Energy Efficient Thermoplastic Composite Manufacturing

DE-EE0005780

Project Team/Boeing, Cytec, Temper, AjaxTOCCO

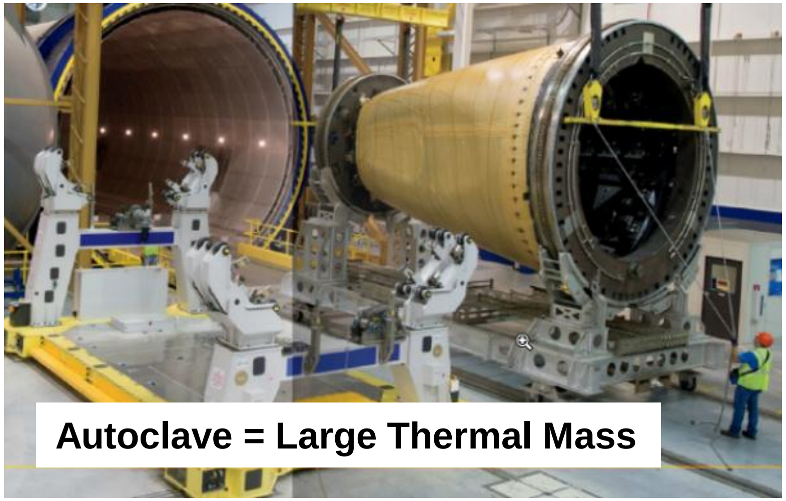
(assuming a May 2015 contract start date) Period #1

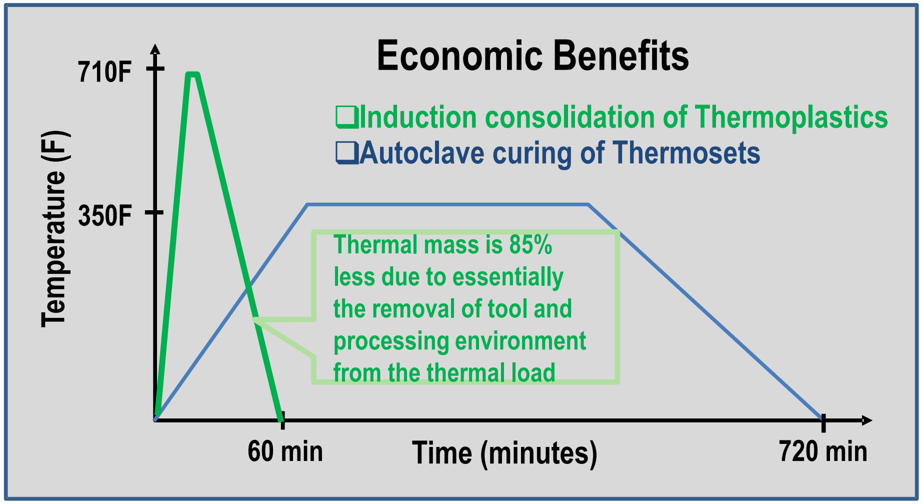
Boeing Research & Technology (Marc Matsen)

U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
May 28-29, 2015

Project Objective

- *The objective of the project is to establish an effective and affordable method to lay-up and consolidate/join large thermoplastic composite aerospace structure with cycle times measured in minutes rather than hours.*
- *Composite airplane designs have proven efficient and effective however future potential product production rates are challenging what the current systems can efficiently produce due to material lay-down constraints and extended thermal cycle times.*
- *The ability to lay-up then rapidly heat, consolidate, and cool large complex composite structures plus very accurately tool them (i.e. matching CTE of composite materials) along with very precise thermal control is a difficult challenge.*



