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# DEMAND AND ARISING OF FERROUS SCRAP: STRAINS AND CONSEQUENCES

# ZAPOTRZEBOWANIE I POWSTAWANIE ZŁOMU ŻELAZNEGO – ZAGROŻENIA I KONSEKWENCJE

Demand for ferrous scrap depends on recent steel production, but availability mainly on the amount of steel consumed in the past. The strong acceleration of steel production at the beginning of the new millennium results in strains the iron scrap market. Calculations on the availability of ferrous scrap were carried out by the author for IISI Working Group on Ferrous Scrap. According to the calculations, the amount of scrap available for the steel industry and the amount used each year are recently approaching the same value and by 2012 the demand may be somewhat larger than the amount of scrap arising in that year. Since earlier not all scrap was used, there is no need to worry about a lack of scrap in terms of quantity, but the scrap remaining uncollected (and to be used later) is always of poorer quality. So, the quality of scrap available for the steel industry is getting poorer with the time and the price of good quality scrap will rise. Developments in global steel industry will influence ferrous scrap market also in the next years.

*Keywords*: steel, ferrous scrap, EAF, BOF steel making, steel consumption, forecast

Zapotrzebowanie na złom żelazny zależy od aktualnej produkcji stali, a zapas zależy głównie od ilości stali zużytej w przeszłości. Silny wzrost produkcji stali na początku nowego millenium spowodował zagrożenia na rynku złomu stalowego. Obliczenia zapasu złomu przeprowadzone były przez autora dla IISI Working Group on Ferrous Scrap. Zgodnie z obliczeniami ilość zapasu złomu dla przemysłu stalowniczego i ilość rocznego zużycia zbliżają się do tej samej wartości i po 2012 roku zapotrzebowanie może być większe niż ilość złomu powstającego w danym roku. Skoro wcześniej nie był użyty cały złom, nie było obawy o jego ilościowy brak, ale złom, który pozostał nie pobrany (i użyty później) ma zawsze niższą jakość. Jakość dostępnego złomu dla przemysłu stalowniczego zmniejsza się z czasem, a cena złomu o dobrej jakości rośnie. Rozwój globalnego przemysłu stalowniczego będzie wpływał na rynek złomu także w kolejnych latach.

## 1. Introduction

At the beginning of the new millennium the world steel industry entered a new period of development: its growth rate has markedly increased. Steel consumption was strongly(~5% per year) increasing between 1950 and 1975; since 2000, the yearly increase7-10%/year.These two strong periods were separated by a period of slow growth *(Fig.1.)*

The dynamic growth of steel production needs more and more charge materials. At the beginning, suppliers of raw materials were surprised by the sudden increase of demand; so for short periods and at different regions even problems with availability were experienced (2004-2005). This situation was effectively exploited by the suppliers: price of iron ore has nearly tripled and that of coking coal nearly doubled since 2003. Demand and supply capacity were very close for a while.

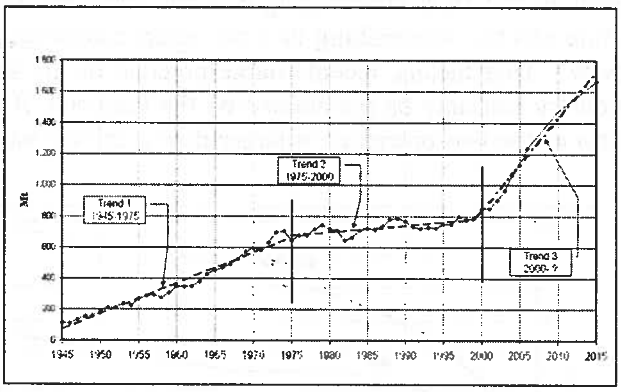


Fig. 1. Trends in the growth of global steel production

Ferrous scrap – the most important charge material of electric steel making – is different from the other charge materials: it is not a natural resource that can be mined, but it is arising partly during the production

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and processing of steel, partly at the end of the life of structures and equipments. Accordingly, its volume depends also on the amount of steel produced/consumed in the past. So, the sudden growth of steel production has strongly influenced the former equilibrium of scrap arising and demand. Ferrous scrap price changes were also large in the past years.

