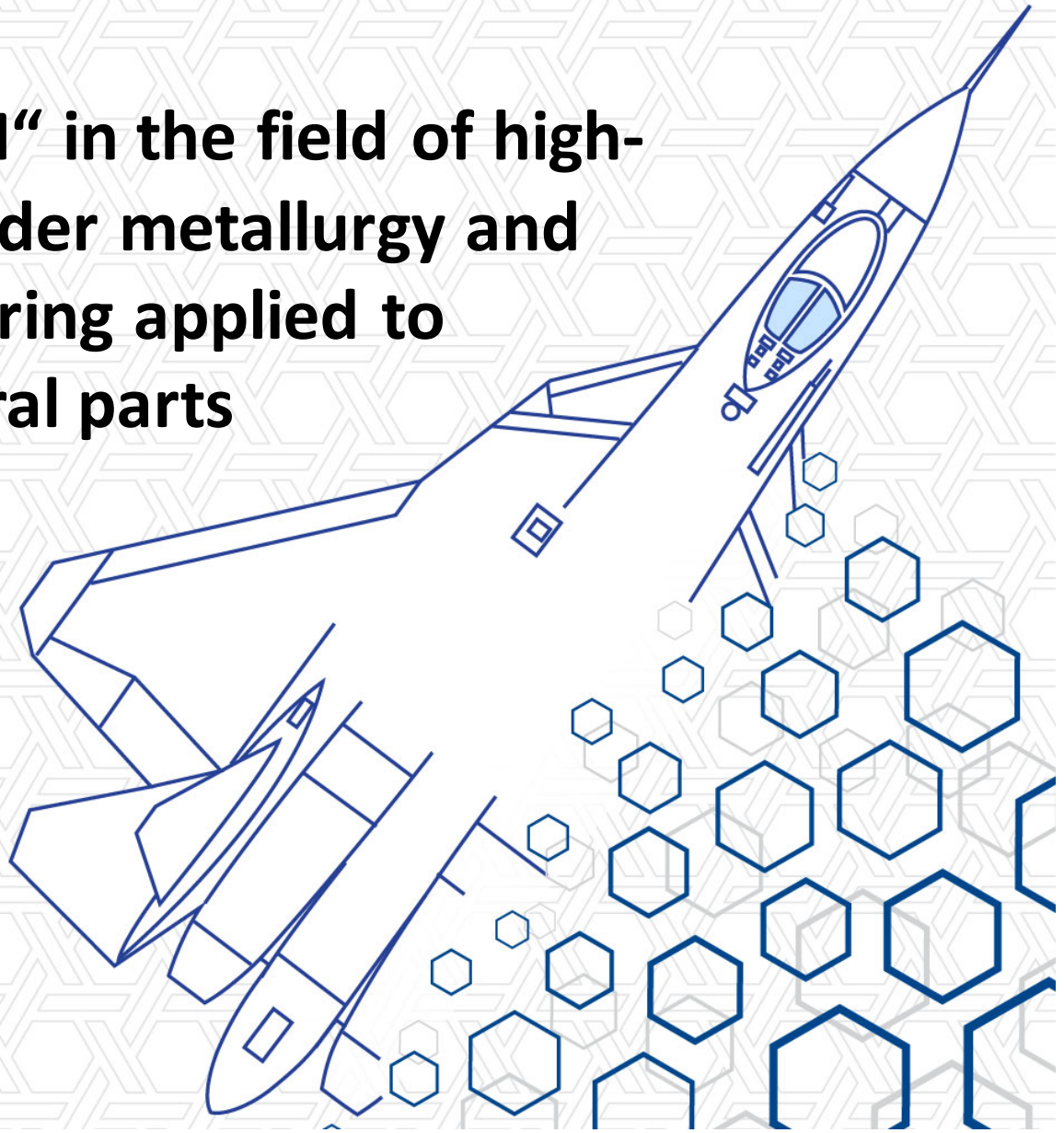
FEDERAL STATE UNITARY ENTERPRISE
ALL-RUSSIAN SCIENTIFIC RESEARCH INSTITUTE OF AVIATION MATERIALS
STATE RESEARCH CENTER OF THE RUSSIAN FEDERATION

