Powder Metal Performance Modeling of Automotive Components – AMD 410

USAMP
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This presentation does not contain any proprietary or confidential information

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Participants and their roles

Management team

Shekhar Wakade	**GM**
Jean Lynn	**Chrysler**
Glen Weber	**Ford**

Principal investigator

Center for Advanced Vehicular Systems (CAVS)
-part of Mississippi State University

Supplier (PM parts maker)

Metaldyne

Program management / PM Consultant

Howard Sanderow

Purpose of work

Develop computer model in a constitutive manner capable of predicting the performance properties based on the manufacturing process history

Computer modeling work performed at Computation Center at CAVS/MSU

4-Yr project - ends at December 2008
$1,243K total ($613K DOE, $630K in-kind)

Purpose of work - continued

The model will:

- **Integrate the history of a PM part from powder to final sintering**
- **Shorten cycle to implement new PM components**
- **Be verified and tested using PM main bearing cap currently in production at GM / Ford / Chrysler**
- **Optimize current design for weight reduction while maintaining performance**
- **Valid for conventional PM components using various materials**
- **Expedite the substitution from current to future light weight materials**

Project Overview

- **Task 1: Literature Survey and Background** — **Complete**

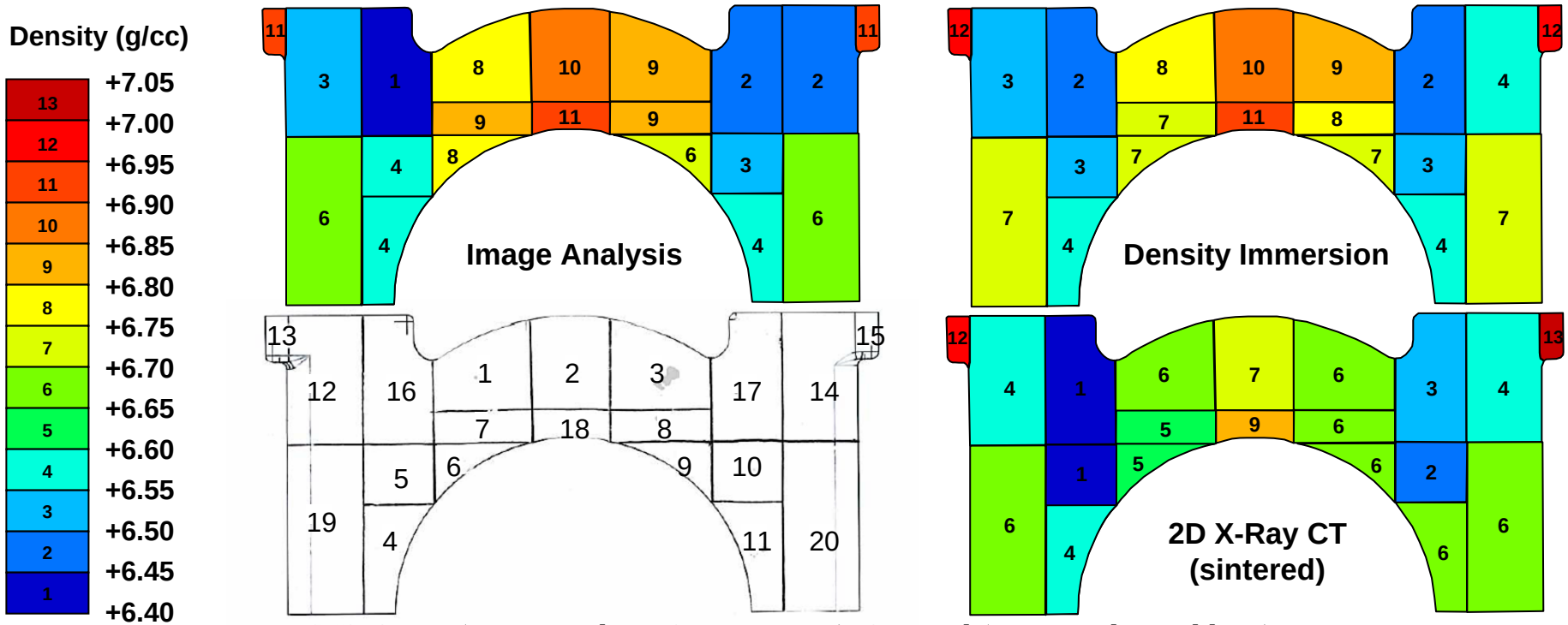
- **Task 2: Development of numerical Modeling Techniques** — **In Process**
  - Review existing models; develop new software for both compaction and sintering processes; determine microstructure- property relationships and incorporate into the model; validate the process models; predict in-service performance.