Developments in the market for ferrous scrap are hitting first of all EAF steel mills. In 2004 and 2005 in the steel industry even signals of panic were experienced sometimes; they were eased mainly by the strong increase of steel prices. A big question is, however, how long the parallel price increase of charge materials and steel products will go on?

Considering the importance of the problem, IISI formed the "Working Group on Ferrous Scrap"; the Group is continuously analyzing the scrap market and its outlooks. Model calculations for the Group were made by the author of this paper; results were regularly discussed at the meetings of the Group. This paper is a result of this activity.

## 2. The importance of the share of EAF/BOF steel making

Globally, about 85 % of the charge is ferrous scrap at electric steel making (the rest being DRI); at integrated steelmaking this figure is changing between 10 and 30 % . The amount of useful scrap originating from the production, processing and use of steel may be 50 – 70% of recent and former steel production globally (more exact calculations will be given later). So, it is obvious that BOF steelmaking is a net scrap producer, while electric steelmaking is a net scrap consumer activity . That means, recent charge practice of the steel industry can only be maintained on the long run, if the ratio of the two processes is larger than a critical value.

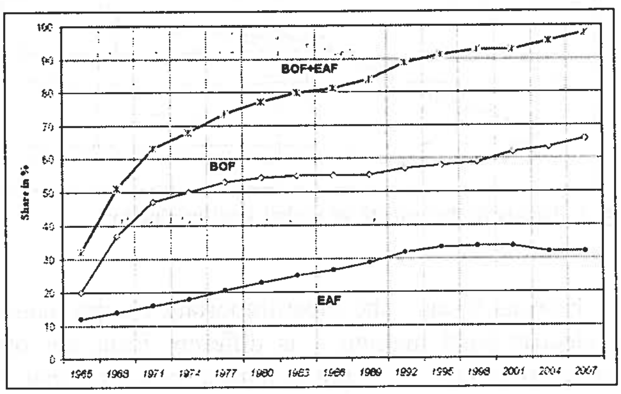


Fig. 2. The share of EAF/BOF steelmaking in global steel industry

In 2003, this value was estimated by us to be about 2/3 integrated and 1/3 electric steelmaking /1,2/.

The actual evolution of the share of the two steelmaking routes is shown on *Fig.2*.

## 3. Estimation of the amount of useful ferrous scrap

According to their origin, ferrous scraps can be classified into three groups: home scrap, process scrap and old scrap. In the last decade a number of calculations were made for the estimation of their volume; differences in the results are sometimes quite large. Our calculation method was formulated having analysed the different methods and their results.

### 3.1. Home scrap

Home scrap is arising at steel companies during the production and processing of steel. In mills producing crude steel, this sort of scrap is consumed by the companies themselves. The situation is more complicated with companies without steelmaking (e.g. hot and cold rolling mills, tube producers). In most cases, steel mills supplying the semiproducts for these steel processors repurchase the scrap, because they know its quality. Part of it, however, will be sold to scrap traders or processors and then it will not be considered as home scrap any more.

It is characteristic for home scrap that its quality is well-known for the steelmakers and it is used in a short time. The specific volume of home scrap was strongly decreasing in the past decades: the introduction of continuous casting and recently near net shape casting, developments in rolling mills reduced the share of home scrap in steel mills to a fraction of the former level. Most experts take it now to about 10 % of crude steel production; we used this value at our calculations. Doubtfulness of the calculations is increased by the amount of scrap sold by steel processors to traders; however, its volume is probably not large, because steel mills are strongly interested in repurchasing it.

### 3.2. Process scrap

Steel consumers are manufacturing parts, elements, structures from steel products; during this process the dimensions and shape of steel products will be changed according to technological requirements. Scrap arising this way is the so called process scrap that is also a valuable charge material in steelmaking: steel types processed can be often easily identified, this sort of scrap is generally not very contaminated, its collection is easy, etc. Steel companies often co-operate with their clients in rebuying the scrap originating from their steel products. Most of it, however, will go to scrap processors and traders and they sell it to steel companies. It can be assumed that most of the process scrap is utilized within one year.

