



CONCR3DE
YOUR 3D POWDERHOUSE



THE **ELEPHANT GRAY** 3D PRINTER

LARGE SCALE STONE 3D PRINTING

OFFICIAL BROCHURE - SUMMER 2023

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3D PRINTING PRINCIPLES



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1. EQUIPMENT PRINCIPLES

The CONCR3DE MAMMOTH is a large scale customizable binder jetting 3D printer used for high precision manufacturing of 3D objects. It is used in industries such as construction, refractory and other high tech applications. It is an industrial system meant to be used in a production setting.

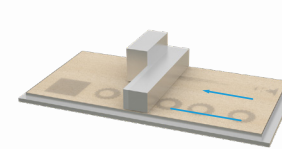
The Mammoth machine uses a powder deposited via a recoater and a moving inkjet system jetting a binder. Together they form high precision 3D printed elements. The equipment principles are as follows



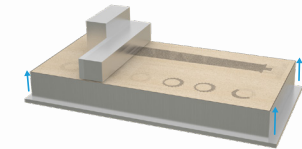
STEP 1 LOADING IN 3D FILES - A batch of .stl or .obj files gets loaded into NOAH, our custom software. It functions as a slicer and a control and monitoring tool of your print job. Multiple objects can be placed in the software and printed simultaneously. An external nesting software can be used in your 3D CAD program to optimize part placement.

STEP 2 STARTING A PRINT - Every print begins with loading powder into the powder recoater. This happens on the service station, where also the printheads get cleaned. Powder can be transported via a vacuum system or a screw conveyor from either a big bag station or a silo, depending on your configuration.

STEP 3 MOVING FORWARD - On the printing beam are both the recoater and inkjet module mounted. Each layer the recoater deposits a layer of powder when the full print beam moves forward. Then, immediately an array of printheads prints a first swath of binder.



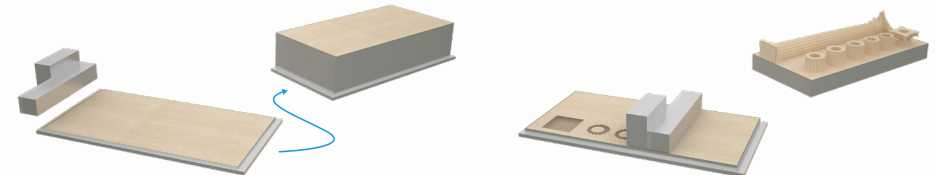
4. Backward pass



5. Building up layers

STEP 4 MOVING BACKWARD - When the first swath is complete, the ink box will move on the X axis to its second position and print the second swath on its way back. This process repeats itself every layer, with the printing box moving upward 1 layer height. Every 10 to 15 layers, the recoater has to be refilled.

STEP 5 TELESCOPIC WALLS - Each layer the printing beam moves upward 1 layer height, typically a distance of 300 μm . With this, the walls of the printbox move along with it.



6. Print complete, switch job boxes

7. Depowder & restart print

STEP 6 PRINT JOB COMPLETE - Once the print is done you can remove the full job box. This can be rolled out and the second job box can be placed.

STEP 7 DEPOWDERING - Can be done on job box 1, while the printer starts another run on job box 2, keeping a continuous flow of printing.

