SECO/EBOOK

PREMIUM SECO/WARWICK© CONTENT APRIL, 2020

ADDITIVE MANUFACTURING WORLD

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INVENTION MEETS RELIABILITY

IMPROVING METAL ADDITIVE MANUFACTURED (AM) PART QUALITY DEPENDS ON CHOOSING THE RIGHT FURNACE

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ADDITIVE MANUFACTURING WORLD

The Additive Manufacturing world requires a proactive approach from heat treatment furnace producers as 3D printing technology is evolving rapidly and furnace design needs to keep up. Don't let heat treatment equipment be 'the weakest link' in your production process.

Metal additive manufacturing (AM) - a top 10 market trend

Metal additive manufacturing (AM), which, according to Gartner, is 'the capability to create a physical object from a digitally encoded design through the deposition of material via a 3D printing process', has become a top 10 strategic technology trend for manufacturing industries.

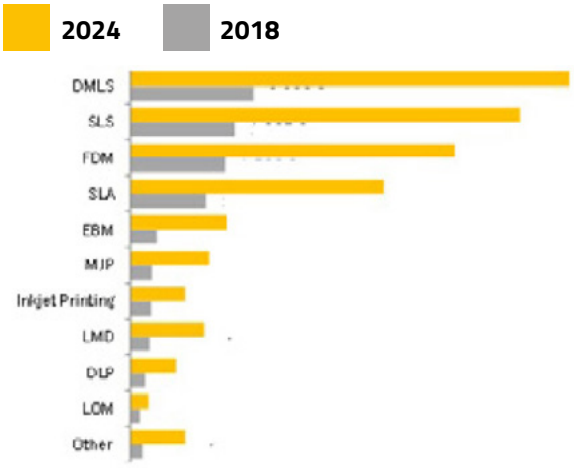
The capability to create a physical object from a digitally encoded design through the deposition of material via a 3D printing process

The reason?

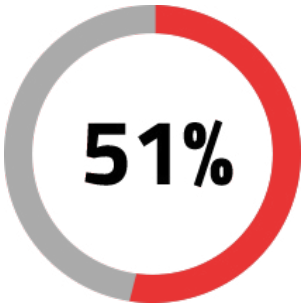
It is much easier and faster to print necessary elements in-house than to wait till the end of the metal casting process. The 3D printing concept is about 30 years old, and Military and Aerospace sectors were among first industries interested in the potential of such a technology. Years have passed and yet, according to Grand View Research and their Trends Analysis Report, the most promising areas of Additive Manufacturing technology development are:

Military **Aerospace** **Medical**

3D Printing Market Size, by Technology, USD MILLION



Over the last few years, the Automotive industry has joined that group due to a new direction of alternative fuel and weight reduction that are main goals for next generation vehicles. As Forbes claims, in 2019 , 51% of enterprises are using 3D printing in the production process, and 80% say that technology allows them to develop innovation faster.



51% enterprises are using 3d printing in the production process

80% enterprises say that technology allows them to develop innovation faster

Data provided by Markets & Markets concerning this technology confirms that the global size of the 3D printing market is expected to reach about 35 USD billion by 2024, and, in comparison, in 2018 it was only 9.9 USD billion. Although perspectives are undoubtedly promising, it is logical to think there will be growing industry demands in other manufacturing applications to achieve the highest possible quality and durability, since metal parts printing is just a first step in an integrated production process.

