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State of the Art and Future of the Blast Furnace

by Dr.-Ing. Hans Bodo Lüngen
VDEh, Düsseldorf

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Ladies and Gentlemen, dear ironmakers,

First of all I would like to express my cordial thanks for your invitation to participate at the 35th meeting of the International Pig Iron Secretariat. It’s a great honour and pleasure for me to present an overview paper about blast furnaces which in contrast to pig iron of the foundry iron furnaces produce basic hot metal. I hope that I will succeed in bringing over the message to you about the state of the art in blast furnace technology today and its future, **figure 1**. On this photo a 2000 years old ancient of the blast furnace is shown which already operated by the basic principles of iron ore reduction still valid today.

The reduction of iron ores can look back on an extremely long development history. The blast furnace, with its typical construction as a “high furnace” (**figure 2**), won through against its predecessors such as the Renn, bloomery and flowing furnace in the middle of the 18th century. It has always been able to meet the continuously increasing technical requirements during its further development, **figure 3**. The blast furnace process had its stormiest development phase during the past few decades, coupled with developments in plant engineering, the quality and supply of raw materials as well as comprehensive process monitoring and control.

Statistics on the use of hot metal for crude steel production are to be used as a first step when dealing with the technical and economical examination of the development of blast furnace technology, thus permitting general statements on the significance of the reduction of iron ores.

Looking at the evolution of the world’s hot metal to crude steel ratio in **figure 4** it is noticeable that, up to the turn of the 20th century, steel was almost exclusively produced on the basis of the reduction of iron ores. The drop in the hot metal to crude steel ratio at the beginning of the last century indicates the increasing reuse of steel scrap. By the way, the reuse of steel scrap for the production of crude steel is one of the oldest recycling processes. It has gained more and more importance in the past years. Another interesting fact is that the use of hot metal has remained more or less the same since the 1930's at approximately 700 kg/t crude steel, independent of the level of the crude steel world production. Steel is today produced via two dominant routes, **figure 5**:

- by the reduction of iron ores via the route blast furnace / oxygen converter and
- by melting of steel scrap via electric arc furnaces

In the production route blast furnace / oxygen converter hot metal is produced as the first step in blast furnaces from lumpy iron ores, like sinter, pellets and lump ores, as well as coke charged at the top. Additionally auxiliary reductants, like coal, oil or natural gas, are injected as coke replacement via the tuyeres into the lower part of the furnace. The hot metal still contains small amounts of unwanted elements for the final steel products, like carbon, silicon, sulphur and phosphor. These are removed in the oxygen steel converter by blowing oxygen into the melt. This process is exothermic and produces heat. For this reason approximately 25 % steel scrap is charged to the converter as cooling agent.

The second process route is based on the melting of solid steel scrap to crude steel in electric arc furnaces. Here electricity is transferred via an electrical arc to the required melting energy.

At this point it has to be mentioned, that mainly the blast furnace / oxygen converter route is used for producing high grade flat steel products with high steel cleanness. It is also possible to produce these steels via the EAF route by the use of suitable charge materials, like clean scrap and/or Direct Reduced Iron.

In the following my report shall focus on the evolution and development of blast furnace hot metal production in the past five decades. For this I take Germany as an example, as here blast furnace technology can be rated today to be the world highest class standard.

Crude steel and hot metal production in Germany since 1945 (figure 6)

Figure 7 shows the evolution of crude steel, hot metal and blast furnace sinter production as well as pellet imports since 1945 for Germany. After the boom years 1973 with 50 million t and 1974 with 53 million t crude steel the third highest level was reached in 2000 with a production of 46.5 million t crude steel. Hot metal production reached 30.6 million t. The curves for sinter and pellets as iron rich agglomerated burden materials for the blast furnace follow the demand. Pellets reached more importance with their technical development and capacity increase since the middle of the 1960's.

The share of steel making processes showed an increase of the electric steel making in the past but an amount of over 70 % oxygen converter steel for 2000, remain as the main basis for our steel industry, **figure 8**. This level is anticipated to remain on the long turn for high grade flat steel products. For comparison: In the world 58.6 % crude steel comes from oxygen converters, 33.8 % from electric arc furnaces and the rest from other process routes.

