SCOPE OF LIGHT ALLOY METALLURGY IN ARMAMENT RESEARCH

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THE immediate aim of Defence Research in the field of armaments is to attain self-sufficiency by the establishment of indigenous manufacture of all armament stores which are required by our Defence forces. This self-sufficiency must be achieved both in respect of the technique of manufacture which would be most suited to the prevailing conditions in the country and in respect of the materials used in the manufacture of these stores. Although we have made an appreciable progress in the former since independence, we have yet to go a long way to achieve the latter goal of self-sufficiency in material. At present a good many items of the armament stores and various components thereof are made of materials (e.g. copper and its alloy) which are non-indigenous. It is, therefore, of utmost importance to us to concentrate our effort on finding appropriate indigenously available substitutes for these strategic materials so that the efficiency of our armed forces is not affected if the supply of these materials from non-indigenous sources is cut off due to some cause or the other. Self-sufficiency in strategic materials used in Defence production is also of vital importance in ensuring independence in the political field without any obligation to or pressure from any quarter. This can only be achieved by planned metallurgical research aimed at finding appropriate substitutes for all non-indigenous materials and this is where the metallurgists have to contribute their mite in finding a speedy and satisfactory solution to this vital problem.

At present, there is quite a number of items of armament stores which are manufactured from copper or its alloy, viz. brass. One such item which consumes a substantial amount of imported copper and zinc is the cartridge case for guns and small arms, as the present design and technique of manufacture of this store is based on 70/30 Brass. The Defence Metallurgical Research Laboratory has already initiated research to establish a suitable design of cartridge case which would enable the use of aluminium or its alloy for their manufacture. Similar research is also needed in respect of the cartridge case for guns. If a satisfactory technique covering the use of aluminium or its alloy can be established in respect of these two items, for which there is definite scope, this would ensure a substantial reduction in the imported quantity of copper and zinc, thus ensuring conservation of foreign exchange to the tune of a few millions of rupees every year. Since our primary aim is to achieve self-sufficiency with a by-product of the conservation of foreign exchange, it should be of no concern if the new technique involving the use of aluminium or its alloy in the make-up of cartridge cases, proves to be more costly and more laborious than at present. In order to enable complete appreciation of the problem, I would discuss the specific role and design requirements of a cartridge case for guns. This has been singled out of the two types mentioned earlier for the dual reason that development work regarding small arms cartridge cases is already in progress at DMRL and also because of their larger size they may pose special problems which may need the best and maximum expert attention.

A typical gun cartridge case with its various parts is shown in Fig. 1. This is basically a metallic container containing the propellant charge which on ignition provides the necessary kinetic energy to the projectile. On ignition of the propellant charge, the case is subjected to severe stresses due to the high gas pressure which is of the order of a few thousand kg per sq cm under the worst conditions. During this period the case is supported by the gun walls and the material of the case is subject to a plastic flow. Hence the conventional method of strength calculation with the help of elastic theories is not applicable in this case. On firing, the internal gas pressure causes the case to expand initially to the diameter of its housing (known as chamber) in the gun after which both the gun and the case expand together. The gun expands elastically and the material of the case is stretched beyond its yield point resulting in plastic strain. For the case to enable easy extraction immediately after firing, the recovery of the case from this strain must exceed that of the gun, i.e. the permanent expansion of the case after firing must not exceed the initial clearance in the chamber. The typical stress-strain curve in Fig. 2 for the present brass cartridge case illustrates this phenomenon. In this figure stress and strain are proportional up to the yield point Y and hence the graph follows a straight line, the slope of which is a measure of the Young's modulus for the material. Beyond the yield point, plastic expansion takes place and on release the pressure elastic recovery takes place along the line ED which may be assumed parallel to YA.

In the diagram illustrating the typical functioning of a cartridge case (Fig. 2), AD represents the permanent expansion of the case. Assuming complete

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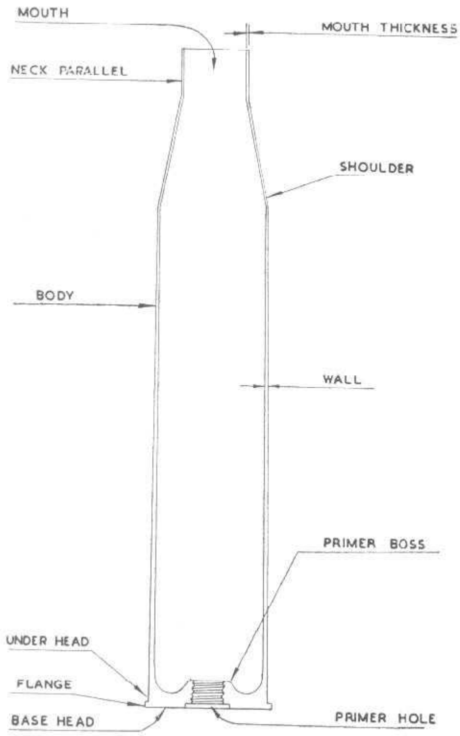

Fig. 1.

