International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 12 | Dec -2016 www.irjet.net p-ISSN: 2395-0072

Design and Analysis of mini disruptor used for bomb disarmament

Avinash K. Bankar[1], Prof. Sachin K. Dahake[2], Nachiket U. Phadke[3]

[1]*Mechanical Engineering, MET's Institute of Engineering Bhujbal Knowledge City, Nashik, avinashbankar100@gmail.com*

[2] *Associate professor, Mechanical Dept., MET's Institute of Engineering BKC, Nashik, sachindahake@gmail.com*

[3] *Chief Engineer, Elenoenergy, Pune, nachiket@elenoenergy.com*

Abstract- *This paper mainly concentrate on increase the security of human and efficiency of bomb disposal and take the action for disarming the explosives without human contact. Now day's terrorism is very dangerous problem which whole world is facing. Terrorist attacks are recently raised at high levels. Robots are taking the place of human in the work of bomb detection, transportation, and removal. But robot can't diffuse or destroy the bomb. Sometimes bombs are difficult to neutralize because of location not suitable to explode for fear of human life or building damage. To achieve these objectives we are design disruptor which can diffuse the bomb at where it located without physical contact of human to reduce the risk of bomb squad life and damage of public property.*

1. INTRODUCTION

Bomb disarmament is the process by which hazardous explosive devices are rendered safe. Many techniques are available for destroy the bomb. Selection of techniques is depending upon the situation. Explosives in remote localities are handled very differently in populated areas. The role of bomb disposal squad is to complete their task as remotely as possible. But laying hands on a bomb is only done in extremely life threatening situation, where the injured to people and damage the public property cannot be reduced. Bomb squad have many tools for remote operations, in which one of the techniques is RCV or remote controlled vehicle which is also known as wheelbarrow. It contains the device similar to X-ray which is used in medical personnel. It also have high performance sensor that can detect the bomb or even captured the image of bomb. Once the bomb squad determine the presence bomb and what contains in it, then they formulate the procedure to disarm the bomb. The specific bomb will allow the technician to remove it from the area. In this case closed vessel is used it is shaped like water tanks, large sphere etc. And then squad place the item in container and retires to an uninhabited area to complete the neutralization. Another technique the squad is used in which a bore is cut into the sidewall of a bomb and explosive contents are extracted through combination of steam or acid bath liquification of bomb contents.

2. LITERATURE REVIEW

Zeng Jian-Jun, Yang Ru-Qing, Zang Wei-jun, Weng Xin-hua, Qian Jun [1] in this paper, they conducted EOD robot system, Super Plus, which has novel semi-automatic bomb fetching the function is presented in this paper. With limited human support super plus scan the cluttered environment with a wrist-mounted laser distance sensor and plan the manipulator a collision free path to fetch the bomb. The model construction of manipulator, bomb and environment, C-space map, path planning and the operation procedure are introduced in detail. The semi-automatic bomb fetching function has greatly improved the operation performance of EOD robot.

Rocco Di Verdi [2] this paper work consists of designs new robotics technologies to disarm explosive remotely, without human contact in order to keep bomb disposal experts safe. A small robotic hand and a data glove were engineered to allow the mimic human movements, such as opening zippers and pulling wires, the hand was constructed with identical parts used in my many locations as possible to reduce cost. A pulley system was used to control the hand, with the pulleys guided by aluminium and flexible plastic tubes. Bend sensors were employed by the date glove to track the position of the hand then read the position of bend sensors and used to reading the control servos in the forearm of the hand. The final hand could constantly grasp medium size object but was inconsistent in grasping small thing objects.

Amon tunwannarux [3] they design and developed of the explosive ordnance disposal robot named. It is enhanced project from the rescue robot called CEO mission. The mechanical arm with the X-rays equipment set attached for the improvised explosive devised inspection id installed on the track wheel type universal robot platform of the CEO mission robot. The X-ray set which is composed of the X-ray sources and screen installed and plugged into the versatile controlling and monitoring system so the X-ray image can be sent to the control system.

Adam Jaroh, JohnstoWn, George Lubert, Jeremy Sitar, Portage, David Metz, Duncasville [4], this paper contain a system for indicating a point of impact projectile from a barrel of gun including a dynamic aiming devices mounted to the barrel having a camera for displaying an image of the target, and processing circuitry for superimposing a crosshair image on the displayed image of the target. The position of the crosshair image is adjusted relative to the distance for indicating the point impact of the projectile red the barrel.

