Fused deposition modeling.

Use of fusible electromagnetically susceptive material in fused deposition modeling. The fusible electromagnetically susceptive material can be heated, melted and extruded in a fused deposition modeling printer and deposited the fusible electromagnetically susceptive material on an object created by means of fused deposition modeling. A fused deposition modeled object formed as described by deposition printing can be heated by means of induction heating, i.e. applying an alternating electromagnetic field to the object. A method of fused deposition modeling an object comprising fused deposition modeling at least one first part of the object fused deposition modeled object using electromagnetically susceptive fusible material, applying an alternating electromagnetic field to the at least one first part of the object fused deposition modeled from electromagnetically susceptive fusible material.
FIELD OF THE INVENTION

The invention relates to a use of electromagnetic susceptible material for fused deposition modeling, a method of fused deposition modeling and a system for fused deposition modeling.

BACKGROUND

In fused deposition modeling objects are formed by layering fusible material in a controlled manner such that a desired three dimensional shape can be created. This way of forming objects is sometimes also referred to as additive printing. Very often for fused deposition modeling a fused deposition modeling printer is used. The printer has a three dimensionally moveable print head. The fusible material is usually fed in the print head in the form of filaments. The print head heats up fusible filament which is subsequently melted, extruded from the print head and deposited on the object on previously deposited layers where it is allowed to cool down and solidify. Thus a fused deposition modeled object grows with each deposited layer and gradually attains its desired shape.

Fusible materials used in the fused deposition modeling can have different thermal expansion coefficients in different production stages of the fused deposition modeled object. This causes mechanical tensions and warping during the printing and cooling down of the fused deposition modeled object.

The mechanical tensions and warping can be prevented by thermal conditioning of the fused deposition modeled object. The fused deposition modeled object can be held in a thermally conditioned space such as an oven, where it is held at a predefined temperature higher than the ambient temperature during the printing. After the printing the finished printed object is allowed to gradually cool off, thus maintaining its original shape without warping.

Holding a fused deposition modeled object in a thermally conditioned space may involve holding the fused deposition modeled object and a three dimensionally moveable fused deposition modeling print head in the thermally conditioned space together to allow the print head to form the fused deposition modeled object. The thermally conditioned space has to be large enough to accommodate both moveable print head and fused deposition modeled object. Substantially the same constant temperature has to be maintained throughout the space which is problematic in larger spaces. Furthermore sufficient printing accuracy has to be maintained in a temperature range sufficiently high for the printing process. Higher temperature ranges require large ovens involving high costs and as the deposition modeling printer is enclosed in the oven, accessibility to deposition modeling printer and fused deposition modeled object is reduced. Higher temperatures also accelerate the aging process of the deposition printer.
SUMMARY

It is therefore an object of the invention to prevent mechanical tension and warping of a fused deposition modeled object during fused deposition modeling of the fused deposition modeled object.

The object is achieved according to another aspect of the invention in a method of fused deposition modeling an object comprising
- fused deposition modeling at least one first part of the object from electromagnetically susceptive fusible material,
- applying an alternating electromagnetic field to the at least one first part of the object, the first part modeled from electromagnetically susceptive fusible material.

The fusible electromagnetically susceptive material can be heated, melted and extruded in a fused deposition modeling printer which can deposit the fusible electromagnetically susceptive material on an object. The fused deposition modeled object formed as described by deposition printing can be heated by means of induction heating, i.e. applying an alternating electromagnetic field to the electromagnetically susceptive parts of the object.

This allows the creation of fused deposition modeled objects, at least portions of which can be heated by means of induction heating such that warping and tensile stress in the object can be relieved. The fused deposition modeled objects can gradually cool down after the fused deposition modeling process has ended. In an embodiment, the gradual cooling down can be facilitated by gradually reducing a strength of the alternating electromagnetic field.

