PURDUE UNIVERSITY

CAPSTONE/SENIOR DESIGN EXPERIENCE 2018

Cooling Package Redesign For Optimized Cleanout

Agricultural & Biological ENGINEERING

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Introduction

Problem Statement:

- Current Caterpillar M3 series motor graders are not optimized for the cleanout process and do not easily allow the cooling cores to be blown out linearly.
- When operating in high dust and high debris environments, the radiator cores must be cleaned often to avoid cooling efficiency issues.

Background:

- Access panels located on either side of the machine
- Operator/Mechanic must clean radiator cores with an
- air wand or pressurized water source
- Cooling fan swings open, allowing access to rear
- side of cooling cores
- Debris in radiator cores reduces cooling efficiency
- Must be cleaned often in high dust and high debris environments

Opportunity to Solve and Constraints

- Next line of motor graders to appear in the open market within the next few years
- Allow for increased access of air wand or pressurized water source to remove debris
- Increasing cleanout efficiency would decrease machine down time
- Operator and owner satisfaction is a key component to the continuation of the Caterpillar success in marketplace

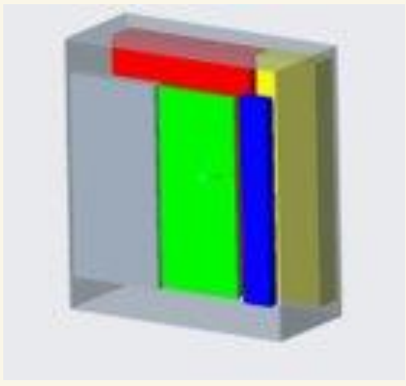
Solution Generation

- Nine solutions generated based on criteria given by Caterpillar and given weights based on important decision making factors
- Top three solutions chosen for further analysis, design iterations, and determination of feasibility

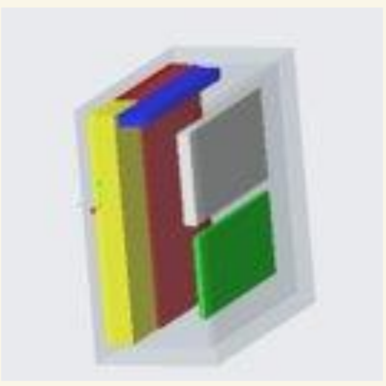
Cooling Package Redesign for Optimized Cleanout	Ranking system with respective percentages						
Max Leiser & Yijie Zhao	10	10	10	10	10	10	60
Initial Design Decision matrix	25%	20%	10%	5%	15%	25%	100%
Options-Initial list of potential solutions for the reel support arm	Price-How expensive is the part? (highest score for the least expensive)	Durabilty-How long does the part last, and does it serve the purpose well? (highest score for most durable)	Repairability-How easy is it to repare the part (highest score for easiest to repair)	Availabilty-How easy can the part be found? (highest score for easiest to find in the market)	Safety-How safe is it to use this part? (highest score is the safest)	Practicality-How practical or feasible is this part able to support the reel (highest score for most practical)	Score
Design	10	10	10	10	10	10	10.0
Vertical Orientation for Oil Cooler, AC Condenser, & Fuel Cooler	9.00	10.00	10.00	10.00	10.00	10.00	9.75
Fine Mesh Grille Insert	7.00	5.00	7.00	7.00	9.00	8.00	7.15
Oreient Fuel Cooler directly below top intake grill and move hydrualic oil cooler/AC condenser back	8.00	8.00	6.00	10.00	10.00	9.00	8.45
Swap Orienation of Radiator & ATAAC with Oil Cooler, AC Condener, & Fuel Cooler	8.00	9.00	8.00	10.00	10.00	5.00	7.85
Add Mechanisms (hindges) to Oil Cooler, AC Condenser, & Fuel Cooler	8.00	7.00	8.00	8.00	9.00	9.00	8.20
Reversible Fans	2.00	8.00	6.00	7.00	10.00	5.00	5.80
Redesign Air Wand	9.00	10.00	10.00	10.00	10.00	9.00	9.50
Redesign cooling core size for better fit	2.00	10.00	10.00	7.00	10.00	1.00	5.60
Increase length of machine for added room	1.00	10.00	10.00	10.00	10.00	1.00	5.50

