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Market and technology report 2022

Additive Manufacturing Enabling Advanced Tool, Die and Mold Making

About FERA

FERA »Ferramentas Manufaturadas Aditivamente« is a project within the program ROTA 2030, an initiative of the Brazilian Government to improve the technological content of vehicles and encourage investments in R&D. It is conducted within the research line addressed to improve the competetiveness of the Brazilian tooling industry, managed by the Support Foundation FUNDEP.

FERA aims at developing Additive Manufacturing applications in the repair and production of tools, dies & molds for the automotive industry in Brazil. To effectively represent the entire production chain as approached in the scope, it engages 26 companies as project partners. The project is coordinated by the Aeronautics Institute of Technology (ITA), represented by Prof. Ronnie Rego, developed together with the SENAI Innovation Institute for Laser Processing and the Institute for Technological Research (IPT), and conducted in cooperation with Fraunhofer IPK.

About this study

This international market and technology report is part of the activities of Fraunhofer IPK within FERA and presents a state-of-the-art assessment regarding the adoption of Additive Manufacturing in industrial applications for tools, dies & molds in Brazil and Germany.

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Additive Manufacturing for Tooling

How can businesses succeed implementing Additive Manufacturing in their tooling processes?

New design trends and technological breakthroughs from research and development push manufacturers to develop new products quickly, necessitating the development of new tools, dies, and molds. Reducing time for tooling and time to market is critical in the global competitive environment. As a result, Additive Manufacturing (AM) holds the tremendous potential to revolutionize the manufacturing industry.

Over the last few decades, AM has grown by double digits. This research aims to identify success factors, economic calculations, hurdles for successful implementtation and compare AM vs. conventional manufacturing for tool, die, and mold making.

The aim of the survey is to first review the situation and then look ahead to find out how tool, die and mold making companies can implement AM successfully and thereby realize new business models.

Method

Survey design and structure

The survey is composed of 35 individual questions divided into four main areas:

- **General information about the companies**
- **Applications and capabilities regarding AM in tooling**
- **Hardware and costs**
- **Current challenges**

The study was conducted in both Brazil (BR) and Germany (DE). For the German market, the survey was conducted in English and for the Brazilian market, in Portuguese.

Participants in the study

The study was conducted as an online survey from April 2022 to October 2022. The results of the study are based on the responses of 55 participants (DE: 30; BR: 25) from various hierarchical levels and functional areas in companies of different sizes and industries.

The participants of the survey in Germany were mainly approached via the Verband Deutscher Werkzeug- und Formenbauer e.V. (German Association of Moldmakers and Toolmakers). Other German participants are direct contacts of Fraunhofer IPK and also work in the field of tool, die and mold making. The Brazilian survey participants were contacted mainly through ABINFER - Associação Brasileira da Indústria de Ferramentais (Brazilian National Die & Tooling Association). Additional survey participants from Brazil were obtained through ITA, within the FERA consortium.

About VDWF

The Verband Deutscher Werkzeug- und Formenbauer e. V. (VDWF) is a German industrial association of companies in the tool and die industry. The association advises the member companies on various issues, provides exchange formats and works on a positive public visibility of the industry.

About ABINFER

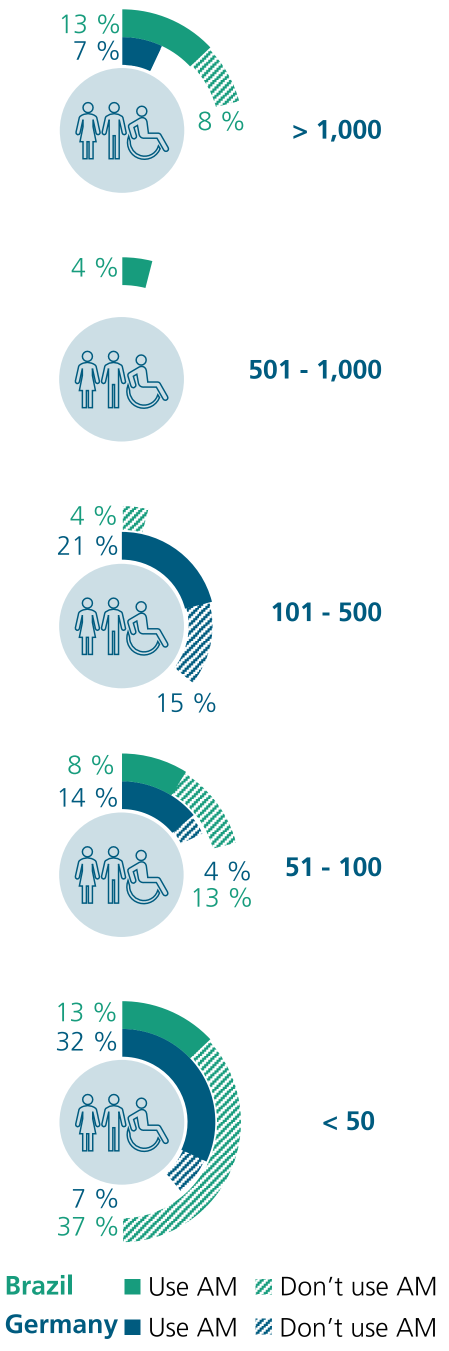
ABINFER - Associação Brasileira da Indústria de Ferramentais is a non-profit business association that represents tooling companies from all over Brazil. It represents the interests towards governmental bodies and private companies as well as promotes and supports the sustainable development of the Brazilian tooling sector, with a long-term vision.

The survey was intended to provide insights into the companies' usage of AM or future usage of AM in the tooling sector. In this study, SMEs (with up to 249 employees and annual sales of no more than € 50 million) and large companies (500 and more employees and annual sales of more than € 50 million) are represented. The classification of the companies into the group of SMEs is defined by EU recommendation.

Results

General Information About the Companies

Company size and AM use



The first part of the survey contains general questions about the companies. In this introductory part essential data on company size and the industry are collected, which are used in later steps to classify organizations.

The survey was intended to provide insights into the companies use of AM especially in the area of tool, die and mold making as well as the individual challenges and need for action.

Therefore, information provided by SMEs as well as large companies was included in the comparison. As the following figure shows, around 40 to 50 % of German and Brazilian participants surveyed for this study work in small-sized businesses with less than 50 employees.

»The engineering department has had a high interest in AM and has seen a clear purpose; the other departments were more sceptical.«

These start-ups and small companies form a technological basis and usually either evolve to medium or large enterprises in case of a success in AM or pivot to other markets and technologies.

It is also worth noting which additional companies had their attention caught to participate in this survey. In Brazil large enterprises which can conduct investments in AM and also absorb the involved technological risks took part. For Germany many medium sized companies participated, which compose the core of Germany´s economy and play an important role in the adoption of new technologies.

Regarding the industrial segment of the participating companies, more than half of them operate in tool, die and mold making (DE: 57 %, BR: 52 %). In Brazil, automotive accounts for the second-largest share (40 %). Other industries represented in the study are Medical, Consumer products, Power / Energy and others. In general, it can be determined that the industries of the German participants are to some degree more diversified than the Brazilian ones.

»AM was gladly used and would have been used more often for die casting tooling, but the extra cost could not always be sold to customers.«

The companies were also asked about the usage of AM in general and its frequency. The vast majority, 89 %, of German companies participating in the survey stated to generally use AM, while in Brazil it's only 37 %. Although the Brazilian companies who participated in this survey were generally larger than the German companies, there are circumstances hindering the adoption of AM which are probably not cost-related and have to be investigated.

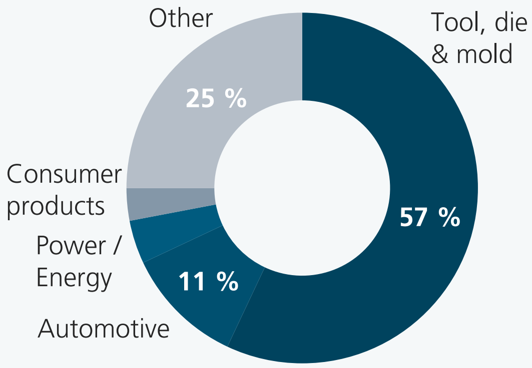
The frequency of use of AM in Germany is striking. The majority (68 %) use AM only rarely. Only 18 % say they use AM frequently and only 3 %, always. It seems that AM is only used for very specific use cases and thus usually no full utilization of the machine tools can be achieved. Thus, there is still a lack of business models that make use of continuous AM.

A case study by Fritz Schäfer GmbH & Co KG, Neunkirchen, Germany and EOS GmbH, Munich, Germany demonstrates the potential of AM for special custom solutions. These are not required in high volumes, but rather offer very specific advantages due to the rapid adaptability of products through AM. Specifically, a gripper was optimized for the removal of storage containers from the injection molding machine. This can be adapted to the respective container to be removed and quickly additively manufactured from PA polymer. Due to a large product portfolio the set-up on the injection molding machine changes several times a day and a universal gripper had a high failure rate. The dedicated grippers adapted to the container sizes and shapes reduce set-up times and significantly reduce operating errors [EOS22].

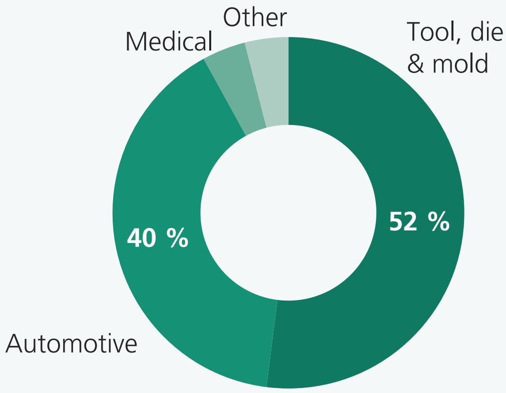
A different picture emerges in Brazil: The majority (63 %) never uses AM, while only less than one third use it rarely. However, 8 % of companies in Brazil say they always use AM. This is more than in Germany and is probably due to small companies that only have AM processes in their portfolio.