3. NEED OF INVESTIGATION

One of the greatest problems for both military and police forces to handle the explosive devices. For instance, in Syria there were regularly over 150 causalities a month resulting from improvised explosive in 2014 and 2015. Even when bomb is found, disarming it is potentially dangerous and unpredictable. Current robots are used in many cases to aid the bomb squads, but they have many limitation. Current bomb disposal robots have grippers which allow the robot to open the doors and access the explosive device. The operator of the robot has fetched the bombs with manipulator, and carries them into a blast protection box for transporting to safe place. Using these disruptor is not attempting to destroy the device. In most cases a human must put themselves in danger by disarming the explosive device manually. The surrounding bombs are unknown and unstructured, which become the potential obstacles during the bomb disposal. Besides, the innovation of explosive theory, creation of variety of bombs and improve the manufacturing technology of bomb make the bomb disarmament more difficult. It makes the disposal operation a big challenge for the bomb squad especially when surrounding is complex and cluttered. The operator may have fear failures of avoiding a collision of manipulator with surroundings or bomb, and this may trigger the bomb. To further reduce the risks associated with bomb disposal, robots must be developed the can actually disarm explosive devices. So we have to design mini disruptors which can disarmament the bomb at where it found without physical contact of human or without bomb transportation to safe place.

4. OBJECTIVE

- To study the existing system.
- To design the mini disruptor.
- To analysing the design for mechanical loads.
- To increase the security and efficiency of bomb disposal operation.
- To validate the results experimentally and analytically.

5. METHODOLOGY

DESIGN CONCEPT OF DISRUPTOR

Fig. 1: Solid model of Mini Disruptor

WATER
The water acts as a projectile that shoots out of the disruptor and hits the target.
GUNPOWDER
The gunpowder is an explosive substance, like propellant, that burns rapidly to create a huge amount of gas pressure to propel the water out of the bore of the disruptor.
CASE
The case holds all the parts i.e. barrel, propellant, and cartridge, and is usually made of brass.

HOW DOES IT WORK?

Now let's understand the mechanism of how a disruptor works in a step-by-step manner. When the water is loaded into the barrel and the ignition take place in cartridge. The gunpowder is ignited. The gunpowder acts as the propellant that pushes the piston forward. The gunpowder explodes rapidly and releases gases that create a huge amount of pressure behind the plastic piston. The water is shot. The mechanism of firing water is based on Newton's third law of motion, which implies that for every action, there is an equal and opposite reaction. So, when the propellant burns, the resulting gas exerts a great force on the water. As there is no way out of the barrel except its open end, the water shoots forward and out of the barrel opening with a great velocity, leaving behind the cartridge and exhaust. The impact of the water on the target depends upon the pressure that builds up due to the burning of the gunpowder. This water is impact on the bag or wooden box which contain the explosive material and then water break the bag and inject in explosive material. Then water is disarmed the bomb or explosive material to prevent the life and property damage.

5.1 DESIGN OF CARTRIDGE

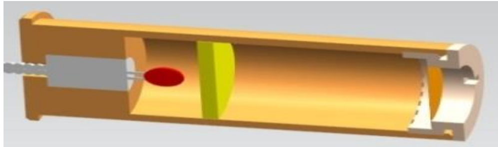

Fig. 2: Cartridge

The cartridge for Mini Disrupter consists of threaded End Cap & Foil assembly, Case & Squib (Filled). Case is having central hole to accommodate squib at one end and End Cap & Foil Assembly at other end. End Cap is soldered with Foil. Case and End Cap both are made up of brass and the Foil is made up Copper material.

ESTIMATION OF STRESSES

(a) Hoop Stress (σ_h)

The design of the cartridge case based on Hoop stress which is predominant

$$\sigma_h = \frac{Pd_i}{2t_c} \qquad (1)$$

where, t_c = Cartridge wall thickness, P Max pressure generated in the case = 30 MPa, d_i Internal Diameter (ID) of the case

$$\sigma_h = \frac{30\times 17}{2\times 1.5} = 170 \text{ MPa}$$

The pressure generated by firing the cartridge inside the CV having volume 150 CC is 28.12 MPa. For safe design we have considered the max pressure 30 MPa.