Heat treatment steps into the spotlight

As 3D printing technology expands, production companies continue to look for technological capabilities to enhance printed product quality, especially due to the nature of sectors interested in the production of complex metal parts with superior mechanical properties. It hasn't been until rela-

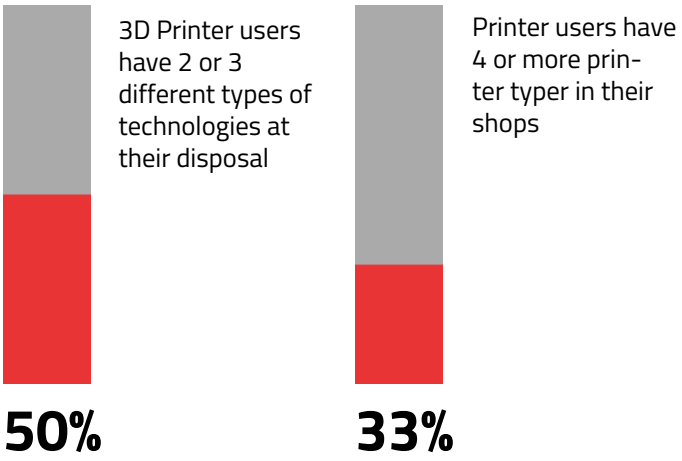
tively recently that heat treatment processes have become quite such an important consideration in the 3D printing technology sector.

With regard to the production process' performance, speed, and costs, more and more insightful data indicate the importance and potential impact of utilizing a heat treatment furnace in the additive manufacturing cycle, putting a brighter spotlight on the significance of heat treatment processes than ever before. A few years ago, having one 3D metal printer was a great accomplishment. According to 'Additive Post-Printing Survey' released by Post Process, today more than 50% of 3D printer users have two or three different types of technologies

Heat treatment processes have become quite such an important consideration in the 3D printing technology sector.

at their disposal. 33% are using four or more printer types in their shops.

According to 'Additive Post-Printing Survey' released by Post Process, today:



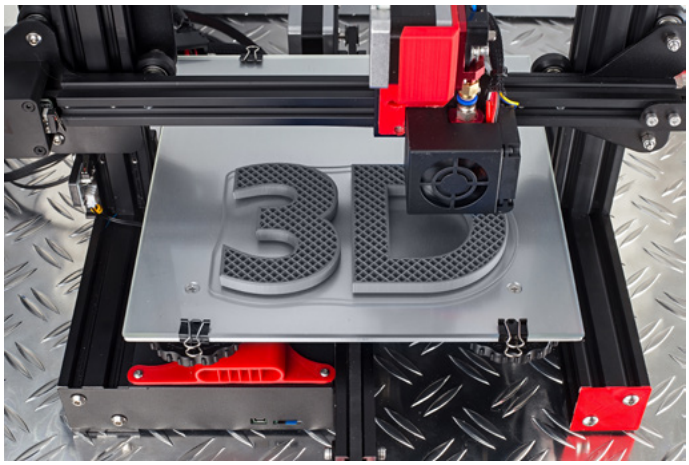
Yet, apart from becoming affordable, the technology itself must produce quality products in both rapid prototyping and mass production. Accordingly, disadvantages of one technology need to be compensated by advantages of other one, and the furnaces, installed somewhere in between, must accommodate both.

A chain is only as strong as the weakest link

It could be said that 3D printing may enhance product development in literally every industry. Bearing in mind that a simple equipment is not enough to satisfy today's 3D printing business needs and requirements, a question arises – what furnace will successfully face the challenge?
For instance SECO/WARWICK. The company is considered to be one of the heat treatment industry leaders, began introducing Metal Additive Manufacturing furnace solutions several years ago. As Sławomir Woźniak, SECO/WARWICK's CEO says:

As a company, we are constantly searching for solutions that will align with our customers' current and future needs, and the field of Metal Additive Manufacturing is no exception.

Heat treatment stayed in the shadows of the 3D printing world for a long time; however, more and more users are beginning to realize the beneficial impact that proper heat treatment solutions contribute in terms of process time and costs. Both laser-based and binder jetting 3D printing techno-



logies are characterized by features needed in the industry. Accordingly, the laser based solution is more common, but there is noticeable and growing industry interest in parts printed as a combination of powder and binder (green part). Nevertheless, the final effect is still far from a solid metal piece. So where is the place for the furnace in either of these technologies?