GRAPHICAL REPRESENTATION OF

TYPICAL FUNCTIONAL CHARACTERISTICS OF CARTGE CASES.

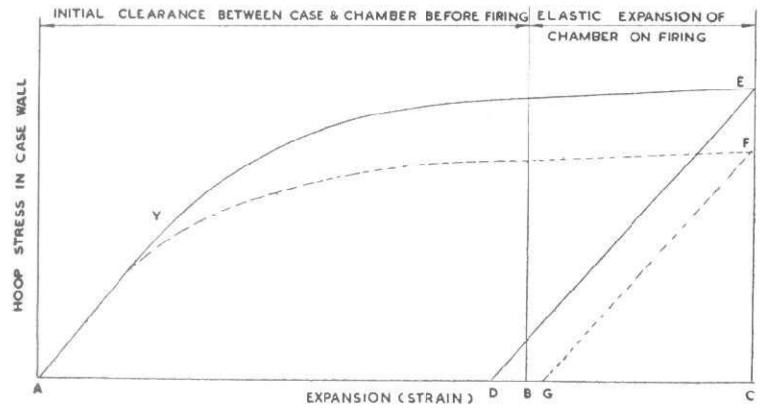

Fig. 2.

elastic expansion of the gun, the chamber would return to a position B after firing and hence the distance BD would represent the clearance between the chamber and the case after firing. The curve represented by the dotted line illustrates the behaviour of a case made from material of the same modulus but of lower yield. This case would, on recovery, follow the line FG, resulting in an interference between case and chamber represented by FG, thus causing hard extraction. The factors affecting free extraction can, therefore, be summarised under the following heads :

(*a*) Yield stress of material,

(*b*) Young's modulus of elasticity for the material (represented by the slope of the initial straight portion of the stress-strain curve which is also assumed to be the same as the slope of the recovery line),

(*c*) Elastic expansion of the gun,

(*d*) Initial clearance of the case in the chamber.

The ideal requirements of a typical gun cartridge case are :

(*a*) Ease of manufacture,

(*b*) To ensure effective protection to the propellant charge against flash and moisture,

(*c*) Freedom from corrosion,

(*d*) Freedom from the tendency of developing cracks or splits during storage,

(*e*) To have sufficient strength to withstand rough use and the force of extraction and be rigid enough to hold the assembled projectile without distortion,

(*f*) Ability to withstand the high temperatures (about 3000°C) and pressures (about 4000 kg/cm^2 under worst conditions) encountered during firing,

(*g*) To provide an appropriate hardness gradient which will ensure correct expansion to the chamber diameter so as to prevent flow of gas between the case and the chamber wall (obturation) but resilient enough to recover after firing to allow free extraction,

(*h*) Capability of being reformed to the correct size a number of times after firing.

The problem, therefore, boils down to the fact that given the design of a cartridge case, it would be for the metallurgists to develop a suitable and appropriate technique which would enable

(*a*) The production of an aluminium/aluminium alloy case to the correct dimensions,

(*b*) To provide a base and with high enough yield (hardness) to ensure free extraction and with mouth end soft enough to provide adequate obturation and to facilitate security of the projectile by indentations.

The process of manufacture would be so adjusted as to control the final hardness of the case by the work hardening produced during the drawing, heading and tapering operations, in conjunction with proper heat treatment and mouth anneals. The development of a light alloy case would also contribute towards a substantial saving in the weight of ammunition. This itself is a main factor in the logistics of modern warfare, as it has been proved that a saving in the weight of equipment without sacrificing its effectiveness contributes towards a significant increase in operational efficiency.

As far as is known to us, the modulus of aluminium is low and hence more suitable than brass for cartridge case manufacture but the yield stresses are rather lower than required. The research should, therefore, be directed towards the development of suitable techniques which would ensure a higher yield. In fulfilling this object, the Defence Ministry and, in particular, the Defence Research Organisation would be ready to provide all reasonable assistance both in the form of technical details and monetary assistance to any one interested in this problem of vital national importance.