(b) Longitudinal Stress (σ_l) = Longitudinal Stress will be half the value of Hoop Stress

$$\sigma_l = 85 \text{ MPa}$$

(c) Equivalent von Mises stress acting on cartridge

$$\sigma_{eq} = \sqrt{\sigma_h^2 + \sigma_l^2 - \sigma_h \times \sigma_l}$$
$$= \sqrt{170^2 + 85^2 - 170\times 85}$$

= 147.22 MPa

(d) The Outer Diameter (OD) of the case (t_c) can be determined as follows –

$d_o = d_i + 2\,t_c = 17 + 2X1.5 = 20$ mm

ESTIMATION OF STRAINS

(a) Hoop Strain (ε_h)

Hoop Strain is calculated by following equation

$$\varepsilon_h = \frac{1}{E}(\sigma_h - \mu\,\sigma_l) \qquad (2)$$

Where, E = Young Modulus of brass material = 100 GPa , $\mu = 0.35$

$$\varepsilon_h = \frac{1}{100\times 10^3}(170 - 0.35\times 85) = 0.001$$

(b) Longitudinal Strain (ε_h)

Longitudinal Strain is calculated by following equation

$$\varepsilon_l = \frac{1}{100\times 10^3}(\sigma_l - \mu\,\sigma_h) \qquad (3)$$

Where

$$\varepsilon_l = \frac{1}{E}(85 - 0.35\times 170) = 0.0002$$

(c) Total strain = $\varepsilon_h + \varepsilon_l = 0.00125$

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 12 | Dec -2016 www.irjet.net p-ISSN: 2395-0072

FACTOR OF SAFETY (FOS)

$$FoS = \frac{Max\ Stress}{Working\ Stress} = \frac{395}{147.22} = 2.68$$

THEORETICAL CHECKING OF BURSTING PRESSURE OF CU FOIL

Shear force experience by Cu foil = Pressure X Cross sectional area = P_i X A

$$= P_i \frac{\pi\, d_o^{\,2}}{4} \quad (4)$$

Tensile stress of Cu foil = 220 MPa
Shear stress of material = 110 MPa
Shear area = π X d_o X t

$$\text{Shear stress} = \frac{ShearForce}{\text{Shear Area}} = \frac{P_i\, d_o}{4\, t} \quad (5)$$

Where d_o = Outside diameter of Foil =15.6 mm , t = 0.08 mm and P_i = 30 MPa

$$\text{Shear stress} = \frac{P_i\, d_o}{4\, t} = \frac{30 \times 15.6}{4 \times 0.08} = 146.25 \text{ MPa}$$

> 110 MPa

2.1. BARREL DESIGN

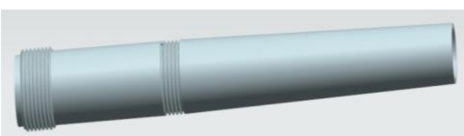

Fig.3: Barrel

The term barrel is used throughout to designate the principle part of mini disruptor which discharge the projectile or produce the water jet. The function of barrel is that it is a primary component of disruptor. Basically it is a tubular pressure vessel, closed at the breech and opened at muzzle.

ESTIMATION OF PRINCIPAL STRESSES

Outer dia: 30 mm, Inner Dia: 18.5 mm

The barrel will be designed for higher pressure i. e. 1.3 times the calculated pressure (Pi) = 30X 1.3 = 39 say 40 MPa

a) σ_1 =Hoop stress =

$$\frac{P_i R_i^{\,2}}{R_o^{\,2} - R_i^{\,2}}\left[1 + \frac{R_o^{\,2}}{R_i^{\,2}}\right] = \frac{40 \times 9.25^2}{15^2 - 9.25^2}\left[1 + \frac{15^2}{9.25^2}\right]$$

$\sigma_1 = \sigma_y$ = 88.85 say 89 MPa

b) σ_2 = Longitudinal stress = $\dfrac{P_i R_i^{\,2}}{R_o^{\,2} - R_i^{\,2}}$

$\sigma_2 = \sigma_z$ = 24.54 say 25 MPa

c) σ_3 = Radial stress = $\dfrac{P_i R_i^{\,2}}{R_o^{\,2} - R_i^{\,2}}\left[1 - \dfrac{R_o^{\,2}}{R_i^{\,2}}\right]$

