

RECENT IMPROVEMENTS AND FUTURE PROSPECTS
IN THE PRODUCTION OF SILICON ALLOYS

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ABSTRACT

Over the last twenty years, the manufacture of silicon alloys has come up against non-stop increases in raw materials and energy costs.

At the same time, customers have become increasingly exacting with regard to the quality of metal supplied, while very considerable time, effort and sums of money had to be spent on environmental improvements.

Silicon alloy producers have had to put their backs into sharpening the ability of their industry to compete and improving product quality.

These efforts have mainly been directed towards :

- Smoother furnace operation, based on :
 - . rigorous selection and control of raw materials,
 - . optimisation of furnace operating conditions,
 - . definition of a policy for furnace operation matched to commercial demands,
 - . limitation of the number and duration of unscheduled shut-downs,
 - . computer-based automation of furnace operation.

- Energy conservation

The furnace off-gases, which are rich in carbon monoxide, carry away a quantity of thermochemical energy close to the electrical power demand. Work on recovering this energy has made great strides over the last decade but there is still room for progress.

- Silicon alloy quality

More effective purification techniques and better choice of raw materials have made it possible to meet tougher and tighter chemical specifications. The generalisation of casting lines has been reflected in cleaner alloys and easier handling.

- Increase in furnace size

The 50-megawatt mark has been passed on furnaces producing ferro-silicon and their productivity has improved accordingly, but the energy and thermal efficiencies so obtained are perhaps not yet all on a par with medium-sized furnaces (30 MW).

Over the last two decades, considerable improvements have been achieved in the manufacture of silicon alloy, despite problems which have frequently been hard to overcome. Nonetheless, the effort has to be kept up since research work under way holds out the promise of substantial further progress in the years ahead.

1. PRESENT ASPECTS OF THE PRODUCTION OF SILICON AND 75 % FERRO-SILICON IN FRANCE

Over the last twenty years, the production of silicon and its alloys has had to contend with numerous shifts and changes on the economic scene : the dwindling supply and increasing cost of certain raw materials (charcoal) ; the use of different materials (coal) ; then the increase in energy costs and environmental problems (dust and sulphur dioxide abatement) ; and, last but not least users' increasingly stiff requirements with regard to purity.

Solutions have been found to these various problems, hand in hand with improvements in the metallurgical performance of production plant.

Two items have a major impact on total production cost, namely :

- energy, which in France accounts for approximately one-third of the total ;
- carbon products (reducing agents and electrodes), which account for another third.

Depending on the country concerned, economic circumstances may vary one way or another - the cost of electrical energy in particular can vary fairly widely - but it is likely that the number of production sites with access to cheap electricity will decrease as industry's demand for power grows.

A point to note is that, despite the increase in costs per man, the impact of the labour component continues to be small by virtue of mechanisation and optimisation of production plant capacities.

1.1. Choice of raw materials

Criteria to be taken into account with regard to raw materials procurement include :

- cost (delivered to plant),
- security of supplies,
- whether purity matches up to the end product envisaged,
- particle size profile and resistance to crumbling,
- physicochemical reactivity,
- resistivity, which needs to be high (particularly as regards carbon products),
- recovery efficiency.

As will be seen from tables 1,2 and 3, there is no one product able simultaneously to meet all these criteria. This is why furnace charges are extremely complex, since the need is to combine as many advantages as are consistent with good metallurgical performance and high metal purity. It is not unusual to employ two, or even three, grades of quartz in the same furnace, together with three, or sometimes even four, different carbon based reducing agents. This calls for facilities able to handle the precision blending of mixes of up to six or eight different constituents.

1.2. Energy

Energy represents a very substantial fraction of the total production cost, and is also the cost component which would increase most rapidly if progress failed to be made in holding down specific consumption.

Over the last ten years, SOFREM has managed to cut specific energy consumption by almost 10 %, to slightly less than 11 000 kWh per tonne for silicon and 8 400 kWh per tonne for 75 % ferrosilicon.

Progress was to an extent obscured in 1977-78-79 by the need to bring dust control facilities into service, increasing energy consumption by ancillaries by approximately 300 kWh per tonne of silicon.