

NEW COAL MINES AND RECONSTRUCTION

YENİ KÖMÜR OCAKLARI VE ESKİLERİN YENİDEN DÜZENLENMESİ

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ABSTRACT

The planning, development and production stages of a new col mine are described in detail

ÖZET

Yeni bir kömür ocağında planlama, hazırlık ve üretim aşamaları ayrıntılı olarak anlatılmaktadır.

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1. GEOLOGICAL ASSESSMENT

Clearly the initial stage in the planning of any proposed coal mine is that of strata assessment. The more detailed information one is able to get at this stage the more accurate, positive and rapid will be the planning process. One would start with wildcat holes which will initially indicate the presence of coal. Once there is evidence of the presence of coal in thickness and quality the more detailed drilling programme can be set up. The cores from this detailed programme will give important information about the coal field itself, the depths, the seam thicknesses, the ranks, the ash contents, the sulphur and chlorine contents, the methane contents, the géothermie gradient and very importantly the nature of the host rocks.

During this detailed programme borehole logging will be carried out. Logging will in itself complement the coring programme and give such information as the nature of the strata, the thickness of the various beds, and the hardness of the strata. It will verify those parts of the borehole which have been cored, verify information about the coal seams and supplement information where parts of cores have been lost.

Hydrogeological examination of strata to indicate potential water problems both in the sinking and drifting programmes and during the actual mining of the coal is a fairly new but vitally important technique. Normally it will be carried out on the centre of each shaft sinking but it can be carried out at other places during the secondary drilling programme. Its benefits are tremendous in that ground treatment methods can be planned with great accuracy and methods of working considered carefully in the vicinity of aquifers. Seismic surveying for the identification of geological structure and faulting in the coal measures is again a fairly new technique and of great value in the planning process.

Finally, ground assessment should be carried out which will include detailed topographical details together with surface soil surveys where structural work and shaft sinking are likely to be carried out.

The deductions from the geological assessment will provide *information on reserves*, the possible accesses to reserves, data on potential ground treatment, initial data on methods of work, coal treatment, surface layout, ventilation needs, the methods of disposal and the market. It is clear the more meaningful and accurate the initial information is the more accurate will be the initial planning.

2. ACCESS AND INITIAL LAYOUT

The next stage in the planning process is to consider the means of access to the reserves. The decision on whether shafts or drifts will be used depends on such matters as depth, the *presence of water bearing strata*, the required capacity, the needs of pillar support, ventilation, manriding and materials handling. One can then begin to look at the underground layout and it would be necessary to take account such

matters as seam depth and thickness, the fault pattern so far as it is known, seam gradients, the nature of the immediate strata above and below the seams, soft floors, heavy sandstone layers, the presence of aquifers, methane, spontaneous combustion risk and rock temperatures.

Clearly these are matters which the mining engineer cannot change but has to face in determining the underground layout. However, there are variable matters which will have to be considered such as output requirements, the proposed methods of work, the proposed coal clearance methods, the men and materials transportation arrangements and the sequence in which the seams are to be worked. When all this data has been assembled it should be possible to produce an initial layout. The specialists such as coal face engineers, strata control engineers, mechanical and electrical engineers, ventilation engineers, engineering geologists and transportation specialists should test the layout against their particular discipline. As more information becomes available the layout can be refined.

3. CIVIL ENGINEERING

One needs to make reference to the importance of the civil engineer in any new mine project. In the past perhaps not enough stress has been placed on the importance of the civil engineering aspect of the new mine design.

Civil engineering will not only be a very necessary consideration for drift portal designs, shaft collar designs, wind loading for high and vulnerable structures, structures subject to high thrust loading, storm drainage of sites and for sewage problems, but also for longer term considerations, the effect of subsidence on the land drainage of the whole area, on rivers and streams and on the security of tips where washery refuse is concerned.

