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TECHNICAL BULLETIN

Basic Carbon Refractories II

Since the 1960's, carbon has been recognized as an essential component of refractories called upon to resist corrosive high temperature slags such as those encountered in Basic Oxygen Furnaces (BOF).[1] It was found that the addition of some form of carbon provided higher residual carbon content than resin or pitch binder alone. This leads to better thermal and chemical resistance, thereby increasing the life of refractory linings and indirectly reducing steel production cost. Carbon is now an integral component of the ceramic-carbon composite for many refractory applications. State-of-the-art magnesia-carbon brick is the accepted standard for linings for BOF and electric steelmaking furnaces and for the slaglines of ladle metallurgy furnaces.[2]

Thermax® N990 Medium thermal carbon black has been used in the manufacture of basic carbon refractories for nearly thirty years. Derived from the thermal decomposition of methane gas, this amorphous carbon is preferred by the refractory industry due to its high purity, low ash and sulphur content and low surface area, as compared to other forms of carbon black. The unique physical and chemical properties (see Table 1) of Thermax® have made it the carbon source of choice in many basic carbon refractory products.

Table 1: Fundamental Properties of Thermax®

Parameter	Typical Value
Form	**Amorphous, derived from thermal decomposition of methane gas**
Ash Content (%)	0.1
Moisture Content (%)	0.0
Toluene Extractables (%)	0.15
Sulphur (ppm)	150
pH	9.8
Specific Gravity	1.8
Nitrogen Surface Area (m^2/g)	9.1
Average Particle Size (nm)	280
Particle Size Distribution (nm)	100 – 700
Oil Absorption Number (m^3/kg)	38
Pour Density ($lbs.ft^3$) (pelletized grade)	40
Pour Density (g/cm^3) (pelletized grade)	0.640

[1] Peter T. Troell, "Evolution of Magnesia-Carbon Refractories," Ceramic Industry, February 1995, p. 41
[2] Ibid, p. 43

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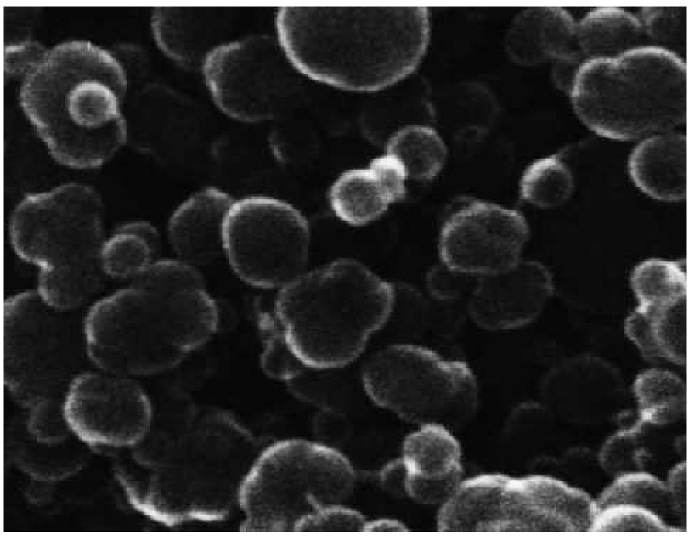
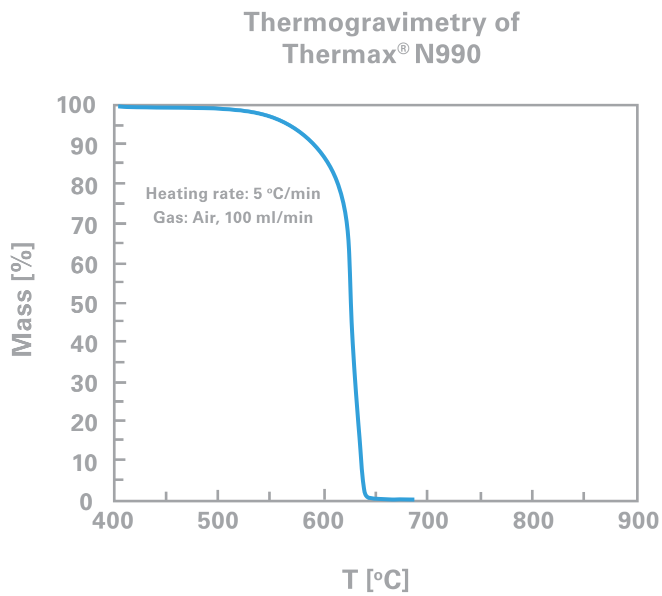
As can be seen in the followingScanning Electron Microscope (SEM) photograph, Thermax® medium thermal carbon black is characterized by large, relatively spherical particles, with a wide range of particle sizes and minimal particle agglomeration. According to disc centrifuge measurements, the average particle diameter is roughly 280 nanometers, with a distribution of 100 – 700 nm.