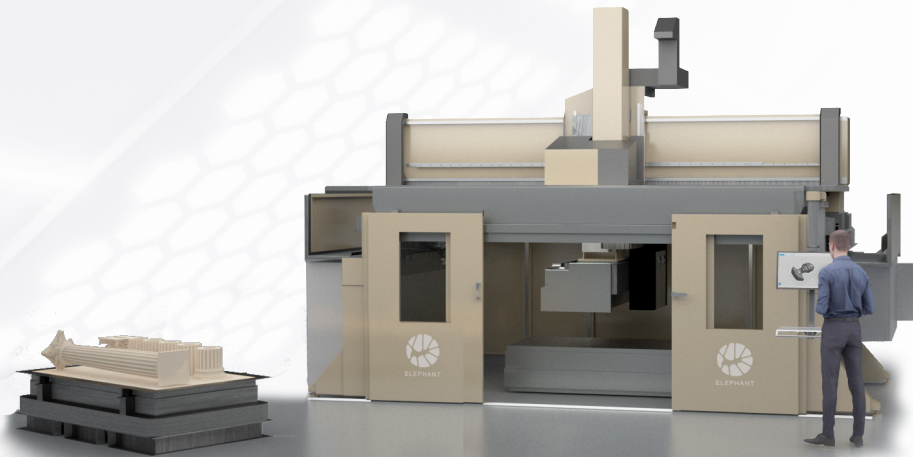
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YOUR **ELEPHANT** 3D PRINTER



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THE **ELEPHANT GRAY** 3D PRINTER

The Elephant is a highly precise binder jetting 3D printer designed for production of stone elements. It is a fully autonomous patented system that uses a recoater and an array of printheads for single pass high precision jetting of an aqueous fluid on a mineral powder bed.

Powder is fed into the printer filling unit by vacuum. The filling unit deposits powder into the recoating system mounted on the gantries' Z-axis. This is also where the inkjet systems are attached and the fluid is fed into.

The jobbox is fully removable and multiple jobboxes can be ordered.

| | |
|--------------------------------|---------------------------|
| Accuracy X, Y, Z (micron) | 50, 50, 30 |
| Repeatability X, Y, Z (micron) | 50, 50, 30 |
| Printing Resolution (dpi) | 400 |
| Layer height (mm) | 0.3 |
| Drop size (pL) | 40 to 200 |
| Speed(cm*h) | 5,4 cm |
| Single pass swath (mm) | 520 |
| Printing bed size (X, Y, Z) | 1 x 2 x 1 m |
| Printer size | 2.800 x 6.500 x 4.500 |
| Ink types | G3CO aqueous binder |
| Powder types | Stone powders |
| Software | NOAH Mammoth (included) |
| Connectivity | Ethernet |
| Power requirements | 2 x 400V |
| Operating temperature | 22 ± 2 °C air conditioned |
| Operating humidity | 55 ± 5 % humidified |
| Colour | RAL 7032 |

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MATERIALS

Two consumable materials are brought together in the binder jetting process: a liquid ink and a powder material. For each print job you will only need to consume the exact volume of your desired part.

BINDER

The liquid binder is an aqueous solution that comes in an IBC container and is stored next to the printer on a drip tray. A pump brings the binder to a reservoir inside the printer, after which it is jetted on the powder bed.

The binder is non-toxic and safe to handle. The lid however must remain closed at all times to prevent spoiling or contamination of the solution, which would cause problems with the printer. We recommend to always store binder on a drip tray.

POWDER

The powder is a carefully engineered mineral. There are 4-6 components in the powder formulation, carefully matched towards each other, the binder and the binder jetting production method. The printer is engineered to the powder and will only have limited settings in order to guarantee a consistent result.

The powder is safe to handle and is non-toxic. But, as it remains a powder we recommend the use of dust masks and gloves when handling the powder – generally similar PPE as for working with stone or concrete.

Powder is typically delivered in big bags and stored in a silo. Multiple silos can be arranged for the use of multiple types of powder.

The process is designed to be as dust-free for the operator as possible. Loading, printing, moving and post processing your prints is all dust-free. Depowdering is the only part of the job where the operator may touch the powder and suitable protective gear will be provided with the depowdering station. The depowdering station will keep powders within its boundaries.



