A composite product and a method of manufacturing the composite product are disclosed. The composite product includes (a) a polymeric material binder and a metal-bearing material or (b) the polymeric material binder and a carbon-bearing material. The method includes heating and mixing the components of the composite product and thereafter forming the heated mixture into a final product shape, with the heating step being sufficient to melt at least a part of the polymeric material binder to facilitate forming the product.
COMPOSITE PRODUCTS AND MANUFACTURING METHOD

[0001] The present invention relates to composite products and to a method of manufacturing the products.

[0002] The present invention relates particularly, although by no means exclusively, to composite products that are made from recycled products.

[0003] The present invention relates particularly, although by no means exclusively, to composite products that are suitable for use in high temperature methods.

[0004] The term “high temperature methods” is understood herein to mean methods that operate at temperatures greater than 400°C, typically at least 600°C.

[0005] Examples of high temperature methods are methods that are carried out in metallurgical furnaces such as steel-making furnaces. In these methods the composite products of the present invention are intended to provide any one or more of metal bearing units and a source of energy.

[0006] Other examples of high temperature methods are methods that are carried out in power stations and kilns, such as cement making kilns, that require heat to be generated by fossil or engineered fuels. In these methods the composite products of the present invention are intended to provide a source of energy as a replacement of fossil fuels.

[0007] The present invention is not confined to composite products that are suitable for use in high temperature methods. By way of example, the composite products of the present invention are suitable for use as building materials or as protective materials for building and wear resistant materials (e.g. for wear resistance or corrosion resistance), such as alternatives to timber products and steel products.

[0008] The present invention is based on the use of a polymeric material as a binder to hold together particles of a metal-bearing material and/or a carbon-bearing material in a composite product that comprises (a) the polymeric material and the metal-bearing material or (b) the polymeric material and the carbon-bearing material or (c) the polymeric material and the metal-bearing material and the carbon-bearing material.

[0009] The present invention is also based on manufacturing these composite products by a combination of heating and mixing the components of the composite product, with the heating step being sufficient to melt at least a part of the polymeric material binder to facilitate forming the product.

[0010] The present invention provides a method of manufacturing a composite product in the form of (a) a polymeric material binder and a metal-bearing material or (b) the polymeric material binder and a carbon-bearing material that comprises heating and mixing the components of the composite product and thereafter forming the heated mixture into a final product shape, with the heating step being sufficient to melt at least a part of the polymeric material binder to facilitate forming the product.

[0011] The heating and mixing steps may be carried out in the order described in the preceding paragraph or in the reverse order or simultaneously.

[0012] The term “metal-bearing material” is understood herein to mean any material that can be processed in a high temperature method such as a high temperature metallurgical method carried out in a metallurgical furnace to produce a metal product. The term “metal” is understood herein to include metal alloys. Steelmaking, particularly electric arc steelmaking, is one metallurgical method of particular interest to the applicant. Other metallurgical methods include, by way of example, basic oxygen steelmaking and ironmaking methods. The present invention is not confined to high temperature metallurgical methods. The metal-bearing material may be a recycled material.

[0013] The method of manufacturing the composite product that comprises the polymeric material binder and the metal-containing material may include mixing other materials, such as materials that are sources of carbon other than the polymeric material binder, with the metal-bearing material and the polymeric material.

[0014] The other sources of carbon may comprise any one or more of biomass, flyash, rubber, paper, coke fines, char fines, coal fines, toner from printers and photocopying machines, and any other suitable organic material. It is noted that, typically, in addition to containing carbon in the form of carbon black, toner contains metal-containing particles (iron oxides) and polymeric material. The other sources of carbon may be recycled materials. The other sources of carbon may be virgin materials.

[0015] The other materials may include burnt lime, dolomite, and magnesite.

[0016] The method may comprise controlling the method and the selection of the metal-bearing material when present), the carbon-bearing material when present), and the polymeric material binder to produce a product having a required porosity. There may be situations in which it is desirable to make the product be non-porous. There may be other situations where the preferred chemical reactions in the high temperature method, such as a high temperature metallurgical method, may make it desirable for the product to have a level of porosity. For example, it may be desirable for chemical reactions to take place within the product within the furnace, in which case a level of porosity to facilitate escape of volatilised reaction products may be desirable.