Figure 1: SEM Photo of Thermax®



The high purity of Thermax® N990, originating from the high purity methane gas feedstock, provides superior oxidation resistance. Extremely low levels of ash and sulphur and corresponding high fixed carbon content inherent in the product enhance the chemical and high temperature resistance of refractories. Figure 2 provides a typical thermogravimetric analysis of Thermax® in air.

Figure 2: Thermogrowlmetric Analasys of Thermax®



Surface Chemistry

Electron spectroscopy for chemical analysis (ESCA) can be used to measure the surface chemistry of materials up to a depth of 50 Å. Thus in addition to the surface, the region near the surface is also studied. Carbon and oxygen are the only elements identifiable on the surface of Thermax®, confirming the high purity. Sulphur and nitrogen are not present, due to the high purity feedstock methane gas. Following is the elemental composition of Thermax® N990 as obtained by ESCA, as compared to an oil-furnace grade N550 carbon black.

Table 2: Elemental Surface Composition by ESCA

	Carbon (%)	Oxygen (%)	Sulphur (%)
Thermax® N990	**98.4%**	**1.6%**	**N/D**
N550 Carbon Black	98.1%	0.9%	1.0%

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Thermax® medium thermal carbon black has been found to improve the physical properties of refractories particularly as to oxidation, chemical resistance, crushing strength (bond strength) and density. Addition of Thermax® N990 or Thermax® Powder N991 into the granular refractory formulation (0.5% to 15% by weight) results in a substantial improvement in furnace service life and at the same time helps to control viscosity of the mix during manufacture. Higher densities in specialized refractories have also been accomplished as the wide fundamental particle size distribution and low level of particle structure of Thermax® help to maximize brick density.

Closer packing of the carbon from both the binder and the carbon black are known to be helpful in the manufacture of a denser brick.

Thermax® N990 is a pelletized form characterized by soft, uniform pellets, with an average pellet diameter of approximately 0.5 mm. These pellets break apart easily and disperse readily and homogeneously in the refractory mix. Thermax® N990 is notably easier to disperse than other carbonaceous materials such as flake graphite.

The advantages of Thermax® medium thermal carbon black are summarized as follows:

- Increased brick density by filling voids, thereby reducing porosity and permeability. Thermax® is characterized by a low order of structure and wide particle size distribution, which helps to fill in porous voids and maximize brick density. Green strength may also be enhanced by the higher packing density.
- Better reactivity than other carbon sources for in-situ carbide formation, e.g. MgC, SiC, AlC, B4C. Thermax® provides more surface area per weight unit of carbon, thereby providing more carbon for reaction with metal additives.
- Highest carbon purity, providing increased residual carbon content of brick. The fixed carbon content of Thermax® is >98%. This provides improved thermal shock resistance, chemical resistance, heat resistance and active slag resistance. This helps to improve the wetting angle against penetration by steel, iron and slag.
- Large particle size and low structure allow for higher loadability and therefore higher carbon content.
- Soft pellets for easy incorporation and homogeneity during refractory manufacturing.
- Uniform pellet size distribution allowing use in bulk and semi-bulk automated and pneumatic material handling systems.

Thermax® is used in both pitch and resin bonded dolomite, magnesia and alumina refractories. It can be used in combination with other forms of carbon including flake graphite. Applications include bricks, castables, ladle slag lines, gates and degassers and many other related products.

The long term benefits of using Thermax® medium thermal carbon black include reduced refractory cost per ton of steel through improved refractory longevity and performance, increased thermal shock resistance, increased oxidation resistance of refractories and improved steel quality by reducing refractory inclusion content.

Patent References

US Patent 6,395,662, Non-Slumping Sprayable Refractory Castables Containing Thermal Black

US Patent 6,313,055, Refractory Castables Containing Thermal Black

US Patent 3,236,664, Pitch-Bonded Refractory Composition

Bibliography

Ruh, Edmund, “Worldwide Trends in Refractories,” Ceramic Industry, February 1995, pp. 31 – 38

Troell, Peter T., “Evolution of Magnesia-Carbon Refractories,” Ceramic Industry, February 1995, pp. 41 – 45