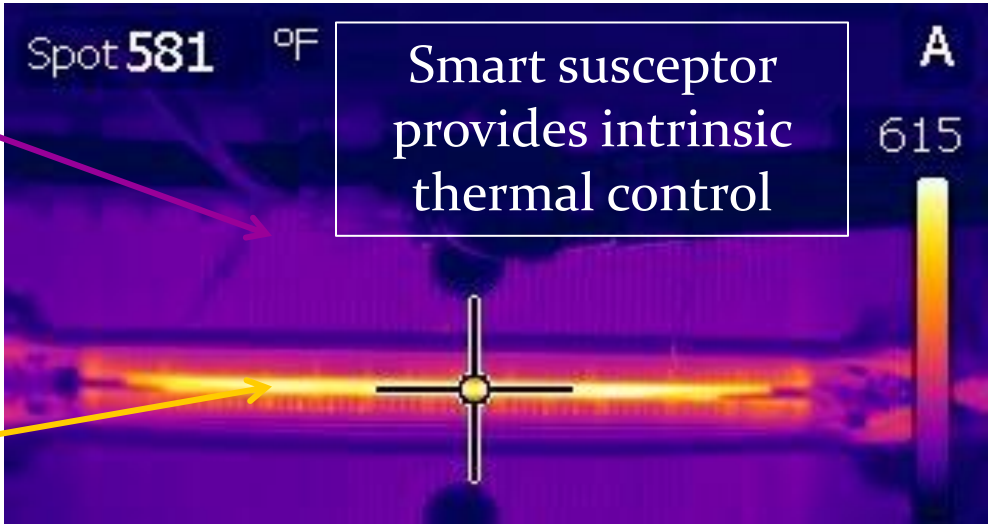


Technical Approach

- *Current systems such as autoclave processing of thermoset materials require long cycle times due to method of heating and the large associated thermal masses. These extended cycle times inhibit the ability to meet higher rate production scenarios due to the need for multiple sets of equipment and tools. In addition, lay-up of thermoset resin based composite requires significant facilities and process flow restrictions at rate.*
- *Thermoplastic composite materials are being used to facilitate more rapid cycle times via the elimination of a need for a cure dwell at temperature. Also, we are utilizing induction heating along with smart susceptors to enable the quick cycle times needed while providing precise intrinsic thermal control.*

The tooling material and/or construction is chosen as to not interact with the induction field and therefore the tool body remains at essentially ambient conditions

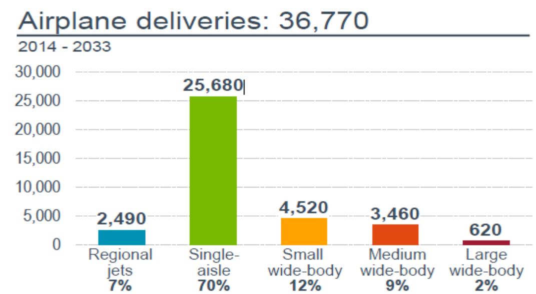
Only the smart susceptor surface of the tool is heated with the remainder of the tool not effected by the magnetic field from the coil



Technical Approach (cont.)

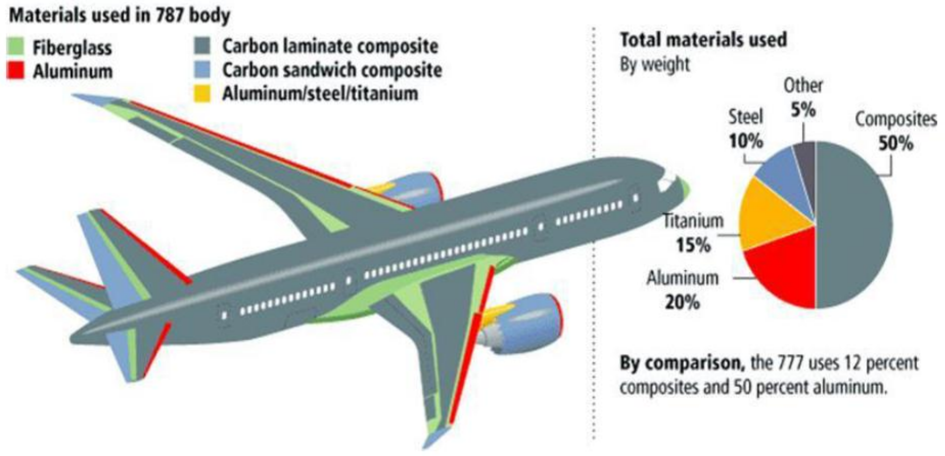
- *The intrinsic control of the induction heating process via the smart susceptors is the key innovation. The ability to rapidly heat and then precisely control the temperature of the consolidation component is paramount to the success of this project. It is this unique processing attribute coupled with the thermoplastic material characteristics along with rapid lay-up methods that are novel and advantageous. This team provides the key industrial elements for making the technical progress needed to be successful.*