4. SHAFT SINKING AND DRIFT DRIVAGE

It is then necessary to plan the shaft sinking or drift drivage processes. So far as both are concerned it is vital to take into account the permeability and porosity deductions from the hydrogeological and laboratory tests carried out on the strata. In the case of shaft sinking there are four main methods of overcoming water problems during the sinking process:

They are, freezing of the strata, ground treatment of chemical or cement grouts (this can be done as stage grouting whilst sinking proceeds or curtain grouting before it starts), and ground water pressure relief. This latter has been singularly successful as a means of removing water pressure during the sinking process.

The shaft lining must be carefully designed on the basis of the known hydrogeological and geological information. It should be designed to cater for the loadings due to hydrostatic and rock loads and also for any of out of balance loads. The type of

linings can vary between monolithic concrete linings, steel and concrete sandwich linings, cast iron segmental linings and the heavy complex linings designed for German coal shafts to accommodate the potential shaft movement involved in the removal of the shaft pillar.

The process of shaft sinking initially involves the excavation and lining of the foreshaft, the installation of the sinking stage and the erection of the sinking headgear. The multi deck stage is usually equipped with a cactus grab for loading hoppits on the shaft floor prior to their being hauled to the surface. The process of shot firing particularly in wet conditions has been improved by the use of a new type of detonator manufactured by ICI called Magnadet.

Apart from basic design considerations such as headframe loading, vibrational stresses and operational conditions, there are a number of parameters which will affect the choice of headframe design. These can be summarised as:

- Cost
- Number and position of Winders
- Height and discharge arrangements
- Ease of access to shaft
- Choice between permanent and temporary headframe
- Ease of installation

Using these parameters a comparison can be made between the advantages and disadvantages of 'Conventional', 'A Frame', and Tower Mounted Headgear design.

The relatively time consuming erection of headframes has recently meant development of various methods of reducing erection time. For example, where no restrictions exist in the availability and capacity of lifting equipment, the design and fabrication of the permanent headgear can be completed in a modular form and erected on a prepared site next to the shaft while shaft sinking operations are being carried out. It can then be lifted to its permanent site by a large crane and thus positioned in its permanent position in one day.

Drift drivage through difficult strata is probably a more hazardous process than sinking a* shaft through similar ground. One reason of course is that the drift takes greater distance to pass through that particularly section of strata. Initially one must look at the section of the drift down the rock head. Where there is a very wet section of soft alluvial strata it may be necessary to have only a short open cut and to dewater the ground down to the point where the drift would reach the rock head. There are of course other alternatives to dewatering such as diaphragm walling or surrounding the proposed portal with interlocking piles. In the drift itself where water bearing strata is likely to be encountered stage grouting as in the shaft is a method frequently used. However in the case of a particularly difficult and soft sand formation freezing from the surface may be necessary. This was used in the Selby drifts and was extremely successful.

It is interesting to examine the specialised treatment needed in three sections of ground during the drifting process into the coal measure strata at Selby. The initial section down to the rock head required complete dewatering and in the permian formation known to contain water a series of grout covers was maintained. Each grout cover covered 30 m for each 12m advance. A pilot hole was maintained in advance of the face of the drift and no advance was restarted until the water make was less than 90 litres per minute.

At the base of the permian formation there was a particularly difficult 8m thick section of soft basal sand. This had been frozen from the surface. The final cover in the low magnesium limestone proved the freeze cut off wall and the final grout cover was carried out. However, clearly the exothermic reaction of the grout pattern against the cut off of the ice wall made the ice wall retreat. So all work in the tunnel was halted until the ice wall had re-established itself. Each of the two tunnels driven into the coal measure strata was lined with spheroidal graphite cast iron segmental lining. The length of this spheroidal graphite lining from the surface into the coal measures was 830m.

The drivage equipment used from the surface over this distance consisted of a boom cutter loader mounted in a circular shield. The shield had facilities for the erection of the circular segmental lining. At the base of the water bearing formation the shield was removed, a track mounted cutter loader was installed to cut out a D section roadway supported by 3 piece arch girders. Average advances of 70m per week were obtained. Eventually a Robbins full face tunnelling machine was installed in one of the spine roads which had to be driven a distance of 13,000m.