Regardless if the manufacturer uses a high resolution laser-based printer or a fast, economical

binder jetting solution, the heat treatment process will have an important impact on the performance of the final part. For example, the binder jetting sintering process uses a binder which needs to be removed. After debinding, the part is put into the furnace where the right sintering recipe makes all the magic. However, if the binder in the printed part comprises about 2%, debinding is no longer needed thanks to innovative solutions.

Furnaces with the proper technology and recipes are capable of removing the binder, then starting the sintering process immediately afterward.
In the case of laser printed parts, heat treatment furnaces are being used for stress relieving and annealing processes in order to achieve the best possible material homogeneity and quality.

Various needs. One challenge.

Taking into consideration the size of laboratory furnaces, they are perfect for small batches and R&D purposes, but for medium and high volume production industrial furnaces are required. S. Woźniak specifies:"In certain areas printing takes less time than heat treatment itself, and this is the reason why the furnace size needs to be adjusted to match estimated production capacity. Eventually, to achieve final properties required by the end user, printed parts need to be further processed. Dealing with a green part is only a tip of the iceberg, especially considering the importance of current requirements regarding certifications and standardization of printed components. So, having the capability of performing numerous processes in house will become an increasingly valuable benefit."

Aerospace, medical and automotive sectors are main targets for 3D printer producers and those sectors deal mainly with special types of steels and superalloys. Benefits of processing such materials in vacuum heat treatment furnaces are already well documented, including integrated process controls which directly influence the part's deformation or shrinkage aspect. Regardless of the binder base technology, this is a great solution.

To be one step ahead

Currently, vacuum heat treatment furnaces seem to be the most comprehensive heat treatment solution for 3D printing needs, even as those needs may vary.
For instance, one technology requires sintering, while another needs stress relieving. Thus, taking into consideration the manufacturer's future goals - such as standardization of a furnace, mass production, or constant flow of orders - investment in the right industrial furnace allows companies to avoid most of the obstacles before they even occur. In fact, companies are constantly searching for dedicated solutions for their particular needs, and this is the reason that more and more customers from the 3D metal printing world are turning to heat treatment solutions from SECO/WARWICK Group.

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FREQUENTLY ASKED QUESTIONS

SECO/WARWICK

1) Do I need a furnace for metal 3D printing processes?

Heat Treatment is necessary for the most common metal 3D printing technology on the market. Laser based technology (EOS, SLM, etc) makes it possible to print metal parts; however, such elements have an irregular molecular structure. Stress relieving processes or aging processes help to achieve more uniform structure free from inside tensions. As a result, printed elements will have less tendency to crack in unexpected ways.

In terms of Binder Jetting technology (ExOne, Desktop Metal, etc.), heat treatment is not only an option but part of the printing process. As a result of printing, a "green part" is produced that is a combination of metal powder and binder. In sintering process metal powder melts together and the binder is removed. The heat treatment process converts the green part to metal.

Both processes can be performed in VECTOR® 3D vacuum furnace. This state-of-the-art vacuum furnace is specifically designed for dealing with binder particles and contamination produced from the sintering process.

METAL 3D PRINTING TECHNOLOGY	HOW IT WORKS?	PRINTING RESULT
Laser-based (EOS, SLM, etc.)	Makes it possible to print metal parts; elements have an irregular molecular structure. Stress-relieving processes or aging processes help to achieve a more uniform structure free from inside tensions.	Printed elements will have less tendency to crack in unexpected ways.
Binder Jetting (ExOne, Desktop Metal, etc.)	Heat treatment is a part of the printing process.	A "green part" is produced - a combination of metal powder and binder. In sintering process, metal powder melts together and the binder is removed. The heat treatment process converts the green part to metal.

2) What kind of heat treatment processes are common for metal 3D printing?

Sintering, stress relieving and aging are the most common ones; however, it depends on the printing technology. In the case of binder jetting technology, we obtain a “green part” that is a combination of metal powder and binder. In the sintering process, metal powder melts together and the binder must be removed. It means that the green part becomes metal after the heat treatment process.