- *Boeing has a key leadership position within the aerospace industrial community. While many requirements and influencing factors decide the materials and processes utilized for future airplane construction, the forecast of accelerated production rates and the recent performance successes of composites in airplane construction provide an opportunity for this processing technology to have significant influence. This technology has the potential to assist in reducing financial risk of high rate composite structure fabrication capability thru rate insensitivity.*



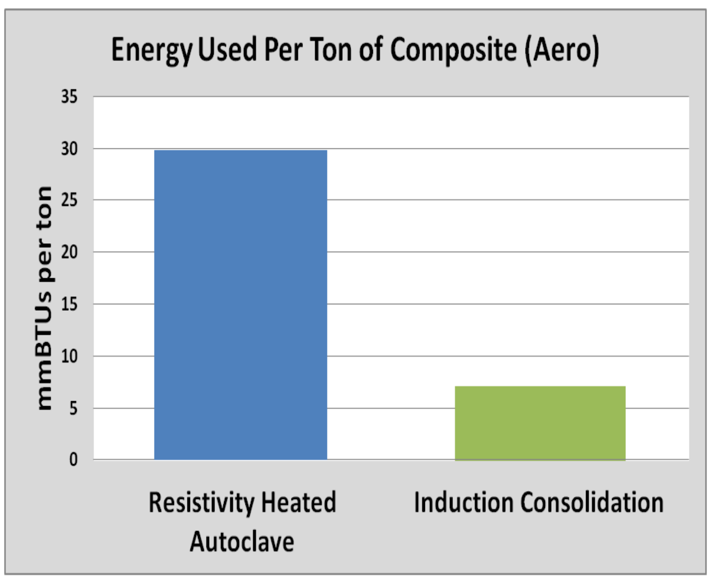
Transition and Deployment

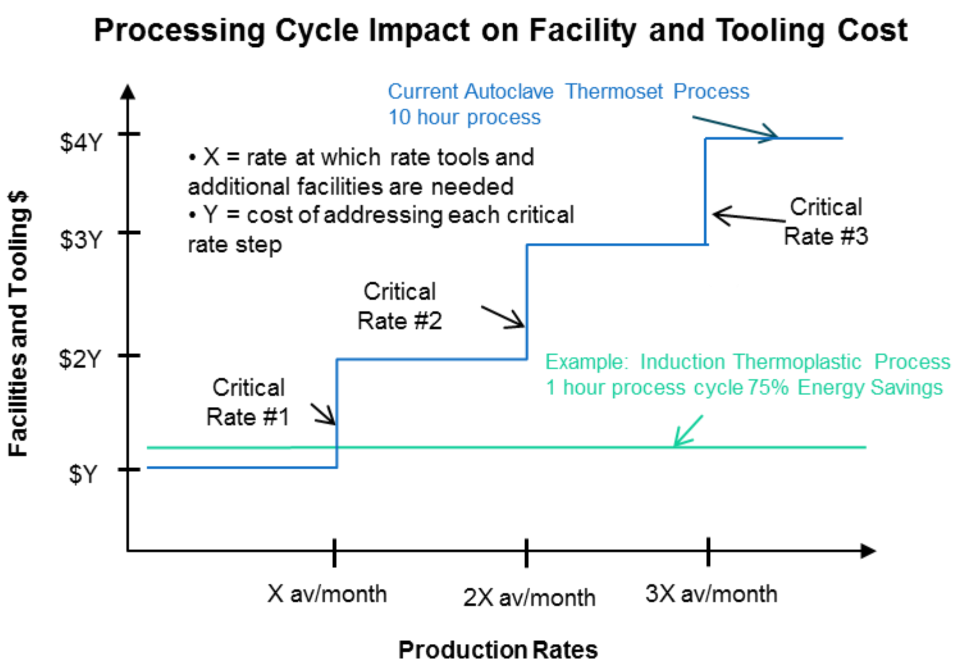
- *As Boeing defines its future products, new more efficient production methods that enable improved performance like this process will be vital to reaching long term goals. The Department of Energy and Boeing will be interested in the significant energy savings that is enabled by this technology over the use of standard processes like autoclaves.*
- *The aerospace industry will be the end user of the process. The intent is that this process will be used to fabricate composite aerospace structure affordably and efficiently at accelerated rates of production. This is important since composite aerospace structures have shown to provide significant performance advantages.*
- *Boeing would further develop this process for internal and external fabrication sourcing for large components.*
- *Internal use by Boeing could provide technology sustainment with further growth provided by out-sourcing and adoption by composite fabrication industry in general.*