Experience of FSUE "VIAM“ in the field of high-temperature alloys powder metallurgy and additive manufacturing applied to GTE structural parts



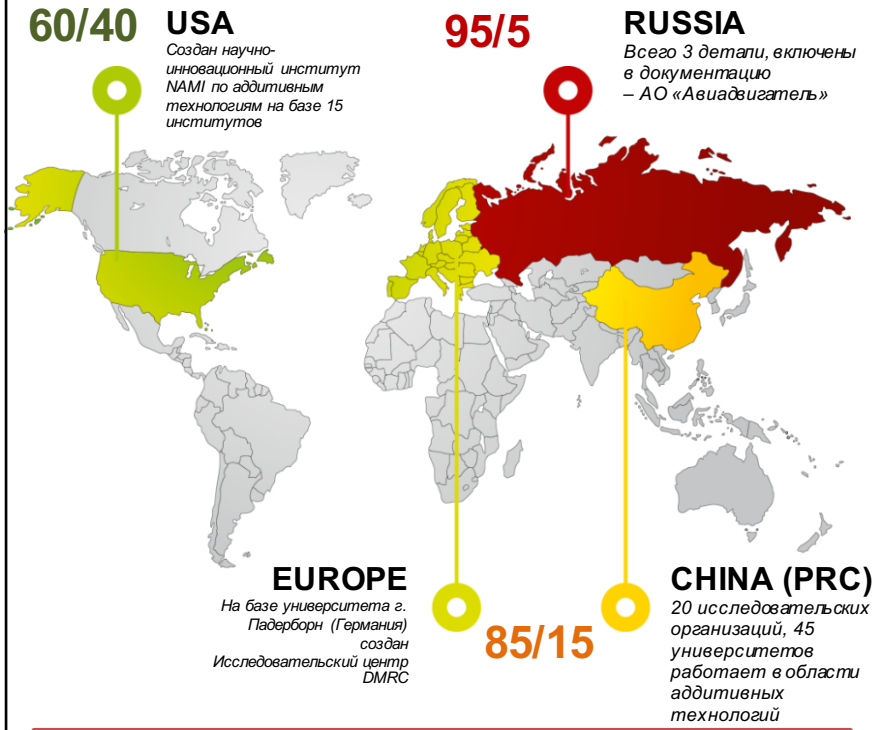
Speaker:
Head of Research Group
Dmitry Suhov

Implementation levels of additive manufacturing

Additive manufacturing allows to realize the principle of unity:
MATERIAL-TECHNOLOGY-CONSTRUCTION

1 level	2 level	3 level
Auxiliary production	Production of demonstration parts	Production of serial parts
		
Manufacturing of equipment, burn-out models for casting parts, etc.	Prototypes of parts and structural elements (without the provision of design specification requirements)	Manufacturing of parts that meet design specifications, for use in current engineering models
RESOURCE DETAILS ARE PRODUCED BY TRADITIONAL TECHNOLOGIES		**RESOURCE DETAILS ARE PRODUCED BY ADDITIVE MANUFACTURING**

The ratio of the number of parts produced at the 1-st and 2-nd levels of the implementation of additive technologies, to the number of parts produced at the 3rd level of implementation

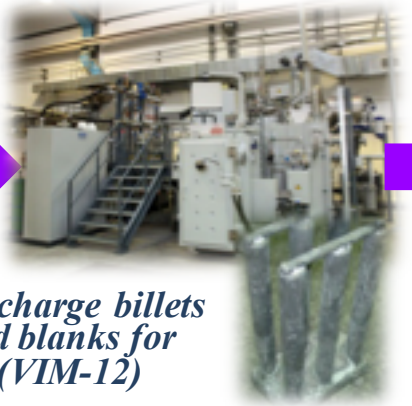


The USA has set a goal to achieve by 2020 the ratio of 20:80
(80% of the details will be produced at the third level of implementation of AT)

Materials and additive manufacturing for GTE parts and components

Additive full cycle production:

Development of metal powder compositions, 3D models, construction of support structures, development of synthesis technology parameters (laser power, laser scanning strategy, speed and hatch spacing), followed by heat treatment and hot isostatic pressing of critical parts with the release of a complete set of regulatory documents