Laser-based technology can also print metal parts, however, such elements have an irregular molecular structure. Stress relieving or aging processes help to achieve more uniform structure free from inside tensions. As a result, printed elements will have less tendency to crack in unexpected ways. It is i portant to remember that the printed part, after necessary postprocessing, might require further heat treatment processes, the same as a cast element produced in the traditional way. It is worth considering a furnace that will be in a position to perform further heat treatment processes.

SECO/WARWICK’s VECTOR 3D vacuum furnace is a perfect example of a universal unit where all possible processes can be performed. Additionally, the furnace is able to deal with binder particles that are the natural side effect of sintering. 5 different protection systems keep the furnace in good condition and guaranteed long performance life.

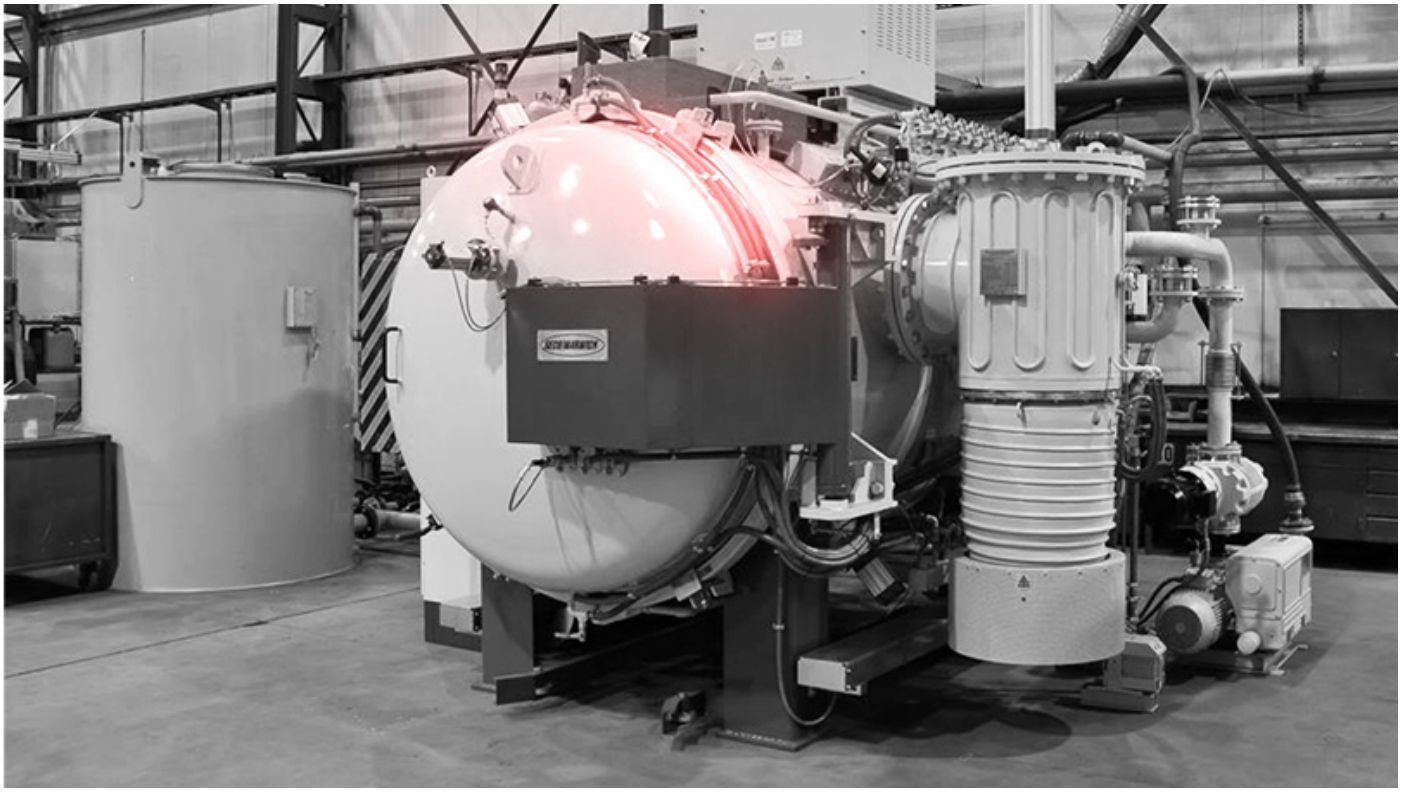
3) I already have vacuum furnace. Can I use it also for 3D printing applications?