[0017] The method may comprise mixing the metal-bearing material and the polymeric material binder so that there is a uniform dispersion of the metal-bearing material through the product.

[0018] The method may comprise mixing the carbon-bearing material and the polymeric material binder so that there is a uniform dispersion of the carbon-bearing material through the product.

[0019] The method may comprise heating the mixture of the components of the product at a temperature that is sufficiently high to completely melt the polymeric material binder. The temperature may be any suitable temperature having regard to the particular selection of the polymeric material binder, the other components of the mixture, and the requirements of the particular method of forming the composite product. By way of example, in the case of a polymeric material binder in the form of low density polyethylene, typically the temperature is of the order of 150-175°C.

[0020] The method may comprise selecting the metal-bearing material and the carbon-bearing material so that these materials remain as solids during the heating step.

[0021] The method may comprise controlling the method and the selection of the metal-bearing material when present), the carbon-bearing material when present), and the polymeric material binder to produce a product having a required density. For example, when the product is a feed material for a steelmaking process it may be preferred that the product have a density that allows the product to float on a molten metal pool that forms in the process.
The metal-bearing material and the carbon-bearing material may be in a particulate form.

By way of particular example that is relevant to steelmaking methods, the metal-bearing material may be in the form of iron-bearing particles.

The iron-bearing particles may be in the form of fines.

By way of particular example, the iron-bearing particles may be in the form of mill scale fines or baghouse dust or other by-products from a steelmaking plant or an ironmaking plant.

In the context of iron-bearing particles for use in making steel in an electric arc steelmaking furnace, the term “fines” is understood herein to denote particles that have a major dimension of less than 6 mm.

In a wider context of metal-bearing particles for use in high temperature methods in metallurgical furnaces, the term “fines” is understood herein to denote particles that have a major dimension of less than 6 mm.

The use of the polymeric material as a binder for metal-containing or carbon-containing materials in the composite product of the present invention is not confined to composite products for high temperature methods carried out in metallurgical furnaces and extends to high temperature methods generally that require the composite product of the invention. In this context, the present invention is not confined to fines and extends to metal-bearing and to carbon-bearing materials that have a major dimension of greater than 6 mm.

The polymeric material binder may be any suitable material. An important requirement of the polymeric material binder is that it be capable of acting as a binder of the other components of the composite product under the specified materials handling and operational conditions for the product. By way of example, the specified conditions may include storage for prolonged periods in the outside atmosphere. By way of further example, the specified conditions may include particular materials handling requirements for the product.

The polymeric material binder may be a recycled polymeric material.

The polymeric material binder may be a recycled polyethylene such as a low density polyethylene or a high density polypropylene or a recycled polypropylene.

The carbon-bearing material may be in the form of biomass, flyash, rubber, paper, coke fines, char fines, coal fines, used toner from printers and photocopying machines, and any other suitable organic material. The carbon-bearing material may be recycled materials. The carbon-bearing material may be virgin materials.

The method may include any suitable forming step for forming a final product shape.

The forming step may be any one of an extrusion step, a moulding step (including injection moulding), and a briquetting or other type of pressing step.

By way of example, step (c) may include forming the heated mixture into the composite product by extruding the heated mixture.

The extrudate may be in the final product shape.

Alternatively, it may be necessary to cut the extrudate to form the final product shape. For example, step (c) may include forming a continuous extrudate and thereafter cutting the extrudate as it emerges from the extruder into the final product shape.

In a situation in which the extrudate emerges from the extruder as a continuous “rope” (of small or large cross-section), the method may include cutting the rope into smaller lengths, whereby the smaller lengths of the extrudate form the product.

The final product shape may be any suitable shape and any suitable size.

The shape and size of the final product shape may be determined having regard to the materials handling and process requirements for the metallurgical method and metallurgical furnace in which the product is to be used.

The product may be in the form of pellets.

The product may be in the form of granules.

The product may be in the form of larger products that can be described as blocks, pigs, putties, plugs and pucks.

The larger product may have a major dimension of at least 10 cm.

The larger product may have a major dimension of at least 15 cm.

The larger product may be at least 1 kg.