Industries

Germany

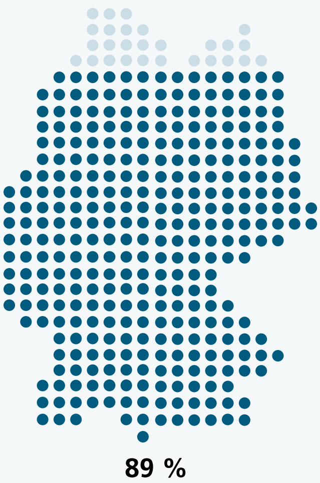


Brazil



Companies using AM

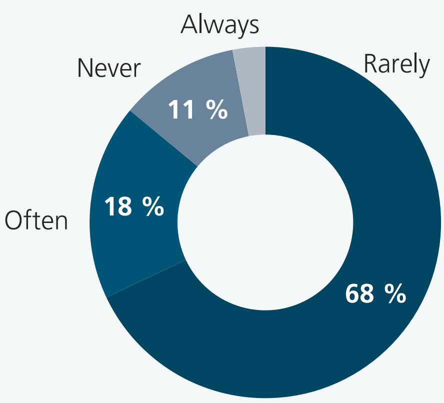
Germany



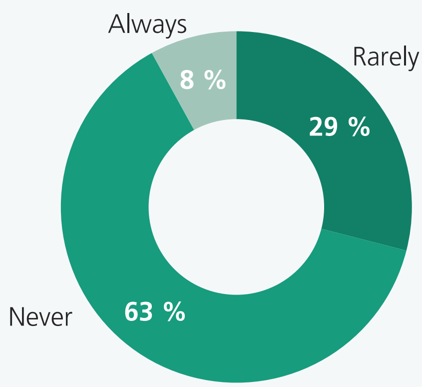
Brazil

Frequency of AM usage

Germany



Brazil



Applications and Capabilities Regarding Additive Manufacturing in Tooling

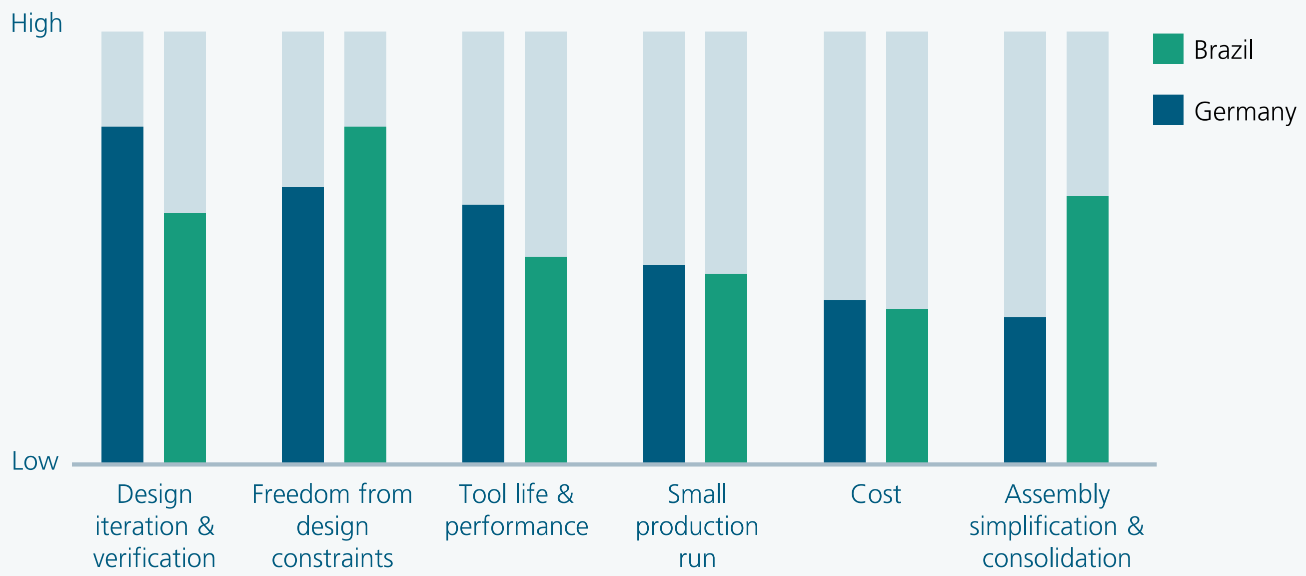
The second part of the interviews focuses on advantages, current applications and challenges of Additive Manufacturing for tool, die and mold making.

For Germany and Brazil, the benefits of AM in the specific industry were ranked slightly different. While Germany sees the biggest advantages in **design iteration & verification** as well as **freedom from design constraints**, Brazilian companies agree with the advantage of design freedom but voted **assembly simplification & consolidation** second place. This could be due to the different distribution of the companies' industries or the fact that AM is used less often from Brazilian participants and therefore the benefits are assessed differently.

In summary, it can be stated here that the possibilities of AM in terms of the design of the tools is still much more decisive than the cost. One participant in the study stated that, in principle, attempts are made to manufacture most parts conventionally, but that this is not always possible. AM is utilized for these recurring special use cases.

An example that demonstrates a successful **design iteration and verification** is a case study conducted by the company MATSUURA MACHINERY CORPORATION, FUKUI, JAPAN. The case study describes a tool for manufacturing housings to demonstrate the production in very few process steps compared to conventional manufacturing [MAT22].

Benefits AM adds to the industries



No additional splitting of mold dies is required, eliminating the assembly and adjustment stages. In addition, conformal cooling can be integrated directly as part of the manufacturing process. A change in the design can also be implemented quickly due to the small number of process steps [MAT22].

The **freedom from design constraints** is well illustrated by a case study of Oak Ridge National Laboratory, Tennessee, US and ExOne PLC, North Huntingdon, US. The mold for cup production was equipped with an elaborated conformal cooling system. Due to the round cup shape, conventional straight bores are not ideal for homogeneous cooling. This can be realized with AM by curved cooling channels along the surface [EXO22].

An increase in **tool life** and an improvement in **performance** is demonstrated in a case study by ABB Ltd, Zurich, Switzerland and SLM Solutions AG, Lübeck, Germany. The goal of this case study was a reduction in cycle time for a cabling grommet by redesigning and optimizing the cooling of a tooling insert. The original design was completely without any cooling inserts and had cycle time of 60 seconds. An optimized conformal cooling via AM resulted in a cycle time of 15 seconds and fewer defective products [ABB22].

Another advantage that AM brings to toolmaking is the ability to produce a small number of components at low cost. The **small production run** benefit is illustrated in a case study by Guhring Inc., Brookfield, UK and Markforged, Watertown, US. Special tooling can take up to eight weeks to design, test and manufacture. Smaller companies in particular with lower volumes can therefore often not be supplied with special tools. In this case study a functional prototype was developed and manufactured within one day using extrusion-based AM. A fully functional metal cutter body was then developed and produced within 5 days. This showcases a reduction of lead times and managing timelines for small customers of special tools [MAR22].

A case study by Etteplan OYJ, ESPOO, Finnland and SLM Solutions PLC, Lübeck Germany shows how intelligent nesting of components on the AM build plate can enable high-volume production and significantly reduce **costs** compared to conventional manufacturing. A y-connector of a robotic sander's dust extraction channel had high costs, a long supply chain and a large footprint that caused problems in the assembly line. Therefore, it was optimized for AM via Powder Bed Fusion (PBF) with Design for Additive Manufacturing (DfAM) methods. The nesting of multiple parts increased the total time needed for the build job, but significantly decreased the production time per part. An additional parameter optimization led to another 25 % build time reduction. Compared to the conventional manufacturing method, the weight of the part was reduced by 50 % and the overall cost was reduced by 40 % [ETT22].

»Costs go down due to shorter cycle times with near-contour cooling with AM.«

The **assembly simplification and consolidation** is demonstrated by a case study conducted by the companies Fronius International GmbH, Pettenbach, Austria and SLM Solutions PLC, Lübeck, Germany. A cross-jet unit for protecting laser optics during a welding process originally consisted of 18 individual parts. The AM process PBF made it possible to reduce the 18-part assembly into a single component in one build job. In addition, the weight of the component was reduced by 70 %, costs were reduced by 45 %, and the need for sealing was eliminated [FRO22].

Applications

Furthermore, the participants were asked about current and prospective applications of AM in tool, die and mold making. **Injection molds** and **inserts** are the most commonly used application as well as the one that's seen as most promising by non-AM-users. Brazilian companies which do not use AM consider **stamping tools** as far more promising than German non-users do (BR: 24 %; DE: 3 %), while in Germany they are already used more than in Brazil (BR: 8 %; DE: 17 %). This indicates high potential for Brazilian companies regarding the implementation of AM for **stamping tools**. One possible use case is the repair of **stamping tools** by Directed Energy Deposition (DED).

Case studies show that the application of AM for **injection molds** and **inserts** leads to freedom of design for cooling channels and therefore a possible decrease of production cost and cycle times. Depending on the shape and size of the molded part, cooling time can be reduced up to 60 % with properly designed cooling structures.

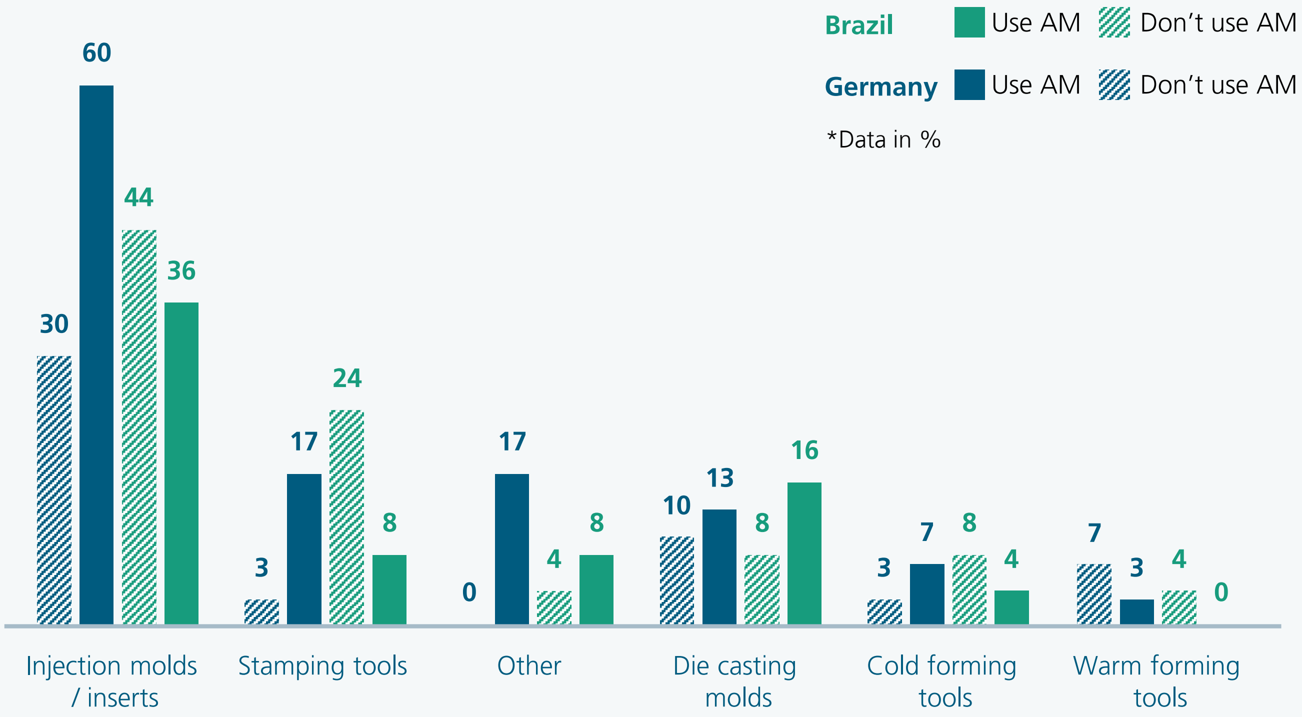
A case study by ZAHORANSKY AG, TODTNAU GESCHWEND, GERMANY and ADDUP INC., CINCINNATI, US, illustrates how additively manufactured injection molds can reduce cycle times. A total of 8 bores, each of which must be sealed with O-rings, were replaced by additively manufactured conformal cooling channels. The cooling channels have the same cooling capacity and length as the conventionally manufactured channels. Both the cycle time and the production time of the mold could be improved [ADD22].

Another example of how AM can reduce the cycle time of injection molds with the aid of conformal cooling is presented in a case study of the companies OSKAR FRECH GMBH, SCHORNDORF, GERMANY and SLM SOLUTIONS PLC, LÜBECK, GERMANY. The core for a die casting mold shows better performance and higher profitability compared to a conventional one [OSK22].

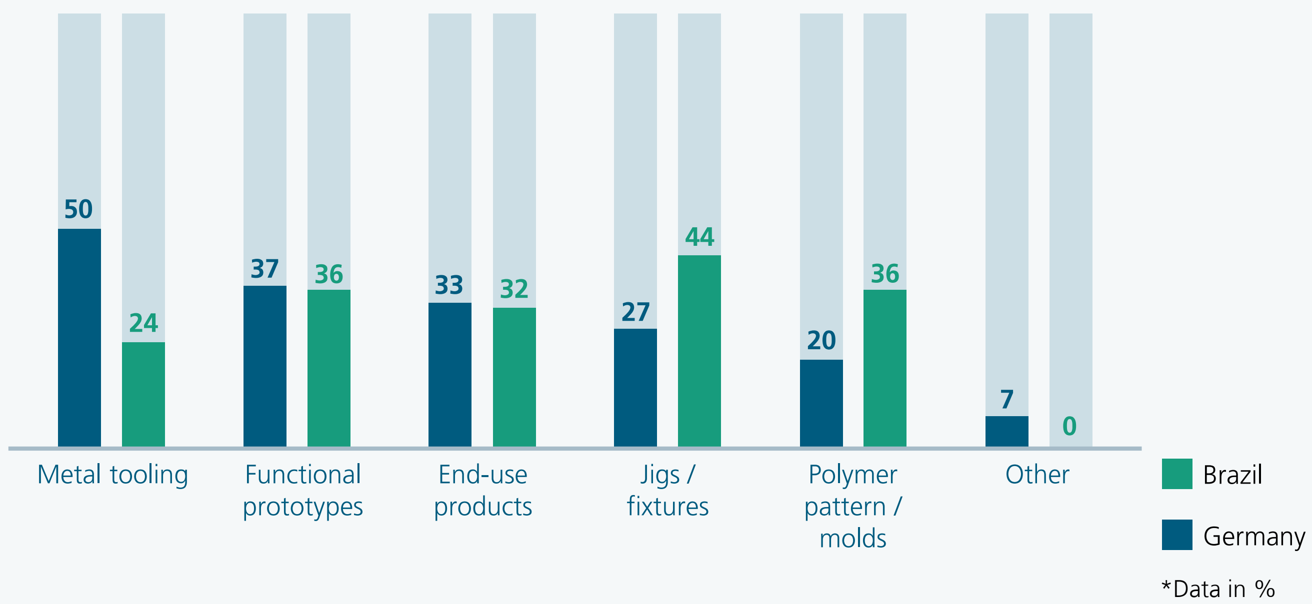
As the chart »AM Applications« illustrates, the most commonly used applications for AM in the surveyed Brazilian companies are **jigs** and **fixtures** (44 %) as well as **functional prototypes** and **polymer patterns** (36 % each). While in Germany half of the participants vote for **metal tooling** as an established application, it's only voted fifth place in Brazil. This clearly shows parallels to the different spread of material usage in the two countries: While the most voted materials in Germany are stainless and tool steels, Brazil equally uses polymers besides tool steels [CHART »Types of AM materials«]. As a result, AM for metal tooling is twice as common in Germany than in Brazil. The higher utilization of AM for polymer patterns in Brazil is therefore explained, considering the material usage.

