Low Cost PM Technology for Particle Reinforced Titanium Automotive Components:

Manufacturing Process Feasibility Study – AMD 310

USAMP

2008 DOE Peer Review Presentation

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This presentation does not contain any proprietary or confidential information

USAMP AMD 310 – Low Cost PM Technology for Particle Reinforced Titanium Automotive Components

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Participants and their roles

Management team

Russell Chernenkoff	**Ford** (retired Feb 2007)
Bill Jandeska	**GM** (retired March 2005)
Mark Osborne	**GM**
Jean Lynn	**Chrysler LLC**

Principal investigator

ADMA Products, Inc.

Titanium Consultant

University of Idaho

Purpose of work

Lower-reciprocating-mass components, like connecting rods, have compound effect in reducing weight and improving fuel economy

Develop simple powder metallurgy (PM) manufacturing process capable of fully densified compacts using novel materials and processing technology

This one-year feasibility study ended August 2004
$340K total ($130K DOE, $180K in-kind)

Certain experiments needed for the goal and the subsequent property evaluation did overflow into 2005 and 2006.

Final report was published March 2007

Purpose of work - continued

The original intent was to use hydrogenated Ti powder as feedstock (ADMA process)

However, neither hydrogenated powder nor hydrogenation process was available at beginning

Only Ti powders– reduced by Na, Mg, Ca, etc. were used.
Ti powder from ITP became available at the end

Reinforcing particles were added to improve stiffness
– Titanium metal matrix composite (Ti-MMC)

The resultant mechanical properties
From machined coupons using fully densified compacts
Compared with target set for Ti-MMC

Ultimate Tensile Strength	**750 MPA (107 KSI)**
Yield Strength	**670 MPA (96 KSI)**
Elongation	**6%**

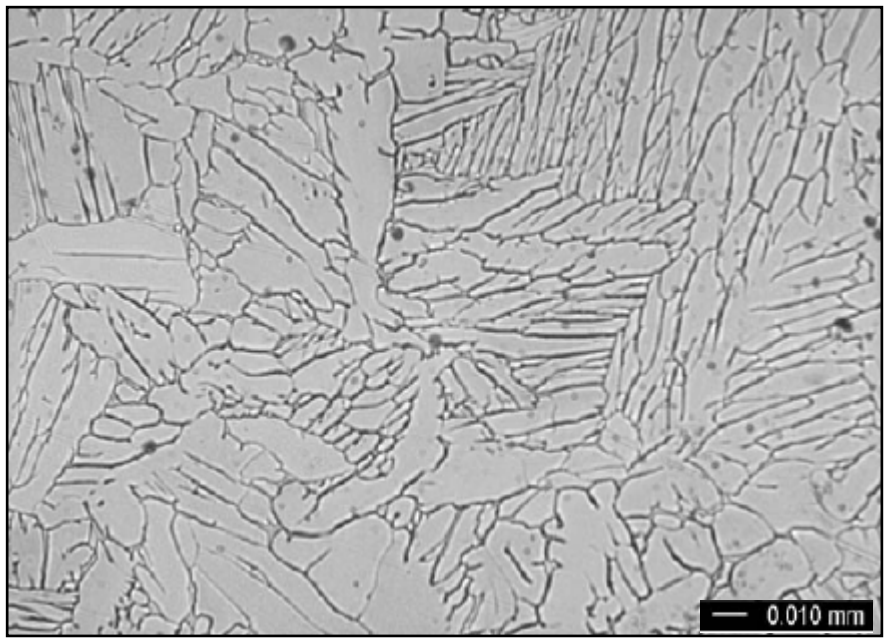
Microstructure – uniform and free of segregation

50% weight reduction and less than 3 times of the cost of current powder forged steel connecting rod

Accomplishments

Homogeneous structure

Ti–6Al–4V alloy



Sodium reduced Ti sponge fines – RMI Products

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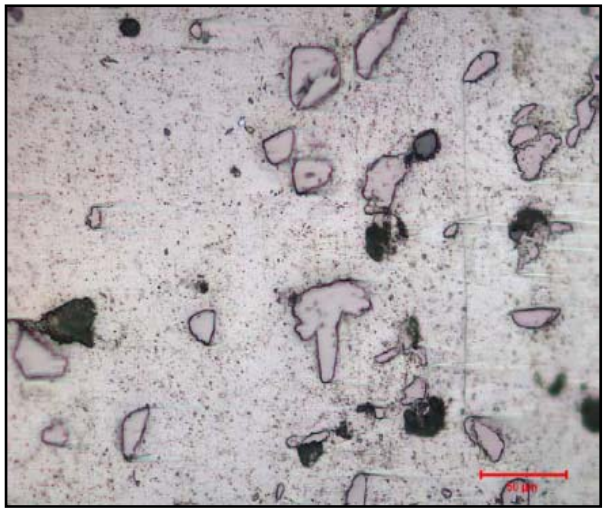
Ti- MMC

