Tank Packaging Design and Testing

Martin Capula, Harsha Dharmaraj, Andrew Ockey, Justin Peltz, Skyler Rapp, Ryuto Thew, Aison Tran, Sidney Vass, Sreenidhi Yaratha

Joint Science and Technology Institute, Virtual 2021

Introduction

Packaging and shipping are integral to the engineering process. Once an item is prototyped, the item must be transported to the warfighter. During transit, there could be multiple issues such as potential water damage, vibrational shock, changes in pressure, and a multitude of other threats. Packaging is a crucial process when it comes to providing undamaged material to the Warfighter. Participants in the JSTI 2021 cohort were tasked with designing armor for a given tank kit assembled during the two week residency. The model tank was then packaged and tested under different packaging method configurations in order to determine the best method.

Background

A tank is a military vehicle that can be heavily armored to suit the needs of the terrain it's facing. The military uses many different types of packaging materials that have many purposes. There are certain materials for electrical static preventative packaging as well as waterproof and water vapor proof containers. Those containers are needed to protect very delicate, expensive and critical that the Warfighters need, such as sensors and other damage prone-things. Participants were provided with the following requirements when designing their tank armor and packaging their tank kit.

Tank Armor Requirements

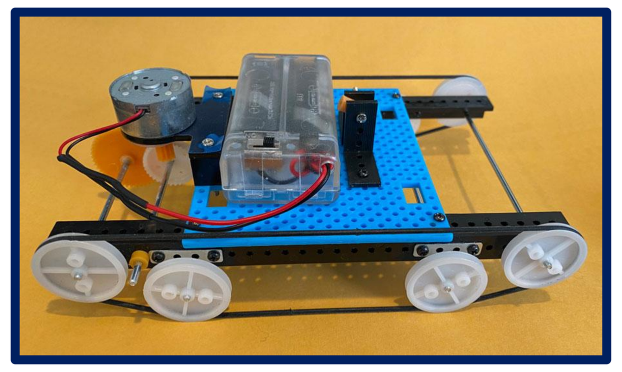
- Document design in 3D modeling software
- Follow dimensions, 18' x 10.5' x 0.75' for first deck, 10.5 'x 9' x 3' for second deck
- OWL or Overall Weight Limit not to exceed 16 tons

Tank Packaging Requirements

- 10-year storage life
- Capable of surviving outside storage conditions:
  - -25°F to 160°F
  - 15% to 90% relative humidity
- Transportation by all modes (air, water, rail, highway)
- All packaging, including tank, must be capable of one-person lift
- Unpackaged and fully operational within 7 minutes of receipt

Materials

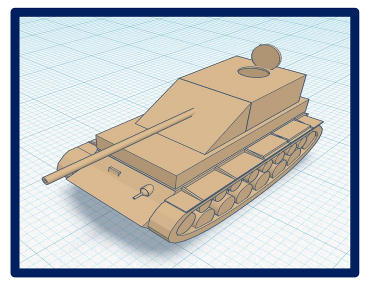
- DIY Tank Kit
- A-A-59135 Class 1 Cushioning Wrap
- AA Batteries x2
- TinkerCAD 3D Design Software
- Scotch Brand 2" Packaging Tape
- 7"x7"x7" Corrugated Fiberboard Box x2
- 8"x6"x4" Corrugated Fiberboard Box x2
- 8"x8"x8" Corrugated Fiberboard Box x2
- 7" x 14"x 4" Millimeter Poly Bag x4



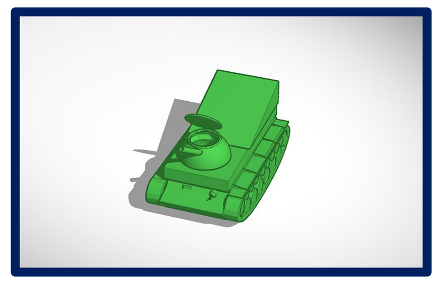
Participants were allowed to use household items in their designs.

Methods

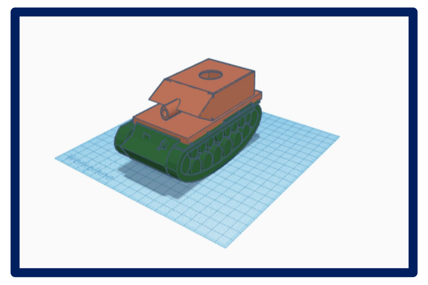
Participants spent a day brainstorming different armor ideas, creating concept sketches, and then presented preliminary designs to Advanced Design and Manufacturing mentors in a Preliminary Design Review. Participants then created 3D models using Tinkercad software. Participants designed tank armor that met the requirements given while modeling it in TinkerCad. A model kit was provided to build and to use to scale 3D images. Participants used 490 lb/ft^2 as the density of steel in order to determine the weight total of the designed tank decks. The total weight was subtracted from the requirement weight in order to determine the reserve weight which could be allocated for armor. Students presented final designs and calculations during a Critical Design Review. Final designs must have shown scaling that allowed students to 3D print their designs for model kit they built.