»For mold inserts and sliders, AM was mainly used for conformal cooling.«

Type of tools, dies and molds for which AM is applied or where its implementation is most promising



AM applications



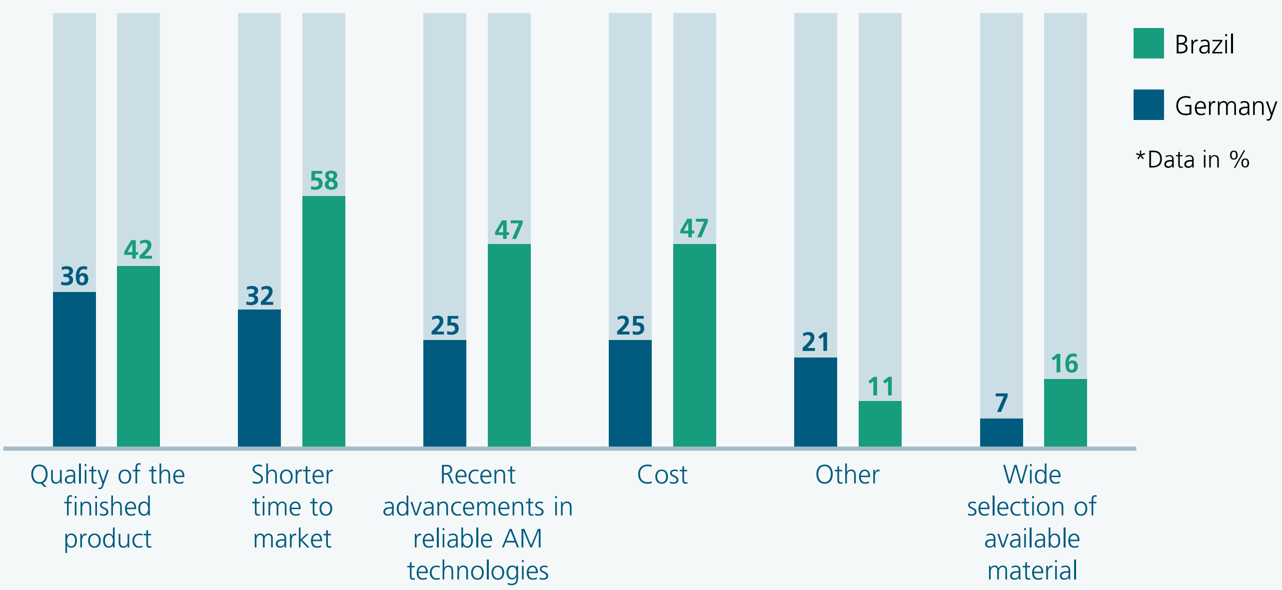
»The focus of the implementation was on reducing the injection cycle. We had great success in this implementation, with cycle reduction of more than 30 %.«

AM applications are often established to replace conventional manufacturing processes in production chains. The reasons for that are **shorter time to market**, **cost savings** and **recent advancements in reliable AM technologies**, according to the participants.

The Brazilian participants were almost twice as likely to see a benefit in **recent advancements in reliable AM technologies** and **costs** as the German participants. It seems that Brazilian companies are optimistic regarding further industrialization of AM.

It is noteworthy that the variety **of available materials** is voted last place in Germany and second last in Brazil with only 7 % and 16 % of votes, respectively. Consequently, expanding the diversity of material is an important challenge for future AM applications.

Benefits of AM compared to conventional manufacturing



Capabilities

Especially for small and medium-sized companies, it can be difficult to implement an entirely new technology to an existing production chain. The main challenges, according to the participants, are seen in the **technical knowledge** of the responsible staff as well as in the company's **strategic vision** during implementation. This is mentioned even before the **return on investment**, which indicates that the possibilities of AM are not yet fully known.

Regarding the technical knowledge of the staff working in the additive environment, opinions differ from Germany to Brazil. While German participants value **material science** and **CAD/CAM** skills highest, Brazilian companies also consider practical knowledge in **AM equipment operation** very important.

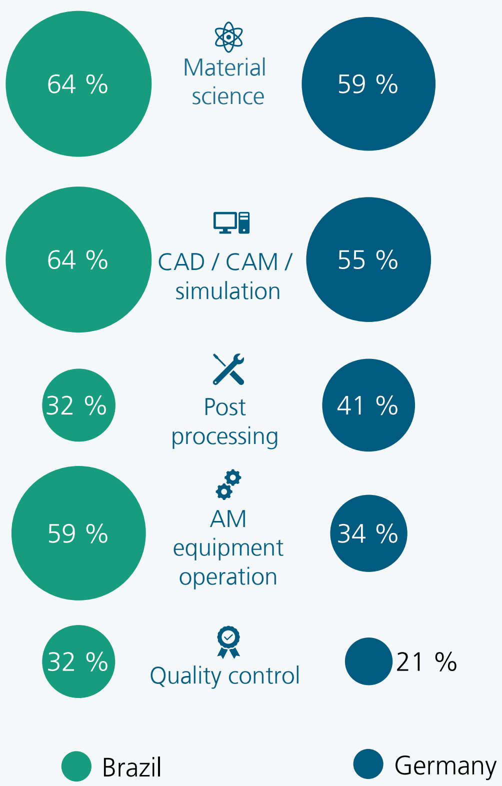
The importance of **material science** in both countries can be explained by the complex metallurgical phenomena in metal AM. Different materials require different process parameters as well as an aligned heat treatment.

Competencies in software are considered almost equally important, probably due to the Design for Additive Manufacturing (DfAM) philosophy and the need for simulation due to higher costs for empirical tests and the search for first-time-right processes in metal AM.

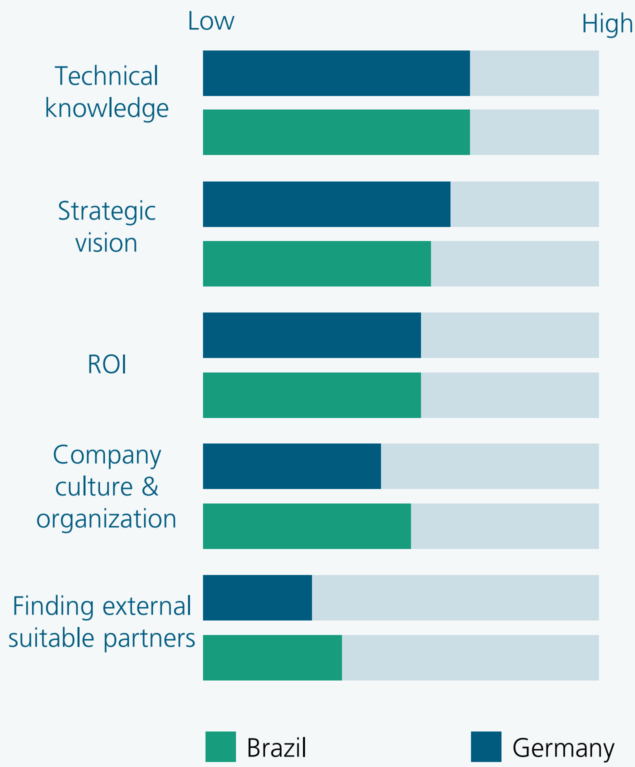
This results in a need for training and education of employees in Germany and Brazil. In Germany, the focus of training should be on material science and software, while in Brazil machine operation is also crucial. The different use of the machines can be seen in [CHART »AM machine configurations«].

The organizational structure for AM in the companies was evaluated by three additional questions. The first question focused on the employees for the AM process chain. It becomes clear that most companies train existing employees and that new employees are less likely to be hired specifically for AM. Furthermore, there is usually no specific department for AM in the companies.

Competencies for the technical staff



Aspects for a successful implementation of AM

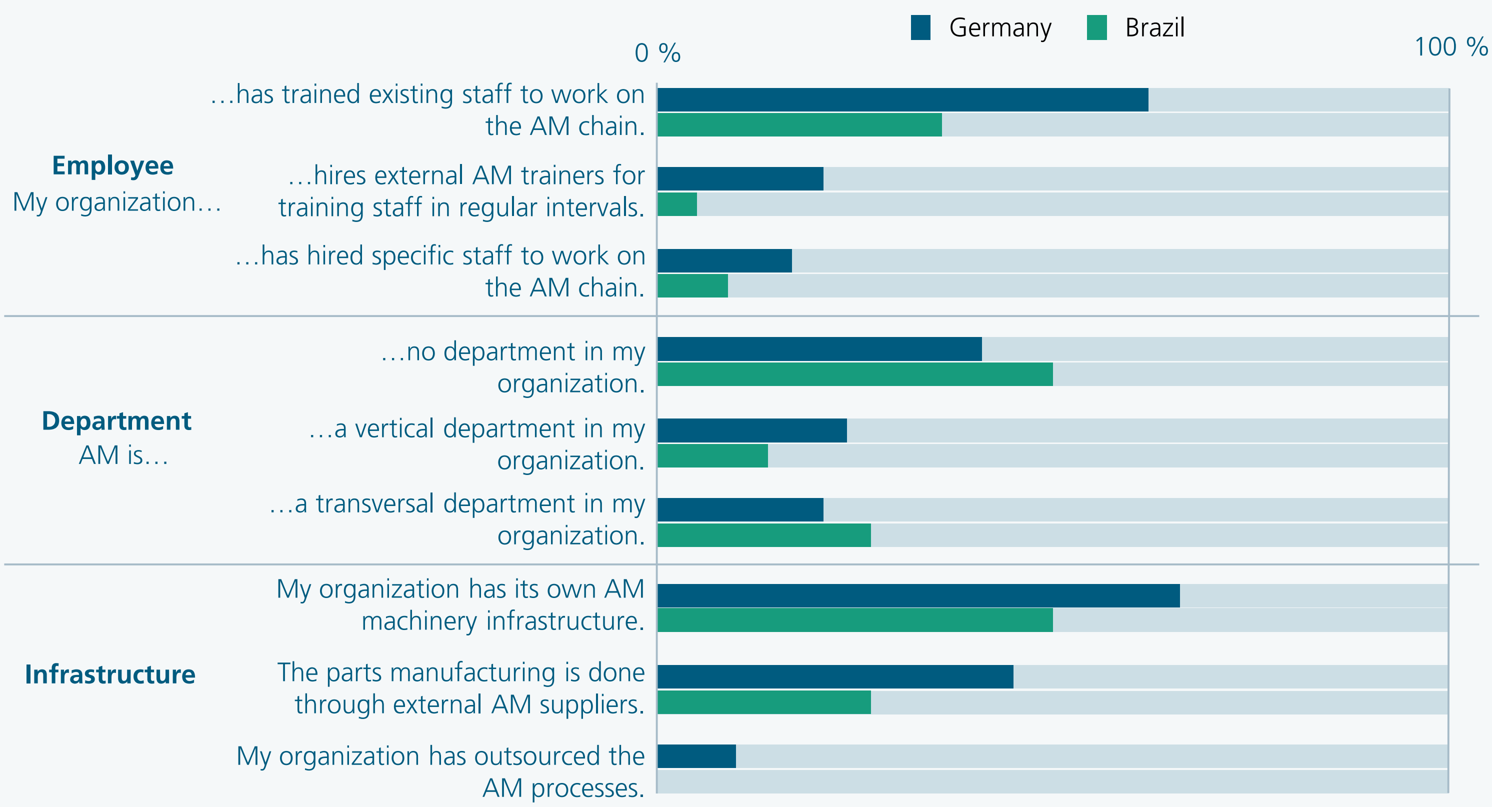


In Germany, the vertical department structure for AM predominates, whereas in Brazil the transversal department structure for AM dominates. This might be an indicative that German companies are creating specific departments and hierarchical functions to deal with AM technologies, whereas in Brazil companies tend to gather employees from existing departments to work on AM initiatives. Most companies have their own AM infrastructure, but a large proportion of components in Germany and Brazil are manufactured by external service providers. Some German companies have even outsourced their entire AM processes.