4.1. Shaft and Drift Capacity

It is interesting to compare the potential capacities of shafts and drifts.

It is now considered economic to devote one shaft at a high capacity convey solely to coal winding. Such a single purpose shaft with completely automatic loading, winding and unloading offers great advantages for the maintenance of high production and for lower manpower requirements. In a shaft winding from 1,000m one pair of balanced skips could raise 2.2 Million tonnes of coal per year. In a similar shaft with dual winding arrangements and two pairs of balanced skip a yearly output of 4.4 Million tonnes would be possible.

The winding system using a skip (or cage) winding against a counterweight is used mainly where a number of different levels have to be served or where the shaft section is too small for two skips. Normally when winding mineral in skips from a few levels near together it is usually preferable to have only one skip loading level and mineral from nearby levels can be transported to it.

Recent advances in skip (and cage) construction have made use of light metal alloys to give a saving in weight compared with all steel construction. It is imprac-

tical, however, to have all parts constructed in the lighter alloy (using aluminium) and parts such as guide shoes, wearing plates and mine car rails remain in steel. The ratio of tare weight to payload for this type of skip should be around 0.7.

The remaining shaft should be designed for the transport of men and materials. The criteria should be that each cage would be designed for maximum payload. For example consideration should be given to designing a cage large enough to complete the winding of a shift of men in the minimum number of journeys possible and the accommodation of large items of equipment such as heading machines with the minimum of dismantling and subsequent re-assembly.

So far as drifts are concerned there is a higher potential capacity made possible by the use of fast moving steel cored or cable belts. Such belts can have the drive at the surface and can have variable speeds up to 8.5m per second. At Selby for example the cable belt in the north drift is capable of raising a maximum of 2,750 tonnes per hour whilst the steel cored belt in the South drift has a capacity of 3,225 tonnes per hour.

5. SURFACE LAYOUT

At a very early stage indeed, immediately after the shaft or drift question has been decided a preliminary surface layout can be devised. With the more detailed information to hand a more precise surface design can be pursued. We should now know for example the output rate per hour both at peak and average.

There should be a fairly precise idea of the service requirements, that is to say fresh water, process water, sewage and electricity. The planners should know the area of ground available for the surface, the road and rail accesses and the environmental limitations. It is at this stage possible to start the preparation of detailed flow sheets. The first flow sheet should be the run of mine coal to the coal preparation plant and should take into consideration the need for a bunker or stockpile.

The second should be the coal preparation flow sheet. Testwork will have to be undertaken on the ROM coal to determine whether it will require treatment in order to meet market specifications and, if so, to help determine the preferred treatment method(s).

Such testwork may include:

- Ash and moisture content determination
- Size analysis
- Washability (float and sink) analysis
- Assessment of frothing characteristics

The results of this testwork will, to a large extent, dictate the initial design of the surface handling and preparation facilities. Due consideration will, of course,

be given at this stage to achieving the optimum balance between maximising required product yield, minimising adverse environmental impact and minimising capital and operational costs.

Based on the data already collected regarding the site, the ROM coal characteristics and the market requirements, the nature and extent of the raw coal handling of the preparation and of the product handling facilities will be investigated and the types, sizes and quantities of each required item of equipment will be recommended.

Typically raw coal handling facilities may include:

- Screening
- Milling, grinding or crushing
- Conveying
- Storage
- Reclaiming
- **Weighing**

Invariably the choice and design of these facilities will be aimed at providing a regular and consistent feed either to the subsequent preparation facilities, or, if the coal is of suitable quality without upgrading, for despatch to the ultimate consumer(s).

However, as mechanisation of coal winning increases, seams become dirtier and consumer requirements tighten, so the need to upgrade ROM coal increases.

All available preparation techniques will be evaluated in conjunction with the information derived previously in order to arrive at the optimum process route(s). The design of all major items of equipment will also be tailored to best suit the particular coal characteristics and the market requirements.

