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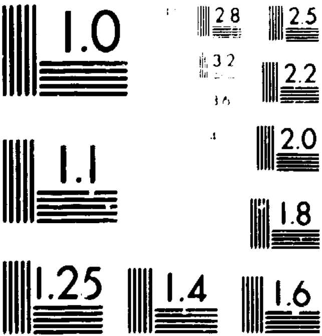

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Interregional Cement Technology Forum

Benghazi, Libyan Arab Jamahiriya, 13-20 April 1982

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INTRODUCTION

The Interregional Cement Technology Forum was held at Benghazi, Libyan Arab Jamahiriya, from 13 to 20 April 1982. It was organized by the United Nations Industrial Development Organization (UNIDO) in co-operation with the Libyan authorities concerned with the development of the cement industry.

The Cement Forum was implemented as a fund-in-trust project financed by the Libyan authorities for the benefit of a large number of developing countries.

The purpose of the Interregional Cement Technology Forum was to collect and disseminate information of interest for the developing countries and give their cement specialists a possibility to meet and discuss opportunities, problems and successes with colleagues and specialists from developed and developing countries.

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Annexes

Part one. Report of the Forum

I. ORGANIZATION OF THE FORUM

The Interregional Cement Technology Forum was attended by 104 participants from developing countries and commercial organizations (see annex I). The agenda covered developments in cement technology, taking into account such matters as energy conservation and environment protection (see annex II). Technical and country papers were presented by participants from Algeria, Angola, Chad, China, Democratic Yemen, India, Iran, Mozambique, Philippines, Poland, Syrian Arab Republic, Thailand, Turkey and Uganda (see annex III).

Mr. Omar El Montaser, Secretary of Heavy Industry Secretariat opened the Forum, which was held in the Training Centre for Cement and Building Materials Industry, at Benghazi.

During the opening ceremony further introductory remarks were offered by Mr. Ali M. El-Gheriany, Under-Secretary of Heavy Industry Secretariat, Mr. C. E. Rydeng, UNIDO, Director of the Forum and Mr. Mohamed M. El Neihoum, General Director of the Libyan Cement Company and Chief of the Organizing Committee for the Forum. The members of the Committee are listed in annex IV.

Participants were met at Tripoli by Libyan officials from the Committee for Preparation and Supervision and were given assistance with customs formalities etc. and transfers to Benghazi. The same support was also organized for the departure of participants after the closing of the Forum.

The daily sessions of the Forum were conducted by Mr. El Neihoum, in consultation with concerned officials and committees.

II. COMMENTS AND OBSERVATIONS

Most developing countries have interesting proposals for developing their cement industry over the next 20 years, far exceeding the capacity available today. The problems that require investigation in order to secure a healthy developing cement industry are capacity utilization, energy conservation and management continuity.

Low capacity utilization is part of a vicious circle which weakens the position of the cement industry by failing to generate sufficient turnover to respond to obligations, the problems of the purchase of spare parts and the need to secure well-trained personnel.

Energy conservation is a problem of national economic and local importance. Maximum economy in fuel utilization helps the factory to be competitive, while the national trade balance may be favourably influenced.

Management continuity is the most important condition for full utilization of equipment, personnel and resources, and only with continuing involvement in the problems is it possible to lay the foundations for a healthy developing cement industry.

Most new plants are built with the aid of know-how from abroad; but once a new management team has been established, it should continuously develop and strengthen its capacity in order to reach a level comparable to the suppliers of equipment and know-how.

Once local know-how has reached such a level, national experts will have all the necessary background for solving recurrent problems in their own factories and in being able to maintain full production.

The key to upgrading personnel to secure capacity utilization etc., is training. The best training is organized within the factory where the trained personnel is needed, and all developing factories should consider establishing permanent training systems designed to obtain the necessary skills for the efficient handling of all duties, both on day and on night shifts.

Executive personnel should further be trained in other factories, either at home or abroad, to learn as much as possible from seeing, working with and studying other technical solutions.

In this respect, it should be pointed out that maintenance is not only necessary for the equipment, but that it is also needed for maintaining the capacity of individuals and working teams in order to secure maximum utilization of resources and continuous development.

One way of helping executives from the cement industry to learn about other technical solutions and to discuss problems and solutions is to promote their participation in technical meetings of cement producers and international organizations.

UNIDO cement meetings are specially designed to meet the demand from the developing countries; UNIDO is constantly urged to continue its meeting activity, both by experts from developing and developed countries.

The present Technology Forum was the result of a new approach whereby UNIDO invited different experts to present their ideas and to tell the Organization about interesting aspects of new technology, problems they have solved and how they achieved their solutions.