The analysis of capabilities within the companies leads to the question of the extent to which the companies believe that they already implemented an AM culture (see appendix »AM culture in the company«). It is striking that only a small proportion have established what they consider to be an adequate AM culture (DE: 20 %; BR: 6 %). In summary, the German companies tend to have a partial AM culture, whereas the Brazilian companies in the survey tend to have a less pronounced AM culture.

»AM parts in internal operating equipment are largely made from polymer.«

Organizational structure for AM

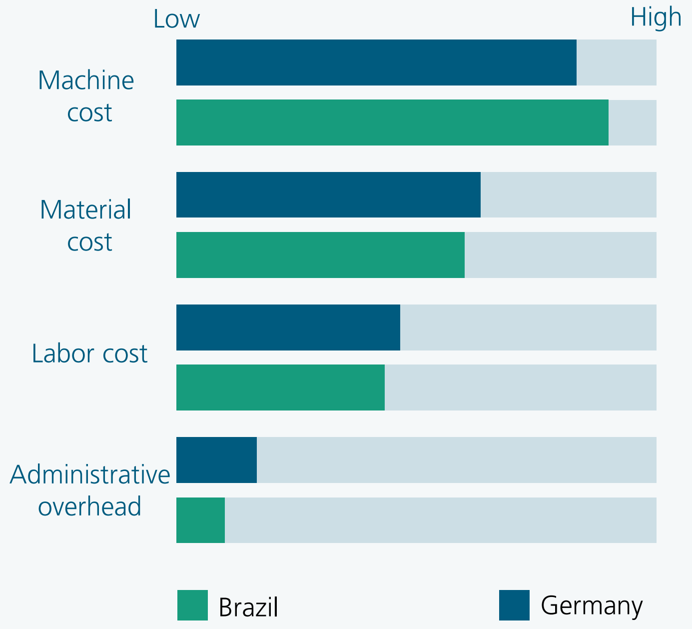


Hardware and Costs

The third part of the interview focuses on hardware and costs of Additive Manufacturing for tool, die and mold making.

If companies want to invest in AM and even acquire their own infrastructure, the cost aspect is inevitably decisive. Furthermore, the technologies and associated materials to be invested in must be planned on a case-by-case basis. The following diagram highlights the main cost drivers that will occur. Machine costs are considered the most decisive costs in both Brazil and Germany. Material costs are also a relevant cost driver in both countries. Labor cost seems to be less important and the administrative overhead is by far the least important cost.

Impact of cost aspects of additively manufactured products



Machines and their costs

Like illustrated before in [CHART »AM applications«], in Germany mainly finished tools and end products are manufactured using AM, whereas in Brazil mainly operating and auxiliary materials as well as prototypes are manufactured. This is also reflected in the machine equipment used and the resulting cost. Almost half of the AM users in Germany state that they use the very large **production systems**. In Brazil, on the other hand, none of the respondents resort to this very large form of plant technology. Around a quarter of the respondents in Germany and Brazil each use the somewhat smaller **shop systems**. In Brazil, the proportion of those resorting to **experimental setups** and **other** systems is larger than in Germany. This could be due to the greater use of polymers compared with metals, as shown in [CHART »Type of AM materials«]. This could be due to the different distribution of the companies' industries or the fact that AM is used less often from Brazilian participants and therefore the benefits are assessed differently.

In another question, the average component dimensions were asked (see appendix »Average component dimension«). It is noticeable that significantly more companies in Brazil manufacture components smaller than l = 50 mm additively (X-Y: 17 %; Z: 33 %) than it is the case in Germany (X-Y: 4 %; Z: 8 %). Most companies report component sizes between l = 100 mm and l = 150 mm, which indicates, among other things, the very widespread Powder Bed Fusion (PBF) process [CHART »AM technologies«]. Very large components over l = 350 mm are more widespread in Germany (X-Y: 20 %; Z: 20 %) than in Brazil (X-Y: 17 %; Z: 8 %).

The distribution of equipment is also reflected in the costs. In Brazil, the majority of respondents report using very low cost machines with a price below **50,000 €**. Machines for processing polymers are mainly offered in this price range. Furthermore, new companies are appearing to offer nationally AM metal systems. In Germany, low-cost machines are much less represented. There, the proportion of medium-priced and, above all, high-priced machines with costs over **300,000 €** is more pronounced. This is probably due to the increased use of metals for AM of end products and finished tools.

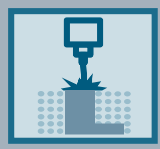
»

For tools with higher dimensions, we usually select a critical part region for AM-optimization. It doesn't make sense to additively manufacture 50 kilograms of steel.«

In another question, participants were asked about the Return On Investment (ROI), which they felt was suitable for an AM setup (see appendix »Suitable ROI for an AM setup«). 75 % of the German respondents indicate 3 years to 5 years, 13 % see a positive ROI after more than 5 years. In Brazil, on the other hand, ROI is expected to be achieved much sooner. Just over a third see 6 months to a year as realistic and another third after 3 years to 5 years. There might be a correlation between the faster expected ROI and the lower adoption of AM in Brazil, since business models tend to be more selective and hard to find. It can be assumed that larger companies tend to consider a ROI after a longer period to be acceptable compared to smaller companies.

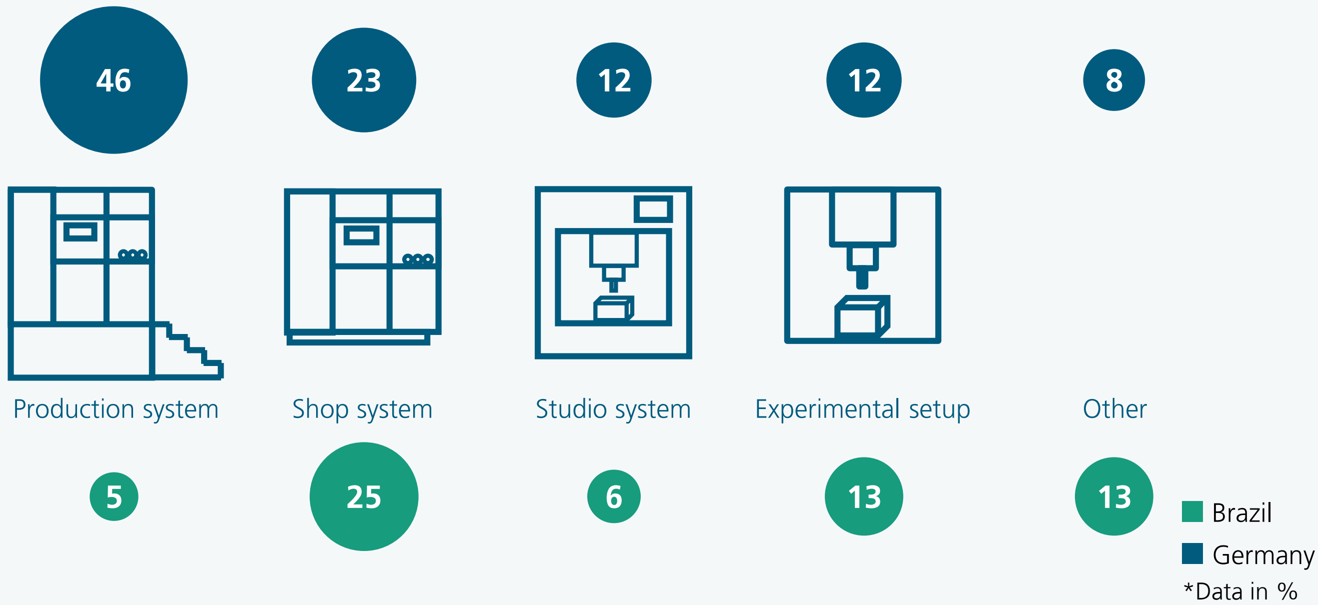
For a comprehensive answer to the question of costs, it must be taken into account how precisely these can be recorded within the companies in the first place. In many cases, manual work steps such as setting up the machine or reworking cannot be precisely quantified in terms of price. The costs of experimental plant developments are also often difficult to quantify. For this reason, a further question was asked to determine how precisely the companies track their costs (see appendix »Cost tracking throughout the AM value chain«). In fact, more than one third of the respondents in Brazil and Germany state that they track costs only partly. Of the German companies, 13 % do not even record their costs at all. On the other hand, only 13 % record their costs accurately.

PBF

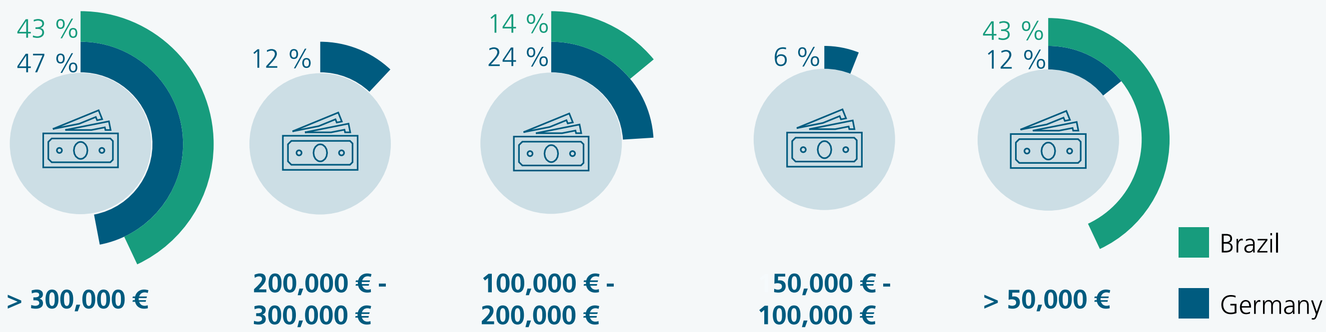


Powder Bed Fusion (PBF): Additive Manufacturing process in which thermal energy selectively fuses regions of a powder bed [DIN52900].