The amount of process scrap is determined by several factors. Steel user companies that use modern design methods and processing equipments try to decrease the amount of scrap. So, generally, the specific volume of scrap related to a certain product, is lower in developed countries.

The specific volume of scrap is generally lower during the processing of long steel products; at flat products the shape of the fabricated product is generally much more complicated, thus more material is scrapped.

Estimations on the specific volume of process scrap in different steel user branches are diverse; opinions on their reliability are different. In my calculations, based mainly on US information, the starting point was, that the largest consumer of long products is the building and construction industry, where the average specific volume of process scrap may be ~ 6 %. Evaluating the information on flat products it was estimated that the average specific scrap volume, arising at branches other than construction industry, may be about 20 % /3/.

For the estimation of the volume of process scrap information on the share of the steel consumed in different industrial branches is also necessary. According to IISI, the share of the construction industry in steel consumption is generally higher in developing and transition countries, than in developed countries having already good infrastructure and housing conditions /4/. Accordingly, in our calculations the share of construction industry in global steel consumption was changing. Considering the dramatic increase of China's and other less developed countries share in global steel consumption 40 % was assumed for the mid 1990-s and 48 % for 2012. Naturally the share of other industrial branches was decreased respectively.

### 3.3. Old scrap

Old scrap arises at the demolition of end-of-life equipments, machinery, constructions, etc. The estimation of its volume is the most complicated and doubtful step of forecasting; at the same time – as you will see– its share in total scrap arising is recently more than 50%.

Old scrap has two characteristics differing from the former two scrap types:

- because it is arising from equipments, structures manufactured earlier, its volume depends on the volume of former steel consumption,
- its quality is changing in a very wide range. Its physical consistency, chemical composition, contamination is strongly varying depending on several factors.

For the estimation of the volume of old scrap the life cycle of constructions, machines, etc. containing steel parts has to be considered. On this issue opinions are very different. In US literature, e.g., fairly well defined average life cycles are used, changing according to the type of machine or construction. E.g. steel used for packaging can be scrapped within some months and well designed and built bridges, steel constructions can be used for several decades. To simplify the problem, Japanese experts use sometimes an average of 45 years for everything /5/.

For our estimations the same method was used as in the case of process scrap. Consumer branches were classified into two groups: building and construction industry (generally the largest steel consumer) and all the rest (vehicles industry, machine industry, white goods, etc.). Based on various sources, life cycle value was estimated for the two groups as follows.

*Building and construction industry: 35 years*
*All other branches: 15 years.*

Considering the remarks made in Point 3.2., the share of building and construction industry was estimated to fall from 55% to 49% in the 1960's and the 1970's, and a further 45% to 40% decrease was assumed from the 1980's to the 1990's. Accordingly the share of other industries increased with the respective values. (These years had to be used in the calculations according to the 35 and 15 year life cycles.)

Steel parts of end-of-life equipments, constructions are only partly in a condition appropriate for collection and reuse in steel-works . A certain proportion of scrap necessarily gets wasted: too intensively corroded, too difficult to collect, too difficult to separate from contaminating materials etc. Analysing the information collected from scrap experts the portion of such losses was estimated:

*For constructions: 40%*
*For other structures, equipments: 20%.*

After the deduction of these losses the scrap left is theoretically available for collection and processing („accessible scrap"). Accessible scrap comprises scrap types of very different quality, also the expenses of their collection and processing can widely vary. As the storage of ferrous scrap is not profitable, the volume of yearly collection generally is not larger than yearly use, i.e. it is equal to the yearly scrap demand of the steel industry. The rest, as a part of a scrap reservoir, is available for collection and processing in the future.

Steel production and consumption data used in our calculations were published by IISI, VDEh and other organisations; production and consumption data for the years 2008-2012 were forecasted by IISI.