$\sigma_3 = \sigma_x$ = 40 MPa (Compression)

The allowable tensile stress σ at elastic limit can be determined as :

$$\sigma = \left[\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2}\right]$$

σ = 157.99 MPa say 158

ESTIMATION OF FACTOR OF SAFETY

0.2 % P S (Proof Stress) of this material = 700 MPa

$$FoS = \frac{Max\ Stress}{Working\ Stress} = \frac{600}{158} = 3.79$$

As the design principle stress is less than Proof Stress of material, the design is safe.

MARGIN OF SAFETY

Margin of Safety is = FOS -1

Therefore Margin of Safety = 2.79

THE NORMAL STRESS

σ_n on the octahedral plane can be found by taking the average of stresses as

$$\sigma_n = \left[\frac{\sigma_1 + \sigma_2 + \sigma_3}{3}\right]$$

σ_n = 51.33 MPa

6. ANALYSIS

MESH

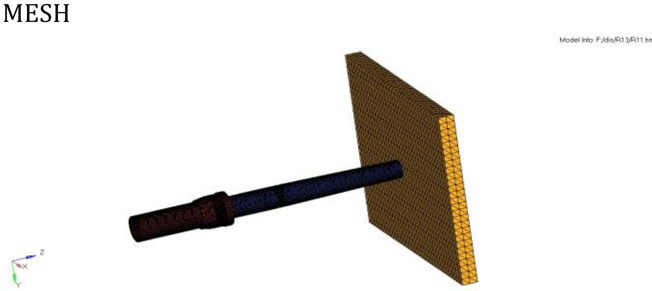

Fig.4: Meshing model of disruptor

1. SHELL MESH for Barrel, Cartridge and Breech Module.
   No. of Element: 70080
2. TETRADEHRON MESH for Plastic cylinder and Wood.
   No. of Element: 11384

3. SPH for Water and Gun powder
No. of Element: 451

ANALYSIS

After the giving boundary condition then run the analysis in LS-DYNA software. After Analysis Run successfully completed we got the following result.

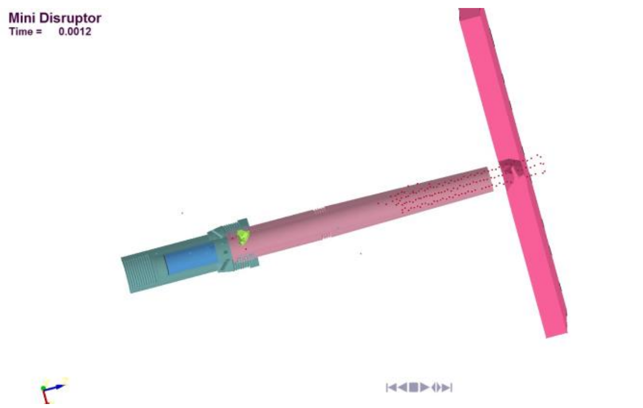

Fig.5: Water breaks the plywood in 0.001 second.

Water shoot from barrel with high velocity and impact on wood which is break the wood. After braking plywood surface water is injected on the IED's or explosive material to disarming purpose. Penetrated area on plywood surface which is 25 mm radius of hole and water jet velocity is 607 m/s measure in LS-pre-post.

Fig.6: 25 mm radius of hole created by disrupter on plywood

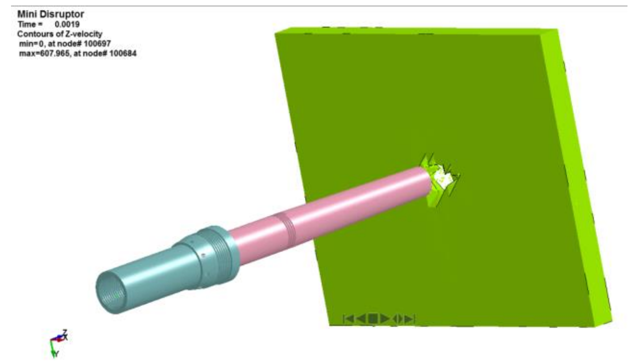

Fig.7: Water Jet velocity 607m/s.