AM machine configurations



Average prices of AM machines

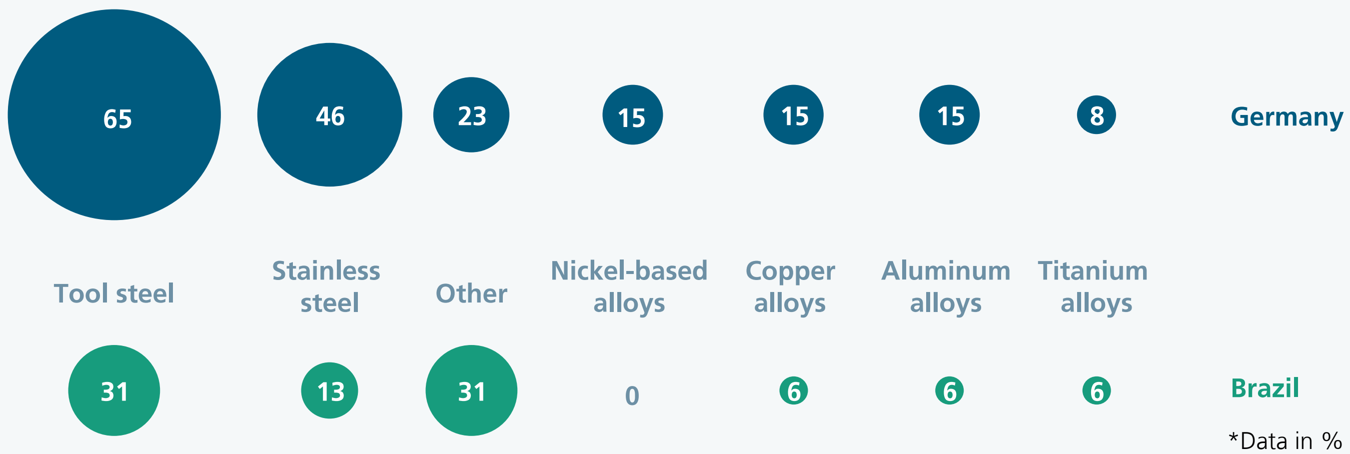


Materials and technologies

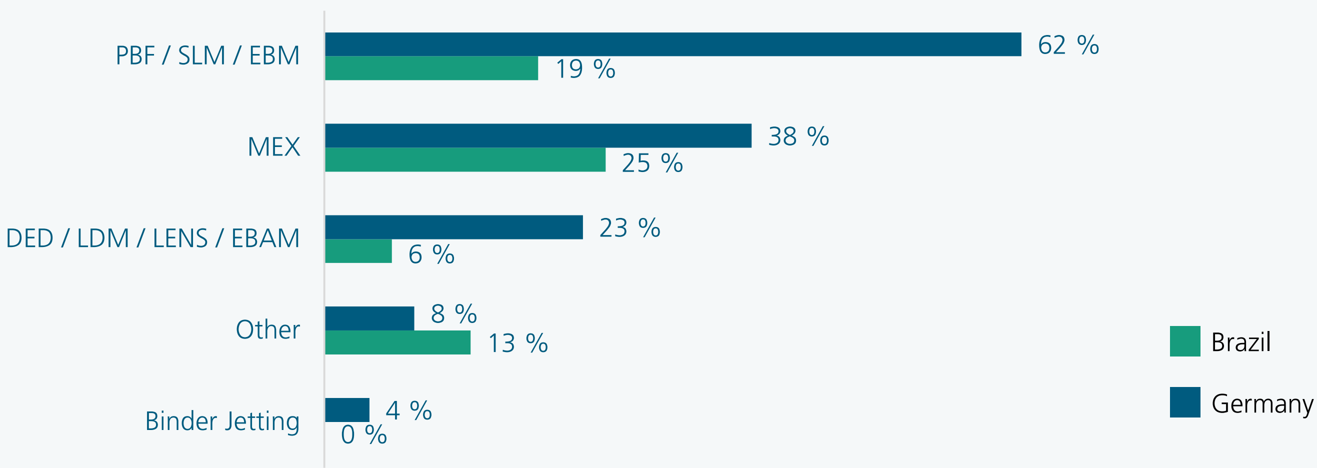
The use of materials is closely linked to the AM technology used. In Germany, just under two thirds of the respondents use tool steels and almost half use stainless steels. Two very widespread technologies are thus Powder Bed Fusion (62 %) and Directed Energy Deposition (23 %). In Brazil, on the other hand, polymers are most probably the most used (other: 31 %), which is why a quarter and thus most of the respondents here use Material Extrusion (MEX). High-end materials such as high-strength titanium aluminides or heat-resistant nickel-based alloys are much less common in both countries. The difficult-to-weld materials aluminum and copper alloys are also less common.

> **For AM to become more widespread in the tool and die industry, materials and speed must improve.«**

Types of AM materials



AM technologies



Current challenges

The fourth part of the interview focuses on current challenges of Additive Manufacturing in the field of tool, die and mold making.

The following pages highlight the challenges of AM compared to conventional manufacturing processes. First, pre-processing and essentially software-related challenges will be discussed. Subsequently, post-processing and quality assurance will be analyzed, among other things, under the aspect of challenges. Finally, the main challenges of AM in tool and die making are presented and whether conventional processes are being replaced by additive ones.

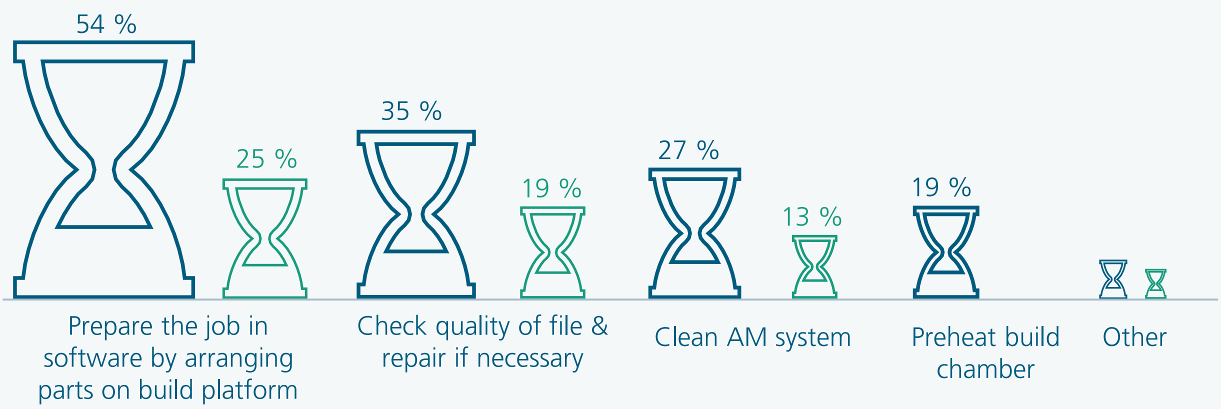
Pre-processing

By far the most time-consuming pre-processing task is directly linked to the usage of the corresponding software. **Preparing the build job and arranging the parts on the build platform** is a very challenging task that can be handled by different software tools. The most widespread tool which more than half of the participants in Germany use is **Magics by Materialise NV**. This software tool is also very common in Brazil, although machine proprietary systems are also widely used. Another time-consuming task is the **quality check and repair of the part files**, which is also performed within the software systems. It can thus be stated that the main time drivers in pre-processing are digital in nature, which is why the software tools used are of particular importance.

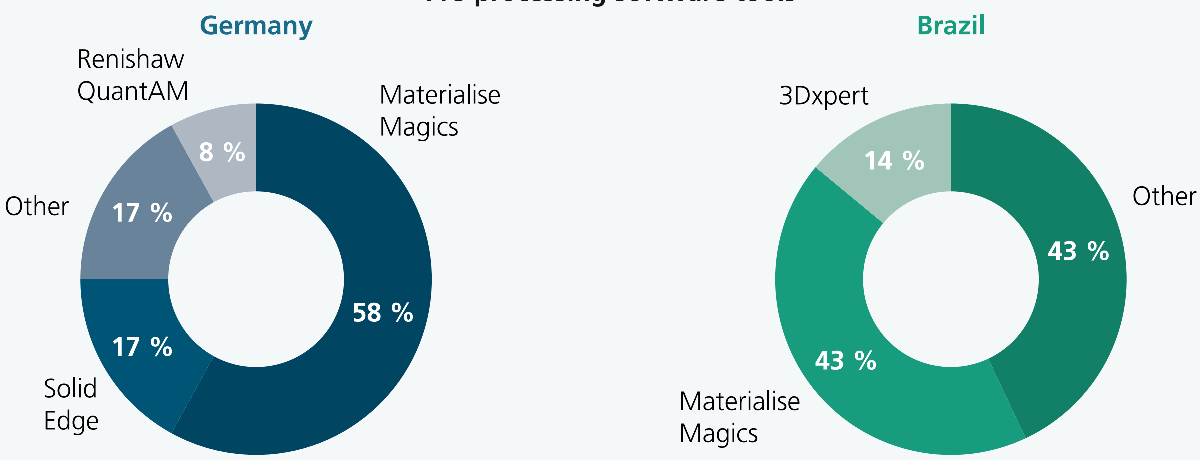
DED

Directed Energy Deposition (DED): Additive Manufacturing process in which focused thermal energy is used to fuse materials by melting as they are being deposited [DIN52900].

Time consuming pre-processing steps



Pre-processing software tools



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»

A successful implementation of AM in tool, die & mold applications doesn`t only depend on AM technologies itself, but most importantly on the whole engineering process needed for optimum tool design.«

Post-processing

The importance of post-processing can be seen in the time it takes to complete it (see Appendix »Average time for post-processing«). In Germany, all the companies surveyed said they needed at least one hour. 56 % of them need 1 hour to 3 hours, 17 % 3 hours to 6 hours and 17 need more than 6 hours. In Brazil, 9 % of respondents say they need less than one hour for post-processing. The majority of respondents in Brazil need between 1 hour and 9 hours for post-processing.

»

Post-processing had to be taken into account as early as the mold design phase.«

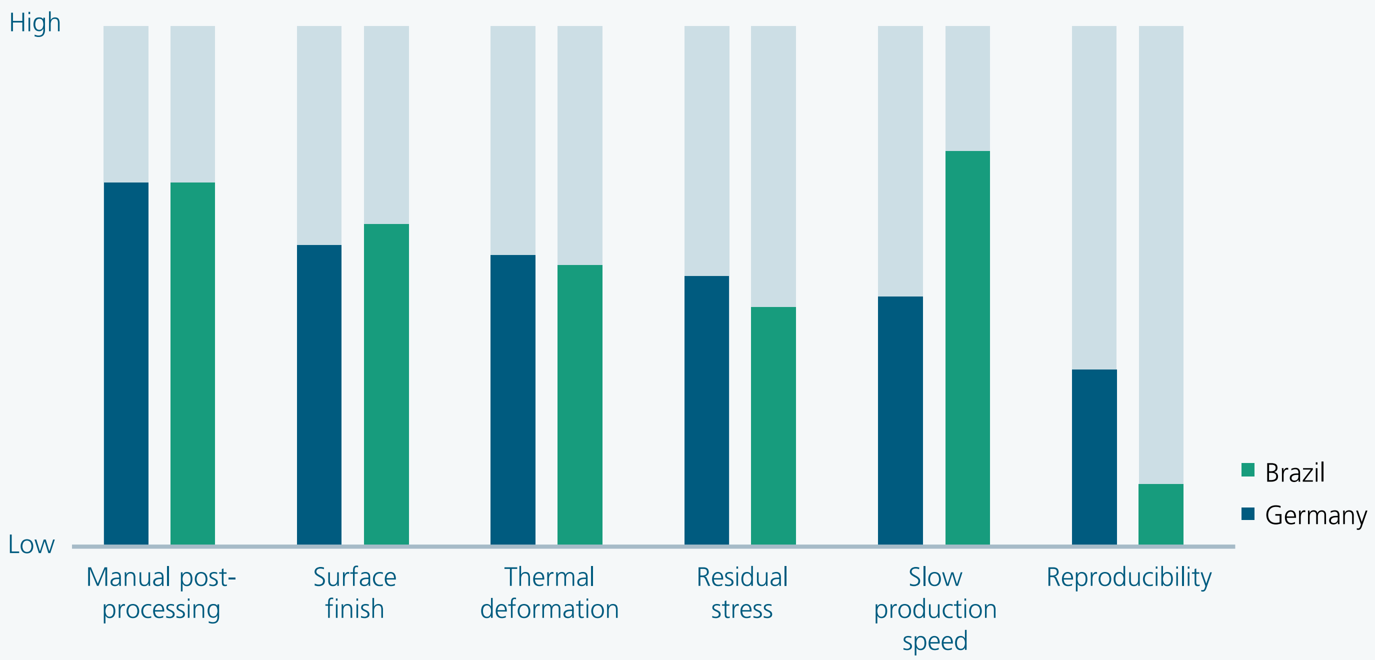
Manual post-processing is seen as one of the key challenges of AM in tool and die making in both countries. The categories surface finish, thermal deformation and residual stress are considered almost equal in importance. There are major differences with regard to the assessment by Brazil and Germany in the categories **slow production speed** and **reproducibility**.

A broader portfolio of different post-processing technologies is used within the German companies. More than two thirds use **turning and milling** and almost two thirds have to **remove support structures** in Germany. **Surface finishing** by means of **polishing** and **blasting** is carried out by 35 % of German companies in each case. In Brazil, the widespread use of polymers is reflected in a lower need for finishing. Blasting processes, however, are relatively widespread in Brazil at 31 %. The very expensive heat treatment process **hot isostatic pressing (HIP)** is used very little in both Germany and Brazil. Less than half of the companies use turning and milling for finishing, and only a quarter of the companies surveyed remove support structures or polish the component in each case. While slow production speed is considered a greater challenge in Brazil, German companies are more concerned with reproducibility issues.