The larger product may be at least 2 kg.

The larger product may be at least 3 kg.

The larger product may be less than 10 kg.

In any given situation, the factors affecting the shape and the size of the product may include the following factors.

The product should have sufficient strength and toughness to be able to be handled within a high temperature processing plant such as a metallurgical plant and to be charged into a high temperature furnace such as a metallurgical furnace in the plant without significant breakdown of the product into smaller sized products, with generation of fines outside and/or inside the furnace.

The product should be sufficiently large and have required mechanical properties such as strength to withstand the high temperature and reactive conditions in the high temperature furnace such as the metallurgical furnace to facilitate controlled dissolution of the product in the furnace over a required time period. Depending on the high temperature method, this time period may be a relatively short time period or a longer time period. The required dissolution rate may vary depending on the chemical reaction requirements of the high temperature method and the overall time period of the method. For example, in some methods it may be important to have combustion of combustible components in the product as soon as possible. In other situations, it may be important to have relatively slow dissolution of the product so that there is consumption of the product during the whole operating period of the method.

The present invention also provides a composite product that comprises a metal-bearing material and a polymeric material that acts as a binder for the metal-bearing material.

The product described in the preceding paragraph may include other materials, such as materials that are sources of carbon other than the polymeric material binder.

The present invention also provides a composite product that comprises a carbon-bearing material and a polymeric material that acts as a binder for the carbon-bearing material.

The product described in the preceding paragraph may include other materials, such as a metal-bearing material.
The product may comprise a continuous network of the polymeric material and a uniform dispersion of the metal-bearing material or the carbon-bearing material. The product may be a porous product. The product may be a non-porous product and hence be at least substantially waterproof. This is an advantageous feature in situations where any one or more of the components of the product is susceptible to taking up moisture while being stockpiled or transported. For example, this is particularly the case with products that include biomass as the metal-bearing material of the product. The product may comprise an outer covering of the polymeric material. The covering may make the product non-porous. In addition or alternatively, the covering may thereby encapsulate fines in the product and minimise the release of the fines during materials handling and transportation. In any given situation, the relative amounts of the polymeric binder material, the metal-bearing material (when present), the carbon-bearing material (when present) and other materials will be a function of factors such as the binder requirements for the composite products, the requirement for metal-bearing materials in an end-use application for the products, and the energy requirements for the products in the end-use application. The polymeric material binder may comprise greater than 10 wt. % of the product. The polymeric material binder may comprise greater than 15 wt. % of the product. The polymeric material binder may comprise less than 50 wt. % of the product. The polymeric material binder may comprise less than 45 wt. % of the product. The polymeric material binder may have a vapourisation temperature lower than the temperature of a molten bath in the metallurgical furnace. The polymeric material binder may be a recycled polymeric material. The polymeric material binder may be a recycled polyethylene such as a low density polyethylene or a high density polyethylene or a recycled polypropylene. The metal-bearing material may be in the form of iron-bearing particles. The iron-bearing particles may be in the form of fines. The iron-bearing particles may be in the form of iron oxide particles. The iron-bearing particles may be in the form of mill scale fines and/or baghouse dust or other by-products from a steelmaking plant. The carbon-bearing material may be in the form of particles of biomass, flyash, rubber, paper, coke fines, char fines, used toner from printers and photocopiers, machines, and any other suitable organic materials. The carbon-bearing material may recycled materials. The carbon-bearing material may be virgin materials. The product may be made completely from recycled materials, with each of the polymeric binder material and the metal-bearing material (when present) and the carbon-bearing material (when present) being recycled materials. The recycled materials may be obtained from any suitable source. By way of example, the metal-bearing units may be in the form of mill scale fines, the polymeric binder material binder in the form of recycled polyethylene, and the carbon-bearing units may be in the form of coke fines or recycled rubber. The product may be any suitable size and shape. The product shape and size may be as described above. The product may be suitable for use in a high temperature method. The product may be suitable for use as a source of energy as a replacement for fossil fuels in power stations and kilns, such as cement making kilns, and other applications that require heat to be generated by fossil fuels. When used as a source of energy, the product may be described as an "engineered fuel". The product may be suitable for use as building materials or as protective materials for building materials (e.g., for heat resistance or corrosion resistance) or as protective materials for mining consumables (e.g., for wear resistance on mining consumable parts for mineral processing or mining extraction equipment), as alternatives to timber products and steel products. The present invention also provides a high temperature method that comprises supplying the above-described composite product that contains metal-bearing units and carbon-bearing units (a polymeric material binder) as a feed material for the method. The high temperature method may be a method for producing a molten metal (which term includes a metal alloy, including a ferroalloy) in a metallurgical furnace. The method may be a method of producing steel. The steelmaking method may be an electric arc steelmaking method. The steelmaking method may be a basic oxygen steelmaking method. The method may be a method of producing iron. The present invention is based on a realisation of the applicant during the course of a research and development project that it is possible to produce a composite product that comprises metal bearing units, more particularly, iron-bearing units in the form of mill scale fines and a polymeric material binder in the form of recycled low density polyethylene that is well-suited in terms of materials handling, chemistry, and processing properties for use in an electric arc furnace steelmaking method. In particular, the applicant found in the course of the project that the polymeric material acted as an effective binder for the iron-bearing fines in the composite product and provided a source of energy. The present invention is also based on a realisation of the applicant during the course of the project that it is possible to produce a composite product that comprises carbon-bearing units in the form of coke fines and a polymeric material binder in the form of recycled low density polyethylene that is well-suited in terms of materials handling, chemistry, and processing properties for use in an electric arc furnace steelmaking method. The present invention is also based on a realisation of the applicant during the course of the project that hot forming, for example by hot extrusion, of mixtures of the above-described metal-bearing units and/or carbon-bearing units and polymeric material binder at temperatures at which at least part of the polymeric material binder had melted and the other components of the mixture remained as solids is an effective method of producing composite products with the
required materials handling, chemistry, and processing properties for use in an electric arc furnace steelmaking method.

