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Design of Fragment Selector

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Abstract. The existing manual process of weight categorization of Service shells into various standard weight groups is lengthy as well as time consuming. A method has been suggested for designing an apparatus 'Fragment Selector' which will save much labour and time in categorisation of shells.

1. Introduction

To work out lethal efficiency of a service shell it is essential to categorize the fragments of the projectile into various standard weight groups. The existing process of weight categorization is lengthy as each fragment is weighed and put in the appropriate weight group. This involves much time and labour. The paper describes the design of an apparatus 'Fragment Selector' which will save much time and labour for categorizing the fragments into standard weight groups.

2. Theory

In designing standard weight group 'Fragment Selector', the effect of electromagnetic force has been taken into account. For establishing the magnetic field, the energy supplied to the exciting coil of electromagnet is spent in two ways :

(i) Part of it goes to meet I^2R loss and is lost once for all.

(ii) Part of it creats flux and is stored in the magnetic field as potential energy.

Formula relating the force P and the magnetic flux density B is given as

$$P = \frac{B^2 a}{19.62\mu_0} \text{ kg. wt.} \tag{1}$$

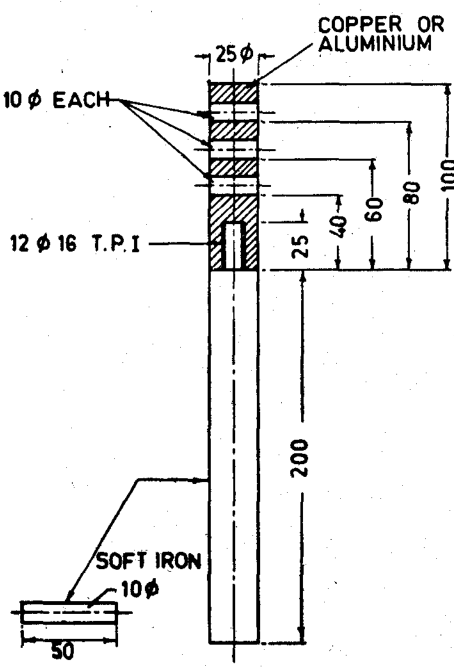
$$B = \frac{\mu_0 N_i}{l} \qquad (\mu_r = 1 \text{ for air})$$

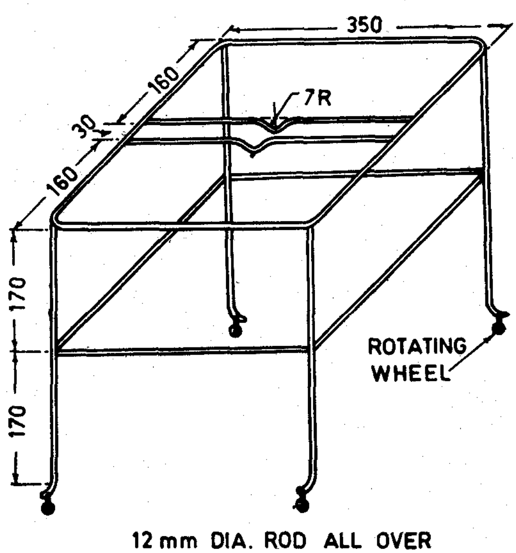
3. Experimental

To verify the theoretical values with that of experimental values of current, a rod of soft iron of dia 25 mm and of length 200 mm is used as the core of the solenoid. For this experimental set up the formula relating the current i and mass m of the fragment to be lifted is given as

$$i = 1783 \frac{\sqrt{m}}{N} \tag{2}$$

Theoretical values of the current required for lifting the fragments of particular weight group is calculated by using Eqn. 2. To provide movement to the lifting end of the fragment selector over the fragments spread on a platform, a trolley made of aluminium is used. Details in respect of core of the solenoid and trolley are given in Figs. 1 & 2 respectively. The fragments of a projectile are spread over a smooth cement ladder type platform which is used to provide constant distance between the lifting end of the fragment selector and the upper portion of the fragment. The lifting end of the fragment selector is brought over the fragments and the current is slowly increased through the solenoid, the specific value of current produces the lifting force required to lift a fragment of particular weight. To lift the fragments of a weight group, the value of the current is increased from the lower limit to the upper limit so as to create the lifting force just required to lift the lower weight and the upper weight of the standard group.