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MATERIAL TECHNICAL DATA



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CONCR3DE MATERIALS

CONCR3DE provides standardized 'G3CO' stone based powders and binders. The properties of these materials have been validated according to the fixed parameters below.

| | |
|-----------------|------------------|
| DPI | 400 |
| Layer thickness | 250 µm |
| Drop size | 150-200 pL |
| Binder | G3CO binder |
| Powder | G3CO powder |
| Support | Not required |
| Accuracy | ± 2% or ± 0.2 mm |
| Walls | Min. 1-2 mm |

After printing and curing your parts using these base materials will have the following properties.

| Mechanical properties (250 µm) | Standard | Result |
|--------------------------------|--------------|--------|
| Compressive strength (MPa) | ASTM C349-18 | 17 |
| Flexural strength (Mpa) | ASTM C348-21 | 2.2 |
| Density (kg/cm3) | ASTM | 1750 |
| Porosity (%) | ASTM | 30-35 |
| Heat resistance (degrees) | ASTM | 1200 |



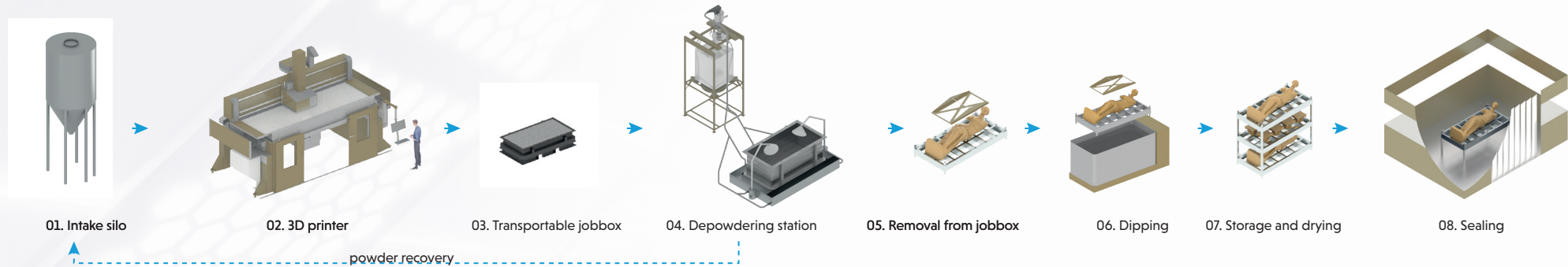
CUSTOM MATERIALS

It is possible to develop custom materials for your printer using your waste stream or other locally available materials. In this case a report will have to be made what material properties can be achieved. CONCR3DE has excellent know-how in developing printable materials and can advise you on material compositions, development and properties.

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FULL FACTORY OVERVIEW



FULL PROCESS

3D printing is key to the manufacturing process but not the whole story. After 3D printing, parts are transported, depowdered and post processed. Waste powder is recycled back into the production system and the prints can be finished. The full process should be taken into account when designing the factory.

The process assumes a factory hall with 5 m ceiling height. The factory temperature must remain between 10 and 25 degrees Celcius.

Your printer will have humidity and temperature control. High humidity will have an effect on the drying time of elements and it is up to the factory operator whether he wants to take this into account.

The process assumes an overhead crane with at least 3 ton capacity. If not available a forklift or other type of crane may be used. It also assumes a pallet car is available.

The following space considerations must be taken into account. CONCR3DE engineers are available to support the factory layout design.

FUNCTION

SPACE REQUIRED

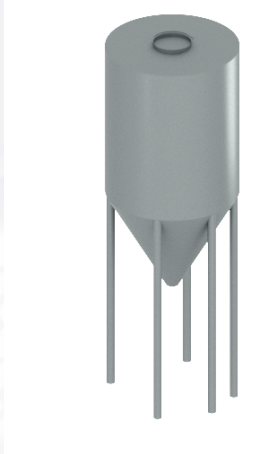
| | |
|----------------------------------|--------|
| Powder silo/big bag | 3 m2 |
| IBC container | 3 m2 |
| Printer | 18 m2 |
| Depowdering station | 9 m2 |
| Big bag station | 3 m2 |
| Desk | 3 m2 |
| Powder storage | 10 m2 |
| Print storage | 20 m2 |
| Manouvering room / hallway space | 45 m2 |
| Total space required | 114 m2 |

| | |
|------------------------------|-------|
| Additional space per printer | 80 m2 |
|------------------------------|-------|