Alternative Designs

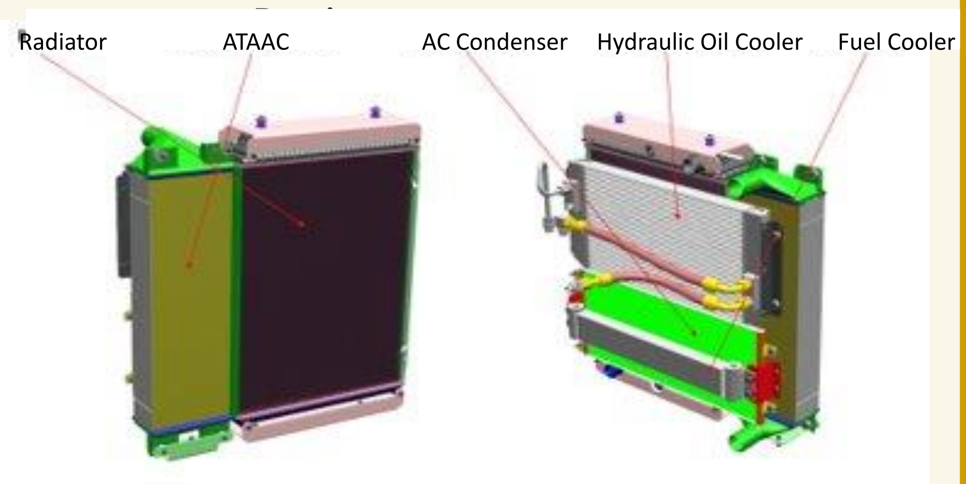
Vertical Orientation



Overhead Fuel Cooler

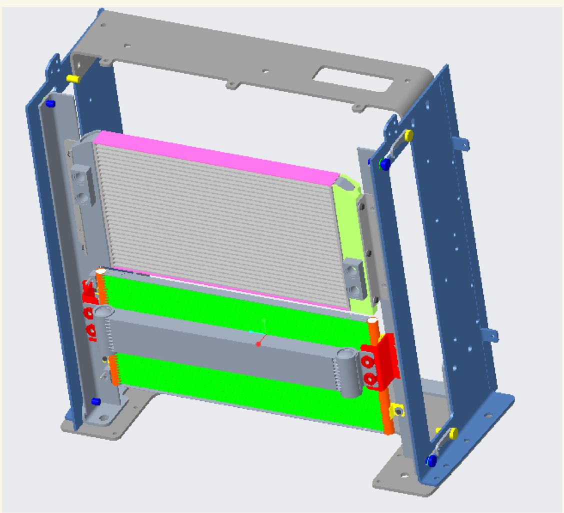


Current Production

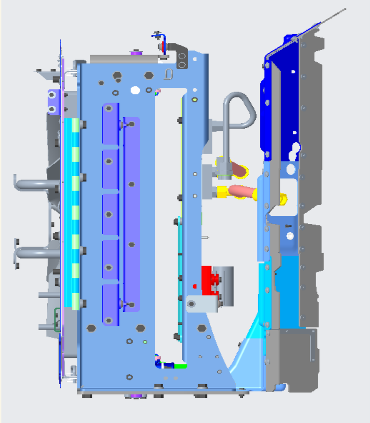


Final Design

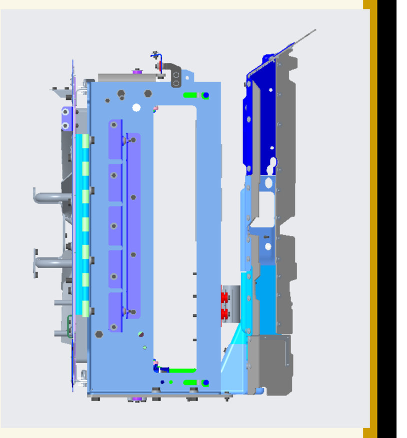
- Cores slide forward to the engine baffle with minor clearance
- Utilization of original hardware simplifies manufacturing and design process
- Addition of a slider mechanism/latch to minor cores will securely fasten them in place



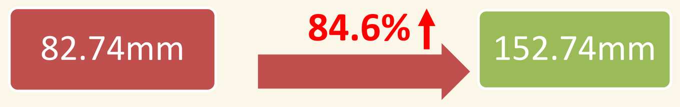
Original



Modified



Expected Results



- Increased space allows cores to be cleaned more efficiently.
- Cores can be locked in place in both cleaning and operating positions.
- Cooling performance impact is minimized because operating position has not changed from current design.