As mentioned before, the stormiest development of blast furnaces took place in the last decades, resulting in the change over from many small units to a few large ones. **Figure 9** clearly demonstrates, that between 1945 and 1960 after repair of world war II damages many furnaces were recommissioned or newly built with a peak of 130 operated blast furnaces in 1960 which on average produced 200 000 t hot metal a year. The average production per furnace and year increased to 1.9 million t in 2000. This corresponds to an improvement of average yearly output rate by 850 %, compared to 40 years ago. Only 16 furnaces were operated last year.

The unrelenting pressure for improved competition on the market by reducing hot metal costs have led to remarkable development of blast furnaces output rates, and, above all, in blast furnace size, as to be seen in **figure 10**. The daily production rate, as another example, increased from about 2000 t to more than 12 000 t hot metal per day, and the blast furnace proved to be unbeatable in productivity and economy for large, integrated iron and steelworks. The production increase was not only achieved by larger furnace volumes but also by more specific productivity results. This was one prerequisite for reduced production costs and improved competitiveness.

Increase of blast furnace productivity (figure 11)

The definition of blast furnace productivity will give me the red thread through the explanation of technology and operation development how blast furnace operators succeeded in pushing the process.

The blast furnace productivity (**figure 12**) is the quotient between possible gas throughput per unit of time and required specific gas generation for one tonne of hot metal. Consequently, an increase in productivity on the one hand requires an increase in the gas throughput, which implies improvement in furnace permeability, and on the other hand a reduction in the specific gas requirement, which finally means a reduction in the specific consumption of reducing agents. This sounds easy but, believe me, in reality it’s a very complex process with many influencing and correlating factors.

The blast furnace is a counter current reactor in which the reducing gas is produced by coke carbon gasification with the oxygen of the hot blast injected via tuyeres in the lower part of the furnace. This reducing gas flows upwards reducing the iron bearing materials charged at the top of the furnace. Permeability of the ferrous burden and coke column for the gas flow is inseparably linked together with the increase of gas throughput. This task results from the schematic drawing in **figure 13** which shows the current ideas on the structure of the burden column with the associated curves of the isotherms and process zones. Namely, the structure of a burden column of charge materials ore and coke with properties which extensively ensure the voidage necessary for the permeability, in spite of mechanical, thermal and chemical loadings that take place on the way from the top, via the softening and melting area and down to the lower furnace. Therefore, many quality criteria for ferrous burden materials and coke have been defined with ever increasing demands.

One prerequisite for achieving high quality ferrous burden materials was the development of agglomerating fine iron ores to sinter and pellets and the increased use of these materials, as to be seen in **figure 14** as average for all German blast furnaces. Sinter, which is produced in the works’ own sintering plants, amounts to approximately 70 % share, pellets which are produced by iron ore suppliers to 30 % share. The remaining 10 % are lump ores, which are cheaper in prices but may effect productivity. It has to be noted, that the sinter plays an important metallurgical role for the blast furnace. Sinter contains the slag carriers for all burden materials and has more suitable metallurgical properties related to the requirements of the blast furnace than the other ferrous burden materials.

Here it has to be noted, that ferrous burden composition of the individual companies depends on the sintering capacities and operating philosophies. It differs in a wide range, **figure 15**. High sinter rates of over 62 % are operated at TKS, HKM, EKO and ROGESA, high pellet rates of over 57 % at Stahlwerke Bremen and Neue Maxhütte. Remarkable is the high lump ore rate at Salzgitter AG. The general practice has shown in all cases that it is advisable to prepare a homogeneous mix of all iron bearing components before charging to the blast furnace to achieve excellent permeability and suitable melting behaviour.

The second precondition for high productivity is a decrease of the specific gas production. This can mainly be achieved by decreasing the specific consumption of reducing agents which are gasified in the furnace. **Figure 16** shows the reduction of the weighted average consumption of reducing agents in German blast furnaces that has occurred since 1948, as well as the main measures that have contributed to this.