Finally, it should be stated that UNIDO, through its mandate from the United Nations, is designated to assist the developing countries in their industrialization. UNIDO is ready to assist and support all national efforts for building and expanding a healthy developing cement industry.

Comments on the report or questions regarding possible technical assistance and training should be directed to Mr. C. Rydeng, UNIDO, Vienna International Centre, A-1400 Vienna, Austria.

Part two. Summaries of papers presented and discussions

Mining methods and advantages of using hydraulic excavators

Raymond Bonnkirch

The introduction in 1978 of the Demag H241, the world's largest hydraulic excavator, was a milestone in modern mining operations. This 270 t hydraulic excavator with its 14 m^3 rock-bucket is an appropriate tool for the new generation of 150 t dump-trucks. Until now the dominating tool in hard rock and open-cast mining operations was the cable shovel with well-proven longevity, dependability and high digging force. It was also well suited in tough rock. These advantages also apply to the H241 with an added bonus of having a prying and tearing-out force of 95 t. It is more mobile (2.5 km/h), has better gradability and is capable of digging beneath the ground surface.

This hydraulic mining shovel is built in modules so that transport to the job site and from place to place does not involve large problems and costs. The heaviest part of the machine weighs only 53,000 kg and this can easily be transported by conventional low-bed trailers.

Assembly time takes an average of five working days, and the acquisition and ownership cost are lower than other mining and loading tools of the same production capacity.

In the following discussion a question was asked with regard to the dumping height of hydraulic excavators, especially as the dumping height of wheel-loaders was 3 m and trucks were generally higher. In reply it was said that hydraulic excavators of equal bucket size had a much higher dumping height, especially when using bull-clamp buckets. The Demag H71 hydraulic excavator, with a 5.5 m^3 bull-clamp bucket had a dumping height of 7.5 m.

Another question asked was whether it was possible to change from a loader bucket to a back-hoel bucket, and what changes were necessary to make the changeover and how long it took.

The answer was that the smaller Demag hydraulic excavator could be changed from a loader bucket to a back-hoe bucket simply by reversing the bucket. It was pointed out that Demag hydraulic mining shovels could be transformed by changing the boom arms. The boom and stick cylinders were interchangeable. Depending on the lifting tools at the job site, changeover could be effected within 4 to 5 hours.

A further question was with regard to the ability of the hydraulic mining shovel in stripping hard rock. Depending on the hardness of the rock, it was stated that stripping with or without blasting could be achieved, especially in medium to hard limestone. The H241 had a prying and tearing-out force of 95 t at the bucket lip which enabled it to remove the remaining sections at the foot of the face. This kind of work could not be done either with rope shovels or with wheel-loaders because of the lack of the necessary prying force.

A final question involved the reach of the hydraulic shovel. The reply was that the reaching height of a Demag H71 with a 5.5 m^3 bucket was 11 m. The H121 with a 7.5 m^3 bucket was 13 m, and the H241 with a 14 m^3 bucket was 15.5 m. Furthermore, one of the main assets of the hydraulic excavator was that it was able, because of its prying force at the bucket lip, to loosen material at dangerously high places on the rock face.

Criteria for the selection of grinding mills

Helmut Wuestner

The relevant criteria governing the choice of raw mill systems were described. One potential selection criterion was the grindability and moisture of raw materials. This was shown in diagramatic form with respect to a choice between either an air-swept mill system or a bucket-elevator mill system. A further criterion was mill throughput. Mills with larger diameters would limit gas throughput, as power requirements and the throughput of mills increase to the third power, while free mill cross-section increases to the second power.

KHD Humboldt Wedag AG has developed the "tandem" mill during the last 15 years. The tandem mill system is a well-known air-swept mill with an integrated impact hammer mill system. A new type of hammer was developed for the impact hammer mill.

The tandem mill enables the use of a central drive system, and two mills are at present in operation with this drive system. The latest development introduced in the tandem mill system is the removal of the classifier, with direct separation of the finished product in an electrostatic precipitator. An advantage of this system is smaller-sized buildings.

It was asked in the discussion what degree of fineness was required when additives were made to cement as slag or pozzolanic earth. In reply it was stated that the amount of slag or pozzolanic earth added to clinker depended on the quality of these additives or the limitations set by quality controls in various countries. The required fineness finally depended on the required cement strength. To ensure a good distribution of the final product, closed circuit grinding with high efficiency separators at the cyclone air separator were recommended. Grinding and drying could be achieved at the same time. In that case, an hydrite had to be employed.

