The outlook for local processing of metals : the case of copper in Africa

THE OUTLOOK FOR LOCAL PROCESSING OF METALS:

THE CASE OF COPPER IN AFRICA

by

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The developing countries presently produce about 60 % of the world copper mine production. More than 90 % of the copper is exported mainly to the industrialized countries in the form of refined copper. However, in the sector of copper (and copper alloy) semis-wire (rod), rods and sections, plate, sheet, strip and tubes - the situation is completely reversed. The share of the developing countries in semis production reached only 13 % in 1985, despite rapid growth in the past decades. Almost 60 % of the developing countries' production takes place in South Korea, Taiwan, Brazil and Mexico. The share of the copper-exporting countries (such as Peru, Chile, Zambia and Zaire) in Western semis production amounts to only 1 %.

In Africa the situation is even more unbalanced. The share of Africa in world (Western) copper mine production is almost 20 % (1.25 million tones Cu content). About 98 % of the production is exported. In contrast, the share of Africa in world semis production is less than 0.5 % . Consumption of semis is still at low levels, but nevertheless imports of semis surpassed 75,000 tones in 1984 (with more than 85 % imported by Northern African countries).

The question addressed to in this article is : Why do copper producing countries not process copper on a (much) larger scale into (and copper alloy) semis? What are the major obstacles limiting this possible form of resources based export-oriented industrialization? In approaching this issue it proved useful to distinguish between possible exports to countries and production for regional markets. These two topics have been investigated in detail for South-Eastern Africa[1]

The obstacles for exports to industrialized countries

In the literature the very limited production (and export) of semis in the copper producing countries is mainly explained by the three factors :

- the special nature of the products
- the high transport costs of semis
- the capital-intensive, technically complicated, large scale production processes[2]

The first two factors will be dealt with below and the last one in the final section of this article.

It is often asserted that lack of standardization would force a developing country to produce a very large range of products, including tailor-made products in close contact with customers. This is certainly not the case for CCR (continuous cast rod), a standard product. Besides, for sections, plates, etc. and tubes, the standardization issue is often exaggerated. It is true that for these products there is an enormous number of variation in sizes and alloys. However, because many final products have been standardized, the same uniformity holds for the semis to produce them. Consequently, the bulk of the production of semis consist of a limited number of sizes and alloys.

More important market-related factors are the market structure in the industrialized countries and trade barriers. Since most African countries have duty-free access to the EEC market, the restrictive trade policies of the industrialized countries will not be elaborated upon here. However, the highly oligopolistic nature of the semis markets in the industrialized countries makes it very difficult for any potential "newcomer" to penetrate those markets. Concentration of market power and vertical integration make it almost impossible to compete with these companies. Only co-operation (a "joint -venture") would assure successful market penetration.

Transport costs prove to be an important factor when considering the feasibility of copper semis exports . However, copper producing countries enjoy one important advantage from the fact that the country concerned saves the transport cost of refined copper to overseas markets when producing copper semis locally. In the case of Zambia advantage amounts to $ 134 per tonne (mid 1986).

The savings are, however, not sufficient to cover the costs (of containerized) transport of semis from Zambia to Western Europe. Even in the case of CCR (the semi with the lowest transport costs) production costs in Zambia would have to be about 40 % lower than the current international value added (production costs plus profit). This is impossible. It is therefore concluded that a producer in southern Africa (e. g. Zambia) cannot penetrate the Western European market.

It seems, however, not impossible for a Zambian producer to compete with European companies on the Indian market and in the Middle East. Particularly in the case of CCR the transport cost advantage is very considerable (more than 100 %), provided there are direct transport links to these destinations. For semis with a higher value added (extrusions and rolled products) the relative transport advantage on these markets is only in the order of magnitude of 5 to 20 per cent of the international value added. This is not likely to be sufficient to compete, particularly with the semis industry still in its infancy.

Exports to regional markets

Production of extrusions and flat-rolled products in Zambia / Zimbabwe would largely have to be geared towards the local and regional market because of high transport costs to overseas markets. In case of Zambian exports of extruded products to countries in the region, the transport advantage over a European competitor ranges between 15 and 35 per cent of the international value added.

For rolling mill products (with a higher value added) the relative advantage is lower, namely in the order of 100 % . In both cases the advantage is smallest when exporting to Kenya, partly due to high wharfage costs enroute in Dar es Salaam.