The first to be listed are again the preparation of the ferrous burden as well as the use of iron rich ores from overseas. The considerable reduction in the amount of slag, from around 800 kg/t HM in the 1950's to today's average of 250 kg/t HM, resulting from the changed composition of the charge materials, has also made a substantial contribution to the reduction of reducing agents. The development of hot blast stoves with blast temperatures of over 1200 °C and the oxygen enrichment of blast contribute to productivity increase and to the injection of coke replacing auxiliary reductants like coal, oil and waste plastics.

In 2000 the consumption of reducing agents in German blast furnaces amounted to only 475 kg/t HM, with an average coke rate of 360 kg/t HM and a total injection rate of 114 kg/t HM, **figure 17**. Injection rates of 140 kg oil or 180 kg coal have been reached at individual furnaces as yearly average with coke rates down to 300 kg/t HM.

As a result of all these measures productivity increase on average of all furnaces was from 1.5 to 2.5 t/m^3 working volume and 24 h, which is an increase of 67 % in 2000 compared to 1973, **figure 18**. Additional productivity reserves could be utilized by changing the reducing agent structure in conjunction with the use of higher amounts of oxygen as well as in improvements in burden quality. Further change in reducing agent structure means a further decrease in coke consumption. The headword "coke" leads me over to the question of the role coke plays in the blast furnace.

Role of coke in the blast furnace, figure 19

Figure 20 will accompany us in the explanation of the main tasks of the coke in the blast furnace. It is another imagination how we believe it looks inside the black box blast furnace. Hot metal production in blast furnaces is inseparably linked with coke and its availability. A blast furnace, on the one hand, cannot be operated without coke for physical reasons. On the other hand, coke is generally the most expensive charge material for blast furnaces. The blast furnace operators will therefore always try to reduce the coke consumption of blast furnaces to the lowest level technically possible by injecting coal, oil or other alternative reducing agents.

In contradictory to cupola furnaces, where coke is used as a fuel, coke in blast furnaces, besides guaranteeing permeability, plays dominantly a chemical role, supplying reducing gas, and is therefore regarded as reducing agent!

But why do we call it reducing agent? To answer the question as to what extent the blast furnace process utilizes the reducing agents and the energy it is supplied with, one can refer to the following quotation from an expert report carried out by Prof. Jeschar of Technical University Clausthal: “Approximately 70 % of the energy supplied by the coke is discharged together with the hot metal as chemically-bonded energy: 13 % is supplied as low calorific value with the compulsory produced top gas for use in other plants of the works. 14 % is required as sensible heat for the hot metal and slag. The chemically bonded enthalpy and sensible heat in the hot metal are fully utilised in the oxygen steel shop. Only approximately 3 %, which is discharged with the top gas as sensible heat or covers the heat losses at the walls, is to be regarded as ‘loss’”. The utilization ratio of reducing agents and energy used for the blast furnace process thus amounts to 97 %, which is an outstanding value.

Coke plays generally a triple role in the blast furnace, namely a physical, thermal and chemical, of which the physical and chemical are most important.

Physical role: As ferrous materials change their chemical and physical properties when passing from the stock line to the hearth of the furnace, as a consequence of reduction, softening and melting, the coke remains the only solid material below the melting zone of the iron bearing materials. The coke has to guarantee the furnace permeability in three parts of the furnace, for the furnace gas in the dry region above the cohesive zone, in the cohesive zone itself and for gas and molten products in the hearth. A very important role is credited to the coke in the cohesive zone where the softening and melting iron-bearing materials are believed to form impermeable layers as a result of softening and melting, separated by permeable coke layers or windows. The coke in the cohesive zone also forms a strong grid which supports part of the weight of the overlying burden. This is the reason why blast furnace operation without coke is not possible on a purely physical basis.

Chemical role: The coke supplies the carbon for the production of reducing gases (CO) in the high temperature zone of the furnace. It also acts as reductant for the direct reduction of iron oxides, for the reduction of alloying elements like silicon and manganese and last, but not least, it is responsible for the carburisation of the hot metal, which is necessary to decrease the melting temperature of iron.