The present invention is also based on a realisation of the applicant during the course of the project that the metal-bearing based composite product and the carbon unit based composite product of the invention has wider end-uses than steelmaking. In particular, the applicant has realised that the carbon unit-based composite product of the invention has applications as a replacement for fossil fuels in power stations and kilns, such as cement making kilns, and other applications that require heat to be generated by fossil or engineered fuels.

The research and development project included laboratory work on a wide range of products having 10-45 wt. % of a polymeric material in the form of low density polyethylene in accordance with the present invention.

The laboratory work included work on composite products comprising metal-bearing, specifically iron-bearing, material in the form of mill scale and the polymeric material in the above ranges. The laboratory work found almost 100% reduction of the iron oxide in these products to molten iron.

The laboratory work also included work on composite products comprising carbon-bearing material in the form of coke fines and the polymeric material in the above ranges.

One example of the product had a composition of 24 wt. % low density polyethylene binder, 1 wt. % processing aid, 75 wt. % coke fines and other carbon-containing material.

The research and development project also included a 1 tonne trial of a sample composition of the product of the present invention in an electric arc steelmaking furnace of the applicant.

The sample product for the trial was extruded successfully on a standard commercial hot extruder.

The continuous “rope” that was produced by the extruder was formed into large “pattie” shapes, of the order of 3 kg.

The sample product had a composition of 24 wt. % low density polyethylene, 1 wt. % processing aid, 7 wt. % coke, and 68 wt. % mill scale.

<table>
<thead>
<tr>
<th>Composition by Material</th>
<th>wt. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill scale</td>
<td>68</td>
</tr>
<tr>
<td>Coke fines</td>
<td>7</td>
</tr>
<tr>
<td>Recycled LDPE</td>
<td>24</td>
</tr>
<tr>
<td>Processing Aid</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composition by Element</th>
<th>wt. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron (≈75 wt. % Fe in mill scale)</td>
<td>51</td>
</tr>
<tr>
<td>Carbon (≈85 wt. % C in LDPE/≈85 wt. % C in coke)</td>
<td>26</td>
</tr>
<tr>
<td>Oxygen (≈25 wt. % O in mill scale)</td>
<td>17</td>
</tr>
<tr>
<td>Hydrogen (≈15 wt. % H in polymer)</td>
<td>4</td>
</tr>
</tbody>
</table>

The 1 tonne of the product patties was charged into a hot heel of the electric arc furnace. The effect of the addition of the charge of the product was monitored via cameras and standard data recording of chemistry and method operating parameters.