- **Task 3: Model Validation and Product Optimization** — **In Process**
  - Validate the model outputs with actual performance measures from a main bearing cap (MBC); optimize product geometry and processing for lowest cost and mass; determine aluminum MBC characteristics for optimum performance and lowest cost.

- **Task 4: Technology Transfer** — **Not Begun**
  - Identify modeling experts at industry participants; facilitate modeling training sessions at CAVS to transfer the modeling technology to industry participants; further modeling sessions at industry locations using actual PM components.

Bearing Cap Density Measurements:

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Image Analysis	6.79	6.90	6.84	6.59	6.56	6.76	6.85	6.81	6.73	6.55	6.59	6.51	6.94	6.49	6.94	6.42	6.46	6.91	6.69	6.68
Immersion Density	6.80	6.88	6.83	6.57	6.51	6.71	6.71	6.80	6.72	6.51	6.59	6.54	6.98	6.58	6.96	6.48	6.50	6.95	6.72	6.71
2D X-Ray CT (sint.)	6.66	6.73	6.68	6.58	6.43	6.62	6.63	6.67	6.67	6.50	6.66	6.56	6.99	6.59	7.03	6.42	6.51	6.82	6.68	6.70
Metaldyne Results	6.96	6.99	6.97	6.63	6.55	6.79	6.99	7.01	6.82	6.57	6.62	6.68	6.4	6.69	6.44	6.69	6.69	7.00	6.68	6.69

