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"Suppressing IED using non-Newtonian fluid"

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ABSTRACT: Mobile Explosive Containment Vessels (MECV) referred as Total Containment Vessels (TCV) are fully enclosed vessels use to absorb the explosion forces the enclosure is spherical and made of high-strength steel from 25mm to 40mm. which increases too much weight. The efforts in this project are to reduce the metal thickness of mobile explosive containment vehicle (MECV) by filling it with a non-Newtonian fluid which could reduce overall weight, absorb the impact force, reduce the manufacturing cost. A comparison was made for the metal container vs plastic container filled with partial and full non-Newtonian fluid for the same blast impact load. Live data readings were recorded using force sensors and the data was analyzed using scientific methods

KEYWORDS: MECV, TCV, vessel, non-Newtonian, sensor,

I. INTRODUCTION

Thousands of lives are being lost every year due to IED (improvise explosive device). IEDs were responsible for approximately 63% of coalition deaths in Iraq An IED consists of a switch (activator), an initiator (fuse), container (body), charge (explosive), and a power source (battery) or manual ignition. Not every IED can be electronically diffuse but involves a great risk of touch explosion. so here comes the into play (MECV) Mobile Explosive Containment Vessels. But the challenging factor is weight to the mobility ratio. Generally, these vessels have a thickness from 25mm to 40 mm made of high-speed steel (HSS) which makes its too bulky for mobility. finding the alternative, we can reduce the thickness of this Mobile Explosive Containment Vessels by replacing the steel thickness with composite layer of non -Newtonian fluid which acts as shock absorber. To do so many factors need to be considered like the explosion pressure, time period, shockwave etc. as the system involves dynamic forces.

Fig 1 shows an IED explosion

II. GENERAL CALCULATIONS

Before the experiment is carried out environmental parameters are collected which would be used further for the design calculation. material data and specifications are collected. Generally, the sutli bomb contains 25 grams gun powder having 3 Mega Joules of energy per 1 kg that equals 3000 joules per 1 gram. By using Brodes equation we can estimate pressure of explosion.

$2\ KNO_3 + S + 3\ C \rightarrow K_2S + N_2 + 3\ CO_2$.

Atmospheric pressure (p_1) = 1.01 bar
Chamber pressure (p_2) = ?
Volume of container = 0.003 m^3 (cooker 3lts)

Blast wave pressure when one sutli bomb containing 25g gunpowder explodes in pressure cooker of 3liters

(3000 X 25grams)
= 75000 joules
=0.7500 m^3 bar

As per brodes equation

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$$E = \frac{(P_2 - P_1)V}{\gamma - 1}$$

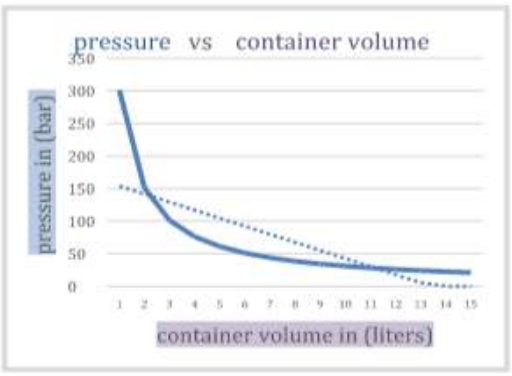
P_2 = 101 bars,
P_2 = 102 kg/cm^2 for 0.005 sec

using brodes, equation, we can see the effect of pressure (p_2) based on different container volume

$$E = \frac{(p_2 - P_1) \times v}{\gamma - 1}$$

container volume (lts)	container volume (m3)	pressure generated (p2) in bar
1	0.001	301
2	0.002	151
3	0.003	101
4	0.004	76
5	0.005	61
6	0.006	51
7	0.007	44
8	0.008	39
9	0.009	34
10	0.01	31
11	0.011	28
12	0.012	26
13	0.013	24
14	0.014	22
15	0.015	21

table .2 shows the volume vs pressure



Graph.1 shows the volume vs pressure

Considering three different samples. Sample A stainless steel (cooker), sample B polypropylene (pp) cylinder + half-filled Newtonian fluid, sample C polypropylene (pp) cylinder + full-filled Newtonian fluid are subjected to the sutli bomb explosion force and the stress values are calculated using the force sensors connected to the Arduino uno.

