KADDB ATV DEVELOPMENT PROCESS
AGENDA

• About KING ABDULLAH II DESIGN AND DEVELOPMENT BUREAU.

• Overview.

• KADDB ATV Development Analysis:
  • Requirements and Main Input Parameters.
  • Tractive Effort Calculations.
  • Suspension and Steering System Design.
  • Structure Design.
  • Finite Element Analysis (FEA).
  • Manufacturing

• Challenges

• Final Product.
Overview

• Illustration of ATV Development:
  Methodology & steps followed to design and analyze 1st All-Terrain Vehicle (ATV) by KADDB.

• Development Time:
  April 2011.

• Current Status:
  • Final stages of testing & evaluation
  • Presented in SOFEX 2012
KING ABDULLAH II DESIGN AND DEVELOPMENT BUREAU (KADDB)

- Established on the 24th of August 1999 by a royal decree.
- Independent Government entity within JAF.
- Financed by the Jordanian defense vote and own clients.
- JAF’s partner and key provider of defense solutions.
- Main supplier of defense solutions and commercial requirements
KADDB ATV Development Analysis

• **Working Cycle:**

1. **Hard-Points**
2. **Dynamic Simulation**
3. **Finite Element Analysis**
4. **Final Design**
5. **Manufacturing**
6. **Verifications**
7. **Load Cases**
8. **Modifications**

- **CAD Model**
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- **Requirements and Main Input Parameters:**
  
  - **Mobility:**
    - **Mobility Category**
      All Terrain Vehicle.
    - **Gradients**
      60%
    - **Turning Circle**
      9m
  
  - **Load Carriage**
    - **Passengers**
      Two Passengers (Driver Included)
    - **Additional Pay Loads**
      250kg
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• Requirements and Main Input Parameters:

  • Transport and Recovery:
    • Air Transportability
    • Towing and Recovery.

  • Sub-System Characteristics:
    • Four Wheel Drive System.
    • Identical Four Wheel, Hub and Side Axles.
    • Diesel Fuel
### KADDB ATV Development Analysis

**Tractive Effort Calculations:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Total Power Required:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GVW (Kg)</td>
<td>1300</td>
<td>26.5 hp.</td>
</tr>
<tr>
<td>Road Speed (km/h)</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Vehicle Frontal Area (m²)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Climbing Gradient</td>
<td>60%</td>
<td></td>
</tr>
</tbody>
</table>
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- Suspension and Steering System Design:
  - Suspension System:
    - Double Wishbone Suspension.
    - Wheel Travel.
    - Ride Comfort.
  - Steering System:
    - Steering Wheel Effort.
    - Turning Circle.
    - Steering Return-ability.
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• Suspension and Steering System Design:
  • Dynamic simulation: ADAMS/Car.

• Simulation Process:
  • Kinematics simulation.
  • Parameters curves.
  • Modifying hard points.
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- Suspension and Steering System Design:
  - Parallel Wheel Travel (Kinematic):
    - Front Suspension:
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• Suspension and Steering System Design:
  • Parallel Wheel Travel (Kinematic):
  • Rear Suspension:
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• Suspension and Steering System Design:
  • Steering System:
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- Suspension and Steering System Design:
  - Steering System:
    - Steering Different Positions:
      - Level.
      - Full Bounce.
      - Full Rebound.
      - Opposite Travel.
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• Suspension and Steering System Design:
  • Preparing Load Cases:
    • A set of load cases prepared based on the environment affecting the vehicle during applications.
    • Each subcomponent were analyzed (based on the load cases) and verified.
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- **Structure Design:**
  - Using Autodesk Inventor Package.
  - **Subcomponent Design:**
    - Transferring hard-points into CAD model

Front Knuckle:

Rear Knuckle:
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- Structure Design:
  - Subcomponent Design:

Front Wishbone UCA:  Rear Wishbone UCA:
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• Structure Design:
  • Prevent structural discontinuity
  • Maintenance accessibility.
  • Strong roll cage offering safety for the crew.
  • Rear Bed for multifunction use or additional payloads.
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- Structure Design:
  - Subsystem Packaging:
    - Engine and transmission
    - Side axles and drive shafts
    - Front and rear differentials
    - Rack and pinion, steering column and steering wheel
    - Brake system
    - Radiator and cooling fan
    - Electrical systems and dashboard
    - Wheels & tires.
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- Finite Element Analysis:
  - CAD model preparation:
    - Transfer the solid model into shell surface.
    - Attach the surface model from Autodesk Inventor to ANSYS Design Modeler in order to speedup the iterations and design modifications.
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- **Finite Element Analysis:**
  - **FE Modeling:**
    - Chassis meshed with shell element.
    - Suspension component meshed with high order solid tetrahedral elements.
    - All welds and bolted joints replaced by bonded contact.
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- Finite Element Analysis:
  - FE Modeling (Cont.):
    - Inertia relief was applied to all models.
    - S270 steel Material was used for chassis and suspension components.
    - Minimum quoted material yield strength 275MPa was used as comparison to predicted FE stresses.
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- Finite Element Analysis:
  - Subcomponent Analysis:
    - Front Knuckle (Upright):
      - Baseline
      - New rib
      - Rib extended and widened
      - Notch removed
      - Iteration
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- Finite Element Analysis:
  - Subcomponent Analysis:
    - Front Knuckle (Upright):

[Images of baseline and iteration models with peak stress markers]
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- Finite Element Analysis:
  - Subcomponent Analysis:
    - Rear Knuckle (Upright):
      The Peak stress was below yield for all load cases therefore no design modifications were required.
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- Finite Element Analysis:
  - Subcomponent Analysis:
    - Upper Wishbone Arm (Front):

Pipe Thickness were increased

Baseline

Area has been redesigned by adding material.

Iteration
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- Finite Element Analysis:
  - Subcomponent Analysis:
    - Upper Wishbone Arm (Front):

![Baseline](image1)

![Iteration](image2)
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- Finite Element Analysis:
  - Subcomponent Analysis:
    - Upper Wishbone Arm (Rear):
      - Pipe Thickness were increased
      - The Machined Part were redesigned.

Baseline

Iteration
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- Finite Element Analysis:
  - Subcomponent Analysis:
    - Upper Wishbone Arm (Rear):

![Peak Stress](image)

Baseline

Iteration
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- Finite Element Analysis:
  - Subcomponent Analysis:
    - Lower Wishbone Arm (Front and Rear):
      The Peak stress was below yield for all load cases therefore no design modifications were required.
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• Finite Element Analysis:
  • Chassis:

  The Peak Stress exceeds yield in several locations.
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- Finite Element Analysis:
  - Chassis:
    - The Peak Stress exceeds yield in front damper mount and wishbone attachment point.
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- **Finite Element Analysis:**
  - **Chassis (Cont.):**
    - Top damper mount and lower wishbone mount both were reinforced using web design to spread loads at the connections with longitudinal tubes.
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- Finite Element Analysis:
  - Chassis (Cont.):
    The Peak Stress exceeded yield in the connection between flat bed to main roll cage.
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- Finite Element Analysis:
  - Chassis (Cont.):
    The Peak stress was below yield for all load cases.
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- Finite Element Analysis:
  - Chassis (Cont.):
    - Extend mount bracket up to flatbed level. Two side supports added.
    - The Peak Stress exceeds yield in rear damper mount.
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- Finite Element Analysis:
  - Enhance the Approach and Departure Angles:
    - CAD model Modifications:
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• Finite Element Analysis:
  • Approach Angle 64 deg. instead of 41 deg.
  • Departure Angle 81 deg. instead of 62 deg.
• Finite Element Analysis:
  - Analyzing the effect of this modification on the suspension mount:

    The Peak stress is below yield for all load cases therefore no design modifications were required.
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- **Manufacturing:**
  - The Chassis was splitted into three main parts, front, rear and intermediate, each part have its own jig.
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• Manufacturing:

Assembling Jig
Challenges

- Automotive Design experience:
- Limited local market.
- Development Time
Final Product

Final Design

Final Product
Final Product
Questions