Calculations for the period 1996-2012 are given in *Figure 3*. Between 1996 and 2012 the volume of ferrous scrap available for collection grows from 450 Mt to 705 Mt (57% increase). The ratio of old scrap did not change until 2002 (60-62%) but fall to nearly 50% until 2012 due to the acceleration of steel production and consumption (sources of home and process scrap)

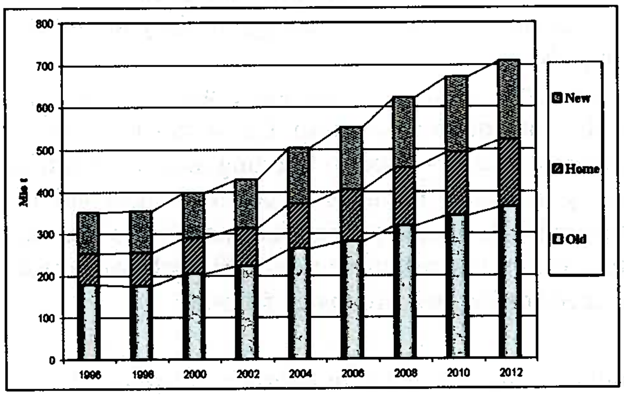


Fig. 3. Yearly formation of different scrap types

This model for the calculation of process scrap and old scrap is applicable for the calculation of global figures only; for the calculation of regional or national data, direct and indirect steel trade should be taken into consideration. Process scrap is produced in the country importing the steel products (i.e. in the country where it will be consumed), old scrap similarly arises from the exported machines, equipments in the importing country (that is both steel and machine export mean the export of potential scrap). Earlier China was an important net steel importer, since 2006 China is a net exporter. This problem can be eliminated by calculating the volume of process scrap from steel consumption.

We can assume, that China was a net importer in the period analysed as regards the import of machines and equipments (goods of 15 years' life cycle). According to rough estimations the surplus of old scrap arising from imported machinery would be low, so it has been neglected by the present calculations.

## 4. The evolution of scrap demand of the steel industry

### 4.1. The method used for the calculation of scrap demand

There is a simple possibility for the estimation of scrap demand using the average specific scrap consumption of steelmaking: in the case of EAF steelmaking the amount of ferrous scrap plus DRI is about 1100 – 1150 kg/t crude steel, at BOF steelmaking it is changing between 100 to 300 kg/t crude steel. So, knowing the volume of steel produced by EAF and BOF technology, total demand can be estimated. More exact calculations can not be carried out because of the lack of reliable information on the specific scrap use at BOF steelmaking, which is changing in a larger wide range. So, this method was neglected.

Our method is based on the iron balance of steelmaking:

$$Fe_{input} - Fe_{losses} = F_{ecrudesteel},$$

and

$$Fe_{input} = Fe_{pigiron} + Fe_{DRI} + Fe_{scrap}$$

On the amount of losses in steelmaking there are only few reliable data available. At the beginning of the 1990's IISI elaborated a survey where the specific volume of loss was about 10% of production (due to Fe in slags, dusts, sludges, scaffolds, etc.). Two years ago a new study was started, but the final results are still missing, so we used 10% loss in our calculations.

Considering the Fe-content of charge materials, following assumptions were used:

$Fe_{pigiron} = 95\%$
$Fe_{DRI} = 90\%$
$Fe_{scrap} = 90\%$

These data are the results of several discussions between members of the IISI Working Group on Ferrous Scrap (in this working group experts of the largest steel companies like ArcelorMittal, Nippon Steel, Corus, Gerdau, ThyssenKrupp, etc. are involved).

Average Fe content of crude steel

$$Fe_{crudesteel} = 99{,}5\%$$

### 4.2. Scrap demand of the steel industry 1996-2012

Data on the production of pig iron, crude steel and DRI were collected from IISI statistics and forecasts. Results are shown on *Figs. 4 – 6*. Because of the weight and special feature of the Chinese steel industry their data are given separately in the figures. Some of the special