ALL DIMENSIONS ARE IN mm

Figure 1. Core for the solenoid. **Figure 2.** Aluminium trolley.

The magnetising force is then decreased gradually by reducing solenoid current to make the fragments leave the lifting end in appropriate weight groups. A core of soft iron material having high permeability and low remanence and coercivity may be used, it gets magnetised and demagnetised very easily. The theoretical and observed values of currents are given in Table 1.

Values of $\sqrt{m}$ obtained from Table 1 are plotted against the calculated and observed values of current for two solenoids having number of turns $n_1 = 1000$, resistance $R_1 = 26.4\ \Omega$ and number of turns $n_2 = 1600$, resistance $R_2 = 39.2\ \Omega$ respectively as shown in Figs. 3 and 4. It will be seen that the points for each solenoid lie on a straight line. Experimental values of current are higher than the theoretical values as a part of it goes to meet I^2R loss and is lost once for all. Theoretical values are also calculated for the weights indicating the lower and upper limits of the standard weight groups and corresponding values of current are taken from the graphs drawn for the practical values of current. These values are given in Table 2 and utilised

Table 1.

Weight			$n_1 = 1000$, $R_1 = 26.4\ \Omega$ Current (A)		$n_2 = 1600$, $R_2 = 39.2\ \Omega$ Current (A)	
gm	Kg (m)	$\sqrt{m}$	Calculated	Observed	Calculated	Observed
121.72	0.12172	0.350	0.624	0.660	0.390	0.400
59.79	0.05979	0.244	0.435	0.500	0.272	0.290
56.51	0.05651	0.237	0 425	0.480	0.265	0.280
55.70	0.05570	0.236	0.421	0.470	0.263	0.275
43.90	0.04390	0.209	0.375	0.450	0.233	0.250
43.19	0.04319	0.207	0.369	0.430	0.231	0.250
14.11	0.01411	0.119	0.212	0.300	0.133	0.170
13.10	0.01310	0.114	0.203	0.290	0.127	0.150
12.12	0.01212	0.109	0.195	0.280	0.122	0.150
11.58	0.01158	0.107	0.191	0.275	0.119	0.145
10.16	0.01016	0.106	0.189	0.270	0.118	0.140

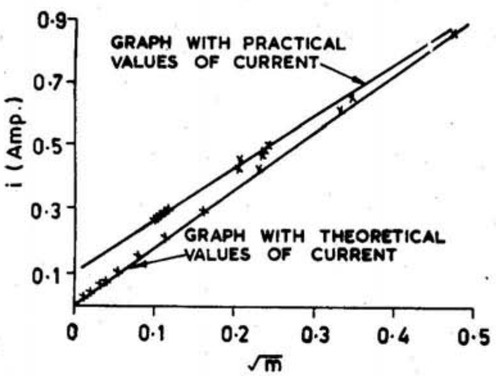


Figure 3. Graph between current i and $\sqrt{m}$. (Solenoid = 1, $N = 1000$ and $R = 26{\cdot}4\ \Omega$)

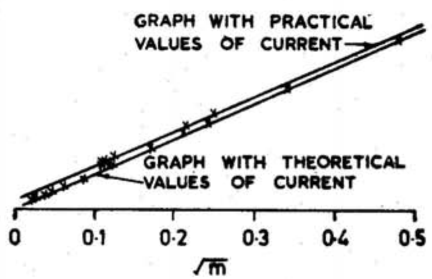


Figure 4. Graph between current i and $\sqrt{m}$. (Solenoid = 2, $N = 1600$ and $R = 39.2\ \Omega$)

for the calibration of the equipment. The relationship between the current and the weight of the fragment to be lifted can be expressed by the formula

$$i = \frac{K\sqrt{m}}{N}.$$

Table 2.