Thermal role: The carbon of the coke and of the injectants supply the major part, approximately 80 %, of the heat required for the process. The remaining 20 % is supplied by the hot blast.

Coke quality test standards and requirements for chemical and physical properties can be related to the tasks coke performs in the blast furnace and the mode of blast furnace operation.

The physical and mechanical properties are today described by the level of coke stabilisation, grain size distribution, its cold strength for the dry part of the furnace (for example I_{40}, I_{10}) and for the high temperature zone by the coke CRI value (Coke Reactivity Index) and the CSR index (Coke Strength after Reaction with CO_2).

The chemical properties are evaluated in terms of the level of tramp elements in the ash, for example alkalis, zinc, sulphur and phosphor contents which negatively effect blast furnace operation and hot metal quality. Very high coke moisture (over 5 %) and chlorine contents can also be a problem for efficient furnace operation.

Highlights in Blast Furnace Technology (figure 21)

Besides manifold metallurgical aspects the today's high standard blast furnace operation would have been impossible without many realized developments in blast furnace engineering. To point out all important innovative developments would of course break up the time availability for my speech. Some have already been mentioned in previous figures. But generally speaking all measures aim at a decrease of overall hot metal costs and are accompanied by a high blast furnace availability with long campaign lifes at optimum blast furnace operation, comprehensive process monitoring and instrumentation and the fulfilment of all environmental aspects.

The design of a blast furnace influences the duration of its campaign. Furnace campaigns, that means the time between two complete relinings, of approximately 10 years are state of the art. 15 to 20 years are generally aimed at. The main determining factor is the durability of the furnace hearth. The most problematic zone is the transition area between hearth bottom and hearth wall, **figure 22**. When comparing wear patterns of different blast furnaces, it is noticeable that there is a pronounced typical wear in this area which is called "mushroom formation", particularly in the case of furnaces with very little wear in the bottom, independent of its sump depth. The sump depth, which means the distance of the taphole to the upper hearth bottom brick layers, has from theory a significant influence whether a dead man floats or sits which influence peripheral flow of hot metal during tapping and wear. Furnaces without mushroom formation had an even wear in the upper bottom refractory blocks. It appears that, for preventing mushroom formation, the hearth should have refractory qualities at the bottom which enables the hot metal to create a concave flow area over the hearth bottom.

As an example **figure 23** shows typical hearth constructions. On the left in the figure a hearth is shown with walls, made of micro porous blocks, and, in the upper part, amorphous carbon bricks. Towards the shell, highly conducting graphite bricks are used. The hearth bottom consists of horizontally installed amorphous carbon blocks with graphite underneath.

The right drawing shows a hearth with a straight wall made of micro porous blocks, graphite protected. The hearth bottom has three insulating chamotte layers in the upper part and carbon blocks at the bottom. The hearth is protected right through with a ceramic cup. The shell has a very large inclination angle to make possible thicker refractory lining in the critical transition region.

It has once again to be noted that a basic prerequisite for refractory conserving conditions in the hearth is an excellent coke quality which enables the building up of the coke cone in the hearth (“dead man”) being permeable for the furnace gas, the hot metal and the slag.

Another prerequisite for long campaign life is an effective furnace shell cooling. Typical cooling systems are copper cooling boxes, cast iron staves a well as spray cooling or double jacket cooling for the hearth walls. The latest developments concerning the cooling of a blast furnace are copper staves, **figure 24**. The most highly stressed zones of a blast furnace are the belly and lower stack. The highest heat dispersion takes place here via the cooling system. The cooling system can be constructed in different variants. Compact plate coolers or plate coolers with intermediate flat coolers, cast iron staves with integrated refractory material or the newly developed copper staves are used.

There is a significant difference between the consistency of heat dispersion of modular cast iron and copper staves, **figure 25**. Compared with cast iron staves, copper staves permit significantly more intensive heat removal thus forming a stable protective layer by the burden materials. The use of expensive refractory materials to increase the service life of the copper staves can be dispensed with. These protective layers reduce the heat throughput and the wear of the staves to more or less zero. Due to the low thermal expansion coefficient of the copper staves, these can be longer than cast iron staves. They are also considerably thinner, so they make possible increased furnace volume with unchanged shell size. As the first furnaces in the world, Stahlwerke Bremen No. 2 and HKM No. B received copper staves for hearth wall cooling during their relining in 1999 and 2000, respectively.