The heat balance for the addition is set out below.

<table>
<thead>
<tr>
<th>Product</th>
<th>Heat In</th>
<th>Heat Out</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 kg FeO + 680 kg Fe + 240 kg LDPE + 70 kg Coke</td>
<td>240 kg LDPE × 12.9 kWh/kg = 3,096 kWh</td>
<td>Iron oxide reduction + 2 kWh/kg × 680 kg - 1,360 kWh</td>
<td>3,096 - 1,360 = 1,736 kWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Iron melt = 510 kg × 0.44 kWh/kg = 225 kWh</td>
<td>+1,511 kWh</td>
</tr>
</tbody>
</table>

It is noted that the above heat balance is based on theoretical data from standard reference materials and data obtained from an electric arc steelmaking plant of the applicant in NSW, Australia.

Some key findings of the trial are as follows.

1. The product patties were a source of energy.
2. The product patties were magnetic—therefore, the patties could be handled using a standard furnace scrap magnet crane—500 kg/load.
3. The product patties were tough—no breakout with regular blocks.
4. The product patties were waterproof—no noticeable weight increase submerged in water for 1 week.
5. The product patties settled at the bath/slag interface and started reacting within the furnace.
6. The product patties remained intact and reacted at a controlled rate for extended period with some patties lasting >15 minutes.
7. The product patties produced strong heat generation.
8. There was very little fume generation compared to plastic and rubber alternative products.
9. Charge reaction—no noticeable change adding 100 kg, 200 kg and 300 kg/heat in bottom bucket 1.
10. The results of the trial indicate significant business opportunities based on the composite product of the present invention.

In particular, the applicant realised from the trial that a composite product of the present invention that is based on a polymeric material binder that holds together carbon-bearing material could be a significant source of energy that has wider applications than the steelmaking industry, with these applications including as a replacement for fossil fuels in power stations and kilns, such as cement making kilns, and other applications that require heat to be generated by fossil or engineered fuels.

In addition, the applicant realised from the trial that a composite product of the present invention makes it possible to introduce different ratios of steelmaking feed materials and sources of energy in a charge bucket to an electric arc furnace. Hence, depending on the requirements, there may be more or less of each of the iron-bearing materials and other steelmaking feed materials and the polymeric material (as a binder and a source of energy) in a charge bucket. Hence, the composite product of the present invention provides an opportunity for flexibility in the supply of feed materials to a steelmaking process and, in particular, an opportunity to optimise energy utilisation.
Another key benefit of the sample product patties, which is a benefit that should facilitate use of the composite product of the invention in electric arc furnaces and other high temperature methods is that there is a controlled and metered rate of reaction and heat generation because of the physical and chemical composition of the product patties. The controlled rate of fuel release leads to complete combustion and utilisation of heat in a furnace rather than in the offgas system. Therefore, there is a lower risk of high gas duct temperatures and buoyant hobs as well as unburnt fuel or flame in the off-gas duct leading to explosions. In the 1 tonne trial it was observed that the sample product patties (~3 kg each) took longer than 10 minutes to combust when added to the hot heel of the furnace. This was a key observation and significant benefit and should allow the sample product patties to be used like “burners” under scrap charge at a controlled rate during meltdown rather than reacting too fast immediately after charging and causing flame and flame to exit the furnace. In comparison, when a small amount of plastic film bound together or pieces of rubber tyre was added to the furnace it reacted and was burnt within a few minutes. The sample product patties were observed to ignite and sustain a strong flame for a long period.

Based on the trial, the applicant believes that if the composite product patties are located under the scrap in an electric arc furnace, the product patties will potentially provide preheating and reduce the power on time and electrical energy consumption.