In a preferred embodiment, the method further comprises fused deposition modeling at least one second part of the object using electromagnetically low- or non-susceptive fusible material. Low-susceptive fusible material includes material substantially less electromagnetic susceptive than the material used in the fused deposition modeling at least one first part of the fused deposition modeled object using electromagnetically susceptive fusible material.

In an embodiment, the fused deposition modeling of the at least one first part of the object from electromagnetically susceptive fusible material is performed prior to the fused deposition modeling at least one second part of the object using electromagnetically low- or non-susceptive fusible material. This allows the first part to be heated whilst or prior to the fused deposition modeling of the second part. Thus the second part is modeled in a warm environment of the induction heated first part and warping is prevented.

In an embodiment according to the invention the method further comprises fused deposition modeling the at least one second part of the object around the at least one first part of the object modeled from electromagnetically susceptive fusible material. This allows the fused deposition modeled object to be heated from the inside.
In a preferred embodiment according to the invention the method further comprises fused deposition modeling the at least one first part of the object modeled from electromagnetically susceptive fusible material around the at least one second part of the object modeled from electromagnetically low-susceptive fusible material. This allows the low-susceptive material inside to be kept warm at its periphery, where otherwise the greatest tension and warping would occur due to cooling down.

In an embodiment according to the invention the applying an alternating electromagnetic field to the at least one first part of object modeled from electromagnetically susceptive fusible material comprises

- arranging an induction coil near the fused deposition modeled object,
- activating the induction coil with an high frequency electric signal.

In a further embodiment according to the invention, the arranging an induction coil near the fused deposition modeled object comprises arranging an induction coil having its windings below the fused deposition modeled object. This allows easy access of the fused deposition modeled object from above the induction coil.

In another embodiment the arranging an induction coil near the fused deposition modeled object comprises arranging an induction coil having its windings laterally arranged with respect to the fused deposition modeled object. This allows easy access of the fused deposition modeled object from a side of the induction coil.

The object is also achieved according to another aspect of the invention by a system for fused deposition modeling, comprising a deposition modeling printing assembly comprising at least two deposition print heads, positioning means for positioning the deposition modeling printing assembly, at least one electromagnetic field generation device and a high frequency power supply for supplying the at least one electromagnetic field generation device.

In an embodiment, the at least one electromagnetic field generation device is an induction coil. By applying an alternating voltage to terminals of the induction coil an alternating electromagnetic field is generated which can be used for heating electromagnetic susceptive material used in fused deposition modeling as described.

In another the induction coil is an induction coil having windings in a flat surface. This allows the induction coil to be arranged near the object to be formed by the system for fused deposition modeling, i.e. three dimensional printed, without occupying much space, keeping the system for fused deposition modeling compact.

In another embodiment, the induction coil is arranged underneath the object to be fused deposition modeled. Thereby the object is easily accessible and where necessary separated from the induction coil by a stage, platform and the like.
In another embodiment, the induction coil is arranged lateral to the object to be fused deposition modeled. Thereby the object is easily accessible from a side of the object.

In another embodiment, the two induction coils are laterally arranged on opposite sides of an object to be fused deposition modeled. This allows fused deposition modeled objects to be placed between the induction coils for better capture of the electromagnetic field generated by the coils.

The object is also achieved according to another aspect of the invention in a use of fusible electromagnetically susceptible material in fused deposition modeling.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1a shows a cross section of a fused deposition modeled object according to an embodiment according to the invention.

Fig. 1b shows a cross section of a fused deposition modeled object according to another embodiment according to the invention.

Fig. 1c shows a cross section of a fused deposition modeled object according to another embodiment according to the invention.

Fig. 1d shows the fused deposition modeled object of Fig. 1a in a perspective view.

Fig. 2a shows a fused deposition modeling system according to an embodiment of the invention.