It depends. Most vacuum furnaces can be adjusted to perform stress relieving or aging processes. If the required temperature is in the scope of furnace's range, there should be no issues to cover that area. The situation becomes more complicated in terms of binder jetting technology and sintering processes. The binder produces vapors during heat treatment processes and those vapors might accumulate on a cold section of the furnace, pumping system or power feedthrough. As a result, it could decrease the lifetime of some furnace components or even cause a serious short circuit that might result in a fire.

Most vacuum furnaces can be adjusted to perform stress relieving or aging processes. If the required temperature is in the scope of furnace's range, there should be no issues to cover that area.

Vacuum furnaces, like the VECTOR 3D, are specially designed for Binder Jetting processes. They are additionally equipped with protective systems which help to keep the furnace in good condition for a long time.

Naturally, a furnace designed for binder jetting can be used for any other processes the same as regular vacuum furnace. Bottom line, a vacuum furnace is the best possible solution for AM applications; however, not every vacuum furnace is prepared to deal with the specific requirements related to AM processes.



4) I am planning to have several metal 3D printers in several technologies. Can I have a furnace that will handle all of them?

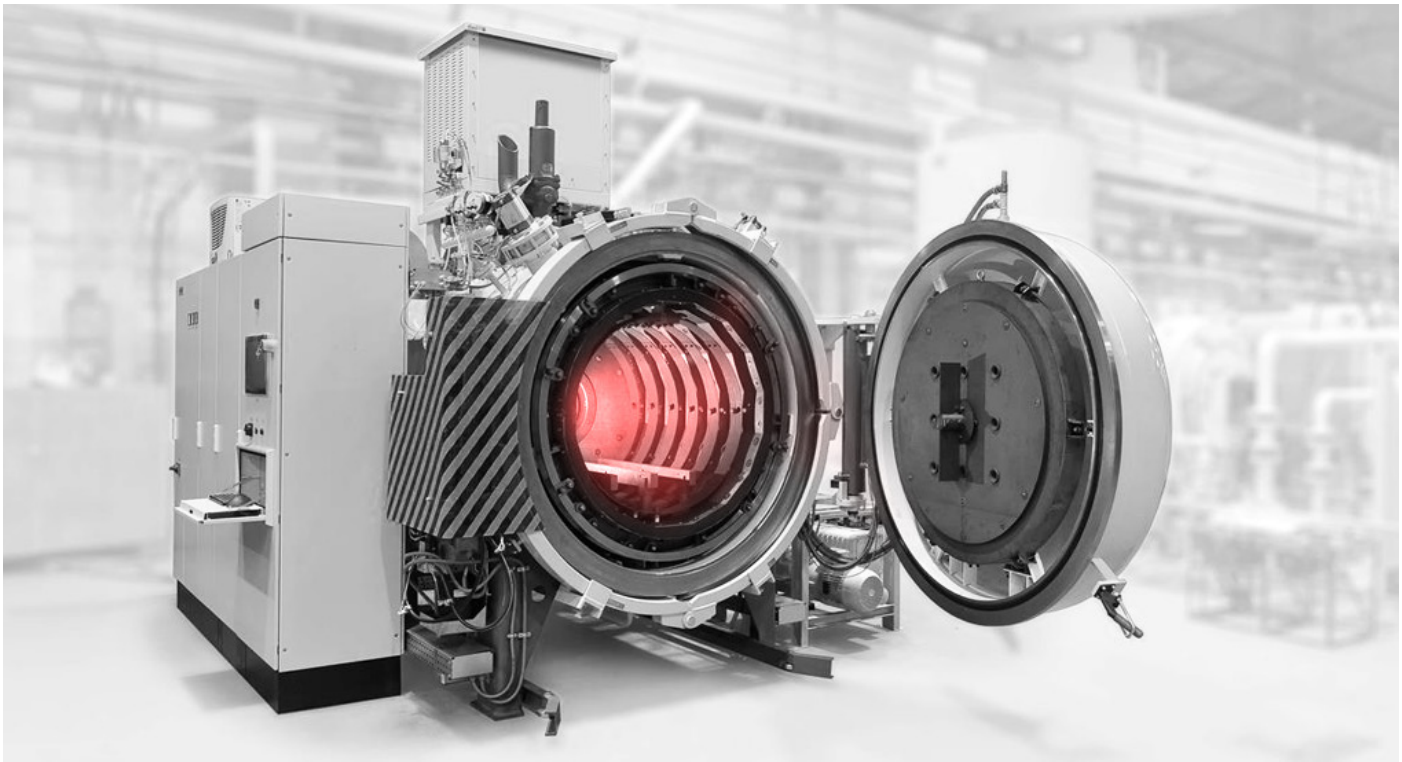
Yes. Vacuum furnaces are universal units that can handle most of the heat treatment process:

/sintering,
/stress relieving,
/aging,
/ hardening,
/carburizing,
/annealing,
/brazing,
/coating,
/tempering,
/solution heat treatment.

Naturally, the furnace needs to be configurated accordingly during the design and construction stage. Aftermarket upgrades might be too expensive. As the furnace is usually a 10-30 year investment it is always wise to think about your needs in the future.

SECO/WARWICK's VECTOR 3D vacuum furnace is a perfect example of a universal unit, where all the HT processes can be performed.

Additionally, it is configured for AM process including debinding operations.

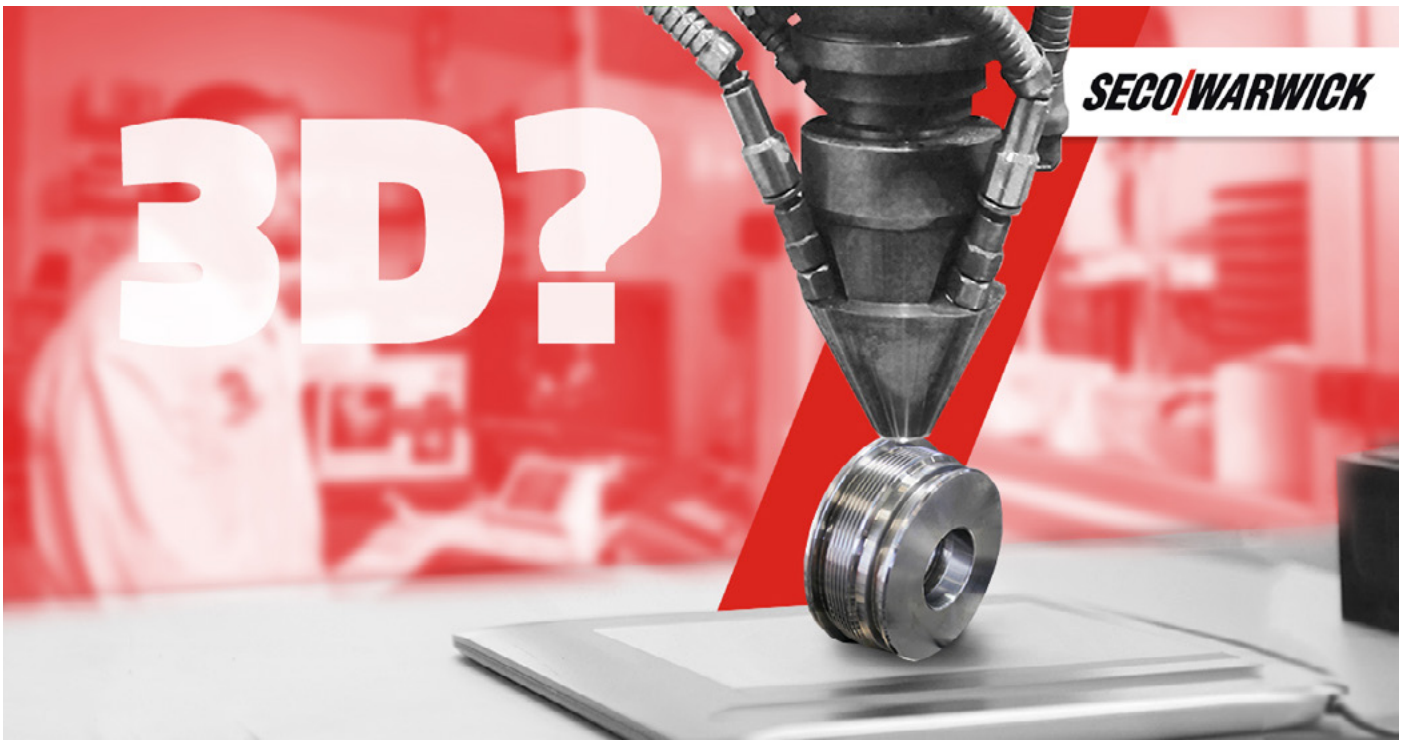


5) There are many types of furnaces on the market. Which one is the most optimal for metal 3D printing applications?

Today metal 3D printing concentrates on stainless steel and superalloys like titanium-based or aluminum-based material, etc. In these cases, heat treatment processes need to be performed in a zero oxygen environment; this can be achieved either by using an atmospheric-type furnace with the protective atmosphere guaranteed by gas mixtures or by a vacuum-type furnace where the oxygen level is reduced by a certain level of vacuum.

Trends on the market show that basic atmospheric lab size furnaces are being used for low volume production of simple components and prototyping, mainly due to low equipment cost, or wherever utilization costs and preparation time is not an important factor.

For medium and large size production of components for specialty markets such as aerospace, vacuum type furnaces like the VECTOR 3D is a preferred choice. Higher purchase costs compared to simple atmospheric type equipment are offset by extended furnace utilization.



6) My printer working zone is 400x250x250. Shall I consider the same furnace size?

It depends. For prototyping purposes where the printing process takes place only occasionally, this might be an optimal solution. However, for medium and high volume production, equipment efficiency needs to be taken into consideration. Increasing printing speed is one of the key factors for all printer producers nowadays. As a result, printing speed is growing from one month to another. On the other hand, batch heat treatment processes generally run in fixed timeframes, so speed improvement is not that simple because it is impossible to cheat the physics. This is the reason why printer users often decide on a larger furnace capable of processing several printed batches at the same time. This is how the size of the furnace can compensate for the increasing speed of printers.