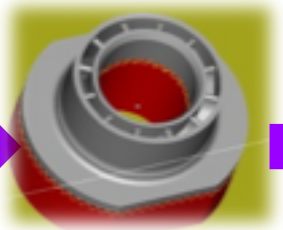


Manufacture of charge billets (VIM-150) and blanks for atomization (VIM-12)

Production of metal powder compositions by gas atomization

Sieving and gas-dynamic separation of powders

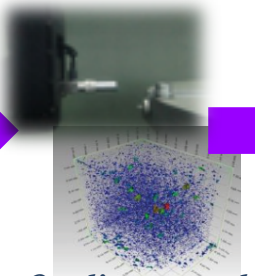
Development of 3D models of parts



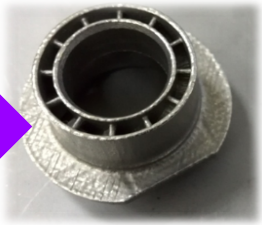
Support structures modeling, generation of layers

Development of laser synthesis technologies: laser power, laser scanning strategy, speed and hatch spacing

Heat treatment and hot isostatic pressing



Quality control and characteristics measurement



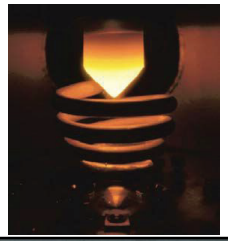
Final part

The created infrastructure allows us to develop technologies in a short time and produce parts that meet the requirements of regulatory documentation (level 3)

Materials for domestic SLM and DMD machines

United Engine Corporation

The view of the metal powder compositions workshop for additive production (2018)



VIP-GR atomizer is designed using digital technologies and manufactured in FSUE "VIAM"

2018 year

Production of direct domestic analogues

Steels: Х18Н10Т (**18-10**), ВНЛ3 (**316L**)
Alloys: ХК62М6Л (**CoCrMo MP1**); ЭК61 (**Inconel718**); АЛ4

Production of original alloys

High-temperature nickel alloys: **ЭП648; ВЖ98; ВЖ159** and etc.
Aluminum alloys: **Д16, 1933** and etc.
Steels: Martensitic Aging (**ВКС 240, ВНЛ14** and etc.)
Cobalt alloys: **ВЛК1** (CoCrNiW)
Titanium alloys: **ВТ6, ВТ20св, ВТ18л, TiAl**

- Equipment development

- Development of materials (VIAM)

Application of the materials being developed (selective laser melting technology)

United Engine Corporation

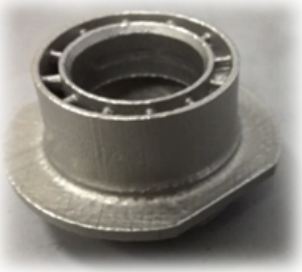
Laser synthesis of "swirler" parts for PD-14 (made of EP648 nickel alloy)

АВИАДВИГАТЕЛЬ

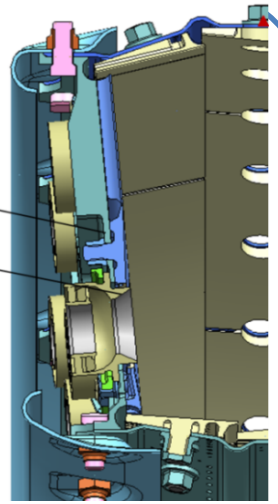
Tests were carried out, design specifications was issued.

Supplied 4 sets of swirlers for engines № 007, 008, 009, 010

48 swirlers in each annular combustion chamber PD-14



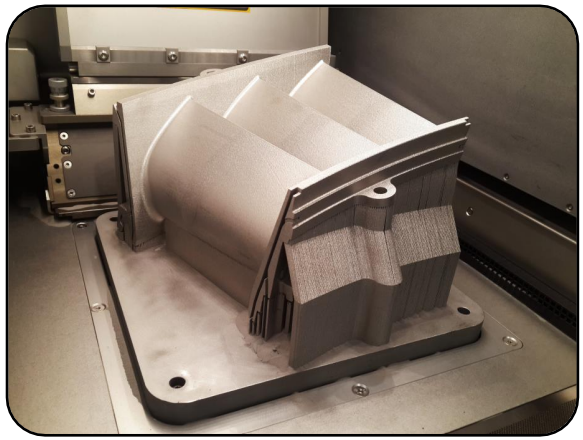
Swirler for PD-14



The first flight of IL76-LL with PD-14 (№007), November 2015.

