



# GRAPHITIZED CARBON

## PRODUCT DEVELOPMENT AND APPLICATIONS

R&D Carbon provides the interface between technology suppliers, coke producers and coke users.

---

Feedstock selection

---

Delayed coking

---

Coke calcining

---

Pilot operation from green coke to graphitized products

---

Electrode and cathode applications

---

Quality assessment and testing



## R&D

Carbon Innovation is our strength...

R&D Carbon Ltd. • P. O. Box 362 • CH-3960 Sierre • Switzerland  
Phone: + 41 27 459 29 29 • Fax: + 41 27 459 29 25 • e-mail: [rdc@rd-carbon.com](mailto:rdc@rd-carbon.com) • [www.rd-carbon.com](http://www.rd-carbon.com)

# R&D Carbon invests in graphitized carbon product development and applications

*Industry urgently needs new carbon products as raw materials input to manufacture graphite electrodes for the steel and graphitized cathodes for the aluminum production. Coal tar based cokes can fulfill the stringent quality requirements for these applications*

**Raymond C. Perruchoud**, R&D Carbon Ltd., Sierre, Switzerland  
**Dr. Ulrich Mannweiler**, Mannweiler Consulting, Zürich, Switzerland

## Introduction

In 2008 the steel industry faced a shortage of needle cokes to make graphite electrodes. With the progressive recovery since 2009, and with the continued growth of the metal sector, we can expect a new shortage in the near future. Especially the emergent countries, like China, India and Russia, which produce and consume large quantities of graphite electrodes, need ever more premium needle coke with a low coefficient of thermal expansion (CTE) as their steel industry installs more ultra-high-power electrical arc furnaces (EAF).

Western countries and Japan cannot supply much more needle coke from their scarce feed stocks of low sulfur decant oil. Therefore, the development and production of first class coke by delayed coking of coal tar pitch is urgently required in the years to come as to respond to the increased demand.

The aluminum smelting industry is moving fast towards using graphitized cathodes for high amperage pots: the low electrical resistivity allows a substantial increase of electric current and so of metal production. As graphitized cathodes are relatively soft, the pots suffer erosion which shortens pot life.

The classical low-sulfur petroleum coke, as used for anodes, was found to be inappropriate for cathodes. Shot cokes and delayed pitch cokes were introduced with mixed success. Therefore, the development of new treated feed stocks but also of adapted processes that are favorable to the hardness of the graphitized end-products are urgently needed to respond to the economical challenges of the Aluminum-industry.

## Delayed Coking Feedstock

For the delayed coking process different combinations of feedstock can be considered as e.g. classical tar,

anthracene oil, slurry oil and other residues. The appropriate coker feeds require specific pre-treatments. Delayed coking has to be adapted in an optimum way so as to obtain the right coke macrostructure that is ranging from an isotropic to anisotropic structure depending on the intended application.

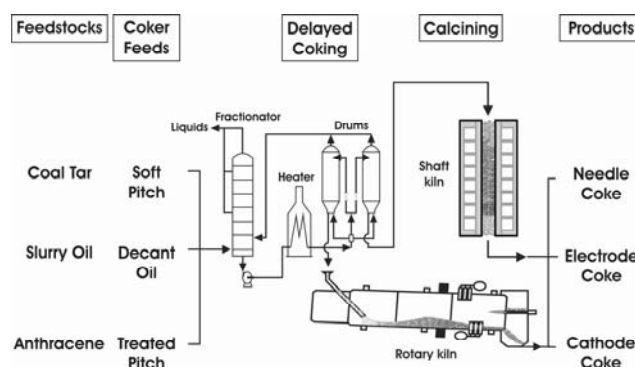


Figure 1: Production of needle, electrode and cathode cokes

R&D Carbon participates in the entire chain of the green coke production by providing expertise to companies specialised in delayed coking, such as the US firm Lummus Technology.

## Pilot Green Coke Preparation

The pilot delayed coker facility of the US Company Intertek PARC for the preparation of green coke test samples is used. The Pittsburgh pilot plant can distill and prepare feed stocks for the later coking step. An 80 liter coker drum processes up to 10 liters of feedstock per hour under optimized conditions for producing needle, electrode or cathode grade green cokes. Typically about 100 kg of green coke are produced by duplicate trials.

## Pilot Plant for Graphitized Carbon Electrodes

R&D Carbon has invested heavily to up-grade the existing prebaked anode pilot plant to enable it to

make graphitized electrode carbon. Now it can also perform detailed and professional evaluations of raw materials for graphitization. From green coke calcinations to graphitization of prebaked cores thru extrusion pressing, we are evaluating raw materials for needle and cathode cokes. These evaluations are decisive for the electrode/cathode quality.

R&D Carbon provides the expert interface between coke producers and coke users. In their pilot plant facility in Sierre, Switzerland the following steps can be performed:

- ❑ Calcining
- ❑ Dry aggregate preparation
- ❑ Paste preparation
- ❑ Forming by extrusion pressing or by vibrating
- ❑ Baking
- ❑ Graphitizing

### Pilot Calcination

The choice both of the calcining technologies and of the corresponding calcination parameters are of paramount importance for the calcined coke quality. In R&D Carbon's pilot plant, carbon materials can be either calcined in a rotary kiln or in a pilot shaft calciner. The plant can reach material throughput of up to 20 kg per hour with corresponding heat-treatment and residence time to guarantee the right degree of calcination for each of the different applications.