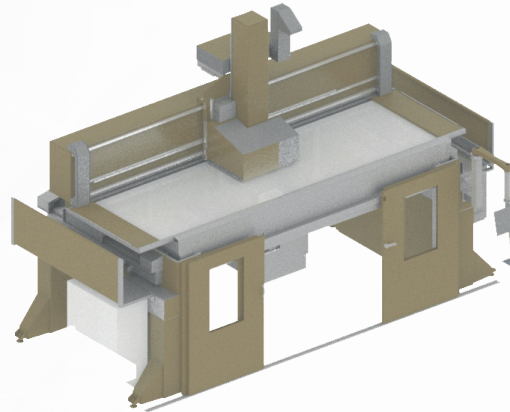
FILLING & PRINTING



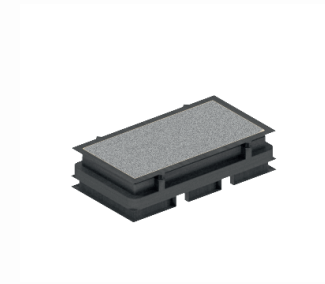
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01. Intake silo



02. 3D printer



03. Transportable jobbox

POWDER INTAKE

Initial powder is collected into a large silo. It can come either from the customers mixer, big bags or a truck. It is loaded, automatically and dust-free, in the silo via compressed air. The height of the silo can be customized to the available ceiling height. When using different powders, additional silos are required. The size of the silo can also be customized to the customers' process.

TRANSFER TO PRINTER

Printing powder is transferred from the main silo to the printer via a dust-free vacuum system. The control of the vacuum system is part of the printer and requires no intervention from the operator.

PRINTING

Printing is also fully autonomous. An operator is only required for basic maintenance, loading in the jobbox and starting the print. The printer will give a signal to the operator when the print is finished. A full batch of 2 m3 takes around 18-20 hours.