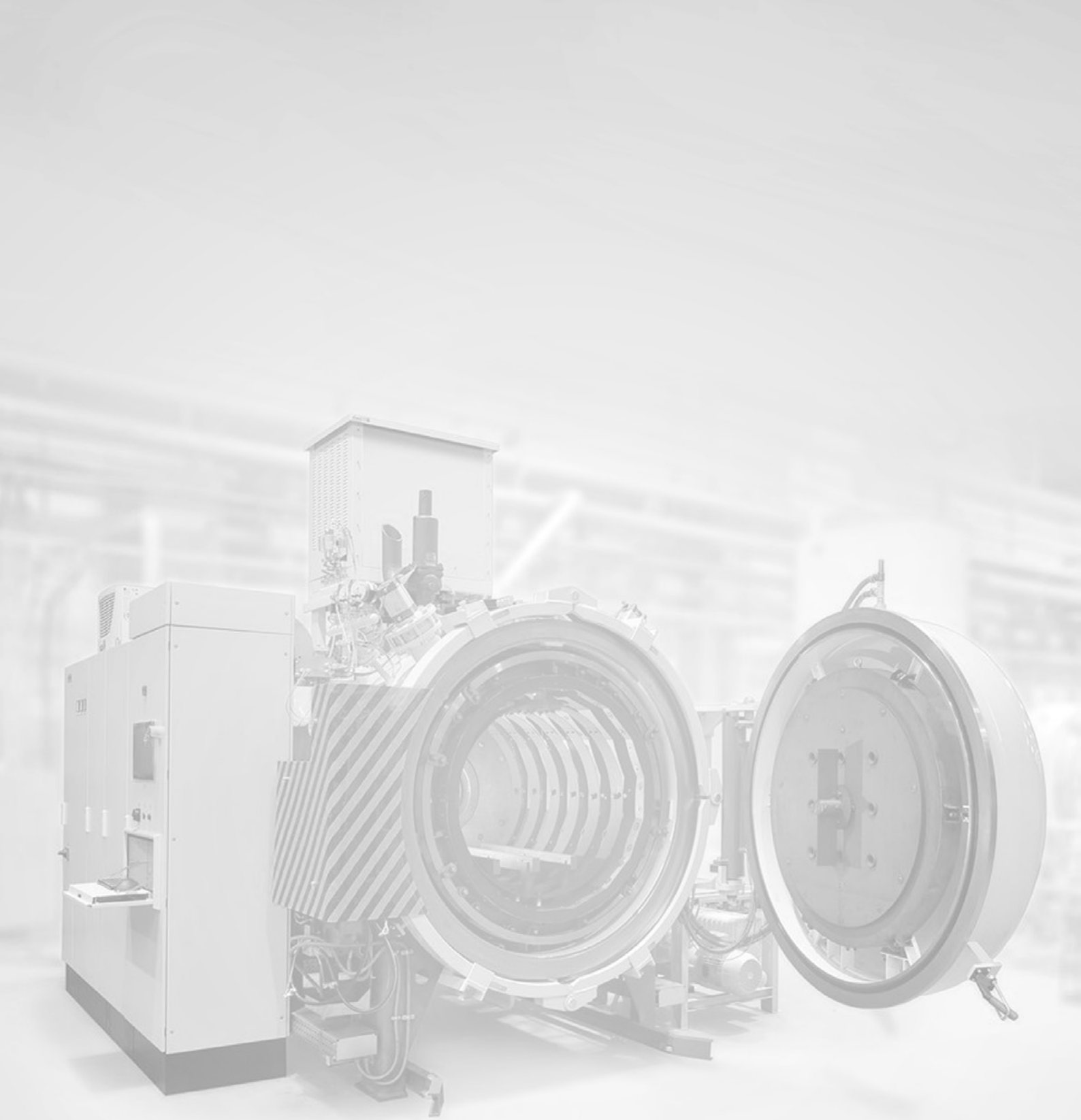
Today, most printer users have more than one unit, so that should be taken into consideration. Furnaces are usually the long life investment, and you don't want it to be "the weakest link in your chain".

This is the reason why the SECO/WARWICK VECTOR 3D is offered in 4 standard sizes

1. 250x250x400
2. 400x400x600
3. 600x600x900
4. 900x900x1200

If the customer requests other dimensions, SECO/WARWICK is always open for custom designs. Numerous custom designed furnaces can be found in the company's portfolio, among them a huge all metal vacuum vacuum furnace 32m long with temperature uniformity +/-3°C and a horizontal vacuum furnace built for 120-ton loads.

Furnaces are usually the long life investment, and you don't want it to be "the weakest link in your chain".



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