Figure 2: Pilot rotary kiln

### Preparation Green Paste and Electrode Artifacts

The dry aggregate is prepared through continuous sieving in fractions and continuous grinding in an air jet mill. Paste is mixed in an intensive impeller mixer. Several batches with different binder contents are prepared for determining the binder requirement.



Figure 3: Pilot plant to prepare dry aggregate

To shape the carbon product, RDC uses either its pilot vibrocompactor for cathode applications, or else its 400 tons extrusion press, producing 80 mm rods. The compacted green samples are baked at 1'100 °C in an electrically heated pilot baking furnace to remove the pitch volatiles.



Figure 4: 400 ton pilot extrusion press

### Graphitization

After machining the samples to 50 mm diameter rods, the final step is to graphitize them. The rods are placed in a lengthwise column for graphitization in an 80KW pilot furnace. The cores remain under pressure (10 bars) during the entire process. The length of the sample provides vital information on the puffing behavior in the temperature range 1'200 to 1'700°C and on the graphitization pattern up to 3'000°C, as shown in Figure 5 on the next page.

### Testing and Results

After cooling, R&D Carbon thoroughly tests the samples in their research laboratory. The relevant properties are measured for each application, mainly using ISO standards, but also by sophisticated methods like X-ray diffractometry, microscopy with image analyzer for porosity and macrostructure determination.

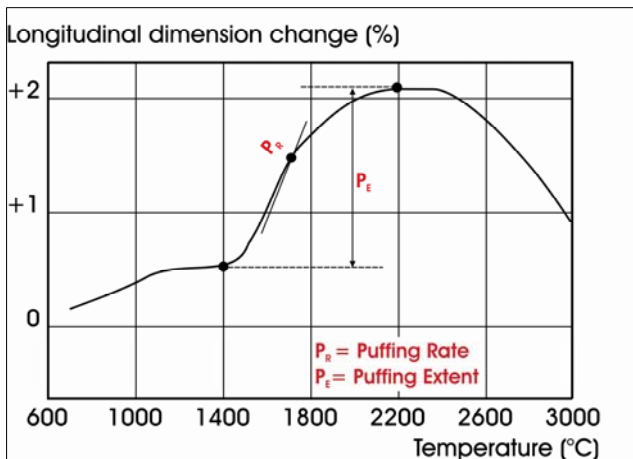


Figure 5: Dilatometry curve during graphitization

The following properties for graphite electrodes and cathode samples are regularly measured:

Property	Unit
Apparent Density	kg/dm <sup>3</sup>
Electrical Resistivity	μΩm
Flexural Strength	MPa
Elasticity Modulus	GPa
Coefficient of Thermal Expansion	10 <sup>-6</sup> /K
Thermal Conductivity	W/mK
Compression Strength	MPa
Abrasion Rate	%
Rapport Swelling Test	%
Sodium Vapor Test	%

Table 1: Measured Properties

Most of the current coke materials have already been tested in graphite electrodes and as graphitized cathodes. The results of this standardized evaluation show whether a given new coke candidate fits in the grey zone representing the range found for each electrode property with existing, satisfactory worldwide cokes.

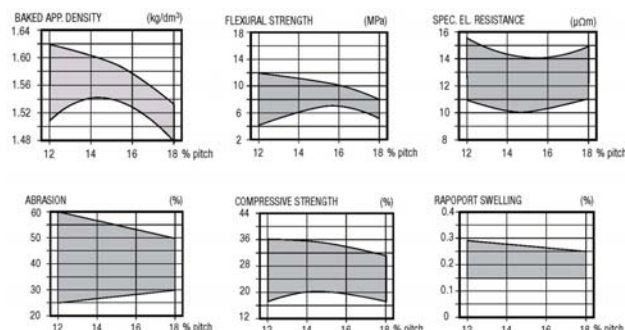


Figure 6: Range of graphitized cathode properties

## Conclusions

New carbon materials can fill the impending gap in supply of raw materials for graphite electrodes to produce steel and graphitized cathodes to produce aluminum. Coal tar based cokes can fulfill the stringent quality requirements for these applications; but the process parameters must first be optimized in careful pilot-scale trials.

With its long experience, know how and infrastructure, R&D Carbon provides the expert interface in the whole chain between technology suppliers, coke producers and coke users so as to :

- ❑ Select feedstock and its preparation steps
- ❑ Define process parameters for delayed coking in view of an optimum coke quality
- ❑ Select coke calcining technology and process optimization
- ❑ Operate pilot plant from green coke to graphite materials
- ❑ Advise on how to use electrode coke for graphite electrodes and cathodes
- ❑ Test and assess quality of coke, electrodes and graphitized cathodes.

For more information contact:

**R&D  
Carbon**

**R&D Carbon Ltd.**

P.O. Box 362, CH-3960 Sierre, Switzerland

Phone: +41 27 459 29 29, Fax: +41 27 459 29 25

[perruchoud@rd-carbon.com](mailto:perruchoud@rd-carbon.com) [www.rd-carbon.com](http://www.rd-carbon.com)

**MANNWEILER  
CONSULTING**

**Mannweiler Consulting, ,**

Hadlaubstrasse 71, CH-8006 Zürich, Switzerland

Phone: +4144 350 46 62, Fax: +41 44 350 46 61

[ulrich@mannweiler.ch](mailto:ulrich@mannweiler.ch) [www.mannweiler.ch](http://www.mannweiler.ch)