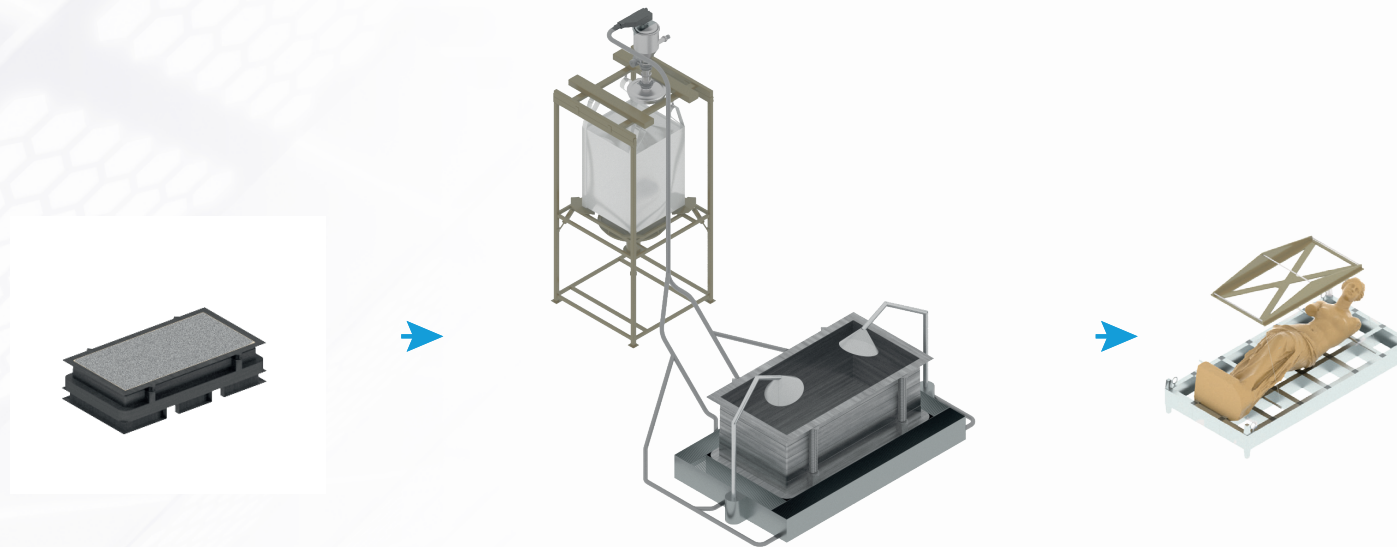
JOB BOX

The job box is a steel box in which the prints are created. It is a movable unit that can be transported with a pallet fork, forklift or AGV. With multiple job boxes the user can switch out a job box each print, so that printing and depowdering can be done simultaneously.

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DEPOWDERING



03. Transportable jobbox

04. Depowdering station

05. Removal from jobbox

JOB BOX TRANSFER

The job box is moved by the operator or AGV into the depowdering station. An additional job box can be purchased so that printing can continue.

DEPOWDERING

The job box can be placed in this dust-proof enclosure where the depowdering process takes place. Several vacuum hoses allow the operator to remove loose powder and recover the 3D prints for post processing. Compressed air with variable pressure is available to aid with removing powder from hard to reach areas. With proper planning, one depowdering station is enough to for 2 printers. With more printers, a larger depowdering station can be commissioned.

PART TRANSFER

Parts can be removed from the depowdering station by crane and placed on top of storage racks for further processing. At this point the parts are in their fragile green state and must be handled carefully. CONCR3DE gives various suggestions for how to safely transport these parts.

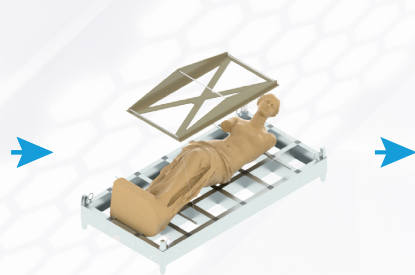
POWDER RECYCLING

Recycled powder from the depowdering process ends up, via a vacuum system, in this big bag unit after which it is sieved and reused in the printer.

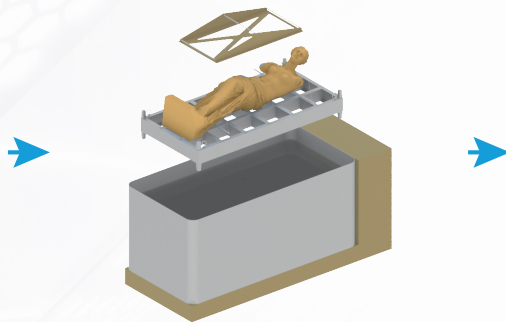
POST PROCESSING



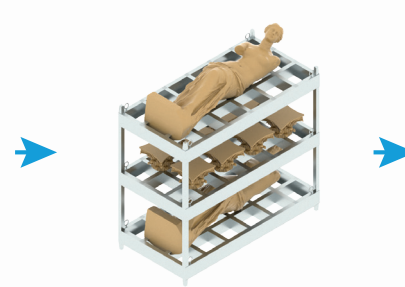
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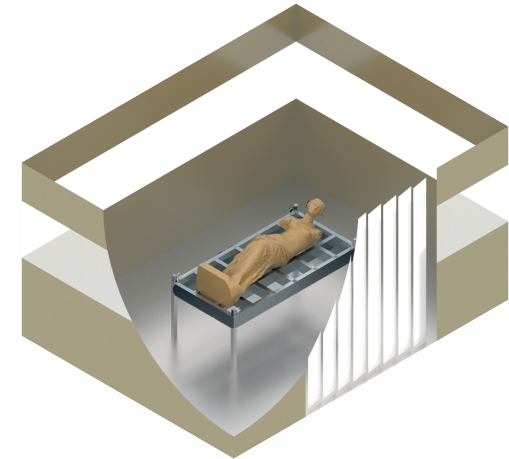
05. Removal from jobbox



