17.6	0.6				0.7	0.4	3.4										-	3.4
Unaccounted						1.4	2.9	0.1				1.2	0.2	2.9										-	2.9
Total					55.0	17.9	316.4	10.8	238.2	176.2	35.9	61.5	40.1	636.6	55.0	26.9	237.4	8.1	176.2	61.5	40.1	8.2	2.4	378.4	258.2

Good practice. All BOS Imported Ore.

Iron and Steel International, April 1974 p.107.

TABLE 4 - ENERGY SAVING FOR SELECTED BLAST FURNACE INJECTANTS

(Source: Battelle - Power for energy conservation in the steel industry V-35)

Injectant	Fuel energy value Million BTU/ton	Replacement ratio	Tons of injectant THM	Energy saving Million BTU/ THM
None	31.5	-	-	-
Coal	26.0	1.1	0.125	1.02
Tar	16.6	1.4	0.075	0.79
Oil	38.4	1.4	0.075	0.43
Natural gas	45.6	1.5	0.05	0.08

The information on the increase in the productivity with the coal injection is rather sketchy.

Heat recovery from other sources

Besides the heat lost at the different stages indicated earlier, there are a variety of other places where the sensible heat is lost and there is need to launch an intensive R and D programme to recover as much sensible heat as is possible. Some such cases are:

1. Sensible heat loss from solids e.g. sinter, slag, lime, iron and steel products
2. Heat loss from cooling water and low grade steam.

The heat loss after the hot rolled product is being cooled in the cooling banks prior to straightening, inspection, dressing and despatch, is quite considerable. One ton of bar at 900-1050°C dissipates 635-740 MJ on cooling down to ambient temperature and there is considerable scope for development of an efficient method of heat collection and usage.

The sensible heat contained in the pig iron being cast into pigs and in the blast furnace slag is also quite considerable and there is need to develop a method for such sensible heat collection and usage.

Energy economy

Besides the energy saving in the steel plants through changes in the operating conditions or installation of new equipment, it is also possible to economise through better house-keeping and re-examination of existing demands of utilities for non-operational use. Some such examples may be noted as:

- Improved repair and maintenance of furnace, including the addition of more insulations, cutting down on radiation losses.
- Conducting frequent combustion tests on fuel and air ratio.
- More frequent inspection and immediate repair of air and steam lines
- Reducing idling time of power driven equipment
- Reducing energy consumption in the rolling stage by increased adoption of hot charging and hot direct rolling and low temperature rolling operations.
- Economising on heating/cooling and plant lighting.
- Increasing the efficiency of energy conversion through improved power and load factor.

The steel industry consumes 24×10^6 to 30×10^6 BTU instead of the theoretical value of 7.06×10^6 BTU per ton of steel. The steep increase in the price of energy and dwindling resources has brought about increased awareness for energy saving that is possible through improved operations, development and adoption of new technology as well as modernisation.

It is reported from different plants and countries that an energy saving of 5-10% has been obtained since the energy crisis and it is hoped that if all the established technological measures are adopted, a saving of about 25% of the present energy consumption is possible. The major energy conservation measures are:

- Use of beneficiated raw materials
- Lowering of blast furnace fuel rate
- BOF gas recovery
- Installation/expansion of continuous casting
- Lowering of reheating furnace fuel rate
- Recovery of waste energy

It is suggested that the energy economy programme be executed through the shop and managerial committees. The shop level being responsible for implementation of the directives of the managerial committee which would also take suitable measures to prevent any leakage and wastage of energy, whilst the higher committee examines the various energy economy measures, recommends on investments leading to energy economy and conservation, inter-departmental coordination resulting from energy economy measures. This committee would also identify new areas that need R and D effort for energy conservation and waste heat utilisation.

It is hoped that with the continuous efforts, the steel industry that has considerably cut down the pollution through the introduction of suitable measures, will also cut down its energy consumption to as close the theoritical limits as is possible.

Possibly the most suitable example to conclude this paper, would be to refer to the most successful battle to slash BTUs at the Ohgishima Works of Nippon Kokan KK in Japan(1). After 60 years of service, the older Keihin Works of NKK has been replaced by the new Keihin Works at a new off-shore island based on land reclaimed from Tokyo Bay. Basic planning for the new complex focussed on 3 goals - a) high productivity, (b) energy and resource conservation and (c) environmental protection and pollution control. Two large computers and 25 process computers have been employed to establish an integrated control complex

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(1) Journal "33" - March 1981, p. 58 to 61 - NKK emerges a victor in its battle to slash BTUs at Ohgishima.

providing on-line, real time operation. The system centralized production planning, material flow control, and automatic mill operations from raw materials receipt to product shipment. Kehin's projected manning target of less than 10,000 employees with estimated productivity set at 600 mt/worker/year in terms of crude steel production; this figure is 2.6 times higher than that achieved during peak production prior to the replacement of the older works. In 1977, NKK launched a 3 year programme designed to ultimately trim crude steel production cost at Keihin by as much as 21.83 $/mt. The reduction was to be effected through a) 40% lower fuel consumption, b) 10% increased yield, c) 10% savings in operational material, d) 10% lower maintenance costs, e) 20% reduced repair costs and f) 10% reduction in transport costs. Perhaps the single most essential component of the cost reduction programme was the drive to consume about or even less than 5 million K cal of energy per ton of crude steel output and this target has been achieved. From April to June 1980, crude steel energy consumption was slated down to 5.10 million K cal/ton down from 5.9 million K cal/ton from April to June 1977. Reportedly, the average energy consumption per ton of steel produced overall by the Japanese steel industry was about 6 million K cal during 1975.

Extensive investigations were carried out to seek out and evaluate energy and resource saving equipment for Ohgishima. One of the foremost results of this quest was the introduction of the Soviet developed coke dry quenching system at the works. Waste heat is recovered as steam and then distributed to various plants and shops throughout the works. Heat quantity retriveable as steam is reportedly equivalent to 40% of the total heat quantity used in the coke ovens.

Six different types of fuels are used at Ohgishima including by-product gases such as blast furnace gas, coke oven gas, BOF gas, LPG, heavy and coker gas (a by-product of petroleum refining). Since by-product gases account for about 65% of total fuel consumption, their utilization directly affects the operating condition of the works. Consequently NKK decided to adopt a mixed gas system as the fuel supply method for the complex. Based on the 5 fuel types employed plus nitrogen gas, the system has guaranteed Keihin a high versatality in the utilisation of by-product gases. According to NKK, energy savings measures to be explored in the future include the recovery and utilization of medium to low temperature waste energies, the conversion of energy and the improvement of its quality and the increase in thermal efficiency through better methods of heat retainment and insulation.