Depending on these last named factors, the selected major treatment process may be one or more of the following:

- The washing of large coal (>37mm) in either dense medium separators or in jigs-
- The cleaning of small coal (< 36 mm) in either jigs or cyclones.
- The recovery of fine coals (< 0.5mm) either by froth flotation or in cyclones.

All ancillary preparation operations, including moisture reduction, product classification, medium recovery, water clarification and re-circulation will also be defined.

Third flow sheet should be that dealing with product handling and storage. Product handling, storage and outloading will be considered. These may typically involve:

- Sampling
- Blending
- Bunkering and/or stockpiling
- Reclaiming
- Weighing
- **Loading to either road or rail vehicles**

All the above information will be presented in the form of the following documents.

- Weighed materials flowsheets in sufficient detail to demonstrate performance capacities of each main unit of equipment
- Quantified liquids flowsheets
- A brief technical description of the whole works
- Basic specifications for all major items of equipment

A flow sheet would be required for reject disposal to cater for both mine debris and washery refuse. The materials handling flow sheet would take into account the size and type of the mine stockyard, the stores and the materials route to the pit top.

A manpower flowsheet will be drawn up to cater for the smooth passage of men through the surface facilities to the underground and vice versa.

The services flows will need to be considered in greater detail; it will be necessary to decide where the process water is to come from; where the fresh water is to come from; details will be required of the fire fighting arrangements, the dust suppression and cooling arrangements; the boilers, pit head baths, the canteen all have a requirement for fresh water. The details of the electrical layout will need to be drawn up. When all these flowsheets have been devised then they can be integrated into one basic surface layout.

Specialist engineers of all disciplines, including including architects, will then produce more detailed design requirements of the various aspects of the surface layout, taking due cognisance of such matters as safety, noise, access, maintenance, manpower activities and environmental aspects. At this stage also sufficient plans and elevations of suitable scale will be produced of all proposed surface facilities as will civils and structural bill of quantities and electrical/control network diagrams.

A capital cost estimate will then be generated to an agreed level of accuracy and broken down as far as required. In addition an estimated programme for carrying out the works will be produced.

To complete the picture, an assessment of operational data will be provided. This will include:

- Assessment of water requirements
- Estimated power consumptions
- Recommended manning levels/levels of automation commensurate with the particular circumstances
- Recommended spares requirements

The aim should be to have a efficient mine surface but one which is aesthetically pleasing.

6. UNDERGROUND TRANSPORTATION

6.1. Coal Transportation

On underground transportation one must first look at the underground transportation of coal and its bunkering. Modern coal face power loaders produce high peak loads. The transportation system must ensure that such faces are protected from outbye delays. A properly designed total conveying system with bunkering established at strategic points will ensure continuous face operation.

Better types of conventional PVC belting means that normal conveyors can transmit higher horse powers than previously possible. Aramid fibres which have been developed for both solid woven and laminated ply textile belting can be twice as strong as PVC and can transmit much higher horse powers. Then of course there are the steel cored bolts to which I have already made reference. Another development of recent years has been the linear drive. In this case power is applied incrementally along the conveyor length. The advantages are much less high belt tensions and so larger loads can be carried on less heavy belting along greater lengths.

Underground bunkers should be in an integral part of the underground conveyor system. These consist of mechanical bunkers, horizontal strata bunkers, vertical strata bunkers, and inclined strata bunkers. It is now possible to design the whole underground belt and bunkering system by computer simulation. The whole system can be tested visually on a VDU. When simulated hold-ups occur due to the system capacity being inadequate then it is necessary to redesign this until the simulation will cater for all eventualities. All trunk conveyor systems should as far as possible be manless.

6.2. Materials Transportation

Materials transportation traditionally is a high risk area for accidents and a high consumer of manpower. Significant developments have taken place over the last few years in the design of rope haulage systems. Better tracks, vehicle trapping, rope management at swillies, the use of special vehicles, variable speed haulages and remote operation from the train itself have contributed to more highly efficient and safe systems.