Measure of Success

- *When successful, this technology could enable affordable and efficient high rate production of large composite aerospace structure. This technology has the potential to assist in de-risking the establishment of high rate composite structures fabrication capability thru rate insensitivity. Lay-up rate and consolidation cycle time along with quality of the components will be key metrics.*
- *This technology is projected to provide 75% energy savings over standard autoclave processing. The economic advantage is lower risk implementation of affordable and efficient high rate production of large composite aerospace structure.*

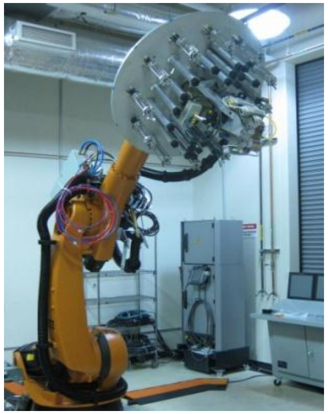




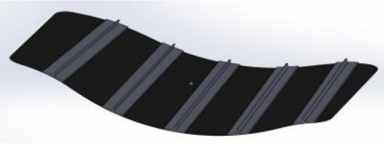
Project Management & Budget

- Start date is 5/14/2015 --- End date is 5/14/2018
- Budget Period #1: *Q4 – Task 2 – milestone 2.3* (complete month 12)*:* *Complex part consolidation with +/- .050" per lineal foot part to engineering accuracy; +/- .030" per lineal foot part per part accuracy;* less than 4% porosity; +/- 30F *thermal uniformity; less than 120 minutes processing time; with 40% improvement in energy consumption over autoclave processing*
- Budget Period #2: *Q8 – Task 8 – milestone 8.4* (complete month 24)*:* *Establishment and integration of scale-up fabrication system capable of processing the 5' by 15' component scale-up demonstration*
- Budget Period #3: *Q11 – Task 14 – milestone 14.2* (complete month 32)*:* *Consolidation of large 5' by 15' complex scale-up component with* +/- .030" *per lineal foot part to engineering accuracy;* +/- .010" *per lineal foot part per part accuracy;* less than 2% porosity; +/- 10F *thermal uniformity; less than 60 minutes processing time; with 80% improvement in energy consumption over autoclave processing*

Laser Assisted Fiber Placement of Thermoplastic Composites

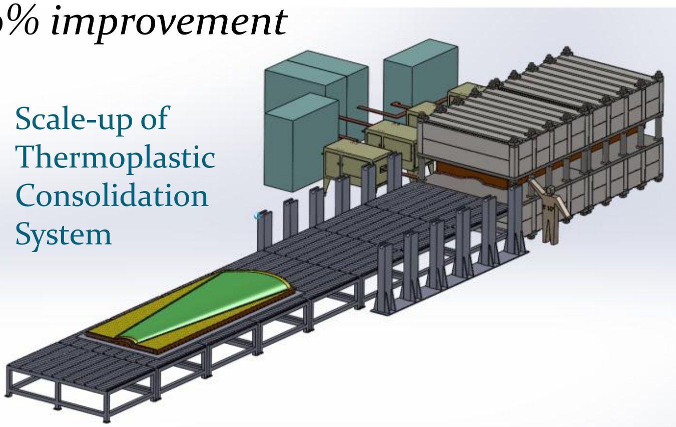


Mid-Sized Thermoplastic Composite Demo-Panel



Total Project Budget	
DOE Investment	$4,500,000
Cost Share	$1,865,603
Project Total	$6,365,603

Scale-up of Thermoplastic Consolidation System



Results and Accomplishments

- *This project was just initiated : 5/14/2015*
- *Recent accomplishments include:*
  - *Continued work on laser assisted fiber placement*
  - *Further refinement of the induction consolidation process parameters*

- *The objective of this project is to demonstrate and document the energy efficiency plus the technical and economic viability of induction consolidation using smart susceptors for full-scale integrated thermoplastic composite structures on an aerospace application. This will be accomplished thru the demonstration on a medium scale component initially for risk mitigation purposes and then development of equipment, tooling, and processes along with the subsequent fabrication of a full-scale component will be performed. This component, when successful fabrication is complete, will demonstrate an improved capability to meet high production rates for large aerospace thermoplastic composite structures.*