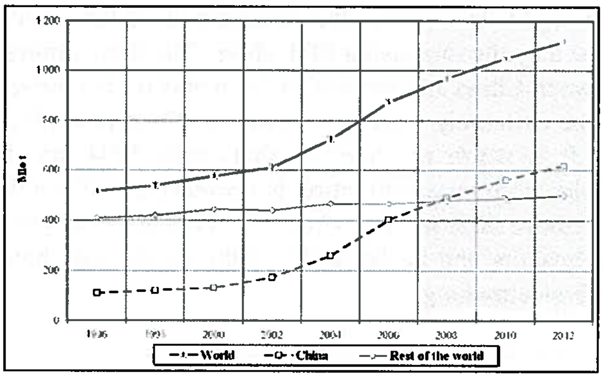


Fig. 4. Pig iron production of the world and China

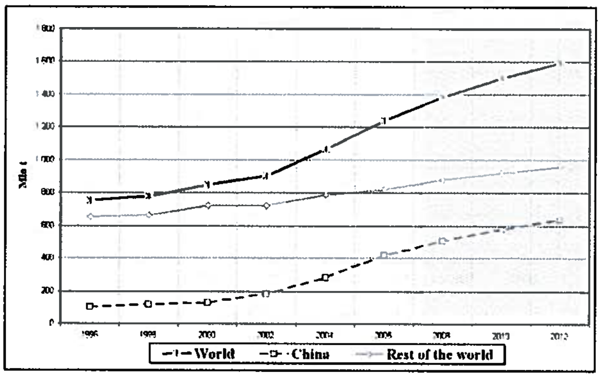


Fig. 5. Crude steel production of the world and China

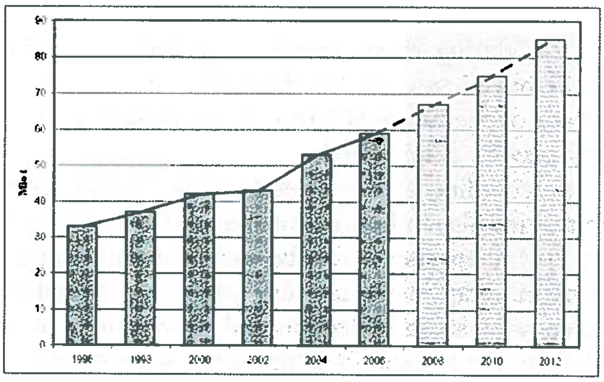

Fig. 6. Global DRI production

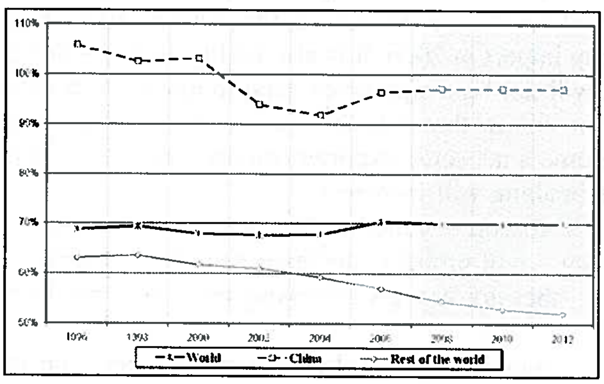


Fig. 7. Pig iron per crude steel production

One of the important special features of the Chinese steel industry can be identified on *Fig.7.*: while globally, the ratio of pig iron/crude steel production is 65-70%, it is much higher in China (90–110%). The explanation of this feature is the dominancy of BOF steelmaking in China (~ 90%), and also the amount of foundry pig iron may be included in the Chinese production data (but we have no reliable information on it).

Using the production data given in the figures and the specific data listed above the total scrap demand of the steel industry was calculated *(Fig.8)*. According to our calculations, global scrap consumption reached 400 Mt around year 2000; it could be about 550 Mt in 2007 and may increase to 700 Mt in 2012. Reliable information on the actual global scrap consumption were not available; problems of scrap statistics are probably contributing to this situation. IISI is publishing statistics on scrap trade; its total volume was 90–95 Mt in 2006. There are some information that global scrap consumption around year 2000 was about 400 Mt; these data are confirming our calculations.