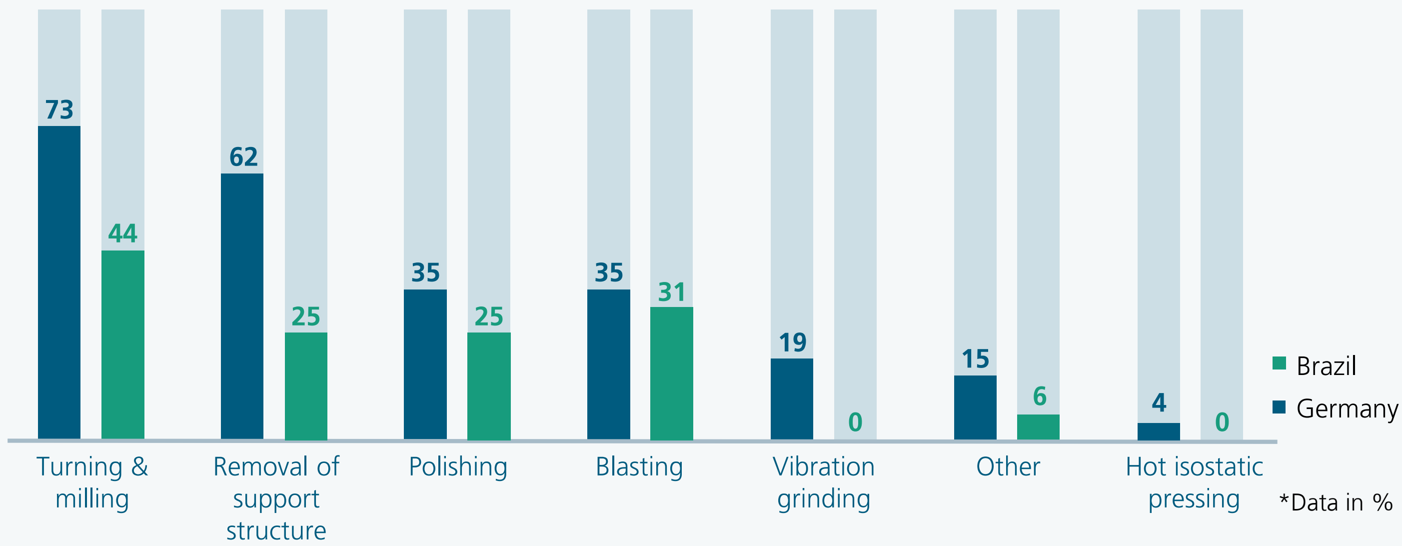
BJT

Binder Jetting (BJT): Additive Manufacturing process in which a liquid bonding agent is selectively deposited to join powder materials [DIN52900].

Process challenges for the use of AM in tool, die or mold making



AM post-processing steps



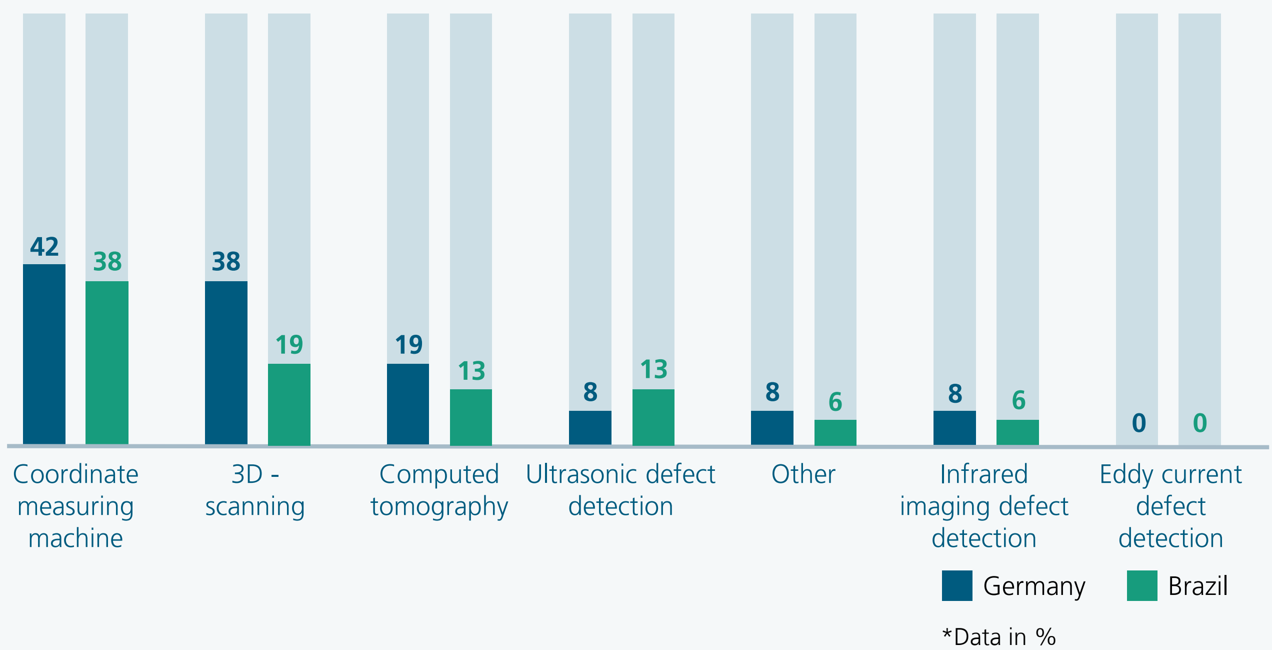
Quality Assurance

Non-destructive defect detection is of major importance in AM due to the very low quantities or even single component production. The most widespread is the verification of surface deviations with coordinate measuring machines. Only half as many Brazilian as German companies use **optical measurement** or **3D-scanning** of components. **Computed tomography**, probably the most expensive but also the most informative quality control for additively manufactured components, follows in third place in Brazil and Germany. Other methods such as **ultrasound**, **infrared** or **eddy current** are still the subject of research in many cases and are therefore less widespread industrially.

MEX

Material Extrusion (MEX): Additive Manufacturing process in which material is selectively dispensed through a nozzle or orifice [DIN52900].

Non-destructive defect detection

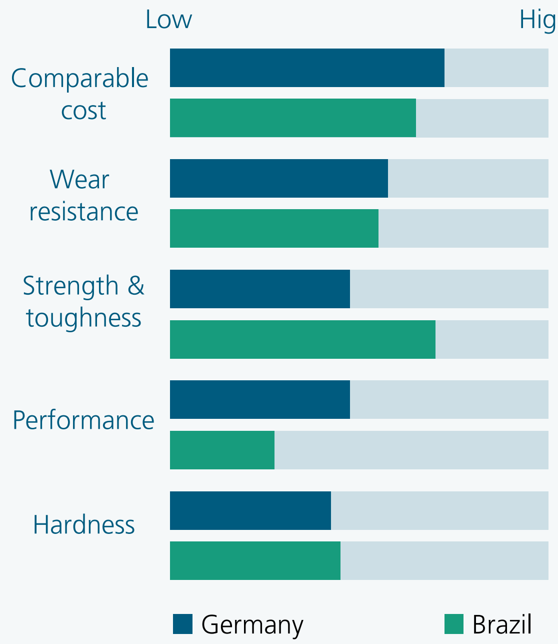


Comparison to conventional manufacturing (I/II)

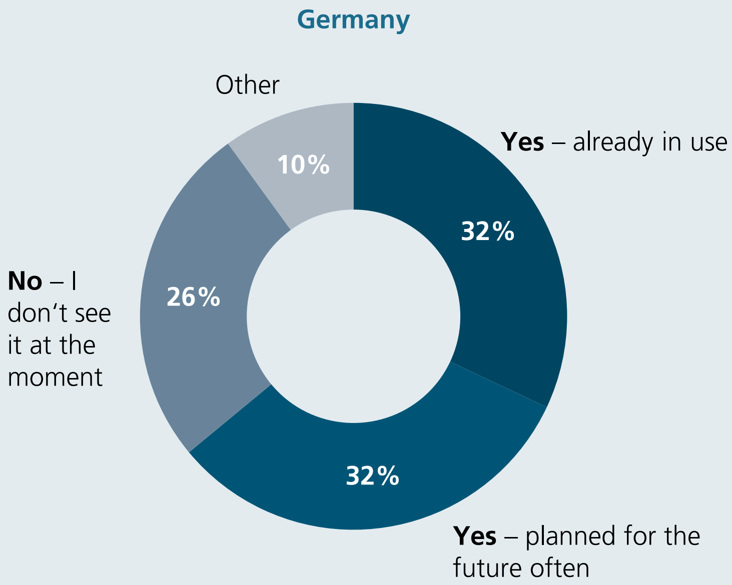
AM still has some significant challenges to overcome in order to gain widespread acceptance in the tool, die and mold industry. The most important aspect is the **comparability of costs** to conventional manufacturing methods.

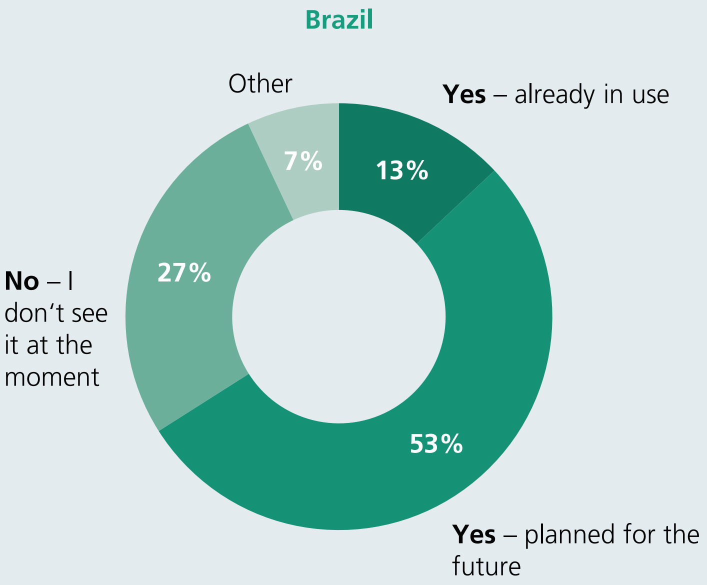
In Brazil and Germany, the **wear resistance** is also still a major challenge compared to conventional processes. The majority of the Brazilian participants also perceive the **strength and toughness** as not yet comparable with conventional processes. This appears to be less of a challenge for German companies.

Difficulty in achieving the following parameters with AM compared to conventional manufacturing



Replacement of conventional manufacturing processes with AM





Comparison to conventional manufacturing (II/II)

Considering the challenges that AM still presents in tool, die and mold making, it is not surprising that only 32 % of German companies have already replaced conventional manufacturing processes with additive ones. This figure is significantly lower than the 89 % of German participants that state to use AM [CHART »Companies using AM]. One possible interpretation is that companies are using AM in very specific applications rather than trying to replace conventional processes with AM.

It is noticeable that the proportion of those planning to replace conventional processes with AM is significantly higher in Brazil than in Germany (BR: 53 %; DE: 32 %). This suggests that there is still great potential here for the introduction of AM processes. In particular, the use of AM in the area of stamping tools seems to be promising [CHART »AM applications«].

Conclusion

The study provides a broad overview of the use of AM in tool, mold and die making. Potentials but also challenges were identified. Furthermore, specific differences between Brazil and Germany were highlighted.

While in Germany many business cases have already been identified and put into practice, in Brazil there is still a high potential for injection molds and stamping tools. In both countries the companies tend to train existing staff instead of hiring new people for AM.

The main cost drivers are in both countries the machine and material. The most widespread technology for AM in tool and mold making in Germany is PBF, which is why mostly large production or shop systems are used with costs often exceeding 300,000 €. Tool- and stainless steels are therefore mainly used on these machines in Germany. In Brazil, many companies also use PBF and systems with costs greater than 300,000 €, but the technologies are somewhat more diversified. Polymers and tool steels are used in roughly equal proportions, and small AM machines and experimental setups are often used as well (up to 50,000 €).