Fig. 2b shows a fused deposition modeling system according to another embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Fused deposition modeling material

Fused deposition modeling filament for fused deposition modeling or three-dimensional additive printing can be made from fusible materials such as thermoplastic materials including ABS, HIPS, PLA, PVA, TPE. Other fusible materials include for example metal alloys with low melting temperature such as tin, indium or bismuth alloys. In the art fused deposition modeling filaments made from these materials are heated and melted in a deposition modeling print head in a fused deposition modeling printer and extruded and deposited in a deposition modeling printer in layers to form a fused deposition modeled object. In order for fused deposition modeled objects or parts thereof made from these materials to be heated during the fused deposition modeling, heatable material can be arranged within or outside the fused deposition modeled object where heating is required, to prevent tension and/or warping.

WO2009002528 A1 describes method and material for inductively heating a composition of polymer and an electromagnetically susceptible filler, the filler comprising i.e. electrically
conductive and/or ferromagnetic particles. The electromagnetically susceptive particles heat up when exposed to an alternating magnetic field due to hysteresis of ferromagnetic properties of the particles or in case of conductive material, by eddy currents in the material.

This type of electromagnetically susceptive material is used for induction welding of objects. In induction welding two parts made of this electromagnetically susceptive material are brought into contact with each other and the overlapping part is locally heated under pressure by means of a locally applied alternating high frequency electromagnetic field. The electromagnetically susceptive material melts where the electromagnetic field is applied and locally and bonds the parts together.

The fusible material can for example be the thermoplastics poly(etheretherketone), polyetherketoneketone, poly(etherimide), polyphenylene sulfide, poly(sulfone), polyethylene terephthalate, polyester, polyamide, polypropylene, polyurethane, polyphenylene oxide, polycarbonate, polypropylene / polyamide, polypolyproylene/ethylene vinyl alcohol, polyethylene, polyolefin oligomers, liquid modified polyolefins or combinations thereof. From US6048599, cited in WO2009002528 A1, electromagnetic susceptive additives, i.e. conductive and ferromagnetic particles known for electromagnetic fusion bonding include NiFe alloys and iron. Also ferromagnetic materials can be considered. Furthermore also fusible metal alloys with low melting temperature can be used such as tin, indium or bismuth alloys, enriched with electromagnetic susceptive additives as described.

This electromagnetically susceptive material can advantageously be made in for example a filament such that it can be used in known fused deposition modeling printers, i.e. three dimensional printers. The electromagnetically susceptive material can also be supplied for example in the form of rods or grains, depending on the requirements and capabilities of the fused deposition modeling printer used. The electromagnetic susceptive material can be deposited and arranged by fused deposition modeling into objects as required, which are inductively heatable during creation of once created by subjecting the objects to an alternating electromagnetic field.

**Fused deposition modeling**

The electromagnetic susceptive material can be used in creating objects from the electromagnetic susceptive material or from a combination of electromagnetic susceptive material and low susceptive fusible material. A fused deposition modeled object from electromagnetic susceptive material alone can be partly or wholly subjected to the alternating electromagnetic field. The alternating electromagnetic field has a certain limited penetration depth into the material, so it is preferred to also use low-susceptive fused deposition printing
material and limit the use of the electromagnetic susceptive material. Below examples of objects made of such a combination of materials are described.

Fig. 1a shows a cross section of a fused deposition modeled object 103 which has been printed using the susceptive deposition modeling print filament. The fused deposition modeled object 103 comprises a body 104 which can be printed using standard fusible fused deposition modeling filament. The fused deposition modeled object can be covered with a conformal heating layer 105 of electromagnetic susceptive deposition material. The conformal heating layer 105 can be printed using a fusion deposition modeling print head of the deposition modeling printer. The conformal heating layer 105 can cover the fused deposition modeled object 103 partly such that only thermally sensitive parts of the object body 104 are covered or can cover all of the object body 104.

The conformal heating layer 105 of susceptive filament material can be printed adjacent to the fused deposition modeled object body 104 without contacting the fused deposition modeled object body material. After completing fused deposition modeling of the fused deposition modeled object, the conformal heating layer 105 can be easily removed. Furthermore, the conformal heating layer 105 can be additionally covered with a thermal insulation layer for preventing thermal losses during the fused deposition modeling and heating of the fused deposition modeled object 103. The conformal heating layer 105 and thermal insulation layer thus form a mantle around the fused deposition modeled object which may also provide structural support to the fused deposition modeled object 103 during the fused deposition modeling of the object 103.