A question was asked whether problems were caused in the hoppers if the raw materials contained more than 6% of initial moisture. The answer was generally no. It depended on the grain size distribution of the materials. If there was a high amount of fines, this might result in clogging.

Finally, it was asked what type of grindability test was used. It was stated that KHD Humboldt Wedag used the Zeisel test for testing grindability of raw materials and clinker. All known kinds of grindability tests had their advantages and disadvantages, and experience was necessary in interpreting the data.

Conditions necessary for establishing new cement plants

Jaques Hoffmeyer

During the next 10 years the developing countries will face a growing demand for cement. It is expected that 30 to 50 cement plants will have to be built each year in countries which are not part of the industrialized world.

To build a new cement plant is a very costly undertaking and it is advisable to make a complete feasibility study before taking a decision.

Feasibility studies are costly and difficult to finance. The purpose of this paper is to draw the attention of future cement producers to the necessity to be sure, before starting the process of feasibility studies, that three basic conditions are met:

(a) Good and sufficient raw materials are available;

(b) A market is available;

(c) Financing is possible.

When future producers are satisfied that these basic conditions have been fulfilled, they can confidently launch the subsequent feasibility study.

It was asked in the ensuing discussion what should be the first consideration in deciding to establish cement plants: raw materials, markets, or financing? The three conditions were interrelated it was answered. However, financing would only be secured when the raw materials and potential market had been ascertained. A preliminary geological survey and a market study should begin first. The former need not be exhaustive; it should give only a reasonable certainty of sufficient raw materials which could be quarried without difficulty or legal and environmental problems. The latter needed to give an approximate size of the market in order to determine the size of the cement plant

High-alumina cement as a building material

Kessete Gabre Kidan

High-alumina cement (HAC) is produced from bauxite and limestone. It hardens rapidly and attains a high strength in 24 hours. It resists sulphate attacks and compared with Portland cement is unique in that with refractory aggregates it resists temperatures up to 1,500°C. It is, however, subject to chemical influences.

Aluminates are formed on hydration which crystalize in the hexagonal system (CAH_{10}) and are meta-stable. In contact with water and at temperatures above 25°C they rapidly transform int stable cubic crystallized compound (C_3AH_6). This results in a reduction in volume and in an increase in concrete porosity; the strength may also be considerably reduced. This process is known as "conversion".

Alarming structural failures in Algeria, France, Federal Republic of Germany, Hungary, Iraq and the United Kingdom made it necessary for the author to carry out research work because of unimpressive research data and differing manufacturing processes.

Commercial HAC was employed throughout the research period in the United Kingdom. A 1:1.6:3 concrete mix, with a water/cement ratio of 0.35 was used with high-frequency vibrators for proper compaction. The cement content needed for such a mix was about 410 kg/m^3 of concrete. Random samples of sand and cement were taken every time a new supply was stocked for chemical analyses.

Concreting was done at temperatures varying from 8-27°C. Each cast contained nine 100 mm x 100 mm x 100 mm cubes, nine 150-mm diameter and 300-mm long cylinders and 100 mm x 100 mm^2 cross-section by 500-mm long prismatic beams. To reduce the high rate of heat of hydration, the concrete specimens were covered with wet sacks and impervious polythene sheet for 8 to 10 hours after the concrete was cast. Approximately 24 hours after casting, the specimens were stored either in a dry room (18°C, 45% R.H.) normal curing (21.5°C and 95 to 100% R.H.) or in a hot water tank (45°C, and 100% R.H.).

Short- and long-term tests of standard specimens were made over a period of 30 months. Compressive strengths in cubes and cylinders and the modulus of rupture were obtained using standard testing machines. Lamb's extensometer was employed to find the stress-strain relationship. Samples were taken from the periodic tests for d.t.a. Non-destructive tests were also performed on cylinders using ultrasonic test.

The following conclusions were drawn from the test results:

(a) The 24 hours strength was nearly the same for all storage regimes;

(b) Storage in the hot water tank showed that the compressive and flexural strengths and the Youngh modulus showed a slight increase up to 3 to 4 days, and a rapid fall in strength after 7 days (95% conversions). With further storage, a cyclic hydration (CAH_{10}) followed by conversion (C_3AH_6) appeared to persist. It is expected that this phenomenon will cease after prolonged storage. The minimum strength is not expected to be lower than that initially found.