06. Dipping



07. Storage and drying



08. Sealing

POST PROCESSING AND DRYING

After depowdering parts will be in their fragile green state. In order to reach their final strength they need to be dipped in water. For this a water tank is available in which water is recycled and where any loose powder is filtered out. Parts can be kept on their designated storage racks and be lifted, by crane, in the water. Parts are left in the water overnight. When fully saturated, they may be removed from the water and, kept on the storage racks, left to dry.

PART DRYING

The exact drying time will depend on the material configuration, the size of the parts and the climate in your factory. Our software will give you a close estimation of the drying time.

OPTIONAL SEALING FOR OUTDOOR USE

After drying parts will be strong. They can be used or can be sealed for outdoor use. Sealing works similar to sealing a concrete or stone element. Parts can be placed in the spray booth and treated with clear silicate sealer. Once the sealer has dried, parts are ready for shipment.

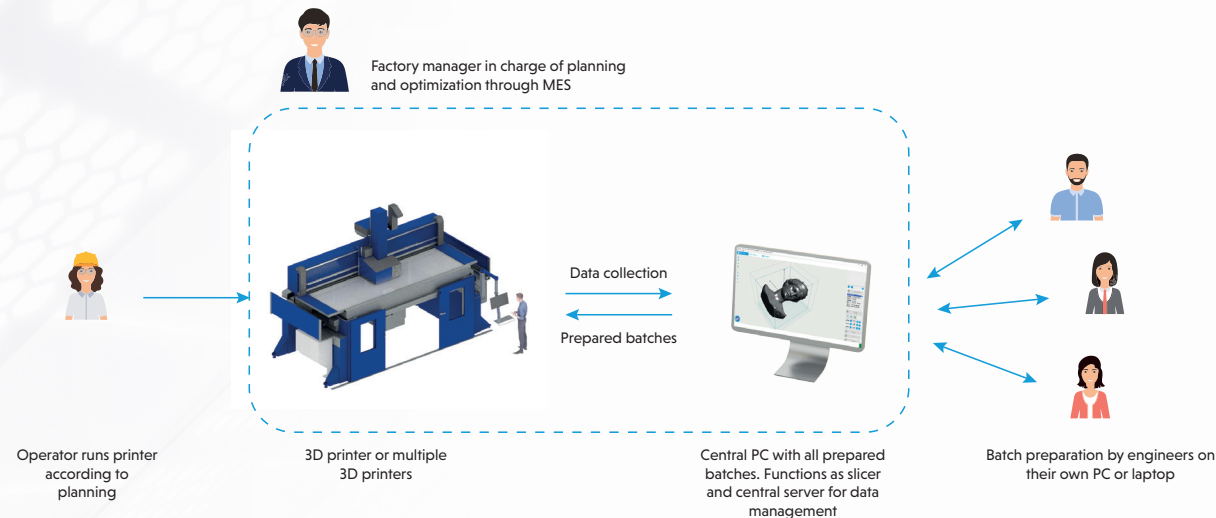
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SOFTWARE



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PREPARING YOUR PRINT

Your Elephant comes with custom slicing software that is installed on a central computer. On this slicing software you can load in printable .stl and .obj files and create batches to print. This central computer will be delivered with the machine. Your staff can remote log in to this computer, from their desk, and prepare batches that can be sent to the printer, either via USB, ethernet or your company server.

Multiple files can be loaded and positioned in each printing batch and you can even use external software to optimize nesting of 3D models inside the printer in order to get the most out of your printing time.