Cost Analysis

Component	Model	Details	Quantity	Unit Cost	Total Cost
Steel	1E0650	Price/Ton	187.98	$500.00	$93,990.00
Alloy Steel Shoulder Bolt	91259A624	3/8" D, 1" Long Shoulder, 5/16"-18 Thread	6000	$1.33	$7,980.00
Nylon Plastic Washer	90295A470	3/8" Screw Size, 0.39" ID, 0.75" OD	12000	$7.36/100	$883.20
Zinc Yellow-Chromate Plated Grade 8 Steel Washer	98023A031	3/8" Screw Size, 0.406" ID, 0.812" OD	6000	$6.41/50	$769.20
Radiator Core Support Plate Machining	CNC	Web Simulation Run	N/a	$0.59	$1,778.00
Core Latch Machining	CNC	Web Simulation Run	N/a	$0.57	$3,410.00
*Based on 1500 Machines produced per year			Total Cost		$108,810.40

FEA analysis

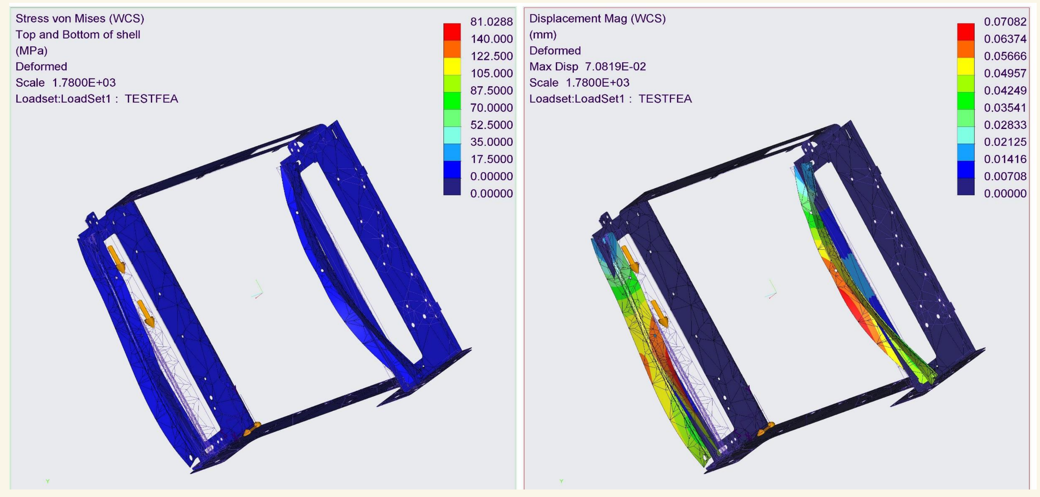
Caterpillar uses a g-loading method as a test criteria for the fatigue strength of their models. The method involves applying multiple gravity loads to the model:

Axis	Multiplier	Total Load mm/sec^2
X	5	49050
Y	3	29430
Z	2	19620

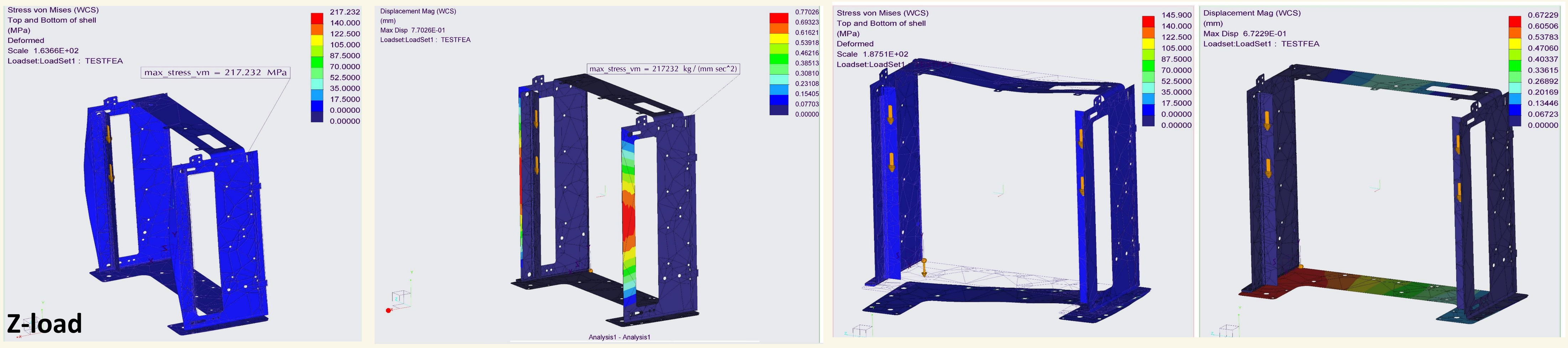
The weight of AC Condenser (4.6kg), Hydraulic Oil Cooler (26kg), and Fuel Cooler (4kg) is also added to the assembly as total of 339.4N.

The fatigue criteria is 40 MPa for welds and 140 MPa for parent materials, which was provided by Caterpillar.

X-load



Y-load



Z-load

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