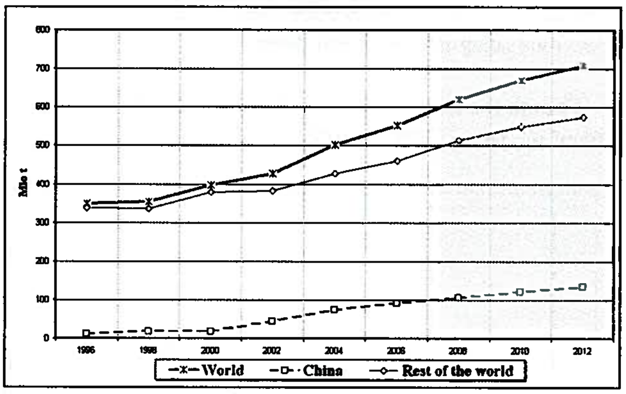


Fig. 8. Calculated scrap demand of the world and China

## 5. Comparison of the arising and demand of ferrous scrap

By combining the data of Figs. 3 and 7, the evolution of scrap arising and demand related to each other can be demonstrated *(Fig.9)*. According to the diagram, until year 2004 about 100 Mt/year scrap was not utilized from the accessible scrap calculated for the same year. It is obvious that the low quality, hardly available, costly processable part of the scrap was not used. This scrap is increasing the amount of scrap in the reservoir, but its consistency, quality is getting continuously lower.

Since year 2006, the difference between the volume of scrap arising and demand is rapidly decreasing. One cause of it is that global steel consumption strongly declined in the early 1990's, because of the collapse of the economy of COMECON countries (production and consumption of equipment having 15 years life cycle went back). Around year 2010 the effects of slow-down in the construction sector in the mid 1970' will be also sensible (scrap from 35 years life cycle structures). In year 2012 scrap demand may be slightly higher than arising, that is lower quality scrap not used before must be collected and processed then. This will influence both scrap prices (increase) and scrap quality (decrease). However, it is clear that the amount of scrap in the scrap reservoir is still very large, so there will be no scrap shortage physically.

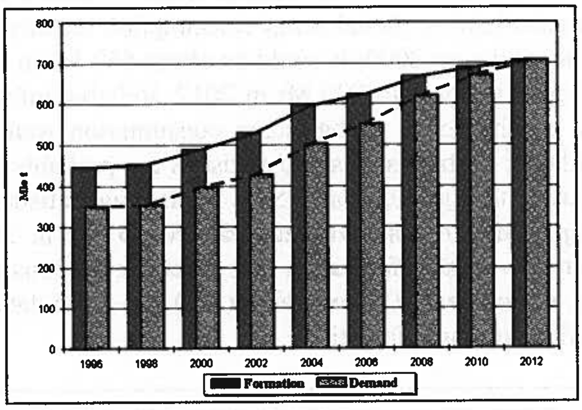


Fig. 9. Total scrap formation and demand

The share of utilized scrap in accessible scrap is so increasing from 79% to 100% *(Fig.10)*.

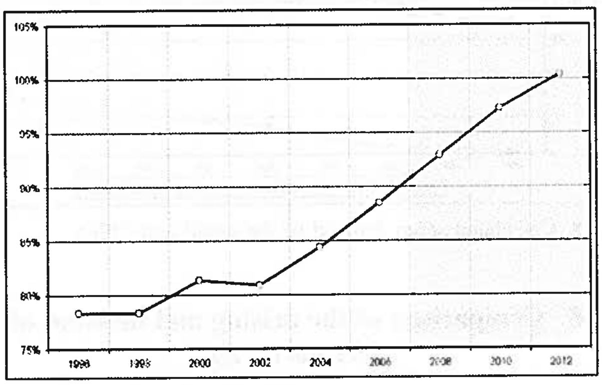


Fig. 10. The share of utilized scrap in total scrap arising

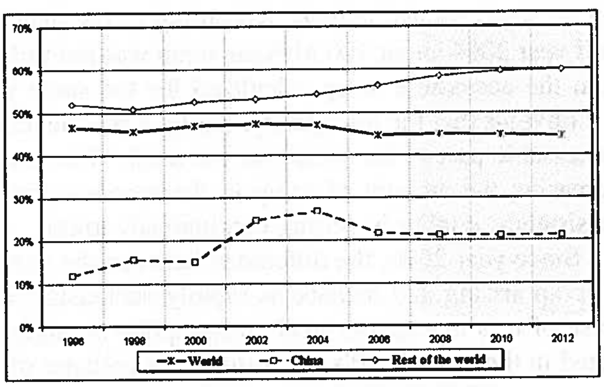


Fig. 11. Specific scrap charge at steelmaking

Specific scrap charge in global steel industry does not change very much between 1996 and 2012 (44-48%). The slight decrease in the second half of the period is caused by the increasing BOF share. The large difference between China and the rest of the world is also the result of the extremely high BOF share in China *(Fig. 11)*.

