Project No. 2019-1-DE02-KA202-006099

mes Training Curriculums

INDI4.0 Project Stuttgart | 06/2021 Workshop documents Intellectual Output “IO2”

Additive manufacturing

Existing additive manufacturing equipment

Stratasys dimension sst 1200es	(FDM)
Stratasys objet350 connex3	(Polyjet Tech.)
Trumpf TruPrint 1000	

Learning situation:

Competence area / subject:	Research and present professional competence / production technology, construction, project competence / information
School type / occupational field / occupation:	Professional school; TPD-MAK; TPD-PGK (tested with TPD-MAK) technical school for machine technology
Curriculum / learning area reference:	Technical product designer TPD-MAK: LF3; LF6; LF8; LF9; LF13 Educational plan for the technical college, specializing in machine technology: - construction - production technology

Reference to the handout "Industry 4.0 - Implementation in the classroom"

- scenario:	1		
- Requirement area:	1		
Time range:	6 TU [TU ≅1 double lesson; 90 min]		[Number] UE
Learning factory:	Festo learning factory		(wss)
	Existing additive manufacturing equipment		
	Stratasys dimension sst 1200es	(FDM)	(mes)
	Stratasys objet350 connex3	(Polyjet Tech.)	(mes)
	Trumpf TruPrint 1000	(SLM)	(mes)
Technical settings:			
Software:			

Brief description and learning objectives this lesson sequence:
Basics and various processes for additive manufacturing, processes for additive manufacturing, FDM modeling

Goal analysis for the binding classification in the learning area lessons / for the course planning:

competency-based goals (1: 1 from BP)	Contents (1: 1 from BP)	Action result	interdisciplinary skills
Developing components made of plastics taking into account primary and forming processes in the context of assemblies	• Pupils inform themselves about different procedures to the emergence of Components • find out about The necessities Work steps for Production of components • find out about the associated costs • find out about the duration to generate of components	• Collect informations and a chain of Assign processes • Complexity of Recognize processes and classify • Being able to understand and explain the working methods of manufacturing processes	• Evaluate and evaluate of information • Representation and presentation of technical information and contexts

Progress planning

Methodical and didactic information

duration	phase	What is learned Desired competencies	How do you learn? Action of the teacher	Action of the pupils	media	material	Cooperation, notices, Explanations
0.25	E.	Leading example bit box:	L informed	...	B (O)	Picture, ...	...
0.25	E.	Classification of manufacturing processes:	L informed	...	B (O)	Slide, picture, ...	...
0.50	ERA	• Assignment: • Additive manufacturing • Subtractive manufacturing	- / -	EA • Collect informations • Associate information • Work out the difference between additive and subtractive manufacturing	B (O)	Slide, picture, ...	...
0.50	ERA	• Knowledge of how subtractive manufacturing processes work	AA	• Collect information and assign it to a chain of processes • Recognize and classify the complexity of processes	Pc	DK	...
0.50	ERA	• Knowledge of how additive manufacturing processes work	AA	• Collect information and assign it to a chain of processes • Recognize and classify the complexity of processes	Pc	DK	...

Progress planning

Methodical and didactic information

duration	phase	What is learned Desired competencies	How do you learn? Action of the teacher	 Action of the pupils	media	material	Cooperation, notices, Explanations
1.50	BA	• Determine the available range of devices • Record the process used by each device for additive manufacturing • Determine and document additive manufacturing processes	AWAY	GA • Prepare PR to classify the additive manufacturing processes according to the technology used	AA; AWAY; Internet research	PR	• Additive manufacturing • Market research on available devices
1.50	BA	• Weigh the advantages and disadvantages of the procedures against each other and document them	AA	• Classify GA \, document and present evaluated information	Internet research, create PR	PR	• Comparison of additive and subtractive manufacturing
0.50	K; R.	• When should which manufacturing process be preferred?	AA	• GA \ evaluate and classify the properties of the processes for their targeted selection	DK, PR	DK, PR	...

Leading example bit box

The components required for a bit box are to be manufactured in the I4.0 learning factory.

The picture on the right shows the bit box without inserted bits and without a bit holder.

Each component can be manufactured from a selection of 9 colors and 6 different bits can be selected from a selection of currently 9 available bits and placed in different positions in the bit box.

This means a large number of variants or, for the individual components, only small quantities down to a lot size of 1.