ЭП648 (EP648) is first domestic material certified for AM

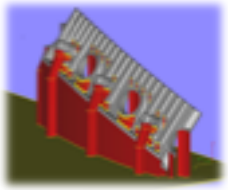
AM for gas-turbine plant



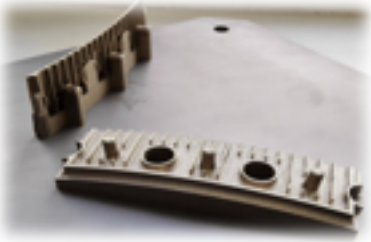
New material for 2nd stage blades of high-pressure section

Novel Cobalt Alloy ВЛК1(VLK1)

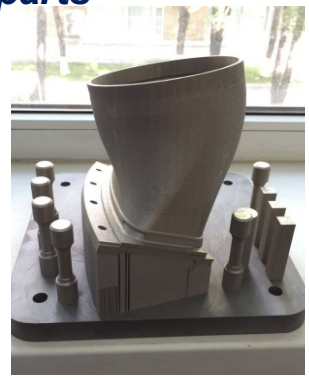
New materials for synthesis of combustion chamber parts



ВКНА1ВР (VKNA1) Alloy



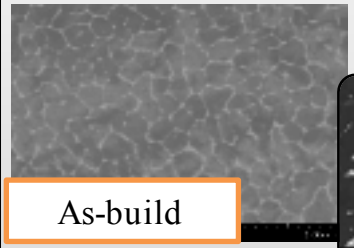
Heat shield

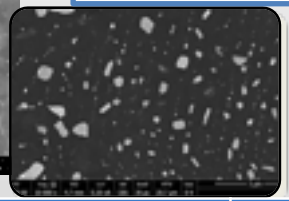


Gas collector ВЖ159 (VJ159) Alloy

General qualification of the novel domestic alloys for additive manufacturing (2018-2019)

CO-BASED ALLOY (ВЛК1)





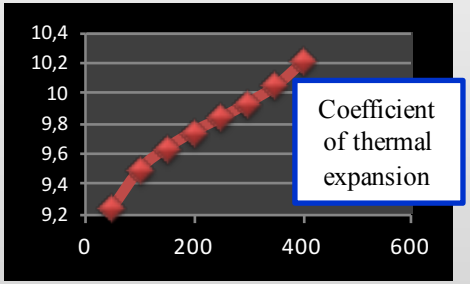
ФОНД ПЕРСПЕКТИВНЫХ ИССЛЕДОВАНИЙ

Alloy	Tensile test, 20°C			σ_{500}^{800}, MPa	σ_{100}^{800}, MPa	σ_{100}^{1100}, MPa
	σ_B, MPa	$\sigma_{0,2}$, MPa	δ, %			
ВЛК1	**1410**	**1040**	**12,5**	**180**	**220**	**25**
MP1 (EOS)	1000-1200	550-650	≥20	-	-	-

The issue of certification document - in 2019

TI-BASED ALLOY (ВТ6)

МИТ



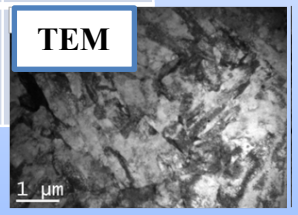
Alloy	Tensile test, 20°C			$\tau_{ср}$, MPa	HRC	KCU, J/см²
	σ_B, MPa	$\sigma_{0,2}$, MPa	δ, %			
Ti-6-4	**1060-1110**	**990-1030**	**7,1-13,0**	**710-760**	**37-38**	**26-31,6**