Locomotives continue to be used extensively and the use of trolley wire locomotives in Great Britain has increased. But whatever system is used it needs to be considered a surface stockyard face system - that is with the minimum of transfer from one haulage system to another with no offloading and reloading if this is possible.

6.3. Men Transportation

It is equally of vital importance to ensure that the travelling time for men to and from the coal face is kept to an absolute minimum. So fast travel from shaft to face or place of work is of prime importance. Again one must consider the options; rope, locomotive, or belt transportation and the use of unit Wains such as a battery driven one an interesting development which is proving popular and successful in Great Britain.

7. UNDERGROUND DEVELOPMENT

The drivage of underground development roadways is a vital part of the design and construction of new coal mines. Such development can of course be in coal or in stone or a combination of both. However, to maintain pace with the modern longwall face particularly if this is retreat, development needs to be fast and efficient. There is a sufficient armoury of excellent development equipment now to make that a reality. The advent of jet assisted cutting has opened up a new dimension in the use of boom cutter loaders in that they are able to cut much harder rock. But even with the best machines the heading organisation needs to be impeccable to get the best results.

The clearance system needs to be carefully planned to minimise machine hold-ups. The ventilation system is equally important for methane dilution and for a high standard of dust suppression.

8. COAL FACE DESIGN

However splendid the surface layout, the underground coal clearance and the men and materials transportation, it is at the coal face where the success or otherwise of the venture will be decided. There is no doubt that there is now a high degree of sophistication of longwall face equipment. Powered supports are of an excellence one could not have dreamed of 10 or 20 years ago. Two British equipped faces have been operating in Australia producing averages over a long period of more than 4,000 tonnes per shift.

Micro electronics are being increasingly applied in the use of powered supports, reducing cycle time making them safer and easier to operate and leading the way to a significant expansion in the application of remote control. AFC's are being produced of tremendous strengths, capacity and toughness. Face signalling systems are also highly efficient.

But the coal face is an integrated operation and the design needs to take into consideration support of face ends, cleaning up machine turn around, methane drainage, services such as water, electricity, hydraulic power etc.

Each face, in my opinion, needs to be comprehensively designed just as precisely as any other part of the mine. I believe that the coal face engineers should assess all the critical data about the proposed face likely to effect it during its life before design work starts and this should be examined in great detail.

9. COMMUNICATIONS, MONITORING AND REMOTE CONTROL

Modern mine communications, monitoring and remote control are an important aspect of new coal mine design. With remote control and monitoring manpower needs are reduced, management is provided with a better and more comprehensive information service, workmen can be moved from hazardous situations, equipment and the underground environment can be continuously monitored and there can be an automatic shutdown of equipment when defects or dangerous conditions are detected.

There are great advantages of being able to remotely control underground conveyors and bunkers, underground booster fans and pumps, and the centralised control and monitoring of coal preparation plant.

10. COSTING

An assessment of the cost of the project should be continuously updated during the planning period. It is essential that the new mine be economically viable, that the capital costs, running costs and replacement costs should be adequately covered by the proceeds and indeed should show the profitable return required"

At the initial planning stages 'ball park' figures from historical data can be applied to most of the items involved in the new mine development. These figures will of course have been updated for inflation. The financial expenditure should be forecast on a yearly basis and should include all items of potential expenditure such as planning, shaft sinking, coal preparation plant, underground drivage and the date at which output can be expected. The quantity of coal mined in the forecast years together with the expected proceeds should be shown. It will then be possible to tabulate on a year by year basis information on income, new capital, replacement, and thus draw up a projected profit and loss account.

