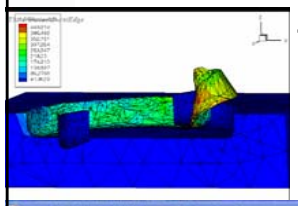
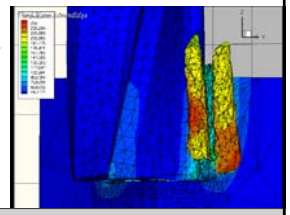
Third Wave Systems, Inc

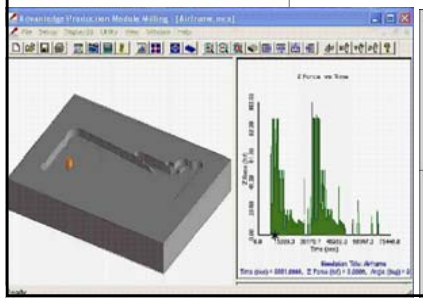
High Performance Machining of Titanium

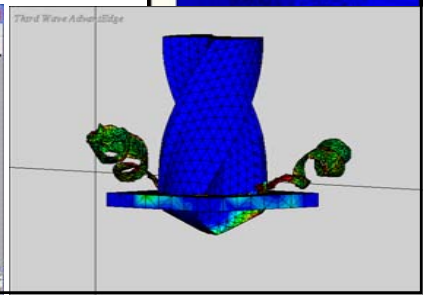


Principal Investigator:
Troy D. Marusich, Ph.D., P.E.
Chief Technical Officer
September 13-15, 2005

Project (PM_11197)







Titanium Machining Consortium

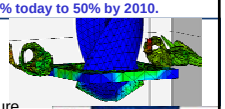
21CTP Technical Goal: **Develop and demonstrate an emissions compliant engine system for Class 7-8 highway trucks that improves the engine system efficiency from ~42% today to 50% by 2010.**

Project Objectives
To improve the material removal rate in machining of Ti-6Al-4V

FY 2005 Focus
Delivery and validation of drilling modeling capability for titanium workpieces

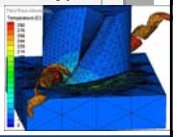
Planned Duration
April 2004 to March 2006

DOE Funding/Industry Cost Share
FY04: $75K/ $75K; FY05: $75K/$75K



- Prediction of Forces
- Prediction of Temperature
- Prediction of Chip Formation
- Modeling of Drilling

Entry/Steady State/Exit



Principal Investigator(s)
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Accomplishments
Addition of the following modeling enhancements/capabilities:
- Drilling simulation capability
- Facemilling simulation capability
- Boring simulation capability

Significant Future Milestones
- Modeling of metal matrix composite tool materials (3-06)
- Modeling of titanium brake rotor machining (3-06)

Project ID/Agreement ID	Program Structure	Sub-Program Element	R&D Phase	Date
PM_11197	Materials Technology	HV Propulsion Materials	Applied Research	8-12-05

THIRD WAVE SYSTEMS

Objectives

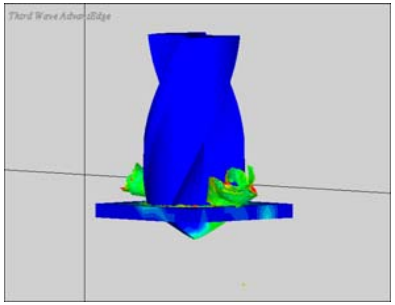
- **Apply innovative high speed machining technologies to Titanium alloys to extend cost savings to these materials.**
- **Develop and validate models for drilling of Ti-6Al-4V**
- **Improve Ti-6Al-4V machining processes to increase machining speed and decrease cost of parts.**

THIRD WAVE SYSTEMS

Relevance to 21CT Goals	Technology Transfer
• Finite Element Modeling provides data needed to reduce machining time leading to enhanced affordability of parts. • 5-10X improvement in MRR for Ti Machining.	• Other Project Partners – Boeing – Caterpillar – Kennametal – TIMET • Developed technology is incorporated into commercially available software.

Approach

- Develop High Speed Machining simulation of Ti-6Al-4V
- Demonstrate machining of full scale parts
- Work Closely with 21CT partners for successful transition of technology into production.
- Achieve dramatic cost and cycle time reductions for titanium alloy parts with no capital equipment investment.
- Meet program affordability target for fabrication of parts which meet qualification criteria



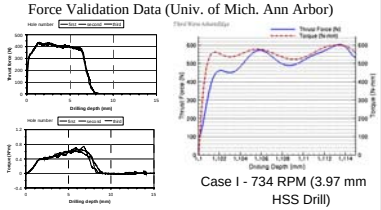
Third Wave Systems *AdvantEdge*™ drilling simulation visualization.

Technical Accomplishments/ Progress/Results

- Demonstrated accuracy of FEM simulations in drilling of Ti-6Al-4V
- Improved simulation speed by 15% (V4.6 vs. V4.7 beta)
- Improved simulation accuracy

Developing Drilling Models for Solid Tools

Force Validation Data (Univ. of Mich. Ann Arbor)



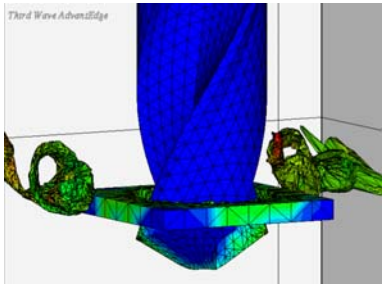
Case I - 734 RPM (3.97 mm HSS Drill)

Force validation conducted by University of Michigan Ann Arbor.

Technical Accomplishments/ Progress/Results

•5-10X improvement in MRR for Ti Machining

•Delivered over 30% cycle time reduction for project partner (USAF) Titanium component



Third Wave Systems *AdvantEdge*™ drilling simulation exit visualization

Future Work

- **Continuous improvement in numerics to achieve a performance improvement goal of 2-5x faster than v4.6(current release) by Fall 2005**
- **Develop High Speed Machining process for Ti-6Al-4V and push envelop for increased overall material removal rate of 200-300 % of current industry practices.**
- **Implement High Speed Machining in prototyping parts for the 21st Century Truck**