Two main challenges of AM compared to conventional manufacturing in tool and die making were identified. These are the comparable costs and the high level of post-processing required for AM. For this reason, not many conventional manufacturing processes were replaced in Germany, but rather specific additional use cases and business models for AM were found. In Brazil, more than half of the companies surveyed plan to replace conventional manufacturing processes with AM processes in the future. This indicates a great potential especially for AM processes for injection molding and stamping tools.

Acknowledgement

Fraunhofer IPK would like to thank all companies that anonymously answered this survey as well as the Aeronautics Institute of Technology (ITA) and the Brazilian National Die & Tooling Association (ABINFER) for their technical feedbacks and support in promoting this assessment to relevant sectors of the Brazilian industry. We would also like to thank the Verband Deutscher Werkzeug- und Formenbauer e. V. (VDWF) for disseminating the survey in Germany.

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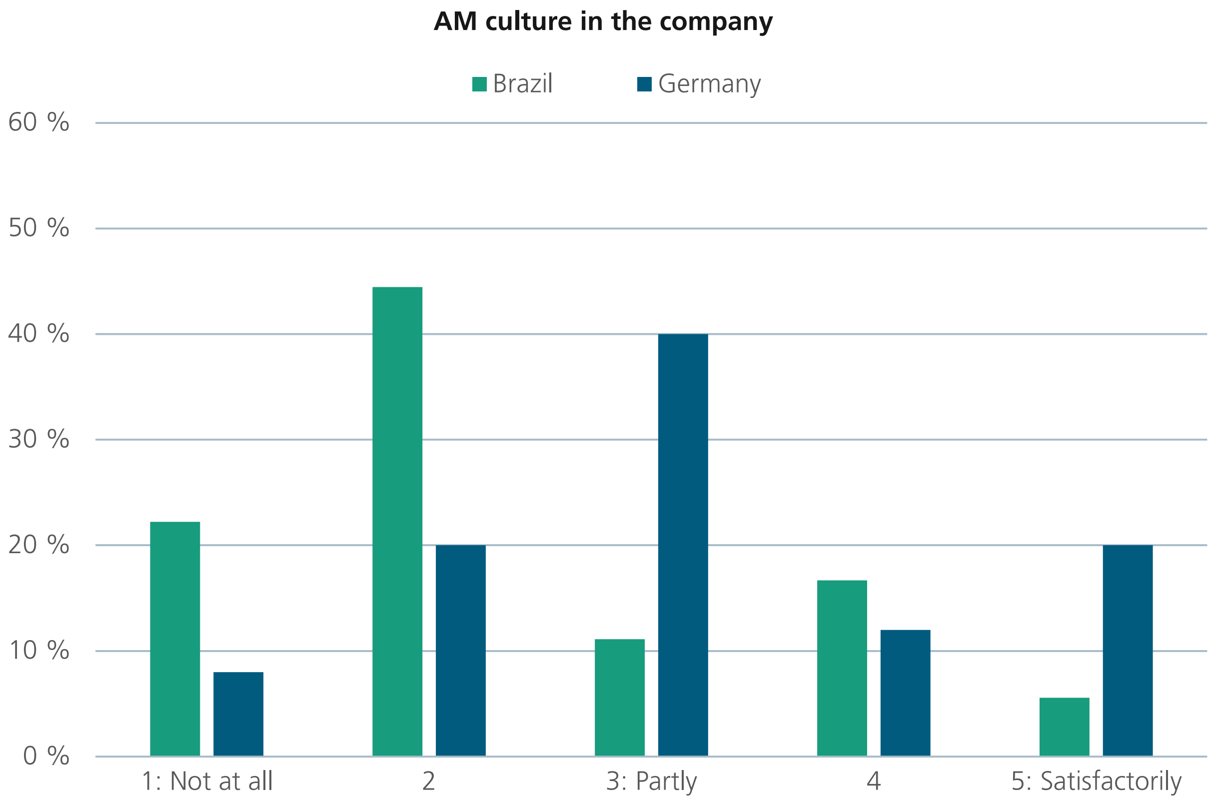
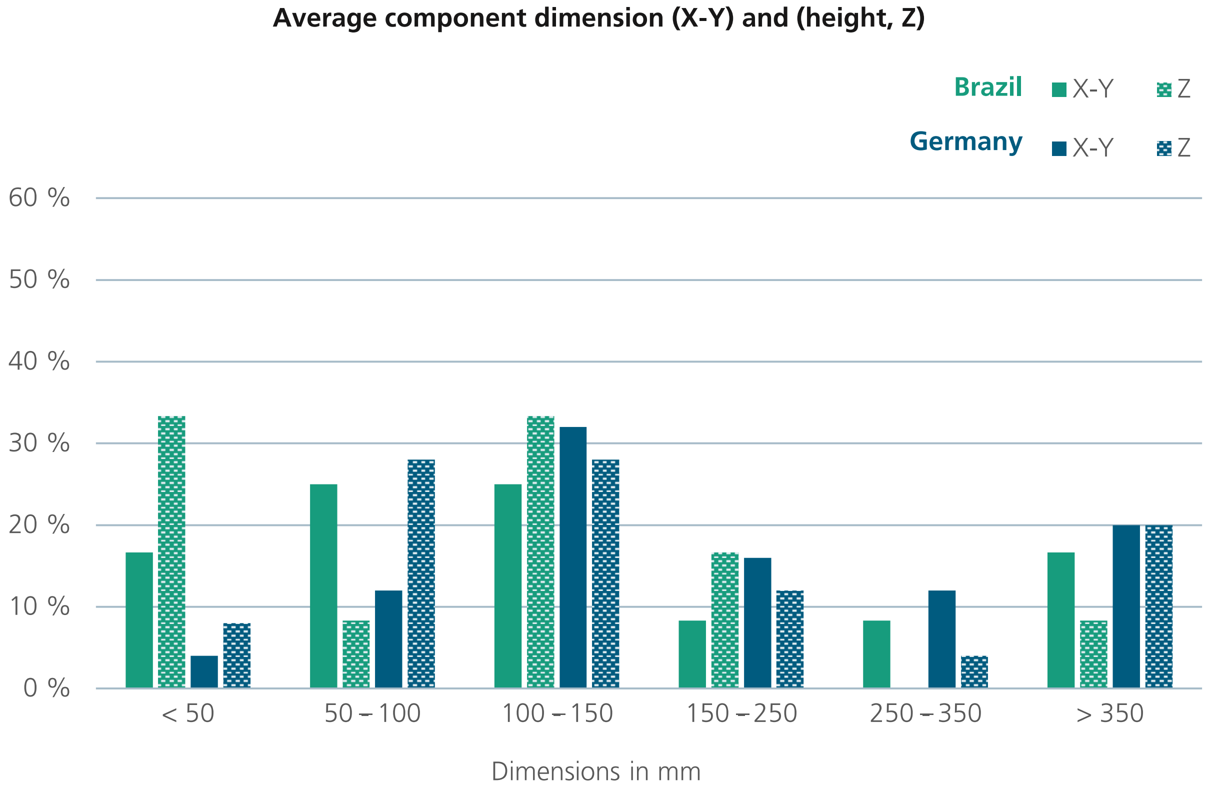
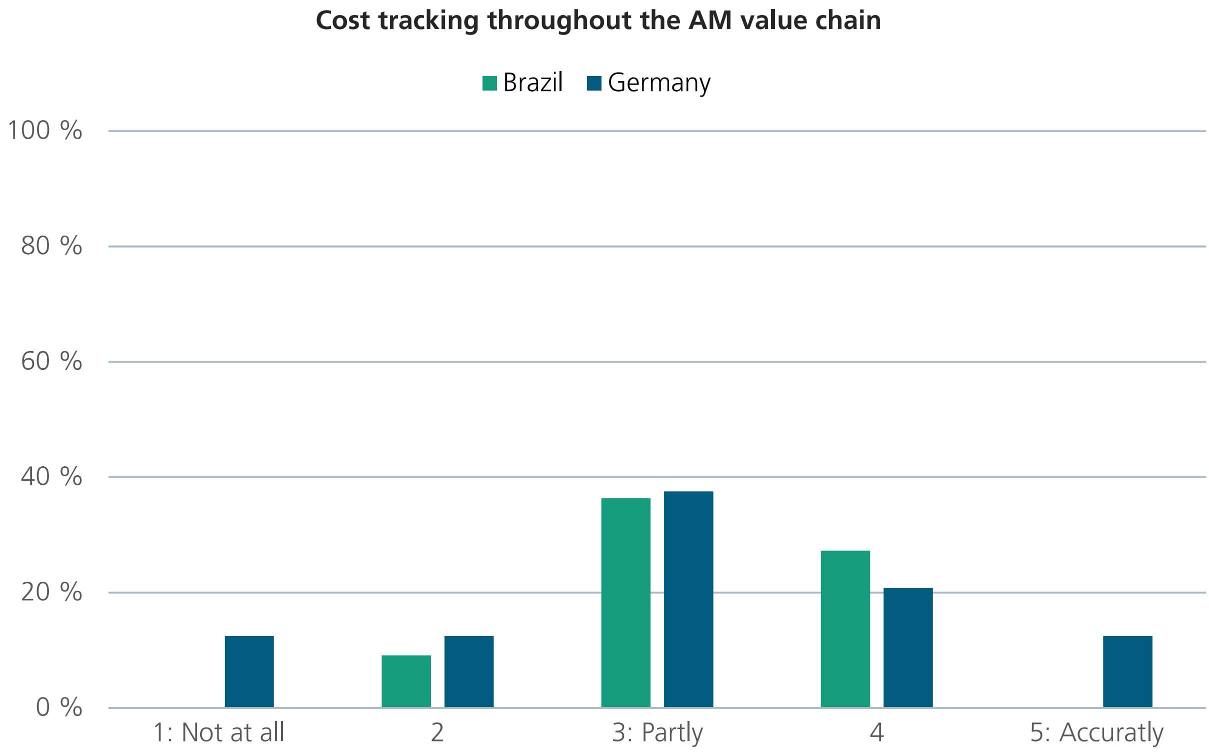
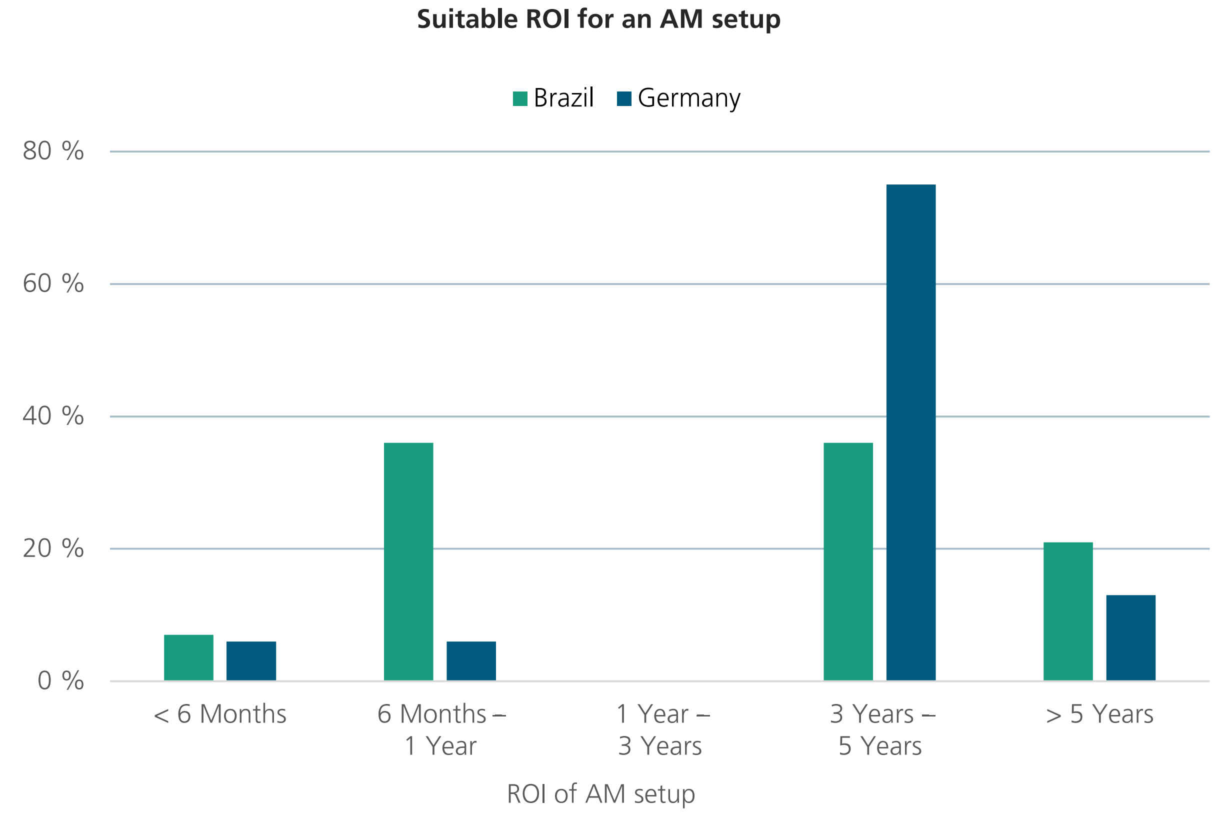
Appendix