Fig. 1b shows another example of a cross section of a fused deposition modeled object 103. The susceptive filament material is distributed throughout the fused deposition modeled object body 104, and is made by simultaneously printing with standard fused deposition modeling filament and susceptive filament material 106, or from susceptive filament material 106 alone.

When the induction coil 101 is excited, heat is generated inside the fused deposition modeled object causing an increased temperature. In this example, since the susceptive filament material is distributed over the entire fused deposition modeled object body 104, the increased temperature is also available throughout the entire fused deposition modeled object body 104.

Fig. 1c shows another example of a cross section of a fused deposition modeled object 103. The fused deposition modeled object 103 has pockets 107 of electromagnetic susceptive material printed in the fused deposition modeled object body 104. Thus specific parts of the fused deposition modeled object body 104 can be selectively heated by the induction coil 101 magnetic field.
The object 103 with the susceptive portions 105, 106 and 107 as described in the examples of figures 1a – 1d, can also be subjected by an alternating magnetic field from one or more alternatively positioned induction coils 101, depending on the structure of the fused deposition modeled object 103.

Fig. 1d shows the fused deposition modeled object of Fig. 1a in a perspective view. It shows that the conformal heating layer 105 of susceptive filament material can also partly cover the fused deposition modeled object body 104.

Fig 2a shows an example of a fused deposition modeling system having an xyz – positioning device 201 for three dimensionally positioning a deposition print head assembly 202. The xyz – positioning device can be a three axis system having a horizontal axis (x), a vertical axis (z) and another horizontal axis (y) connected to the z-axis, arranged perpendicular to the x-axis. Many alternatives, such as robotic arms can be used as xyz-positioning device. The deposition print head assembly 202 connected to the xyz – positioning device has two or more deposition print heads 203a, 203b for fused deposition modeling an object 103 positioned on a stage 108. The deposition print heads 203a, 203b are arranged for extruding and depositing fusible filament 205a, and electromagnetically susceptive fusible material 205b on the object 103 to be modeled. The fusible material filament and electromagnetically susceptive fusible material filament 205a, 205b can be wound onto reels 204a, 204b for dispensing the filaments 205a, 205b to the deposition print heads 203a, 203b respectively. It will be recognized by the skilled person that other means and ways for dispensing the (non-susceptive) fusible material and/or electromagnetically susceptive fusible material are available such as for example in the form of grains, sticks or rods which can be fed into the deposition print heads.

A first deposition print head 203a can for example be used for forming the conformal heating layer 105 of electromagnetically susceptive fusible material as described under figures 1a – 1d, while the other print head 203b can be used for forming the actually desired object body 104 from the fusible material. Forming the conformal heating layer 105 and the object body can be performed simultaneously while the deposition print heads 203a, 203b are suitably positioned. Forming the conformal heating layer 105 and the object body can be performed consecutively while the deposition print heads 203a, 203b are being alternatively suitably positioned.

After forming the conformal heating layer 105, it can for example be subjected to an alternating magnetic field, generated by an induction coil 101 positioned underneath a stage 108 on which the fused deposition modeled object 103 is placed. The induction coil 101 can be inductively excited by a power supply 102 connected to the induction coil 101. The induction coil 101 can be made from conductive windings which are arranged in for example a flat surface. Such an induction coil can also be referred to as a ‘pancake’ coil. The conductive windings of
the induction coil 101 can also be in an annular fashion below the fused deposition modeled object 103. The induction coil windings can be flat, annularly shaped or any other form is possible, including a rectangular shape or polygon shape.