It is worth to underline that since 2004 the share of old scrap in consumption is decreasing and it will be just above 50% in 2010 *(Fig. 12)*. This is good news for steelmakers and is the result of the increasing share of BOF steelmaking.

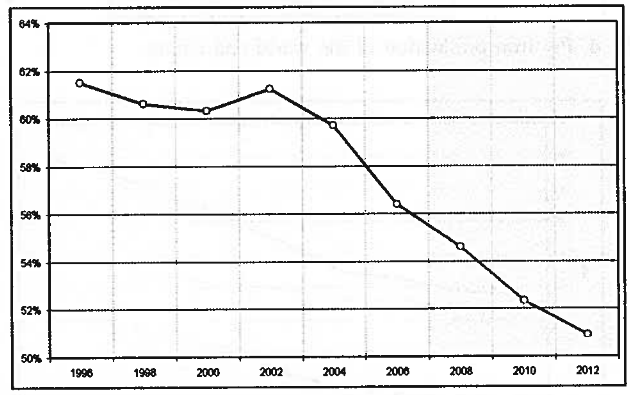


Fig. 12. The share of old scrap in total scrap generation

## 6. Further outlooks

Considering recent trends in global steel industry and the model described in the paper some remarks can be made on the future of ferrous scrap market. Following items may be emphasized:

a. According to recent trends, *China* will prefer BOF steelmaking also in future investments. Considering their very low scrap rate, it can be assumed that China had to import scrap in the last few years only because the efficiency of scrap collection and processing was very low. Only the amount of home scrap and process scrap (~20% of crude steel production) must have almost covered the total demand of their steel industry. A definite signal for this observation is the sudden (50%) drop of scrap import in 2006. It is also highly probable that China will not be a significant scrap importer in the future (as it was in the early 2000's); on the contrary, it may become a net scrap exporter (except if the share of EAF steelmaking will increase).

b. *Russia* – which is the largest scrap exporter recently – will probably decrease its export, because

– they are strongly increasing crude steel production, and

– consequences of the drop in their steel consumption after the political changes in the early 1990's will be sensible (less old scrap from 15 year life cycle equipments). Signs of the reduction of scrap export could be seen already in 2006.

c. Largest scrap importer is *Turkey* (~11-13 M t/year); they import mainly from Russia,

Ukraine and the EU. Because of the decrease of the Russian export they will try to increase scrap import from the EU that may result in market stresses there.

Recent efforts and regulations on the protection of climate (e.g. the introduction of emission trading in the EU) are favouring the increased use of ferrous scrap in steelmaking. This can be done not only by increasing EAF steelmaking, but also by increasing scrap share at BOF steelmaking. This trend will increase scrap demand in the future.

According to IISI statistics, in the last decade EU(25) was either a small net scrap exporter, or a small net scrap importer. In the EU, this is the only charge material available in large quantity; the exploitation of the benefits of using it is important for the region. Considering the recent trends mentioned above it is probable that on the long term the EU will be a net scrap importer.

If the dynamic growth of steel production will be maintained (as it is supposed by several experts now), scrap demand will also strongly increase. As a result of it, improving the efficiency of scrap collection, the development and extension of quality control, quality assurance and standardization in the scrap market is foreseen.

## 7. Conclusions

1. The formation of home and new scrap is increasing parallel with steel production while that of old scrap (more than 50% of all scrap used by the steel industry) is changing according to steel consumption several years before. That is why the strong acceleration of steel production at the beginning of the new millennium resulted in stresses between the demand and availability of scrap.
2. Recently the volume of yearly scrap arising and demand are getting closer to each other and at the beginning of the 2010's demand may be somewhat larger than arising. This will result in the utilization of lower quality scrap not collected and utilised earlier.
3. Due to the very high share of BOF steelmaking in China, their scrap import is decreasing and if the efficiency of scrap collection will improve, they may be net scrap exporter in the near future.
4. There is no danger of a physical shortage of ferrous scrap, but the volume of lower quality scrap used by the steel industry will increase.

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