11. COLUERY RECONSTRUCTION

A great deal of the time of mining engineers and their colleagues is now being devoted to the reconstruction of the older coal mines in order to make them more profitable,, more economic and safer. Much of the information already referred to

in the new mine construction and planning will inevitably be needed. In reconstruction. Again I propose a step by step approach to the reconstruction process to ensure maximum benefit, high productivity and profitability. One must start with a comprehensive analysis of the mine as it exists at present. One must look at reserves potential reserves, strata control, the structure of the reserves including faults, washouts and gradients.

The existing shaft or drift accesses to the reserves will need to be carefully analysed, their size, their condition, their lining, their age, any water problems etc will have to be considered. Every detail of the underground roadways will need to be recorded. The surface equipment and facilities must be examined in detail, including such matters as winding, coal preparation, debris disposal and the existing surface arrangements. Manpower will need to be analysed and the existing costs assessed.

The aim should be to have a comprehensive breakdown of the mine as it exists at present. Then the objects of the reconstruction should be stated in terms of output, manpower, costs, products and markets. Knowing the existing situation and that which is proposed it should be possible for planners to prepare an initial feasibility plan and from this plan certain questions will need to be answered.

Does the plan meet the projected cost per annual tonne? Does it meet the output targets required? Does it meet the manpower targets required? What would be the cost of the coal taking into consideration the reconstruction costs? How long will it take? What would be the life of the mine after reconstruction? Provided the feasibility study is acceptable detailed planning can then start. Access, clearly would be the first consideration.

It may be possible to use the existing access shaft or drifts with bigger and faster skips. Or a new access may be required. The three components of access coal clearance, manriding and materials handling will need careful consideration.

Then it will be necessary to consider the proposed underground roadway layout. It may or may not use the existing mine roadways. The functions of the roadways would be to provide maximum coal clearance and bunkering facilities, to provide fast and safe manriding facilities, to provide an efficient transport system for materials and to provide an efficient ventilation system. Such roads should be maintenance free so far as this is possible. It could be better to drive roadways in stone right into the heart of the proposed extraction area. Having decided on a network of roadways then the underground coal clearance layout can be designed. In a similar fashion the designs for the materials handling system, the manriding system and the ventilation layout should be prepared.

Again the success or failure of the reconstruction will depend to a large extent on the success of the coal getting operations. Initially the existing face and deve-

lopment results of the mine should have been closely scrutinised. The reasons for poor performance should have been assessed. In the reconstruction design ancillary factors such as coal clearance delays, breakdown delays and unnecessary time should be eliminated. Longwall faces should be designed on a planned integrated basis each to take into consideration those factors which it will face during its life. At the same time as the access and underground layout designs are being considered, the conceptual flow sheets for the surface will be drawn up as was done for a new mine. In this case of course it will be necessary to consider the existing facilities as well as the now known requirements, and these flow sheets should take the same forms as those required for a new mine.

Costs should be examined closely. The manpower requirements will now be known, the reconstruction capital cost will be known approximately and a degree of sensitivity analysis should be applied to the cost assessment; that is to say a project may well cost 10 % more than anticipated. It may achieve 20 % less than proposed and manpower may cost 10 % more than was planned. These factors can be applied to the cost assessment to see if the reconstruction will still be viable.

Indeed such a sensitivity analysis is of great importance in the case not only of reconstructions but of new mines.

The detailed planning aspects will follow the same lines as for a new mine. The mechanical and electrical engineers will design the new equipment and the architects the buildings to house the equipment. The civil engineers will plan the structures and the foundations. When it comes to implementing the reconstruction there are alternatives which need consideration. If speed is vital, it might be possible to close the mine for a period so the reconstruction work can be carried out more quickly. Or a partial closure may be possible. The coal for example could be temporarily despatched to another mine for treatment whilst the bulk of the surface work is undertaken.

A method which has been carried out with great success in Great Britain recently has been the establishment of a new access point to service coal clearance and coal preparation from several mines. Connecting roads for coal clearance have been driven underground from the mines to the new facility. The advantage is that the existing mines can operate until the last minute when the new facility becomes operational and takes all the coal and deals with it more efficiently preparing it for the market and despatching it in bulk.