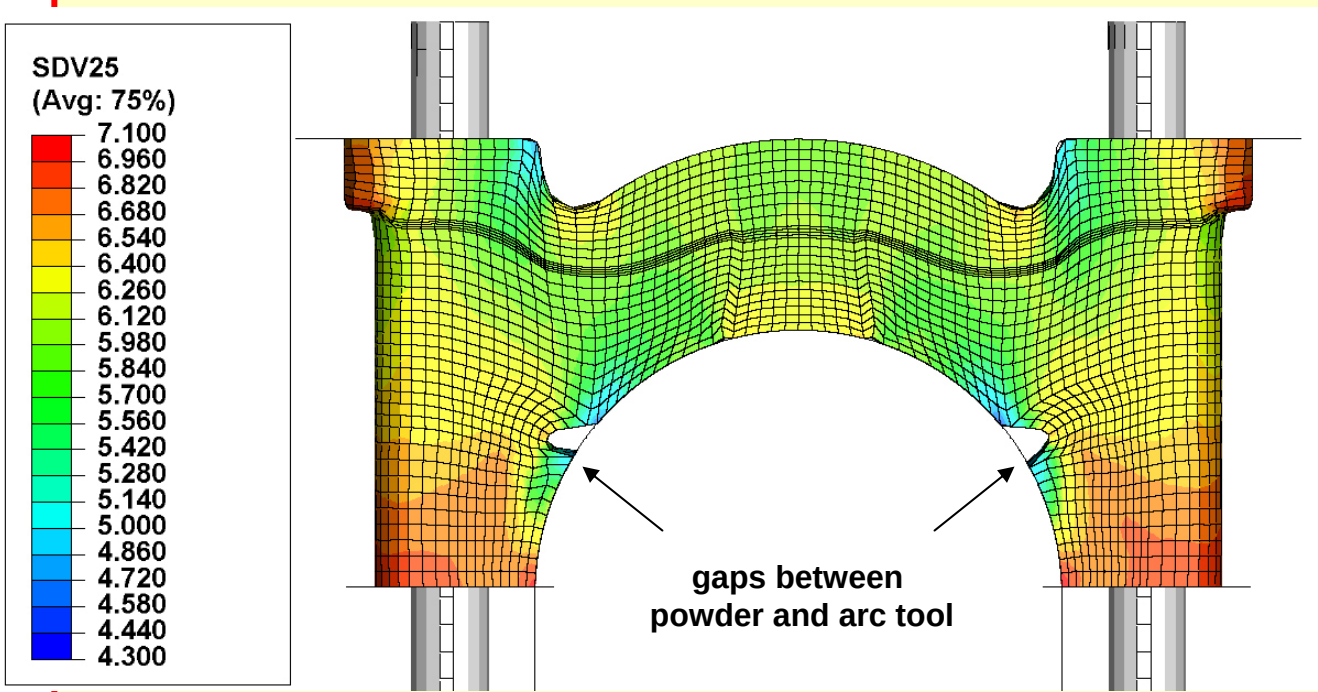


205Q Green (Image analysis & Immersion), Sintered (X-ray and Metaldyne)

edm2@chrysler.com

Bearing Cap Simulation

Numerical issues due to the limitation of the Finite Element Method to represent the powder as a fluid material



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Risks and challenges remaining

Risk/challenge	Plan to overcome challenge	Explanation
Compaction model showing tool motion encountered numerical code issue	Debugging planned for next two weeks	Numerical method producing error islands
Upgrade compaction model from ABAQUS /Explicit to ABAQUS /Standard	Additional time required	Need to debug and test model
No sintering model output has been demonstrated by MSU yet	Additional time needed	Delay in compaction model has delayed sintering model implementation
Bearing cap fatigue performance data – MSU wants to use limited number of caps (10)	Metaldyne to run samples by end of the year and also provide load values	Disagreement between USAMP members and MSU on number of samples needed
Difficult to predict where MBC will break	De-bugging of the model	Bearing cap monotonic performance evaluation using a test fixture based on FEA input
Technology transfer to potential end users / supplier(s)	Identification of personal at participating supplier	Traditionally a weak link if third party (end user) participation is involved
Application of model to light metal system yet to be scheduled	Additional time needed	Team priortized having the models validated for actual PM steel parts before extending to light metal systems
Optimization of the component geometry	Tooling cost and parts making issues not yet discussed	MSU has not considered impact of manufacturing issues on product optimization model

Gantt Chart

	Task Name	2007 9	10	11	12	2008 1	2	3	4	5	6
1	1.1 Identify metals and alloy powders that are able to meet manufactring and component durability requirements										
	1.2 Identify and standardize performance test methods										
	1.3 Identify the testing instrumentation to characterize the metal powder.										
	1.4 Identify all the P/M techniques to process auto parts (production, mixing, cold and hot compaction, sintering, optional and finishing operations, etc.										
	1.5 Identify the existing numerical techniques for simulation P/M forming processes										
	1.6 Identify the important parameters that influence the process										
	1.7 Update all of the findings and publish as part of this study.										
2	2.1 Identify and evaluate existing powder material models that will simulate P/M manufacturing processes										
	2.2 Modify existing software that will predict the effect of process variables and tool design parameters										
	2.3 Perform microstructural and mechnical property tests on P/M cylinder to determine microstructure property relationships.Correlate model.										
	2.4 Predict the material state during the powder compaction and sintering processes w/ developed math-based models for a main bearing cap										
	2.5 Validate process model and property models on P/M bearing cap w/ experiments										
	2.6 Predict in-service life and evaluate w/ experiments										
3	3.1 Incorporate uncertainty from processing and optimization methods in conjunction w/ the validated model to help P/M part quality and durability										
	3.2 Optimize the compacting process of P/M parts by empolying the math based modeling										
	3.3 Optimize the sintering process of P/M parts by employing the math based modeling										
4	4.0 Management and reporting of program activities										
5	5.0 Commercial transfer throughout the automobile value chain										
	5.1 Identify training needs										
	5.2 Conduct on-site training at CAVS										
	5.3 Follow-up training at the P/M industrial sites with new P/M components										

Progress and Future

Detroit 3, supplier, and consultant working closely with CAVS
- **to stay focus and verify the validity of the model**
- **bi-weekly conference call and quarterly meeting / visit**

Verification of the model with actual production component
- **main bearing cap**
- **much more complicated than originally understood**
- **encouraging results on the capability of model**
- **finished by May**

Technology transfer to OEM and P/M industries
- **scheduled for Summer/ Fall**

Application to evaluate future light-weight materials
- **initially main bearing cap**
- **later other automotive components**