ON HER MAJESTY'S SERVICE

CODE No. 27-32

BLACKPOWDER MANUFACTURE

AT NOBELS EXPLOSIVE CO

Mr. M. McLaren

BLACKPOWDER MANUFACTURE AT NOBELS EXPLOSIVE CO., ARDEER

Visited by C C Evans (PERME))
E Steel (ROF Chorley)) 30 June 1978

BACKGROUND

The purpose of this visit was to look over ICI's blackpowder works, now completely shut down, in order to learn about their manufacturing methods and processes. It was a fascinating and informative visit tempered by the realisation of how quickly the expertise is being lost. Our guide, Mr McWhirter, had only taken over blackpowder production in the last year or so prior to closure and most of the elderly process operators have now dispersed or retired.

The MOD requirement of 100 tons per annum represented less than 5% of the possible output from this plant. In its last days the plant was producing 30 tons of powder a week, with a workforce of 14 men.

The blackpowder manufacturing area extends over 100 acres of sandy woodland. My immediate impression was the striking difference between such labour intensive blackpowder production and the manufacture of conventional chemical explosive on one localised site. The day to day problems of providing steam and hydraulic services over such a scattered site and those of maintaining the railway system are daunting. When actually confronted with this expanse, ICI's decision to abandon blackpowder manufacture seems entirely reasonable, especially in view of their 40% holding in a German company who still manufacture. In spite of hopeful assurances, the German blackpowder proved unacceptable for many MOD applications and has since proved unsatisfactory even for ICI's less demanding applications. The trouble has been traced, rather predictably, to the quality of the charcoal used. In consequence ICI have resuscitated their near derelict charcoal plant at Ardeer, drawing on their own stocks of alderwood in order to supply their German connection with satisfactory charcoal.

From ICI's point of view as a leading supplier of blackpowder, the world market has shrunk dramatically in the past 30 years. Slurry explosives have replaced blackpowder for blasting and the demand for fuze cord (in which blackpowder comprises the central core) is such that ICI's fuze cord plant at Ardeer is working at less than one sixth capacity.

In the following I have set down details following the order of manufacture. Each operation was carried out in a well separated building connected to others via the railway system - a nice point being the use of brass tracks within each building.

1. INGREDIENTS

Both potassium nitrate and sulphur were bought in as powders passing a specified sieve mesh size. There were no serious supply problems.

Charcoal, on the other hand, has always been a problem. For best quality gunpowder ICI used alderwood charcoal drawing on their own large stocks. A considerable stockpile of debarked and well weathered alderwood, origin and supplier unknown, still remains at Ardeer. For lower grade blackpowder, eg for blasting purposes and fire-works other charcoals are used, notably beech charcoal from De Gussa, Germany. ICI has a warehouse full of reject charcoals only suitable for directors' barbecues. They even have small quantities of expensive dogwood charcoal available for special jobs.

2. CHARCOAL MANUFACTURE

This venerable carbonising plant (1893) is remote from the main blackpowder area. It comprises a pair of horizontal cylindrical iron retorts heated alternately over a coal fire bed. The carbonising treatment is entirely dependent on the skill of the stoker-operator who knows exactly how to load his retort with a selected blend of wood sizes ranging from sawn tree trunks to the small branches usually called for in the gunpowder literature. Loading is completed ready for firing first thing next day. The coal fire is stoked according to the appearance of the wood smoke emerging from the top of the tall chimney stack. At a certain stage, when 'fully gassing' after about six hours heating, the fire is allowed to go out slowly. The retort may be occasionally turned as the operator deems fit, but continuous mechanical rotation, although possible, was not done. The wood tar distillate was collected as it condensed in the metal trunking between retort and stack. No attempt was made to burn the smoke - chance ignitions were not regarded favourably by neighbouring departments - although traditionally the appearance of the flame is regarded as a reliable guide to the state of carbonisation and also deals effectively with an unpleasant exhaust problem. This plant is due for demolition shortly.

A 1000 lb charge of alderwood gives about 300 lb of good quality charcoal after approximately 6 hours heating. It would be sufficiently cool for unloading next day. A skilled and trusty operator can judge the charcoal quality by the way the product fractures and by the appearance of the fracture faces. From the set up and the carbonising time I am extremely doubtful that the retort contents could have been heated uniformly and it is highly significant that the entire retort load is treated as one batch for blackpowder manufacture. Apparently a skilled operator can consistently achieve a carbon content close to the optimum 74% (cf the dud German charcoal, 84%).

Finally the entire contents of a retort are ground in a pin mill to passing 40 mesh. In the freshly ground state the powder is very surface active and there is a risk of fire. It is stored in metal bins.

In view of the manufacturing problems and impending demolition of the plant ICI are not prepared to make a charcoal stockpile for MOD purchase. We hope to obtain a 50 kg sample, but no more.

3. SIEVING

Prior to mixing and milling all three ingredients are sieved to pass 40 mesh as a final check to remove foreign matter.

4. WEIGHING AND PULVERISING

Charcoal and sulphur are weighed out and, in an adjacent bay, ball milled together in 150 lb batches for 6 hours using lignum vitae* balls. Steel balls are occasionally used for high carbon (= hard) charcoals. Normally one man operated four of these units. The mix was then ready for the conventional edge milling operation at which point the potassium nitrate was added. The pulverising operation appears to be an additional stage compared with the traditional process.