For optimising blast furnace operation especially the measuring and process monitoring at the blast furnace has reached a high standard, especially to control the processes in the inner part of the furnace. **Figure 26** shows the comprehensive measuring installations for evaluating process data at the blast furnace Schwelgern No. 1 of Thyssen Krupp Stahl AG. Special importance have the optimisation and control of the gas composition and gas distribution inside the furnace, the material charge distribution at the top, the pressure losses inside the furnace, the evolution of the temperature inside the refractories as well as all tuyere parameters.

A hierarchically organized computer network for receiving, evaluating and saving all data enable the use of process models for furnace control in all devices. The steadily correlation of all burden and blast furnace condition data enable the steady optimisation of reductant rate efficiency. **Figure 27** shows the modern control room of the blast furnaces Schwelgern 1 and 2 of Thyssen Krupp Stahl AG with the application of computers and models and the installation of a large screen for the demonstration of different process conditions. The development of process control and instrumentation has largely contributed to an optimised blast furnace operation. It makes the effects of changes in operation more predictable and the distance to the optimum operating point determinable.

The last part to highlight blast furnace technologies should shortly deal with measures for environmental protection. Apart from process optimisation and economical utilization of the coupled energy, the environmental compatibility of the blast furnace with its upstream coking plant and sintering plant is of great significance if existing plants or capacities are to be retained or new plants are to be built. It is a fact that standards in different countries or regions are on different levels and they generally influence investment and operating costs and with this compatibility. Even though problems concerning the coking plant and sinter plant in conjunction with blast furnaces are also of great importance.

It’s a matter of concern for me to make two remarks, regarding coking plants and sintering plants: The conventional multi chamber coking system, **figure 28**, has reached with many existing modern plants in Germany and especially with the new construction of coke plant Schwelgern to be commissioned in 2003, which you can see in this figure, the peak of its development and has proven its ability to fulfil all regulations for environmental protection. Therefore, the coke plant is no longer, as often called, the “necessary evil” for the blast furnace, but a reliable partner in coke supply. Iron ore sinter is the main ferrous burden component of our blast furnaces and operating a sinter plant has many advantages for an integrated iron and steelworks. Here, attempts have to be carried on to reduce dioxin emissions to secure continuance of the sinter process in future.

Emissions at the blast furnace, **figure 29**, result from blast furnace top gas, in the cast house, at the hot blast stoves and in the slag granulation system. Blast furnace top gas has always been cleaned in “modern times”, if only to extend the service life of the gas-fixed systems, as this gas is commonly used as fuel for different steel plant equipments. Top gas cleaning systems consisting of dust catcher, cyclone gas cleaner and washer were already built at very early stages. This is worldwide standard for blast furnaces.

The illustration in **figure 30** shows the design of a modern casthouse, together with the associated dedusting systems. The main dust emission areas are the taphole, the main runner, the skimmer, the hot metal and slag runner, and the hot metal and slag transfer points. These dedusting systems have both employee health protection and environmental functions. Cast house dedusting is commonly achieved by extracting the fumes through hoods and cleaning the extracted flow via bag filters or electrostatic precipitators. The extracted gas volume from all sources may reach up to 1.1 million m^3 (S.T.P.) per hour. Current emission levels under standard operating conditions lie under the maximum permitted value.

Granulated blast furnace slag is quite an important raw material for the cement industry. The amount of granulated slag in Germany at the total blast furnace slag production in 2000 was approximately 70 %, **figure 31**. The common process is to granulate the slag by a water-jet in which the slag is instantly cooled from 1500 °C to below 100 °C, then pulverized into fine granules. These plants need fume condensation treatment where smelt is a problem. Here it has to be noted that the operation of a slag granulation plant is of great importance for lowering CO_2 emissions at the blast furnace stage. About 1000 kg CO_2/t of granulated blast furnace slag can be posted as a credit. This is linked with the replacement of cement clinker production.