With the slicer you can easily prepare multiple batches in just a few hours, so your operator is set to print for the coming weeks. The slicer will show you the printing time per batch, so you can easily plan ahead your printing.

Your staff can use their existing regular laptops or pc's to access the slicing software.

PRINTING ON THE ELEPHANT

The operator takes in the batches via a USB stick and loads them in the printer. The operator can choose the batch to print and press start. The printer will automatically level itself and fill itself with powder as it prints. It will tell the operator the printing time required. When the print has finished, a signal will alert the operator the print has completed.

The printer can be connected via a Scalance system to monitor its status.

SOFTWARE UPDATES AND MES INTEGRATION

Software updates are included in your service level agreement. New features will regularly be added to the slicing software to improve its capabilities and level of integration with your manufacturing execution system. Your printer will gather data that you can use to optimize your planning, reduce downtime and get the most out of your investment.

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SAFETY & WASTE

SAFETY

Safety of the operators is a major concern of CONCR3DE and we have taken all precautions to provide a safe and clean process. The process is fully autonomous, meaning operators will never have to touch moving parts – in fact they'll not even be able to. The process is designed to be as dust-free as possible. Proper PPE is provided for when dealing with the materials, that are non-toxic in itself.

The equipment is designed according to EN standards and complies with all EU regulations. Your printer comes with all required certifications and documentation, according to the list below:

| CERTIFICATION | DOCUMENTATION |
|---|--|
| CE declaration of conformity and marking | Drawing / composition drawings (with main dimensions, weight and tolerances) |
| Risk assessment (for CE declaration) | Room plan, load plan, construction requirements |
| Acceptance documents of a technical accredited body | Operational manual |
| Safety data sheets for materials/equipment used | Maintenance & cleaning manual |
| | Technical data sheets of all process elements |



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WASTE

The process is almost entirely waste-free. Minor waste elements will be need to be considered:

- Printer ink. Your printer will clean its printheads every 30 layers of printing. A small amount of printer ink will be purged out of the printheads. This printer ink is collected in a jerrycan inside your printer and will need to be discarded as low caloric waste.
- You will need to replace the water in your dipping station regularly. Used water can be disposed of regularly in the sewer after letting particulate matter sink.
- You will need to clean the filters of the dipping station in which powder that hasn't been depowdered properly will coagulate. This sediment is a regular construction waste and can be disposed of similarly. The estimated amount yearly is less than 1 ton.

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SERVICE & MAINTENANCE

All printers come with a standard 1 year warranty. This warranty may be extended for another year.

CONCR3DE Elephant also comes with different levels of service contract. The following table gives an overview of the different levels of service.

Each service contract comes with a yearly visit by our service crew to do printer maintenance. For this the printer will be offline for a period of 48 hours.

| Service level | Response time | Training | New developments |
|---------------|--|---|---|
| Basic | Online & phone support within 48 hours, local response within 8 business days. Spare parts arrive along with the technician. | Staff training upon machine installation | n/a |
| Manufacturing | Online & phone support within 12 hours, local response within 5 business days, spare parts arrive within 3 business days. | Yearly staff training | n/a |
| Partnership | Online & phone support within 12 hours, local response within 5 business days, spare parts arrive within 3 business days. | Yearly consultations on process optimization Yearly staff training | First access to new materials First access to beta products Customized materials Customizations to software and hardware |



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TRAINING

Each service level comes with training. In this training we will show operators and engineers all aspects of the machine, how to operate it, how to perform basic maintenance, how to work with the software and how to get the most out of the process. Training takes 5 business days and will end with a certificate for the operators that have completed it. We recommend to only let certified employees handle the equipment.



