Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

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Lighter, faster, better...

How AM is reducing material input in production and usage phases

Christoph Klahn

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pd|z linking Education, Research and Reality







Additive Manufacturing @ inspire







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Additive Manufacturing What is this «Additiv Manufacturing»?

Provide the second seco

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Additive Manufacturing Technologies





AM in Production and Useage Phase



Selective Laser Melting (SLM)

Producing 3D parts by welding metal powder in with a laser

The technologie has:

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- Some disatvantages: Costs, tolerances, surface quality
- And a lot of advantages ...



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Three core properties unveiled by Additive Manufacturing





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Manufacturing Readiness Level in Direct Part Production





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Design for Additive Manufacturing Design differently



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Development Process: Laser Cutter Head



Business Case: Laser Cutter Head

	Conventional Part	AM Part	
Cost	300 CHF	900 CHF	
Maintenance	5 x 10 min / Week	1 x 10 min / Week	
		Break Even after 7 Month !	

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Change of Paradigms

	original design	bionic design	integrated design* ("bracket" directly glued into honeycomb)
bracket	330 g	195 g	0 g
assembly weight	1.400 g inkl. fiber mount und HiLocks	1.265 g inkl. fiber mount und HiLocks	300 g
force	35 kN	35 kN	35 kN
savings		135 g pro Bracket - 41%	1.100 g pro Bracket > - 80%

Source: TU Hamburg-Harburg, iLAS





Benefits of Additive Manufacturing Quantifying Economic and Ecologic Added Value



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Weight Saving in Aerospace

Energy consumption approx. 1.5MJ/Available Seat Kilometer 180 Pax, 3000km = 19t Kerosin

1% Reduction in Gross Weight

watter (1)

0.25 – 0.75% Reduction of Fuel Consumption

Source: Babikian 2002, Picture: Airbus

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Less Structural Mass by AM Design

Cabin Monument Bracket

Conventional Design: 330 g AM Design: approx. 195 g

Manufacturing:

Conventional: Alu 7075

 193 MJ/kg Semi-Finished Block
 15 MJ/kg Chips
 126 kWh per Bracket

Additive Manufacturing: Ti64 1231 MJ/kg Part (incl. Powder) 67 kWh pro Bracket

A/C Operations:

- 135 g less Weight
- 0.02 I less Fuel/Flight

1100 Flights in a Year

- 22 | less Fuel/Year
- 210 kWh/Year

Over the A/C Life Time of 30 Years

- 660 | less Fuel
- 6.3 MWh

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Ben Gurion Airport Terminal 3

52'611 Departures 713'312 Pax leaving TLV

Fountain in Departure Hall

- Estimated Energy Consumption:
- approx. 7.5 kW 24h/7d
- 66 MWh/Year

Airport:

System to fill Aircrafts with Passengers

Benefits:

- First-Order Benefits: Negative (construction work)
- Second-Order Benefits: Negative (- 66MWh/Year)
- Third-Order Benefits: Natural effect on 2% of Pax 1.1 kg less Take-Off Weight 0.18 | less Fuel/Flight 9'500 | Fuel/Year (89 MWh/Year) Saving of approx. 3'500 US\$





An Absurd Idea?

« It's not because we need to generate money from the jacks. But ... if you get rid of two [toilets] you can get six seats on a 737. They will all be scurrying to the toilet before the departure gate.»

> Michael O'Leary (CEO Ryanair, 2010)

« By charging for the toilets we are hoping to change passenger behaviour so that they use the bathroom before or after the flight. That will enable us to remove two out of three of the toilets and make way for at least six extra seats on board.» Stephen McNamara

(Spokesman Ryanair, 2010)



Source: http://www.dailymail.co.uk/travel/article-1263905/Ryanair-toilet-charges-phased-in.html http://www.theguardian.com/business/2009/jun/02/ryanair-airline-oleary-toilet-charge



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Economic AM Benefits during Operation

Environmental Control System

- Air-conditioning ducts in aircrafts
- 1 integrated part replaces an assembly of 20+ single parts



Quelle: EO

Quelle: Stratasys

Airline benefits from:

- Less assembly, quality assurance, documentation
- Part management, qualification
- Maintenance, repair, overhaul
- Inventory
- ... and it is a bit lighter





AM Series production at GE

Fuel nozzles of Leap jet engine

- 19 units/engine
- Part count reduced from 18 to 1 single part
- Weight reduction by 25%
- 5x higher durability
- Reduced fuel consumption

http://www.geglobalresearch.com/innovation/3d-printing-creates-new-parts-aircraft-engines

Production ramp-up:

2014 Start of production 2020 100'000 Nozzles p. a.



http://www.gereports.com/post/80701924024/fit-to-print





Identification of AM Benefits

- AM Designs offer most benefits in the use-phase
- Deeper understanding of interaction between product, user and context
- Creative process to generate new product ideas and identify benefits
- Business case and LCA in an early stage of product development







Conclusion

AM Benefits

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- Additive Manufacturing enables new ways in product development
- Products become more efficient, lighter and individual
- Economic and ecologic benefits

Challenges

- Encourage designers to explore new ways in product design
- Top-management decision for a new production process
- End-users benefit most from an AM-design during use-phase
- How to quantify these benefits and turn them into revenue?





Kontakt



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