Figure 2b shows schematically an alternative arrangement for the induction coil 101. Various induction coil arrangements are possible depending on position, size, shape and heating requirements of the fused deposition modeled object 103. In fig 2b two induction coils 207a, 207b are placed on two opposite sides of an object 103, allowing a more uniform electromagnetic field to be created around the object 103, thereby heating the conformal heating layer 105 of electromagnetically susceptive material more uniformly. In figure 2b any fused deposition modeling printer details are not shown.

The above embodiments are described by way of example only. Variations thereof are possible without departing from the scope of protection as defined by the claims set out below.

Summarized, what is described is a method of fused deposition modeling an object comprising

- fused deposition modeling at least one first part of the object from electromagnetically susceptive fusible material;
- applying an alternating electromagnetic field to the at least one first part of the object, the first part modeled from electromagnetically susceptive fusible material.

The method further comprises fused deposition modeling at least one second part of the fused deposition modeled object using electromagnetically low- or non-susceptive fusible material.

The method as described, wherein the fused deposition modeling at least one first part of the fused deposition modeled object from electromagnetically susceptive fusible material is performed prior to the fused deposition modeling at least one second part of the object using electromagnetically low- or non-susceptive fusible material.

The method as described above comprising gradually reducing a strength of the electromagnetic field after the applying an alternating electromagnetic field to the at least one first part of the object, the first part modeled from electromagnetically susceptive fusible material.

The method as described above further comprising fused deposition modeling the at least one second part of the object around the at least one first part of the object modeled from electromagnetically heatable fusible material.

The method as described above further comprising fused deposition modeling the at least one first part of the object around the at least one second part of the object modeled from electromagnetically low-susceptive fusible material.
The method as described above wherein the applying an alternating electromagnetic field to the at least one first part of the fused deposition modeled object from electromagnetically susceptive fusible material comprises

arranging an induction coil near the fused deposition modeled object;

activating the induction coil with an high frequency electric signal.

The method as described above wherein the arranging an induction coil near the fused deposition modeled object comprises arranging an induction coil having its windings below the fused deposition modeled object.

The method as described above wherein the arranging an induction coil near the fused deposition modeled object comprises arranging an induction coil having its windings laterally arranged with respect to the fused deposition modeled object.

Further summarizing, a system is described for fused deposition modeling, comprising:

a fused deposition modeling printing assembly comprising at least two deposition print heads;

positioning means for positioning the deposition modeling printing assembly;

at least one electromagnetic field generation device;

a high frequency power supply for supplying the at least one electromagnetic field generation device.

The system as described above wherein the at least one electromagnetic field generation device is an induction coil.

The system as described above, wherein the induction coil is an induction coil having windings in a flat surface.

The system as described above, wherein the induction coil has annularly arranged windings.

The system as described above, wherein the induction coil is arranged underneath an object to be fused deposition modeled.

The system as described above, having two induction coils, the two induction coils being laterally arranged on opposite sides of the object to be fused deposition modeled.

Use of electromagnetically susceptive fusible material in fused deposition modeling of objects.
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<td>induction heating coil</td>
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<td>102</td>
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CONCLUSIES

1. Werkwijze voor het modelleren van een object met smeltbaar afzettingsmateriaal, omvattende:
   – het uit elektromagnetisch gevoelig smeltbaar afzettingsmateriaal modelleren van ten minste een eerste deel van het object;
   – het aanbrengen van een wisselend elektromagnetisch veld op het ten minste eerste uit elektromagnetisch gevoelig smeltbaar afzettingsmateriaal gemodelleerde deel van het object.

2. Werkwijze overeenkomstig conclusie 1, verder omvattende
   – het uit elektromagnetisch laaggevoelig of ongevoelig smeltbaar afzettingsmateriaal modelleren van ten minste een tweede deel van het object.

3. Werkwijze overeenkomstig conclusie 2, waarbij het uit elektromagnetisch gevoelig smeltbaar afzettingsmateriaal modelleren van het ten minste eerste deel van het object wordt uitgevoerd voorafgaand aan het uit elektromagnetisch laaggevoelig of ongevoelig smeltbaar afzettingsmateriaal modelleren van het ten minste tweede deel van het object.