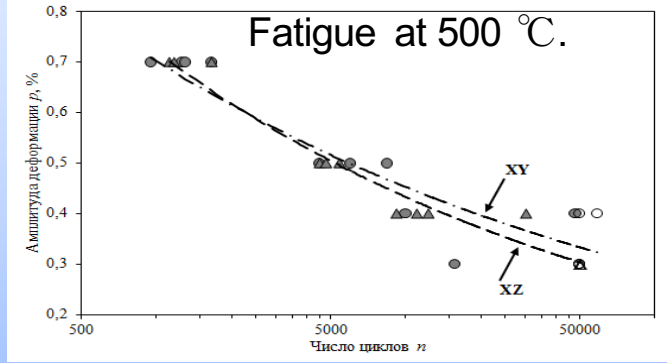
The issue of certification document - in 2018

Сталь	σ_B, MPa	$\sigma_{0,2}$, MPa	δ_5, %	ψ, %	KCU, J/см²	K_Q, MPa·м$^{1/2}$	σ_{100}^{500}, MPa
02Х13Н5К9М4 (ВНЛ14)	**1480-1520**	**1340-1350**	**14,5-17,5**	**63-65**	**100-110**	**155-175**	**> 500**
PH1 (EOS)	**1310-1470**	**1170-1350**	**10-14**	-	-	-	

The issue of certification document - in 2019

STAINLESS STEEL (ВНЛ14)

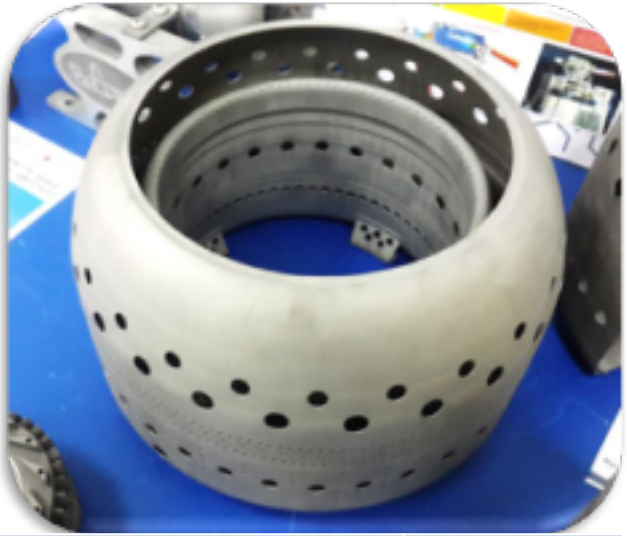




Prospects of using AM in the manufacture of GTE combustion chambers

Combustion chamber manufactured using traditional technologies

Lightweight combustion chamber manufactured using SLM technology with reduced wall thickness up to 0.8mm



Operation	Duration
Manufacturing of equipment and accessories for stamping and welding	2 months
Preparation and processing of sheet blanks (cutting, burning holes, rolling)	15 days
Assembly of the combustion chamber, welding of the basic component and oriented segments (at least 30 blades)	15 days
Product control	3 days

Operation	Duration
Preparation of the electronic project	1 day
Selective laser melting of the combustion chamber **in one process**	7 days
Post-processing (heat treatment and hot isostatic pressing, removal of supporting structures, reduction of roughness)	3 days
Product control	1 day

General manufacturing cycle:
- **Traditional way - 3 months**
- **SLM technology - less than 2 weeks**

Advantages of SLM:
- **Reduce of manufacturing time by x10**
- **The possibility of lightweighting and improving the design**

The list of priority national standards developed within the framework of TC182

Order of Rosstandart No. 1013 dated September 1, 2015 established a technical committee TC 182 “Additive manufacturing “ for the standardization on the basis of FSUE "VIAM"

1. Additive technological processes. Basic principles - part 1. Terms and Definitions
2. Additive technological processes. Basic principles - part 2. Materials for additive technological processes. General requirements.
3. Additive technological processes. Basic principles - Part 3. General requirements.
4. Equipment for additive technological processes. General requirements.
5. Additive technological processes. Basic principles - Part 4. Data processing.
6. Materials for additive technological processes. Methods of control and testing.
7. Additive technological processes. Methods of control and testing.
8. Products obtained by the method of additive technological processes. Terms and Definitions.
9. Products obtained by the method of additive technological processes. General requirements.
10. Products obtained by the method of additive technological processes. Methods of control and testing.

10 NATIONAL STANDARDS are issued

3 PROJECTS are discussed and sent for approval

4 DRAFT national standards are in development