Ti-6Al-4V + 10% TiC



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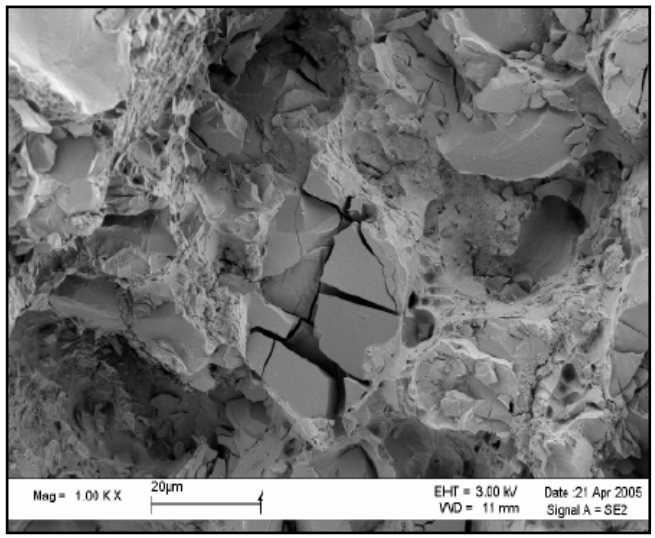

RMI

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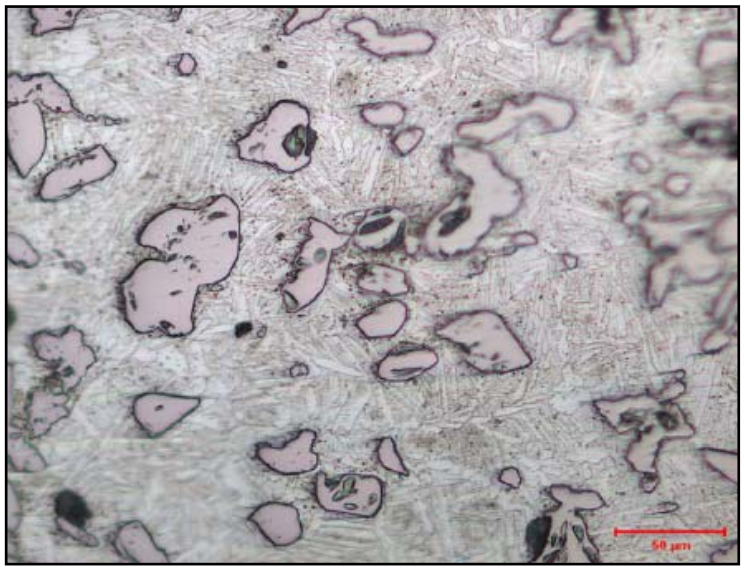
Ti-6Al-4V + 20% TiC



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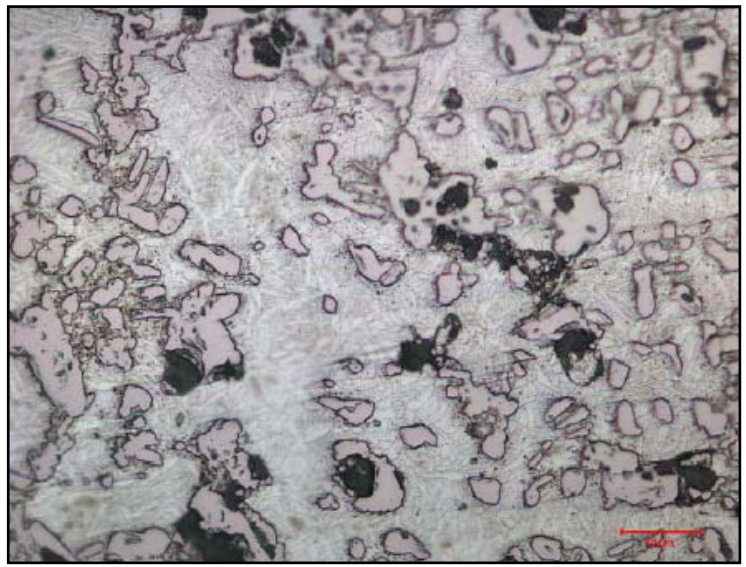