On top of a transport advantage, there is the advantage of the Preferential Trade Area for Eastern and Southern Africa (PTA). Producers within the area enjoy tariff preferences over outside competitors. It is therefore important that the partial implementation of preferential treatment will be completed as soon as possible.

When fully implemented, copper semis exports would, including

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1. The research was done in a co-operative project of the Universities of Eindhoven and Tilburg in the Netherlands and the University of Zambia and sponsored by the Dutch government.

2 P.N. Kirthisingha, "viability of processing in copper-mining areas; an economic analysis", Resources Policy, December 1982, pp. 285-304.

the transport advantage, enjoy a competitive advantage over outside competitors in the order of 25 to 95 % over international value added. Careful analysis indicates, however, that the size of the market in southern and eastern Africa is limited : 1,200 to 1,500 tonnes for extrusions, including tubes and pipes, and a market of about 1,000 tonnes for sheet, strip and foil)[3] With markets of the limited size just mentioned, one extrusion press and one rolling mill could efficiently and effectively supply the major part of demand in the region. Unfortunately the extrusion capacity in the region - with presses in Zimbabwe, Zambia and Kenya - is already many times more than the total (foreseeable) demand. Unless several companies would succeed in the difficult job of exporting certain extrusion products to countries outside the region, a waste of resources seems inevitable due to poor investment co-ordination within the region. A similar situation could arise in the case of flat-rolled products. A second-hand rolling mill is presently being installed in Zimbabwe. There are some doubts about the efficiency of this installation. It could therefore be tempting to install a modern small-scale rolling mill in Zambia.

With access to the market in Zimbabwe, and provided the mill would be operated at a certain level of efficiency, such a rolling mill project could be feasible. However, in case access to the Zimbabwean market would not be possible or not allowed, such a venture would likely become risky.

Small-scale continuous casting/rolling mill

As indicated already, copper and copper alloys (4) are first transformed into semi-products before end-products are manufactured.

The copper semi fabricating sector may be divided into the following subsections :

a) Wire mills, producing wire (rod).

This wire is used for the manufacturing of end-products such as electrical wire and communication wire.

b) Brass mills, which can be subdivided into :

i. Rod mills, producing rods, bars and sections.

Examples of end-products made out of these semis include bolts and nuts.

ii. Rolling mills, producing plate, sheet, strip and foil.

Examples of final products include cartridges and musical instruments.

iii. Tube mills, producing tubes and hollow bars.

End-uses are plumbing, refrigeration, etc.

c) Copper is also used in foundries, the production of powdered copper and in chemicals. These applications however are not considered here.

The first step in the production of copper semis as mentioned under a. and b. is the melting of the copper (alloy) and casting of intermediate products, as wire bars (tapered bars), slabs (blocks of regular cross-sections) and billets (cylindrical rods), which in the next stage are transformed into semis.

In the past these intermediate products used to be cast discontinuously, as wire bars, billets and slabs. This was the starting material for subsequent (billets). Nowadays the intermediate products are often cast continuously. For example, a few decades ago copper rod was produced by hot rolling wirebars. Since then there was a rapid increase in the use of continuous casting for the production of copper wirerod.

Besides the continuous casting of large size products, equivalent in dimension to that obtained from static casting and the starting material for subsequent heavy secondary working processes as hot rolling and extrusion, the production of smaller cross sectional continuous cast products has developed. So a semi finished strip or rod can be produced in a single process, much closer to the final product gauge required than by traditional methods. Further secondary processing may be carried out by relatively lower cost capital equipment, since the need for hot rolling or extrusion processes associated with "heavy" earlier stage manufacturing of sections has been limited[5]

It is claimed that continuous casting offers opportunities to operate competitively on a small scale.[6] There is of course a minimum production required, which among others depends on the total production system, work efficiency, transport of raw and finished material.

Reference 2 gives an example between two cases, the first in which a company purchases its gross annual requirements of 400 tonnes per year of stamping-machining rods and sells back the scrap to the supplier, and the second in which the same company installs a continuous casting machine with an annual net production capacity of 345 tonnes, and recycles its own waste (plus additional scrap and swarf) for conversion to rod. The balance of its requirement of rods is still purchased from outside sources. The total costs in case of an own continuous caster proves to be 11 % less than in case of purchasing all rods from outside sources.

This is of course a very simple case. But as mentioned already, the Zambian small-scale production of CCR seems to be competitive on the Indian market. Krall and Rumrich claim that for the production of strip, casting of slabs and hot rolling only starts to become competitive with horizontal continuous casting with in-line milling at a production exceeding approximately 4000 tonnes per year.[7]

From the economic part of this paper it is clear that an expansion of the extrusion capacity in the considered region is not justified. And since CCR is already produced too, only a small-scale rolling mill, starting with the continuous casting of strip, is considered in some more detail.