7. RESULT

We have compared the both Analysis and Experimental Results as shown in table.

Sr. No.	Parameter	Analysis Method	Experimental Method
1	Water Jet velocity	607 m/s	600 m/s
2	Penetrated Area of plywood	25 mm radius of hole	27 mm radius of hole

8. DISCUSSION

Our main aim is to be water is impact on the bag or wooden box which contain the explosive material and then water break the bag and inject in explosive material. Then water is disarmed the bomb or explosive material so we have achieved this to break the plywood and make 27 mm radius of hole in plywood and getting the water inside on harmful device.

9. CONCLUSION

Mini Disruptor can be used by Indian Army & Paramilitary Forces for disarmament the bomb and explosive devices. In addition the system is intended to be mounted on the RCV for use in disruption of IEDs. And we will be achieved following points:

- Providing the safety to the bomb disposal squad.
- Performing the tasks of disarming explosives without human contact.
- We will increase the efficiency of bomb disposal operation and decrease the mental pressure of the operators.

10. REFERENCES

[1] Zeng Jian-Jun, Yang Ru-Qing, Zang Wei-Jun, Weng Xin-hua, Qian Jun, "Research on Semi-automatic Bomb Fetching for EOD Robot" Research institute of Robotics, shanghais Jiao Toung University, Hausan Road, Shanghai 20030, and Peoples Republic of China. 2012

[2] Rocco Di Verdi, "Miniature Robotic Hand for Bomb Disposal" Massachusetts Academy of science. 2013

[3] Amon tunwannaruxs "The Explosive Ordanance Disposal Robot" 10th WSEAS Int. Conf. on Automatic Control, Modeling and simulation (Acmons08), Istanbul Turkey, May 27-30, (2008

[4] Adam Jaroh, JohnstoWn, George Lubert, Jeremy Sitar, Portage, David Metz, Duncasville, "Aiming Device For A Bomb Disarming Disruptor" United States Patent Application Publication (10) Pub No.. US2012/0180366 A1 Jaroh et al. (43) Pub Date: Jul. 19,2012

[5] Caelois Beltra-Gonzalez, Antonios Gasteratos, Roberto Guzman, Andras Toth, "Methods and techniques for intelligent navigation and manipulation for bomb disposal and rescue operations" International Workshop on Safety, Security and Robotics Rome, Italy, Sept. 2007

[6] Shinde Pushpa D., DAvane Rahul D., Patil poonam B., " Wireless Bomb Disposal Robot" International Research Journal of Engineering and Technology (IRJET), Volume : 03 Issue: 04/ April 2016

[7] Prashant limje, Shailesh N. Khekale, "Bomb Detection and Diffusion in planes By Application of Robotics", Special Issue for national Conference on recent Advances in technology and Management for Integrated growth, ISSN 2319-4847, 2013

[8] Gilles Caprari, kai O. Arras, Roland Siegwart, "The Autonomous Miniature Robot Alice: from Prototypes to Application", Swiss Federal Institute of technology Lausanne, Institute of Robotic System, EPFL, DMT-ISR,CH-1015, Lausanne.

[9] Brian Day, Cindy Bethel, Robin Murphy and Jennifer burke, "A Depth Sensing Display for Bomb Disposal Robots", institute for Safety Security and Rescue Technology at the University of South Florida. 4202E, Fowler Avenue Tempa, USA

BIOGRAPHY

Bankar Avinash Karbhari has completed Bachelor's Degree from BVCOE College of Engineering Nashik. Now pursuing ME Degree in Mechanical Engineering from MET's Institute of Engineering, BKC, Nashik.

Prof. S. K. Dahake is working as assistant professor in MET's Institute of Engineering, BKC Nashik. He has published / presented research papers in National and International Journals / Conferences. His area of interest is Optimization and FEA.

Nachiket U. Phadke is working as Chief Engineer in Elenoenergy, Pune. He has 10+ years of industrial experience in the field of vehicle crash analysis and safety analysis. He was worked with Tata Johnson Controls Ltd., Johnson Controls INC. USA, Tata Johnson system and Net shape Engineering Services Pvt. Ltd.