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CONSUMABLES

The following consumables should be taken into account:

| Consumable | Estimated lifetime |
|----------------------------|--|
| Print head | 2 year lifetime with proper maintenance |
| Print head filters | 3 months |
| Inlet filters | 1 year |
| Service station wiper | 3 months |
| Capping sponge replacement | 3 months |
| Flush binder | 8 liters of flush ink is required to flush the machine during monthly cleaning |



STAFF REQUIREMENTS



BATCH PREPARATION & FACTORY MANAGEMENT

Design and file management - you will need files to print that typically come from a designer. This can be internal or external to your company. Once you have files you want to print, you need to have a planner create batches of prints you want to conduct according your internal process. The organizing of designs into a printable batch should take no more than 30 minutes per batch to be printed, if there are no faults in the 3D geometry. This person should also check the mesh quality and fix possible faults in the 3D file - when you receive external files this will most likely be necessary at least every now and then.

Your planner/engineer can prepare batches for weeks in advance in a single day. It is recommended that this person takes batch size into account in his planning..

OPERATING THE EQUIPMENT: A DAY IN THE LIFE

The operator takes in the batches via a USB stick and loads them in the printer. The operator can choose the batch to print and press start. The printer will automatically level itself and fill itself with powder as it prints. It will tell the operator the printing time required. When the print has finished, a signal will alert the operator the print has completed.

Aside from printing your operator will have several other tasks according to the process. These include depowdering, dipping and sealing prints. One operator should be able to run 2 printers with all adjoining processes, according to the following schedule:

| Time in hours | 1 Elephant printer | 2 Elephant printers |
|---------------|--------------------|---------------------|
| Printing | 0,5 | 1 |
| Depowdering | 2 | 4 |
| Dipping | 0,5 | 1 |
| Transporting | 0,5 | 0,5 |
| Sealing | 0,5 | 1 |

PROCESS TIMING



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PROCESS TIMING

When using CONCR3DE materials, the following production timeline should be kept in mind. It assumes a turnaround time of roughly 1 week from receiving CAD data to having a deliverable part. The table below assumes the turnaround time of 1 full jobbox

| Task | Time in hours | Days after starting |
|---------------------|---------------|---------------------|
| Digital preparation | 1 | Day 1 |
| Printing | 18 | |
| Curing | 2 | |
| Depowdering | 2 | Day 2 |
| Dipping | 20 | |
| Drying | 48 | Day 3 |
| Sealing | 1 | Day 5 |
| Drying | 20 | |
| Shipping | 1 | Day 6 |

The process is designed so 1 full jobbox can be produced every day and only 2 jobboxes are needed for maximum productivity, with the operator only needing to attend regular working hours. Of course not every job requires 1 meter printing height, in that case the operator can time 2 shorter runs every 24 hour cycle.

In a 24-hour cycle, the operator will have at least 4 hours after the print job is completed to start the next run, so he can schedule his day accordingly.

The printer has a delayed starting time option, meaning a print can be started by the operator on friday afternoon, actually start sunday afternoon and finish early monday morning.



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PRODUCTIVITY

At maximum productivity, your Elephant 3D printing process produces 2 cubic meters of parts per day. Assuming 240 production days per year your maximum produceable volume is 480 cubic meters per printer.

However, due to the nature of the process and the requests of your customers, it is unlikely you will reach this volume. You will most likely produce more complex parts meaning there will always be 'empty space' in the printer.

Your exact production level will require on the fill rate of your equipment. The fill rate is the ratio of used space in your job box. The image on the right shows a simulation of a job box filled with consoles - 350 of them to be exact. The shape of the part and the space required in between the parts mean that this job box has a fill rate of 49%.

This fill rate is quite high: as you can see the job box is densely packed. It is our estimation that this will be desirable but fairly uncommon due to the complex geometries you will print.

Your engineers should aim for a fill rate that is as high as possible as it will give you the highest return on your investment. We estimate that a fill rate of 10 to 20% is a realistic goal that should give a significant RoI, with a higher fill rate a bonus.

You could choose to price your parts accordingly and sell printed parts according to a combination of how much space is occupied in the printer, how much material is used and how much printing time is required.



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