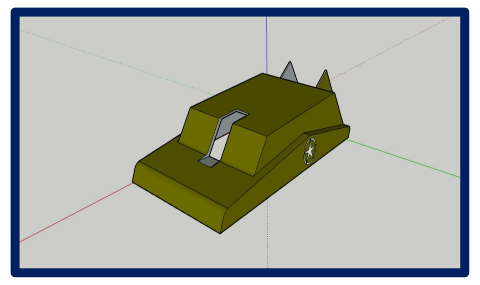
Tank Design 1
Amor Thickness : 2" all around on 1st deck
1.5" front and sides of 2nd deck, back 1"
Steel weight: 15.8 tons
Reserve weight: .2 tons



Tank Design 1
Armor Thickness: 3" front, 1" top and bottom, 2" sides, 2" back for 1st deck
2nd deck 3" all the way around
Steel weight: 14.074 tons
Reserve weight: 1.92 tons



Tank Design 3
Armor Thickness: Front 3", Sides 2", Top/Back 1"
Steel Weight: 13 tons
Reserve Weight: 2.5 Tons (5000 Pounds)



Tank Design 4
Armor Thickness: Front 4", Top 3", Rest 2"
Steel Weight: 15.62 tons
Reserve Weight: 0.38 Tons (760 Pounds)

Participants studied the different packaging procedures presented by mentors. Participants brainstormed, sketched, and packaged the model kit they previously built. Four different design configurations were created to be tested for efficiency. Six drop tests (1 drop per side of the package) from a height of 4 feet were performed in each package. Packages were then shaken for a total of 3 minutes (1 minute side to side in the X, Y, and Z axis) to simulate a vibrational test.

Packaging Design 1: Method 20, physical protection with cushion, Method 31 for rubber material

Packaging Design 2:
Method 10 with blocking using paper plates. Disassembly of object for packaging

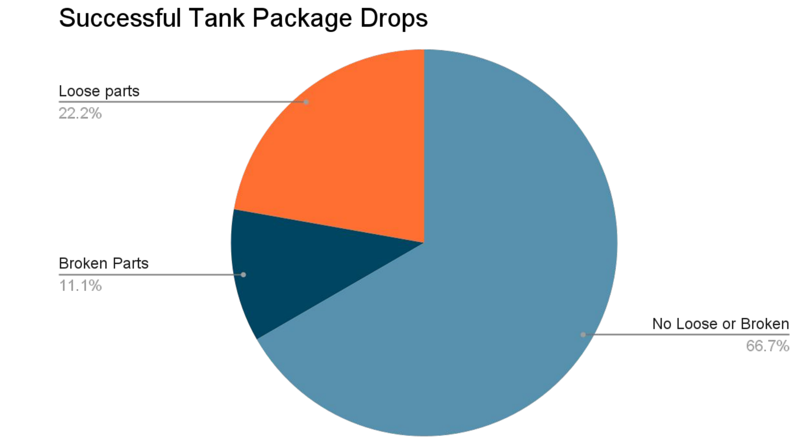
Packaging Design 3:
Method 10 with non-military materials (towel)

Packaging Design 4:
Method 30 enclosed whole tank. Non-military void filler. A-A 59135 cushioning wrap

Results

- The tank armor designs were all below 16 tons (32,000 lbs) and all the of participants' designs met the minimum size requirements, all of which were presented in an online CAD (Computer-Aided Design) program.
- 6 out of 9 participants had successful tests with the tank being undamaged. 2 of the package designs had parts of the tank come loose during testing, and 1 participant had a part break during the tests (see graphs at upper right).
- A critical area found when testing packages was the motor bracket. The bracket was found to be the easiest to break. Another concern was the battery pack, as testing showed that the battery packs often fell or broke off.

Packaging Design	Tank Intact After Drop and Vibrational Test	Loose Parts	Broken Parts
Design 1	Yes	No	No
Design 2	Yes	No	No
Design 3	No	No	Yes
Design 4	Yes	No	No



Conclusions

The tank armor designs had many differences. Some had a more blocky design composed of triangles and squares while other designs were based on curved surfaces. All tank designs met the requirements given. Due to 3D printing limitations due to the virtual nature of JSTI for this cohort, the most effective design wasn't agreed upon because of the lack of testing available. Future recommendations would be to have participants 3D print their tanks in order to perform testing on site.

All packaging designs included the disassembly of the turret which was identified as a critical area during packaging analysis. This action of disassembling was credited with preventing major damage to the package and the tank. Based on our packaging designs, using non-military materials is detrimental to keeping items safe. Design 3 had multiple broken parts. This could have been attributed to the towels being packed very thigh and the tank not having any give when dropped or vibrating. This lack of give would increase the shock force the item would experience. Another problem that emerged was the lack of high quality packaging materials. As such, groups had to adapt and use unconventional materials such as t-shirts to protect their tank.

Future recommendations for the project would be to provide students with more military packaging material. Students will then be able to test packaging methods more accurately. If students are provided with different materials, students may be able to create more diverse packaging methods.

Acknowledgements

Thank you to U.S Army Combat Capabilities Development Command (DEVCOM) Advanced Design and Manufacturing (ADM) mentors David Vincitore, Mary Kay Peck and Bob Pazda. A special thank you to Dr. Ronald Hann and all of Defense Threat Reduction Agency for your priceless dedication to the program. We appreciate the opportunity provided to us by the Defense Threat Reduction Agency (DTRA), Oak Ridge Associated Universities (ORAU) and Education, and the Chemical Biological Center (CBC) at Edgewood. A special thank you to Sergio Estrada.