4. Werkwijze overeenkomstig een van de voorgaande conclusies verder omvattende
   – het geleidelijk verminderen van een sterkte van het elektromagnetisch veld na het aanbrengen van een wisselend elektromagnetisch veld op het ten minste eerste uit elektromagnetisch gevoelig smeltbaar afzettingsmateriaal gemodelleerde deel van het object.

5. Werkwijze overeenkomstig een van de conclusies 2 tot en met 4, verder omvattende
   – het uit elektromagnetisch laaggevoelig of ongevoelig smeltbaar afzettingsmateriaal modelleren van ten minste een tweede deel van het object om het ten minste eerste uit elektromagnetisch gevoelig smeltbaar afzettingsmateriaal gemodelleerde deel van het object.

6. Werkwijze overeenkomstig een van de conclusies 2 tot en met 4, verder omvattende
   – het uit elektromagnetisch gevoelig smeltbaar afzettingsmateriaal modelleren van het ten minste eerste deel van object om het ten minste tweede uit elektromagnetisch laaggevoelig smeltbaar afzettingsmateriaal gemodelleerde deel van het object.

7. Werkwijze overeenkomstig een van de voorgaande conclusies, waarbij het aanbrengen van een wisselend elektromagnetisch veld op het ten minste eerste deel van het met smeltbaar afzettingsmateriaal gemodelleerde object uit elektromagnetisch gevoelig smeltbaar afzettingsmateriaal omvat:
   – het plaatsen van een inductiespoel in de nabijheid van het object;
   – het bekrachtigen van de inductiespoel met een hoogfrequent elektrisch signaal.
8. Werkwijze overeenkomstig conclusie 7, waarbij het plaatsen van een inductiespoel nabij het object omvat:
   - het aanbrengen van een inductiespoel met zijn windingen onder het met smeltbaar afzettingsmateriaal gemodelleerde object.
9. Werkwijze overeenkomstig conclusie 7, waarbij het aanbrengen van een inductiespoel nabij het object omvat:
   - het aanbrengen van een inductiespoel met zijn windingen lateraal aan weerszijden van het object.
10. Systeem voor het met smeltbaar afzettingsmateriaal modelleren van een object, omvattende:
    - een afdruksamenstel voor het met smeltbaar afzettingsmateriaal modelleren omvattende ten minste twee afzettingsafdrukkoppen;
    - positioneermiddelen voor het positioneren van het afdruksamenstel voor het smeltbaar afzettingsmateriaal modelleren;
    - ten minste een elektromagnetisch veld genererende inrichting;
    - een hoogfrequent voeding voor het voeden van de tenminste ene elektromagnetisch veld genererende inrichting.
11. Systeem overeenkomstig conclusie 10, waarbij de ten minste ene elektromagnetisch veld genererende inrichting een inductiespoel is.
12. Systeem overeenkomstig conclusie 11, waarbij de inductiespoel ingericht is met zijn windingen in een vlak oppervlak.
13. Systeem overeenkomstig conclusie 11, waarbij de inductiespoel ringvormige windingen heeft.
14. Systeem overeenkomstig een van de conclusies 11 tot en met 13, waarbij de inductiespoel is aangebracht onder een met smeltbaar afzettingsmateriaal te modelleren object.
15. Systeem overeenkomstig een van de conclusies 11 tot en met conclusie 13, met twee inductiespoelen waarbij de twee inductiespoelen lateraal zijn aangebracht aan de tegenoverliggende zijden van het met smeltbaar afzettingsmateriaal te modelleren object.
16. Het gebruik van elektromagnetisch gevoelig smeltbaar afzettingsmateriaal voor het met smeltbaar afzettingsmateriaal modelleren van objecten.
ABSTRACT

Use of fusible electromagnetically susceptive material in fused deposition modeling. The fusible electromagnetically susceptive material can be heated, melted and extruded in a fused deposition modeling printer and deposited the fusible electromagnetically susceptive material on an object created by means of fused deposition modeling. A fused deposition modeled object formed as described by deposition printing can be heated by means of induction heating, i.e. applying an alternating electromagnetic field to the object.