*Wood from West Indies, density 1.3 g/ml

5. MILLING

We were shown some of the edge runner mills. There were fourteen in all, but two have blown up. The massive components were brought to the site along a specially made road, now since disintegrated, over the sandy terrain. Substantial brick blockhouses were then built around the assembled mills. Trees have since grown. Such mills are no longer commercially available and both ROF Chorley and ICI's German subsidiary are interested in acquiring at least some of them but their removal is a formidable problem.

Each mill comprises two cast iron mill wheels about 4 feet diameter and 1 foot across, arranged to clear the mill bed as they rotate by about $\frac{1}{8}$". Massive bronze ploughs follow each wheel turning the charge into the path of the following wheel. The 250 lb charge comprising premixed C + S and KNO_3 was milled for times varying between 3 and 7 hours depending on the intended use of the powder (eg 3 hours for blasting powder with beech charcoal, 7 hours for gunpowder). Moisture content is maintained between 1.5-1.8% to give good quality mill cake. The mills are electrically driven at two speeds - slowly for a few revolutions to pack down the powder and then fast ($\sim$10 rpm) for the milling operation.

6. PRESSING

The damp milled material (mill cake) was next pressed to produce the traditional presscake using vertical or horizontal presses. The vertical press took a stack of blackpowder/aluminium plate 'sandwiches', about 30 such plates 2'6" square carried on a trolley. Two stacks of plates could be operated alternately.

On account of their higher throughput horizontal presses were preferred. Here a similar number of aluminium plates were held vertically (using wooden spacers) in a long wooden trough, approximately 8' x 2' x 2'. Two men shovelled the powder into the trough, about 1000 lb per load. The wooden spacers were removed and pressing commenced. The pressure used at this stage is a critical feature since it determines the density and burning rate of the final product.

This operation was not regarded as particularly hazardous, the workmen being present throughout. The explosive limit for these buildings was 4000 lb. An interesting feature was the use of fluorescent lighting with an outer case pressurised with nitrogen. Pressure loss in the system turned the lights out.

7. CRACKING

In the cracker house an intermediate stage was carried out in order to reduce the very large press cake to smaller lumps suitable for corning. The moist press cakes, nearly 2' square were fed manually by an operator through bronze cracker rolls comprising two pairs of horizontal rolls about 2'6" wide and 9" diameter having rows of pyramidal projections. The second pair of rollers is finer than the first and in each pair one roller is arranged to rotate a little faster than the other.

8. CORNING

This critical operation was carried out on a remarkable modern (post 1945) plant designed and built by ICI. It consists of an elaborate and substantial wooden framework built to support a conveyor belt system and a series of crushing rolls and vibrating sieves. This plant must represent the ultimate in machinery design and construction in wood. A tribute to the craftsmen who built it, it is already a piece of modern industrial archaeology.

One inch lump material from the cracking operation is loaded into a hopper at floor level and conveyed to the top of the plant in a series of beautifully made leather pouches or scoops attached to a conducting oonveyor belt. The lumps are progressively reduced in size by passing through a pair of bronze rolls similar to the cracker rolls but with smaller pyramidal protrusions (differing rotational speeds again) and the product passed over a vibrating screen. Oversize material was recycled and undersize material passed on to a further pair of smooth rolls followed by sieving. This operation was repeated twice more with smooth rolls, making a total of four rolling and sieving passes in all, using gravity feed between the stages. The bearings of all the rollers were so arranged as to permit vertical movement thereby allowing very hard oversize lumps to pass without incident. Finally the granulated material passed through a rotating sieve for dust removal.

This unique plant could process 50 tons per week and was operated remotely by two men. It was subject to very high standards of cleanliness and maintenance. The building itself was humidified, had GFRP blow out panels along one side and the roof was an enormous GFRP water tank.

Adjacent to the corning house was a considerable 'library' of sieves, reflecting the extensive range of powder sizes which was in production not so very long ago.

9. GLAZING

The operation of polishing the granules alone, or in the presence of graphite powder (giving a very smooth flowing material for ease of filling) was carried out by rotating a charge in surprisingly large wooden drums, about 4' diameter x 8' long. Again considerable craftsmanship was involved in their construction, numerous shaped wooden slats bound together with steel hoops in the manner of a barrel.

One ton of granules (of a given mesh size) was polished as a batch. The operation generated a considerable amount of heat and the powder started to 'sweat', as a consequence of its residual moisute content. At this point a stream of hot dry air was directed through the drum to ensure complete drying. No separate drying stage was then necessary. In addition to rounding the grains, making them hard and resistant to moisture, the glazing operation also increased the bulk density of the granules - for reasons unknown.

10. DUSTING

Prior to packing a final sieving operation was carried out to remove the last traces of dust. The dusts produced at all stages were always reworked.

MEAL POWDER

For this requirement the mill cake from the edge runner mills was ball milled in 150 lb batches using lignum vitae balls.

CONCLUSIONS

From our point of view, wishing to make gunpowder of reference standard quality, the following points are relevant.

1) Charcoal manufacture. Contrary to information in the literature, it appears possible to use the entire alder tree provided a careful blend of timber sizes is used in each carbonising batch.

2) Likewise non uniform carbonising conditions can be tolerated provided the entire retort load is milled to powder as one batch.

3) Pre-milling of carbon and sulphur. Practices differ at this point - pre-milling is thought to reduce the time for the more hazardous milling stage in edge runner mills.

4) Graining - the operation of granulating press cake by cracking and corning. Here the message, for size reduction is quite clearly 'little and often'. The press cake received a minimum of six passes through rolls - more if recycled.

5) Drying - the combined polishing and drying stage neatly avoided the need for a separate drying stage. This approach may still be possible when working on a small scale.

C C Evans

C C EVANS
13 July 1978