Hot blast stoves are controlled on basis of the off-gas and grid temperatures and they have to fulfil emission values regarding dust, NO_X, SO_2 and CO.

The costs for realizing all demands in terms of environmental protections today amounts to about 20 % of the overall capital outlay for a new blast furnace and the operating cost of pollution control facilities to up to 18 % of the total hot metal costs.

Coke-free iron ore reduction processes, figure 32

Coke was and is often rated to be the necessary evil of the blast furnace. Coking plants are expensive in investment costs and had environmental troubles in former years. In the late 1950's therefore coke free iron ore direct reduction plants were developed with the aim to replace blast furnaces.

The advocates of these new coke free processes did a lot of advertising work to support their technology, presenting photos of blast furnaces being blasted as shown in **figure 33**. These direct reduction plants produce DRI (Direct Reduced Iron) which is after oxygen reduction from iron ores still solid and contains all iron ore gangue materials as no slag metallurgy takes place in these processes.

The industrial application of DRI processes started at the end of the 1950's. But they never could fulfil their reputation to replace blast furnaces. Wish, forecast and reality were, as seen in **figure 34**, far away for the world DRI production. This had two remarkable reasons:

1. The current energy situation allows only the operation of these plants at locations with available low cost energy, especially cheap natural gas.

2. The evolution of the market situation for steel scrap as worldwide traded raw material counteracted the forecasted demand for high quality DRI/HBI.

For better understanding I will give you some more details on the current development of different DRI processes, as listed in **figure 35**. They can basically be divided by the use of the kind of reducing agents, namely gas based DRI processes and carbon based DRI processes. Gas based are the shaft furnace, retort and fluidised bed, carbon based are rotary kiln and rotary hearth.

The world leaders are today the gas based processes, **figure 36**, with a share of approximately 93 % at total DRI production, with in total 68 % produced by the Midrex shaft furnaces.

Today, DRI processes are not longer seen as a competitor for the blast furnace. The high quality product DRI/HBI is dominantly charged to electric arc furnaces, especially if high grade flat steel products are to be produced via this route. The high gas prices in Western Europe make the operation of gas based DRI plants uneconomical. They are mainly operated in low energy price regions like South America and India, and here some plants also as pure merchant units.

The rotary hearth furnaces, based on solid reductants especially for the processing of fine ors and also of recycling materials, are actually receiving more importance. They are still on the development stage but on the way to industrial application. One example is the construction of the first commercial Sidcomet plant with the combination of a rotary hearth and an arc furnace for the production of liquid hot metal.

A serious alternative to the blast furnace would be the smelting reduction technology which was first commercialised in 1989. Smelting reduction aims at the production of liquid hot metal on iron ore basis without the use of coke.

From the many proposals and developments of the smelting reduction technology only the Corex process has reached industrial application today. To avoid the cohesive zone of the blast furnace, the Corex process operates in two stages, **figure 37**, the prereduction of lumpy ores (lump ores and pellets) to DRI in a shaft followed by final reduction and melting to hot metal and slag in a melter gasifier unit. This process, which is based on pure oxygen for coal gasification instead of hot blast and oxygen enrichment like the blast furnace, yields a liquid hot metal comparable to that produced by a blast furnace. In 2000 worldwide three existing units in South Korea, India and South Africa produced in total 2 million t hot metal.

The existing industrial units reach yearly outputs of 0.8 million t hot metal (C 2000). Corex plants, which still need for certain reasons a small amount of coke in the hearth, avoid the space of an in-plant coking facility, but the C 2000 unit designs are larger in size than a blast furnace producing 4.2 million t hot metal per annum, **figure 38**. The ultimate economic viability of a Corex plant is determined by the achievable credits from the export gas, produced in much larger quantities than by a blast furnace. Today Corex plants are not seen as a direct competitor of large blast furnaces, but as a possibility for replacement of smaller furnaces or for small steel making plants or mini mills.