A method of fused deposition modeling an object comprising fused deposition modeling at least one first part of the fused deposition modeled object using electromagnetically susceptive fusible material, applying an alternating electromagnetic field to the at least one first part of the object fused deposition modeled from electromagnetically susceptive fusible material.
# SAMENWERKINGSVERDRAG (PCT)

**RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE**

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I. **CLASSIFICATIE VAN HET ONDERWERP** (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC):

- B29C67/00
- B33Y10/00
- B29C71/02
- B33Y30/00
- H05B6/02
- B29C35/08

II. **ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK**

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Onderzocht andere documentatie dan de minimumdocumentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen.

III. **GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES** (opmerkingen op aanvullingsblad)

IV. **GEBREK AAN EENHEID VAN UITVINDING** (opmerkingen op aanvullingsblad)

Form PCT/ISA 201 A (11/2000)
# ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

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Volgens de Internationale Classificatie van ontbreken (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

## B. ONDERZOEKDE GEBIEDEN VAN DE TECHNIEK

Onderzoekde minimum documentatie (classificatie gevolgd door classificatiesymbolen)

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</table>

Onderzoekde andere documentatie dan de minimum documentatie, voor dergelijke documenten, voor zover dergelijke document in de onderzoekde gebieden zijn opgenomen.

## Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte toerwoorden)

**EPO-Internal, WPI Data**

## C. VAN BELANG GEachte DOCUMENTEN

<table>
<thead>
<tr>
<th>Categorie</th>
<th>Geachte documenten, eventueel met aanvulling van speaioal van belang zijnde passages</th>
<th>Van belang voor conclusie na</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5 121 329 A (CRUMP S. SCOTT [US]) 9 juni 1992 (1992-06-09)</td>
<td>1, 2, 7, 10, 11, 16</td>
</tr>
<tr>
<td></td>
<td>* kolom 6, regel 4 - regel 25 *</td>
<td>3-6, 8, 9, 12-15</td>
</tr>
<tr>
<td></td>
<td>* kolom 9, regel 18 - regel 23 *</td>
<td></td>
</tr>
<tr>
<td></td>
<td>* figuur 1 *</td>
<td></td>
</tr>
<tr>
<td></td>
<td>* alinea [0118] - alinea [0121] *</td>
<td>1-9, 16</td>
</tr>
<tr>
<td></td>
<td>* alinea [0133]; figuur 1 *</td>
<td></td>
</tr>
</tbody>
</table>

☐ Verdeere documenten worden vermeld in het verzoek van vak C.

X Leden van dezelfde ochtodsomiteit zijn vermeld in een bijlage

* Specifieke categorieën van aangehaalde documenten
  - "A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft.
  - "B" in de ochtodsomiteit vermeld.
  - "C" eerste opting (aanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven.
  - "D" een andere rekening vermeld, als hiermee om de stand van de techniek wordt vermeld.
  - "E" niet-schriftelijke stand van de techniek

* Toevoeging
  - "F" na de indieningsdatum of de voorrangdatum gepubliceerde literatuur die niet beantwoord is voor de ochtodsomiteit, maar wordt vermeld ter herinnering of voor de conclusie van deze literatuur.
  - "G" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur.
  - "H" de conclusie wordt als inventief beschouwd ten opzichte van deze literatuur.
  - "I" het rapport van de techniek van internationale type is voltooid.