The slower rate of combustion of the product patties was controlled in the trial due to the composite nature of the composite product. The reaction of the polymer material binder or filler materials (mill scale and coke fines) with oxygen was limited to the surface of the product patties due to the low porosity caused by the binder. Therefore, there was very little gas penetration into the product patties. The low porosity limited the surface area for reaction and shielded the reactants within the product. There should be a large thermal gradient from the inside to the surface of the product with reaction taking place on or near to the surface. There would also be some insulation effect from the gas/fume/flame layer formed by the fuming and ignition of the polymer at relatively low temperature (250 to 400°C) and reaction products leaving the surface of the briquette. For example, this should insulate the product patties from the surrounding high temperature steel and slag (1500-1750°C) and allow the product patties to last longer.

Fuel is released at a controlled rate as only that exposed at the surface reacts.

The composite matrix structure of the product patties means that the iron oxide shields the polymer binder and controls the reaction rate. If the filler material has low combustibility, then the rate of supply of a “fuel” to the surface where it can contact oxygen is lower. That is why the iron oxide (mill scale) products would potentially last longer in liquid metal slag than briquettes that contain combustible filler like coke or graphite. The same shielding effect could be achieved by using other filler materials with low rate of combustion (lime, dolomite, baghouse dust, etc.).

The products also slow down the reaction compared to if the fine materials were added individually. For example, both mill scale and coke fines can react quickly or violently through a carbon oxygen reaction when introduced to a liquid steel bath due to the high surface area of these materials.

It follows from the above discussion that the rate of reaction could be controlled by varying the composition of the product patties to increase or decrease the filler and binder materials. This could be applied to many pyrometallurgical applications or other high temperature applications. For example, the applications include mini-blast furnaces or alternate iron making processes or incineration processes or power generation processes.

In the context of the electric arc steelmaking industry, the trial indicated that the composite product of the present invention provides opportunities for scrap replacement, the use of waste products and by-products produced in steelmaking plants and in other industries, the use of feed materials in the form of fines that otherwise would not be suitable for use in electric arc steelmaking furnaces, the use of recycled materials as the polymer material binder and as a source of energy, and the opportunity for selective layering of charges in an electric arc furnace to optimise heat generation and other reactions. The opportunities translate into environmental and financial benefits.

The present invention has the following features and advantages, which are described to a large extent in the context of the use of the composite product of the invention in a steelmaking application but also apply to other end-uses of the product:

The polymeric material binder produces a very tough and in many instances a water-proof product, meaning less product breakdown and longer shelf life in materials handling.

There are additional advantages when the product has a covering of the polymeric material that encapsulates fines and larger size particles in the product. Encapsulation of the fines and larger size particles in the polymeric material may make it possible to store the product outside without appreciable moisture pick-up. Also, by encapsulation provides protection against moisture pick-up/hydration when the product is exposed to atmosphere in any storage situation. In addition, encapsulation of the fines and larger size particles in the polymeric material may prevent or at least minimise leaching of compounds from the product. For example, encapsulation of electric arc furnace dust containing heavy metals in a composite product of the invention to prevent leaching of heavy metals may be an advantage in handling, storage and transportation of the product.

The polymeric material acts as a “clean” binder to carry fines into a high temperature method. The fines are consumed in the furnace and the polymeric material binder exits system as a gas (for example, low density polyethylene melts at 115°C and vaporises ~350°C).

The carbon and hydrogen components of the polymeric material binder may assist in combustion/reduction based methods.

The use of the polymeric material acting as a binder could be applied to any suitable high temperature method and not only high temperature methods in metallurgical furnaces.

The hot extrusion process is suitable for large scale and economically viable production of both product types, namely one product type being based on metal-bearing material and the other product type being based on a carbon-bearing material.
Size control for the polymeric material binder is potentially less stringent due to melting during extrusion process.

The use of recycled polymeric materials as the binder may attract environmental benefit as many polymeric materials would be otherwise sent to landfill.

Hot extrusion technology is potentially applicable to any industry requiring the recovery, transport and processing of fines, including metal-bearing and carbon-bearing fines.

The product is magnetic when it contains iron-bearing units.

The use of the product in an electric arc steelmaking method was energy positive in overall terms.

The use of the product under and within a scrap charge for an electric arc steelmaking method facilitates close contact heating of the scrap charge and potentially improved heat transfer and efficient use of energy.

The use of a hot extruder makes it possible to use feed materials with higher moisture contents due to heating in the extruder.

The invention makes it possible to use feed materials in the form of fines.