	MATERIAL	IMAGE	Weight
Sample A	Stainless steel Cooker		2kg
Sample B	Polypropylene + 50% non-Newtonian fluid		1.5kg
Sample C	Polypropylene + 100% non-Newtonian fluid		0.75 kg

Fig 2 shows the sample A, B, C

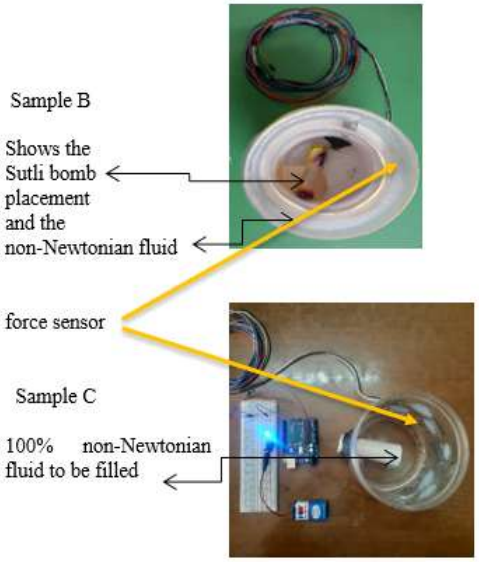


Fig 3 shows the sample B, C force sensor placement

III. EXPERIMENTATION

Three different samples are subjected to the explosion as follows and the results are tabulated the numerical values are obtained from force sensor connected to Arduino.

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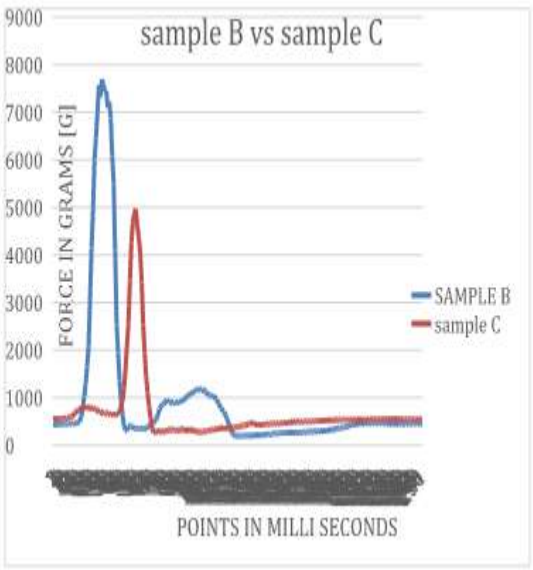
table .3 shows the explosion impact on sample A, B, C as follows.

IV. OBESERVATIONS FROM THE EXPLOSION TESTS CONDUCTED

After the explosion test for the sample A, B, C the readings were imported from the Auridon to the excel for sample B, sample C and the line graph was plotted for 246 data points vs force[F] in grams. For a span of 30 seconds. the sample B line is shown in blue and sample C line is shown in orange.



V. CONCLUSION

After observing the explosion images and the graph analysis we conclude that the sample A which is stainless steel pressure cooker could not with stand the explosion pressure. For the sample B consisting of 50 % non - Newtonian fluid we see that the explosion force could be supress but not completely and the container lid got exploded. the last sample C containing full non-Newtonian fluid the explosion forces could be absorbed. And the blast pressure did not destroy the containers lid. This conclusion is from the graph where we observe a difference of 2000 grams of force comparing the sample B and sample C. and weigh is reduce by 1 kg 25 gm as comparing sample C with sample A.

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