## Datum waarop het onderzoek naar de stand van de techniek van internationale type werd voltooid

14 december 2015

Naam en adres van de instantie

European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HN Rijswijk
Tel. (+31-70) 343-2040,
Fax (+31-70) 343-3016

De bevoegde ambtenaar

Pierre, Nathalie
<table>
<thead>
<tr>
<th>In het rapport</th>
<th>Datum van publicatie</th>
<th>Overseencommendatiewerken</th>
<th>Datum van publicatie</th>
</tr>
</thead>
</table>
This opinion contains indications relating to the following items:

- Box No. I: Basis of the opinion
- Box No. II: Priority
- Box No. III: Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- Box No. IV: Lack of unity of invention
- Box No. V: Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- Box No. VI: Certain documents cited
- Box No. VII: Certain defects in the application
- Box No. VIII: Certain observations on the application
Box No. I  Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:
   
   a. type of material:
      
      - [ ] a sequence listing
      - [ ] table(s) related to the sequence listing
   
   b. format of material:
      
      - [ ] on paper
      - [ ] in electronic form
   
   c. time of filing/furnishing:
      
      - [ ] contained in the application as filed.
      - [ ] filed together with the application in electronic form.
      - [ ] furnished subsequently for the purposes of search.

3. [ ] In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V  Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

<table>
<thead>
<tr>
<th></th>
<th>Yes: Claims</th>
<th>No: Claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novelty</td>
<td>3-9, 12-15</td>
<td>1, 2, 10, 11, 16</td>
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<tr>
<td>Inventive step</td>
<td>3-6, 8, 9</td>
<td>1, 2, 7, 10-16</td>
</tr>
<tr>
<td>Industrial applicability</td>
<td>1-16</td>
<td></td>
</tr>
</tbody>
</table>

2. Citations and explanations

   *see separate sheet*
<table>
<thead>
<tr>
<th>Box No. VII</th>
<th>Certain defects in the application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>see separate sheet</td>
</tr>
<tr>
<td>Box No. VIII</td>
<td>Certain observations on the application</td>
</tr>
<tr>
<td></td>
<td>see separate sheet</td>
</tr>
</tbody>
</table>
Re Item VIII

Certain observations on the application

1. The relative term "low-susceptible fusible material" used in claims 2, 3, 5, and 5 has no well-recognized meaning and leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear.

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:

2. The present application does not meet the criteria of patentability, because the subject-matter of claims 1, 10 and 16 is not new.

2.1 D1 discloses a method of fused deposition modeling an object (see figure 1) comprising
   - fused deposition modeling (see figure 1) at least one first part of the object from electromagnetically susceptible fusible material (see column 6, lines 4 to 25 and column 9, lines 18 to 23);
   - applying an alternating electromagnetic field to that at least one first part of the object, the first part modeled from electromagnetically susceptible fusible material (see column 9, lines 18 to 23).

   Therefore the subject-matter of claim 1 is not new.

2.2 D2 discloses a system for fused deposition modeling comprising:
- a fused deposition modeling printing assembly comprising at least two deposition print heads (see paragraph [0133] and figure 1);
- positioning means for positioning the deposition modeling printing assembly (see paragraph [0133] and figure 1);
- at least one electromagnetic field generation device (see paragraphs [0118] to [0121], in particular paragraph [0120]);
- a high frequency power supply for supplying at least one electromagnetic field generation device (implicit in view of paragraph [0120]).

Therefore the subject-matter of claim 10 is not new.

2.3 D1 discloses further the use of electromagnetically susceptive fusible material in fused deposition modeling of objects (see column 9, lines 18 to 23 and figure 1).

Therefore the subject-matter of claim 16 is not new.

3 Dependent claims 2, 7, 11-15 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of novelty or inventive step. The reasons are as follows:

3.1 D1 discloses further the features of dependent claim 2. (See Item VIII, paragraph 1 and D1 column 9, lines 18 to 23).
D2 discloses further the features of dependent claim 11 (see paragraph [0120])

3.2 The features of dependent claim 7 are considered to relate to an obvious option of applying a magnetic field for the skilled person.
The features of dependent claims 12 to 15 are considered to be obvious technical alternatives for the skilled person.

Re Item VII
Certain defects in the application
1. The relevant background art disclosed in D1 and D2 is not mentioned in the
description, nor are these documents identified therein.