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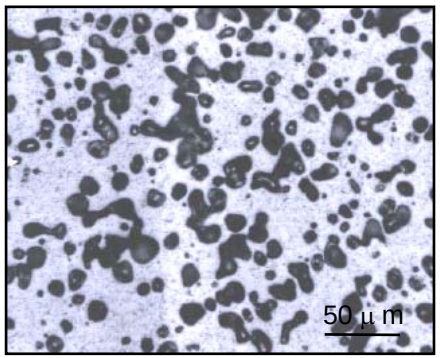
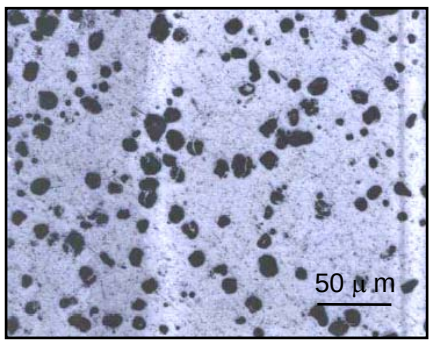
Ti–6Al–4V alloy

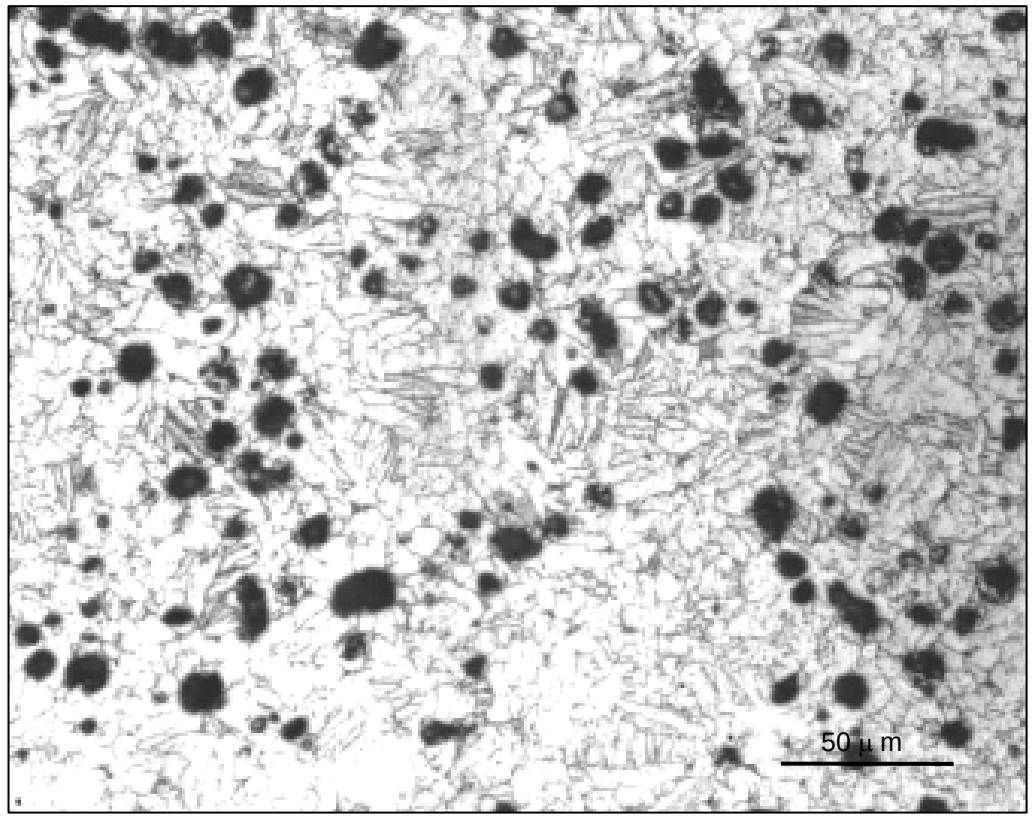
International Titanium Powders - ITP



65% density



86% density



90% density

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Room temperature tensile test results

	Sample No.	Tensile psi	Yield psi	Elongation %	Modulus msi
Ti 6Al-4V	1	143.2	123.1	12.2	16.9
	2	143.6	123.7	13.8	18.3
	3	142.6	122.8	11.4	16.7
	4	142.7	123.1	11.8	16.8
Ti 6Al-4V + 10% TiC	1	150.3	143.5	3.0	17.7
	2	151.4	137.9	3.0	17.7
	3	150.4	142.4	3.0	17.9
	4	150.1	143.0	2.0	18.1
	5	148.5	141.1	2.0	17.5
Ti 6Al-4V + 20% TiC	1	115.0	115.0	2.0	18.3
	2	119.2	119.2	1.0	19.0
	3	124.5	124.5	2.0	20.1
	4	122.3	122.3	2.0	19.5
	5	121.5	121.5	2.0	19.6
Ti 6Al-4V ITP Powder	1	108.1	103.8	1.6	14.2
	2	69.1		0.1	9.3
	3	102.4		1.5	15.8
	4	106.2		0.3	14.9
	5	106.7	105.4	0.4	15

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Recommendation

Additional refinement on sintering cycle for Ti-MMC to improve properties like fatigue in the already full density condition

Cost analysis based on the developed materials and process can be re-established

Hydrogenated powder approach should be explored to search for more cost effective manufacturing process