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TECHNICAL BULLETIN

Coloured Glass Production

Introduction

An important application of Thermax® N990 is in the production of various coloured glasses to make bottles. Thermax® has been used successfully as a carbon reducing agent to produce flint (clear), amber (brown) and green glass colours for wine bottles.

Traditionally glass manufacturers have used an inexpensive carbon source such as petroleum refinery bottoms or crushed coal. The carbon is added to a mixture of silica sand and other chemicals. Carbon acts as a reducing agent producing changes in various ionic species which in turn produce colour changes in glass. Only a small amount of carbon is required to produce a colour change. Typically, only 0.09% – 0.3% of carbon by weight is required to produce a given color. This percentage is based on the amount of total silica used.

Thermax® N990 has successfully replaced both crushed coal and a petroleum refinery product at a limited number of glass producers. As a carbon source Thermax® is classified as a medium thermal carbon black and is one of the purest forms of carbon commercially available. Some of the typical properties of Thermax® N990 are listed in Table I.

In the past one glass manufacturer successfully used Thermax® in the production of flint, green and amber glass bottles. Today Thermax® is used in the production of flint and amber glass.

Presented on the next page are two case studies outlining Thermax's® success in replacing both a petroleum refinery product and crushed coal.

Table I: Typical Properties

ASTM Reference	Test Description	Thermax® N990
D 1506-85	Ash Content, %	0.1
D 1509-83	Heat Loss, %	0.0
	Toluene Extractables, %	0.2
	Sulphur, ppm	170
D 3037-91	Nitrogen Surface Area, m^2/g	9
D 1513	Pour Density, $lbs./ft^3$	40
	g/cm^3	0.64
D 1508-84	Fines Content, %	4.0
D 1512-84	pH Value	9 - 11
	Mean Particle Diameter, nm	250
	Ultimate Specific Gravity	1.8 - 1.9

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Case Studies

Case Study I:
Thermax® N990 Vs. A Petroleum Refinery Product

Thermax® successfully replaced a petroleum refinery carbon by-product in flint, green and amber glass production. The refinery bottoms product contained approximately 77% carbon purity by weight.

Flint Glass

In the production of flint glass Thermax®, sodium carbonate, calcium carbonate, alumina, sodium sulphates, cobalt and selenium are added to silica sand to produce glass. Sodium carbonate, calcium carbonate and alumina are used as process aids. Sodium sulphate is used to absorb any trapped air. Cobalt and selenium are used as decolourizers.

A carbon source is required to reduce any contaminate iron from ferric ($Fe3+$) iron to ferrous ($Fe2+$) iron. Any iron in glass produces a yellow color and in flint glass cobalt and selenium are used as decolourizers to enhance colour of the finished product.

Redox analysis was performed on the finished product to determine the ferrous to ferric iron ratio and the sulphate to sulphite ratio. It was found that a 95% conversion rate was achieved with a 75% reduction in source carbon volume. The end product was equal in quality using Thermax® as compared to the refinery bottoms product.

Table I gives a comparison of Thermax® N990 vs. the refinery product in flint glass production. Values are normalized to 2,000 lbs. sand base, as that is a North American standard for the industry.

Green Glass

In the production of green or reduced glass, a carbon source plays the same role (reduction of ferric to ferrous iron), but in this case iron is added to the mixture to produce a yellow color. Chrome is added to the mixture to produce a blue color. The combination of the two results in green glass. A 57% reduction in volume was realized using Thermax® as a carbon source (see Table II).

Amber Glass

In amber glass (the most critical) additional iron, in two forms (pure iron and iron sulphate), is added to the mixture. Pure iron produces a red color and is reduced by a carbon source to a yellow color and sulphate in the mixture results in the finished amber colour. Thermax® reduced carbon consumption by approximately 50% (see Table II).

General

It was noticed that in the production of the reduced glass (green and amber), Thermax® usage provided colours that were more stable and fewer adjustments had to be made to mix ratios.

On a delivered price basis, Thermax® was more expensive than refinery product. However, due to the reduced volumes (of Thermax®) required, a slight cost savings was realized since volume reductions ranged from 54% - 75% (see Table II). Savings in handling and storage were also realized.

Table II: Comparison of Thermax® N990 Vs. Refinery Carbon

Glass Type	Refinery Carbon	Thermax® N990	% Reduction
Flint	28 oz (794 g)	7 oz (198 g)	75%
Green	56 oz (1588 g)	24 oz (680 g)	57%
Amber	70 oz (1985 g)	32 oz (907 g)	54%

NOTE: All values normalized to 2,000 lbs (907.2 kg) sand base

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Case Study Ii: Thermax® N990 Vs. Crushed Coal

Thermax® N990 has replaced crushed coal in the manufacture of amber glass for beer and wine bottles and clear (flint) glass.

For every 600 kg of silica sand used, only 1.14 – 1.15 kg of Thermax® is required to produce amber glass bottles. Previous to using Thermax® 1.9 kg of crushed coal (80% carbon content) was needed. This represents a 40% reduction in carbon source (see Table III).

For flint glass, 0.45 kg of Thermax® is used.

For the amber glass, Thermax® is premixed with $NaSO_4$ before being added to the silica.

By switching to Thermax® from crushed coal better colour quality and less colour rejects have been achieved.

Table Iil: Comparison of Thermax® N990 Vs. Crushed Coal

Glass Type	Crushed Coal	Thermax® N990	% Reduction
Amber	1.9 kg	1.145 kg	40%

NOTE: All values normalized to 600kg sand base

Advantages of Thermax® in Coloured Glass Production

Greater Surface Area for Enhanced Chemical Reaction

Thermax® reacts more efficiently than the carbon sources cited above because it has a greater surface area per unit weight. In terms of particle size Thermax® has a typical mean particle diameter of 250 nm versus a typical crushed coal particle with a diameter of 4500 nm. A smaller particle size means that more surface area is immediately available to the chemical species to be reduced and as a result you get a more efficient redox reaction.

Highest Possible Carbon Purity

Thermax® has carbon purity greater than 99.5% by weight versus the other carbon sources at approximately 80%. The extremely low levels of impurities in Thermax® ensures that it is one of the best carbon sources available.

A major constituent of contamination in many carbon sources is elemental sulphur. Coal often contains high levels of sulphur. Thermax® N990 by comparison typically contains less than 300 ppm of total sulphur. Most of the sulphur in Thermax® is bound in sulphate. Another constituent impurity in Thermax® is sodium (400 ppm) which is most likely combined with sulphate in the form of sodium sulphate ($NaSO_4$). Sodium sulphate also happens to be an ingredient in amber glass.

The consistent high purity of Thermax® ensures consistency in glass colour while helping to minimize colour rejects.

Ease of Storage and Handling

Using Thermax® in the production of coloured glass can reduce carbon consumption by approximately one half. Therefore, material handling costs are reduced.

Thermax® comes in a dust free pelletized form which is readily dispersible in simple mixing systems. The pellets of Thermax® are free flowing allowing it to be readily used in semi-bulk and automated material handling systems.

The highly stable micro crystalline quasi-graphitic molecular structure of Thermax® presents no explosion hazards in handling, unlike some coal dusts.

General

Many glass companies use crushed coal as their carbon source. Crushed coal is considerably inexpensive versus Thermax® (4 to 5 times cheaper or more). However, the increased reaction efficiency and high quality of Thermax® can potentially make it a competitive value adding ingredient in coloured glass production, as some manufacturers have proven.

Since crushed coal and other carbon sources vary considerably in terms of grades and impurity levels, Thermax® has to be evaluated on a case by case basis to determine its suitability as a coloured glass reducing agent replacement.