A cost comparison, as shown in **figure 39**, of the processes for hot metal production and for direct reduction currently evaluated has shown that the blast furnace with its preceding coking plant represents the most cost-effective route in Germany and particularly for large production units in integrated steelworks. For the Corex process credits for the top gas are a precondition for the competitiveness of the process. Regarding direct reduction it has to be considered that solid DRI requires higher processing costs compared to liquid hot metal for the conversion into steel.

Blast furnace - future outlook (figure 40)

Before closing my presentation with a future outlook I will shortly show the current blast furnace locations in Germany for the year 2000, **figure 41**. In this only integrated steelworks' blast furnaces for basic hot metal production have been considered. They produced 30.2 million t hot metal in 2000 which represents 98 % of the iron production in Germany.

There are seven locations which operated in total 16 blast furnaces. Meanwhile - as you know - the location Dortmund Westfalenhütte with its blast furnace No. 7 has been shut down end of April this year. Six blast furnaces are operated in Duisburg. Two furnaces produce iron in Eisenhüttenstadt, Salzgitter, Bremen and Dillingen and one small furnace in Sulzbach-Rosenberg.

55 % of the hot metal was produced in the Ruhr area, **figure 42**, followed by Dillingen, Salzgitter and Bremen. From these figures it is noticeable that a concentration of hot metal production on a few high performance units has been realized. These are all modern plants in which substantial investment is bound. From this it can be stated that a substantial hot metal basis will exist in future for crude steel production via the oxygen converter route.

The costs of hot metal production to a great extent determine the economic result of an integrated iron and steel works working with the BF/BOF route. The operating time factor of a blast furnace is very important. Frequent unscheduled stoppages are not only unhealthy for the life of the furnace but also negatively influence hot metal costs. Even though blast furnaces have been equipped with increasingly capital-intensive environmental protection facilities and measuring techniques over the last

25 years, the cost of hot metal could still be reduced. This is to be illustrated for Germany in **figure 43**. The hot metal operating costs for 1975 are taken as 100 %. The endeavours of the blast furnace operators to attain a cost-effective mode of operation have been successful. After an increase in the hot metal costs at the beginning of the 1980s by almost 16 % compared with 1975, as a result of the energy crisis and its effects on the operation of furnaces, the costs are now approximately 15 to 20 % below those of 1975. We are today in the range of 235 to 255 DM/t hot metal. This development is of great significance for the international competitiveness of existing capacities, also in view of alternative materials to steel.

One problem not yet mentioned remains.

The German blast furnace operators are in total facing a shortfall in own coke production. Six coking plants of the steel companies and the German mining company have produced 8,7 million t blast furnace coke and sinter coke breeze last year, **figure 44**. Meanwhile the modern coke plant Kaiserstuhl of the mining company has been closed in December 2000. In 2000 app. 3.8 million t of coke have been imported from outside Germany to fulfil the overall demand of the steel industry. On the long term we will expect a coke import demand of 4 to 5 million t a year. In the world coke has become a traded material with China supplying 60 % of the worldwide trade which amounted to 25 million t in 2000. Reason for apprehension is given by the worldwide high age of existing coking capacities of 25 % being over 25 years and the fact that China will reduce coke production by approximately 30 million t due to closures of non-machinery coking plants. In fact, it is a decision of the individual steel producers whether they believe in the future availability of coke on the world market or whether they modernise an existing or build a new coking plant. Building a coking plant has the disadvantage of high investment costs but the advantage that on the one hand the coke is consumed directly where it is produced, avoiding long transportation distances, and on the other hand a coking plant fits remarkably well into the energy network of an integrated iron and steel works.

Worldwide the production of hot metal and crude steel via the blast furnace / converter route is regarded as the dominant process line also in future. Further attempts have to be done to look inside the blast furnace (**figure 45**) by suitable techniques for prolonging blast furnace campaign life, to increase productivity and to decrease reductant consumption.

Ladies and Gentlemen,

I know that in my report I beat the drum for the blast furnace process in our region, but even not coming from a blast furnace plant supplier company proves that I am firmly convinced of this process. It’s a well known proverb which reads “stop your speech, when you have convinced”. I hope I did so and thank you for your attention.