Image: Example of a bit box (Image source: mes Stuttgart)

Due to the small number of pieces for the individual components, conventional manufacturing processes appear complex and too expensive to manufacture.

For this reason, additive manufacturing (3D printing) is chosen as the manufacturing process, as this process appears to be more suitable for small quantities.

In order to be able to decide which of the available processes is suitable, information about the possible additive manufacturing processes must first be collected and compared.

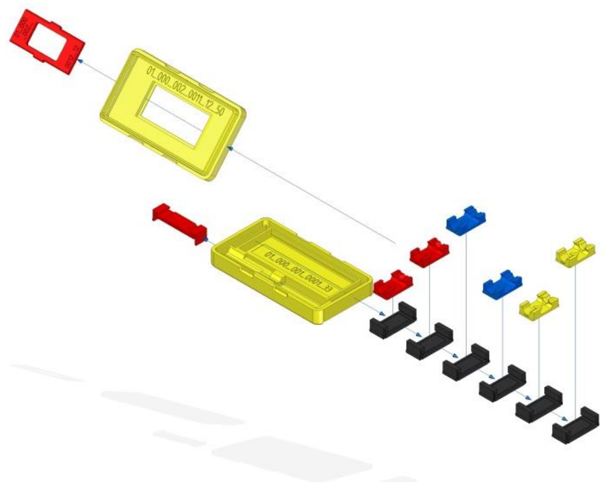

Image: Exploded view of the bit box (Image source: mes Stuttgart)

The development of a component

Subtractive manufacturing:

1. Idea (component for the realization of a function / task)
2. Construction (CAD) taking into account the possible production process, Set tolerances

3rd Manufacture the starting part (sawing off the semi-finished product)

4th Subtractive manufacturing (milling, turning, drilling, thread cutting)

5. Measure, test

Additive manufacturing:

1. Idea (component for the realization of a function / task)
2. Construction (CAD) taking into account the possible production process, Take process tolerances into account

3rd Prepare data (file e.g. in stl format)

4th Send data to printer, start printing

5. Measure, test

Where can additive manufacturing be classified as a process?

classification of manufacturing processes

Main group of manufacturing processes	archetypes	archetypes	separate	assemble	laminated	change material properties
Shape becomes	created	changed	changed	changed	maintain	maintain
cohesion of the material	created	unchanged	removed or reduced	increased	increased	changed
Examples:	- Injection molding - molding - sinter - electroforming	- bend - edging - folding - blow molding - deep molding - molding - shape - forge - press - rolling - wire molding	- cutting - scratching - punch - chisel - threading - disassemble - cut off - etching - flame cutting - saw - drilling - filing	- screw - nail - rivet - glue - solder hard - solder soft - welding	- to brush - splash - immerse - coating powder - rolling up - hot dip galvanizing - electroplate	- glow - harden - carburize - nitrate

Additive manufacturing belongs to the main group archetypes.

classification of manufacturing processes

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How does additive manufacturing work?

3D printing or additive manufacturing is a computer-controlled process that creates 3-dimensional objects that are created by applying material in layers.

Objects can arise which can have almost any shape. There are limitations mainly due to the size of the available installation space in the device used.

Control commands for the 3D printer are generated directly from digital data (CAD), which then build up the object to be printed in layers. The orientation of the layers in the resulting component can have an influence on the component strength and limit the load-bearing capacity of the component. Likewise, the available materials do not cover all desired component properties.

Differences between subtractive and additive manufacturing (example)

	Subtractive manufacturing	Additive manufacturing (e.g. FDM process)
Step 1	A CAD model is created for the task / function of a component to be implemented. The planned manufacturing process must be taken into account, as well as the required material properties when selecting the material.	A CAD model is created for the task / function of a component to be implemented. The planned manufacturing process must be taken into account, as well as the required material properties when selecting the material.
step 2	The required starting piece is cut off from a semi-finished product	A print file (e.g. stl file) is generated from the CAD data and sent to the 3D printer. The construction process starts and works automatically until the component is completed.
step 3	The desired component geometry is roughly worked out by roughing.	Any rework that may be required, such as removing support structures, is carried out.
Step 4	The desired geometry is produced by finishing.	The tolerances are determined by the construction process of the additive process.
Step 5	The functional surfaces are given the required tolerances through fine machining.	By measuring the component, the exact component geometry is recorded and checked.
Step 6	Compliance with the required functional tolerances is checked by measuring the component.	