Many modifications may be made to the present invention described above without departing from the spirit and scope of the invention.

1. A method of manufacturing a composite product in the form of (a) a polymeric material binder and a metal-bearing material or (b) the polymeric material binder and a carbon-bearing material that comprises heating and mixing the components of the composite product and thereafter forming the heated mixture into a final product shape, with the heating step being sufficient to melt at least a part of the polymeric material binder to facilitate forming the product.

2. The method of manufacturing the composite product that comprises the polymeric material binder and the metal-containing material defined in claim 1 includes mixing sources of carbon other than the polymeric material binder, with the metal-bearing material and the polymeric material.

3-5. (canceled)

6. The method defined in claim 1 comprises mixing the metal-bearing material and the polymeric material binder so that there is a uniform dispersion of the metal-bearing material through the product.

7. The method defined in claim 1 comprises mixing the carbon-bearing material and the polymeric material binder so that there is a uniform dispersion of the carbon-bearing material through the product.

8. The method defined in claim 1 comprises heating the mixture of the components of the product at a temperature that is sufficiently high to completely melt the polymeric material binder.

9-12. (canceled)

13. The method defined in claim 1 includes forming the heated mixture into the composite product by extruding the heated mixture.

14. A composite product comprises a metal-bearing material and a polymeric material that acts as a binder for the metal-bearing material.

15. The product defined in claim 14 comprises other materials, such as materials that are sources of carbon other than the polymeric material binder.

16. A composite product comprises a carbon-bearing material and a polymeric material that acts as a binder for the carbon-bearing material.

17. The product defined in claim 16 comprises a metal-bearing material.

18. The product defined in claim 14 comprises a continuous network of the polymeric material and a uniform dispersion of the metal-bearing material.

19. (canceled)

20. The product defined in claim 14 comprises an outer covering of the polymeric material.

21-22. (canceled)

23. The product defined in claim 14 wherein the polymeric material is a recycled polyethylene such as a low density polyethylene or a high density polyethylene or a recycled polypropylene.

24-25. (canceled)

26. The product defined in claim 14 being made completely from recycled materials, with each of the polymeric binder material and the metal-bearing material being recycled materials.

27-29. (canceled)

30. A method for producing a molten metal that comprises supplying the composite product defined in claim 14 as a feed material for the method, with the composite product being formed by the method defined in claim 1 with sufficient strength and toughness to be able to be handled within a high temperature processing plant for carrying out the method of producing the molten metal and to be charged into a high temperature furnace in the plant without significant breakdown of the product into smaller sized products, with generation of fines outside and/or inside the furnace.

31. A method for producing a molten metal that comprises supplying the composite product defined in claim 14 as a feed material for the method, with the composite product being formed by the method defined in claim 1 to be sufficiently large and have required mechanical properties such as strength to withstand high temperature and reactive conditions in a high temperature furnace in a high temperature processing plant for carrying out the method to facilitate controlled dissolution of the product in the furnace over a required time period.

32. The product defined in claim 16 comprises a continuous network of the polymeric material and a uniform dispersion of the carbon-bearing material.

33. The product defined in claim 16 comprises an outer covering of the polymeric material.

34. The product defined in claim 16 wherein the polymeric material is a recycled polyethylene such as a low density polyethylene or a high density polyethylene or a recycled polypropylene.

35. The product defined in claim 16 being made completely from recycled materials, with each of the polymeric binder material and the carbon-bearing material being recycled materials.

36. A method for producing a molten metal that comprises supplying the composite product defined in claim 16 as a feed material for the method, with the composite product being formed by the method defined in claim 1 with sufficient strength and toughness to be able to be handled within a high temperature processing plant for carrying out the method of producing the molten metal and to be charged into a high temperature furnace in the plant without significant break-
down of the product into smaller sized products, with generation of fines outside and/or inside the furnace.

37. A method for producing a molten metal that comprises supplying the composite product defined in claim 16 as a feed material for the method, with the composite product being formed by the method defined in claim 1 to be sufficiently large and have required mechanical properties such as strength to withstand high temperature and reactive conditions in a high temperature furnace in a high temperature processing plant for carrying out the method to facilitate controlled dissolution of the product in the furnace over a required time period.

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