Figure 1 shows the small scale production process for the manufacture of strip and foil.[8]

Melting and casting : horizontal continuous casting (HCC) finds today wide application for the casting of copper and copper-based alloys and other nonferrous metals in the form of rods, billets, tubes, strips and special profiles.

Here it is applied for the casting of strips of 15 mm thick and 320 mm wide. The capacity of the caster is about 1000 tonnes par year and can easily be upgraded to 2000 per year by using a separate melting furnace. In case of a separate melting furnace molten metal from the melting furnace is poured via a ladle or launder in the holding furnace. The holding furnace maintains the required cast temperature and serves as a reservoir for the molten metal for the casting process. Most of the HCC furnaces are of the electric induction type. The possibility of exact control of energy input into the melt allows casting under ideal conditions.

The most important part of a HCC plant is the primary cooling system. At this stage the production rate and the product quality are determined. The primary cooling system comprises a graphite die, in the bore of which metal solidification occurs, surrounded by a water jacket to transfer the heat of solidification.

At the end of the casting line the cast strip will be cut to length or will be upcoiled.Subsequently both surfaces are milled in order to remove the "as cast" surface. The reduction of both sides is about 0.5 mm.

3. The market study covered Kenya, Zimbabwe, Zambia, Tanzania, Malawi, Angola, Mozambique, Botswana, Lesotho and Swaziland.

4. For ease of reading, from now on both copper and copper-alloy-semis are covered by "copper semis".

5. S.R. Cochrane, "Horizontal continuous casting of copper based alloy rods and sections", Rautomated Ltd., P.O. Box 100, Dendee DD1 9 QY, Scotland.

6. Sir Michael Nairn and Dr. R. W. Johnson; "Low capacity Continuous Casting Plants for Non-ferrous Rods and Sections", Edited Proceedings.

7. H. A. Krall and R. F. Rumrich, "Horizontal continuous Casting Plants for the Production of Copper and Copper Alloy Billets, Bars, Rods, and Tubes proceedings international Symposium "Brasses and Bronzes", Bombay 1983, pp. 153 - 163.

8. David H. Mandle and Thomas P. Werdl, "Horizontal continuous casting. A Survey of principle, application and design", Alfred Wertli Ltd., Poststrasse 15, P.O. Box 296, CH - 8406 Winterthur, Switzerland.

Now the material is ready for rolling. This happens on a four high cold rolling reversing mill; without annealing the thickness can be reduced to about 3 mm. For further reduction one has to anneal at about 650°C . The exact temperature differs according the composition of the alloy and of the annealing time.

Cold rolled strips below 3 mm have to be edge-trimmed before further processing. Depending on the final strip thickness another edge-trimming process has to be carried out.

Prior to the final rolling process the strip is pickled to ensure good surface quality. The pickling agent is mostly 8-12 % sulphuric acid. On the finishing line the strip can be rolled to a thickness below 0.1 mm. Depending on the final thickness another annealing process could be necessary.

Finally the edges are trimmed and the strip is slit and cut to length, coiled and packed in agreement with the client.

As mentioned before, the first rolling mill reduces the thickness from 14 mm to 3 mm, however, the mill has the possibility to breakdown to about 0.5 mm.

In this case the strip needs more annealing treatment. It is obvious that the strip can be rolled at any desired thickness between 14 and 0.05 mm, so it is not necessary to pursue the whole process. A feasibility study will be carried out to establish if such a small-scale rolling mill in Zambia could be competitive in the region.

Conclusion

The feasibility of the production of copper-semis in south-eastern Africa for regional markets and export to farther international markets depends on the complexity of the production system (value added of the semis). For semis with the lowest value added as CCR, limited international export seems possible, whilst semis with a higher value added, as extrusion and rolled products, might be only competitive on the regional market. The regional market for these products is small. Continuous casting, however, offers opportunities to operate competitively on a small-scale. In the region considered, CCR is already produced and there is a serious overcapacity for extrusion products, so it seems only justified to consider the installation of a small-scale rolling mill. Meanwhile it is stressed that there should be good regional co-ordination of investments to avoid overcapacity.

Fig.1 : MATERIAL FLOW DIAGRAM FORTHE PRODUCTION OF COOPER ALLOY STRIPS