Weight			$n_1 = 1000$, $R_1 = 26.4\ \Omega$ Current (A)		$n_1 = 1600$, $R_2 = 39.2\ \Omega$ Current (A)	
gm	kg (m)	$\sqrt{m}$	Calculated	Observed	Calculated	Observed
0.284	0.000284	0.01685	0.030	0.130	0.019	0.045
0.568	0.000568	0.02383	0.043	0.145	0.027	0.052
1.134	0.001134	0.03367	0.060	0.160	0.038	0.065
1.758	0.00176	0.04193	0.075	0.170	0.047	0.075
3.544	0.00354	0.05953	0.106	0.200	0.066	0.090
7.087	0.00709	0.08418	0.150	0.240	0.094	0.118
14.175	0.01418	0.11906	0.212	0.300	0.133	0.160
28.35	0.02835	0.16837	0.300	0.375	0.188	0.210
56.70	0.05670	0.23812	0.425	0.485	0.265	0.280
113.40	0.11340	0.33675	0.601	0.650	0.375	0.395
226.80	0.22680	0.47624	0.849	0.875	0.5307	0.550

K is a constant which depends upon the relative permeability of the material, cross section and length of the core. The list of ferromagnetic materials which can be used for the core is given below:

Substance*	Relative Permeability μ_r
Mild steel (.20)	2,000
Iron (.2 impurity)	5,000
Silicon iron (4 Si)	7,000
78 Perm alloy (78.5 Ni)	1,00,000
Purified Iron (.05 impurity)	2,00,000
Superem alloy (5 Mo, 79 Ni)	10,00,000

An iron clad electromagnet is used to provide powerful attraction at short distance. It consists of a short cylindrical soft iron core properly wound with insulated coils and surrounded by an iron tube. The tube and the core being united at one end by an iron yoke. The iron tube acts as a return path for the lines of force produced. Special horseshoe electromagnets can also be utilised.

4. Calibration

Standard weight group fragment selector is calibrated in terms of values of current and the weight groups of the fragments. These values are taken from Table 2. Data

*Percentage composition. Remainder is iron and impurities.

tabulated for the solenoid having $n_1 = 1000$ and $R_1 = 26.4\ \Omega$ is given in Table 3, this chart is attached with the apparatus and used for categorizing the fragments in standard weight groups.

Table 3.

S. NO.	Weight groups: Lower limit g (oz)	Weight groups: Upper limit g (oz)	$n_1 = 1000$, $R_1 = 26.4\ \Omega$ Magnetising current: Current for lower limit (A)	Current for upper limit (A)
1	0.284 (1/100)*	0.568 (1/50)	0.130	0.145
2	0.568 (1/50)	1.134 (1/25)	0.145	0.160
3	1.134 (1/25)	1.758 (1/16)	0.160	0.170
4	1.758 (1/16)	3.544 (1/8)	0.170	0.200
5	3.544 (1/8)	7.087 (1/4)	0.200	0.240
6	7.087 (1/4)	14.175 (1/2)	0.240	0.300
7	14.175 (1/2)	28.350 (1)	0.300	0.375
8	28.350 (1)	56.700 (2)	0.375	0.485
9	56.700 (2)	113.400 (4)	0.485	0.650
10	113.400 (4)	226.800 (8)	0.650	0.875

*Figures in bracket indicate the corresponding weight in oz.

5. Limitations and Precautions

For lifting the fragments of small weight groups the current range variation is very small so great care is needed for lifting these fragments otherwise it may lead to an error for calculating the lethal efficiency of the projectile. Fragments of the lower weight group are to be lifted first and then one by one of higher groups in serial order.

6. Conclusion

The fragment selector will be very much useful to categorize the fragments of the service shell in various standard weight groups for working out its lethal efficiency and will save much time and labour.

Acknowledgement

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