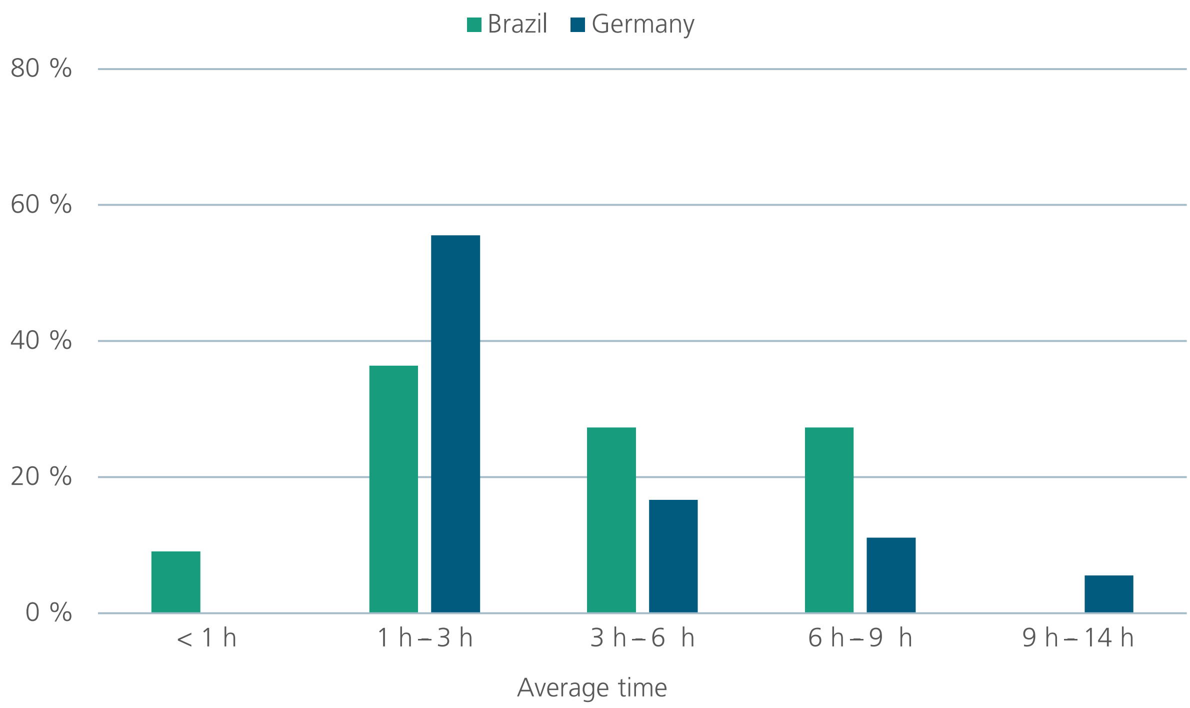

AM culture in the company
Brazil
Germany
60 %
50 %
40 %
30 %
20 %
10 %
0 %
1: Not at all
2
3: Partly
4
5: Satisfactorily


Average component dimension (X-Y) and (height, Z)
Brazil
X-Y
Z
Germany
X-Y
Z
60 %
50 %
40 %
30 %
20 %
10 %
0 %
< 50
50 – 100
100 – 150
150 – 250
250 – 350
> 350
Dimensions in mm

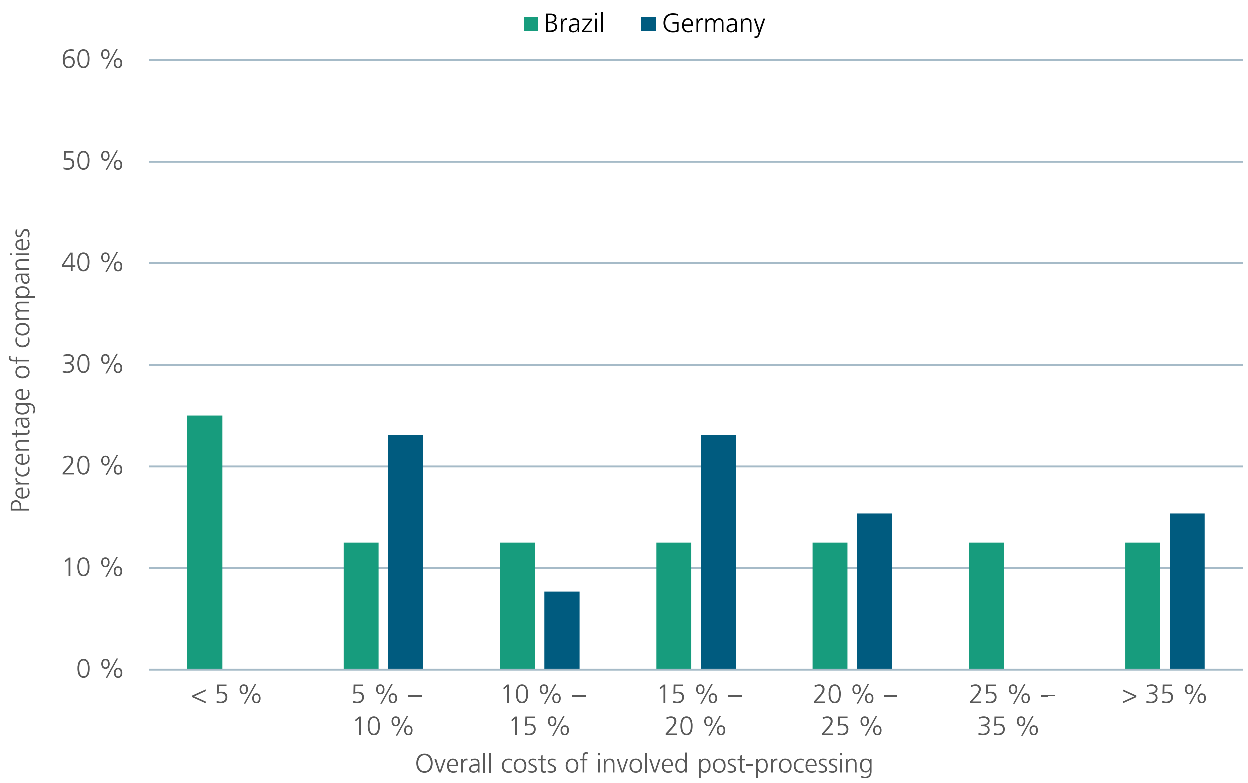

Cost tracking throughout the AM value chain
Brazil
Germany
100 %
80 %
60 %
40 %
20 %
0 %
1: Not at all
2
3: Partly
4
5: Accuratly


Suitable ROI for an AM setup
Brazil
Germany
80 %
60 %
40 %
20 %
0 %
< 6 Months
6 Months – 1 Year
1 Year – 3 Years
3 Years – 5 Years
> 5 Years
ROI of AM setup

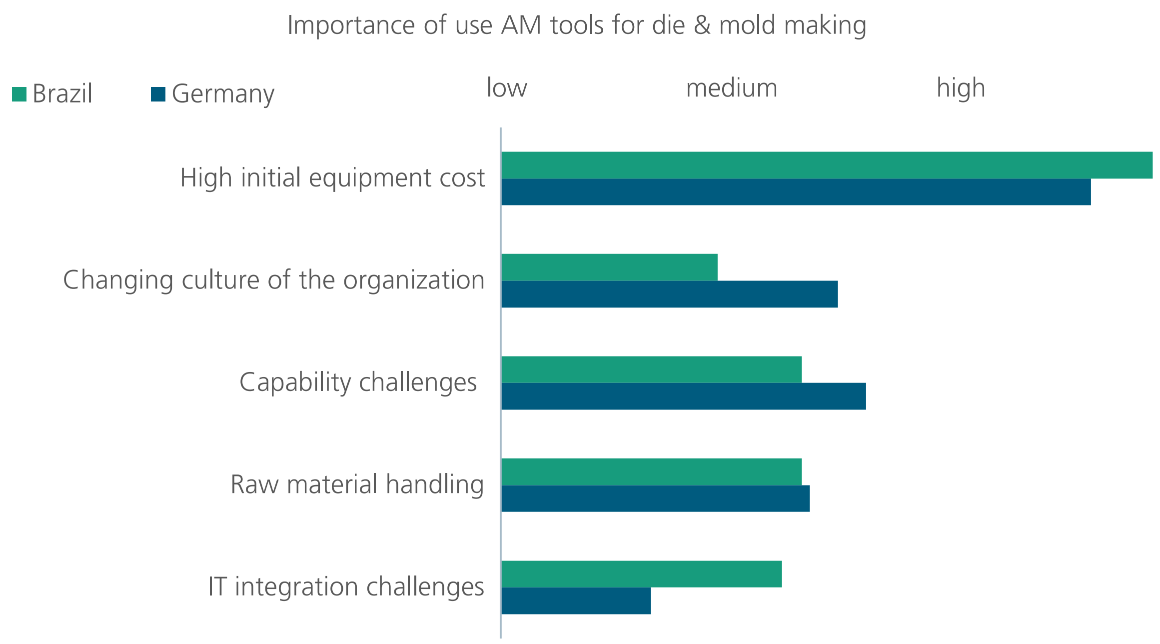
Average time for post-processing



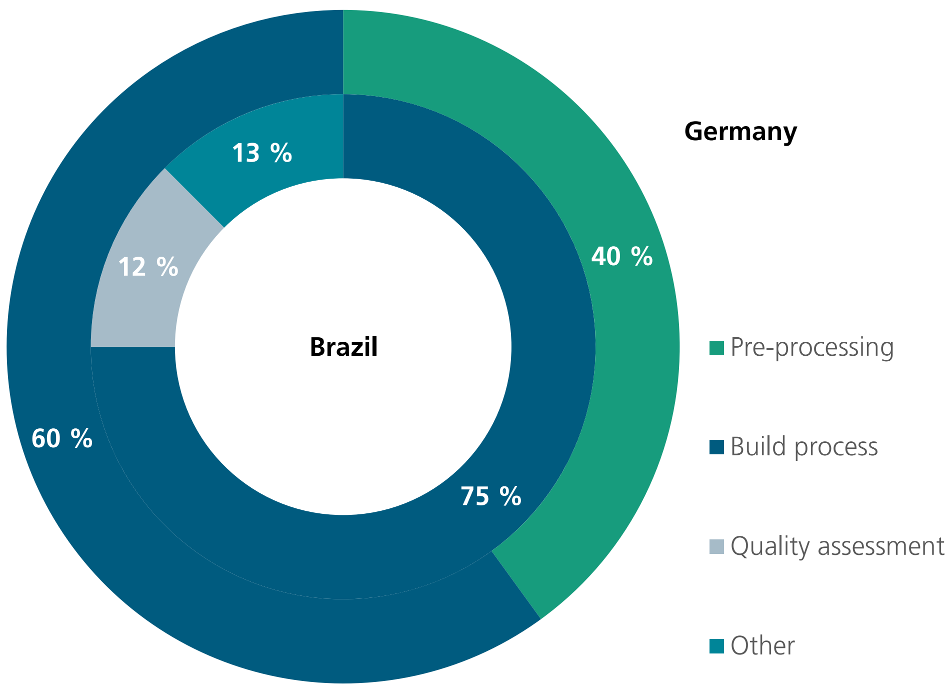
Overall costs for post-processing



Infrastructural hurdles for the use of AM in tool, die and mold making



Most expensive step in the AM production chain



Imprint

Market and technology report 2022:
Additive Manufacturing enabling
advanced tool, die and mold making

DOI: 10.24406/publica-3041

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