(c) Storage in normal curing showed superior strength capacity compared to the other two storage conditions. The reason offered is that because such conditions take sluggish chemical activity of conversion and rehydration and do not lend themselves to appreciable reduction in strength (not lower than 24-hour strength over the long term). The flexural strength appears to have higher strength development if the curing temperature is about 22°C instead of 18°C;

(d) With respect to dry air storage, the compressive and flexural strengths appeared to deteriorate after 400 days. The cause may be because of immaturity of the crystals as a result of an insufficient curing period. Visual inspection showed that the inner cores of both the cubes or the cylinders were found to be extremely weak, and disintegration of paste and aggregates was markedly vivid. Strength reduction is therefore not always associated with conversion;

(e) The modulus of elasticity for the three storage régimes has little variation and can be assumed to be constant for all practical purposes;

(f) The indirect tensile strength can also be assumed the same for all storage régimes considering the lowest value.

In the discussion it was asked if the deterioration in dry rooms could be due to carbonation.

In reply it was stated that carbonation was normally associated with shrinkage and not with strength, although it may have some effect if carbonation shrinkage persisted. In this case, it had nothing to do with carbonation and conversion. It was thought that the cause was due to improper curing applied in specimens which affecting the proper growth of the crystals.

Oolitic limestone for use in the cement industry in North Africa

Abd El Rahim Marei

Limestone is by far the most important and common raw material used in cement raw mixes, apart from clay. The paper dealt with a well-known type of limestone widely distributed on the north coast of Africa in Algeria, Egypt, Libyan Arab Jamahiriya, Morocco and Tunisia.

The paper discussed the geomorphological features accompanying the formation of this limestone. It described the method of investigation used in research. The petrography of this type is represented by rounded, oval, elongated carbonate grains, similar in shape and size to the ova form of a fish. The oolites possess an outer cortex of concertrically lamellar, crypto-crystalline aragonite.

These concentric layers reach up to 42 in number. The author showed that these layers ranged from 2 or 3 up to 30 layers. Within the coat, or in the centre of the ooids, a detrital nucleus could be recognized. This nucleus is commonly represented by a broken piece of an old oid, a fragment of calcite, a grain of quartz (sand), foraminifera or shell fragment. The origin of these oolites according to many authors, was a result of two theories, either wind-borne or of aqueous origin.

According to the author's research there is another theory for the oolitic limestone origin, this is the tidal range or sea-shore origin.

The author believes that the growth process of the ooids is because local detritus was trapped among algal filaments found on the sea-shore, which were moved by the action of tidal currents over the sea bottom. Rolling action could be responsible for the radial concentric layers surrounding such detritus.

Polishing of the ooids may be due to the action of abrasion of ooids when moving against one another. The sphericity and the ovality can be attributed to the balance between precipitation of aragonite and abrasion over the different parts of the ooid. The origin of the radial fibrous calcite represented in the ooids is due to the fact that detritus, presumably once aragonite, has been replaced by calcite over a long geological period. Sorting of ooids is because of the speed of their burial, and the smaller grain size.

The coarser the oolites the longer they have been exposed to a growth environment, all other thing being equal. The presence of friable sand pockets or lenses associated with the oolitic limestone ridges may be due to the sand-dunes which accumulated at the time of formation of the oolites along the sea-shore. These sand-dunes had been buried under sea water in the tidal range.

Development of rotary kilns with the Humboldt preheater

Rudolf Kuhs

The paper quoted important kiln developments over a period of 60 years and the logical advances made with regard to rotary kilns for the processing of raw materials of varying properties.

The worldwide increase in consumption of cement required the use of raw materials for burning Portland cement clinker which were considered useless a few years ago.

Humboldt Wedag has developed suitable technical concepts for meeting both these requirements.

For the first situation the use of the Pyrorapid kiln was recommended. It consisted of a particularly short rotary kiln of a diameter to length ratio of about 1:10; and was equipped with a five-stage Pyroclon preheater.

In the latter instance, the facility applied included a short rotary kiln with a Pyroclon preheater fitted with a by-pass that could be adjusted for withdrawing 0-100% of the waste gases. In the discussion which followed it was asked what was the Kcal per by-pass. In reply it was stated that 1.5-2.5 Kcal per % by-pass was due to the total amount of by-pass; the higher the amount of by-pass, the lower the amount of Kcal/kg clinker.

It was then asked what was the free lime content of clinker for the 2,000 t/d Pyrorapid clinker production line. The reply was that the maximum free lime content in the clinker was about 1% CaO.

Another question was on with regard to the maximum amount of SO_3 content allowed in coal. The possible SO_3 content, said the author, was up to 4.5%, but because of the chemical composition of the used raw meal for clinker burning a gas by-pass system for the kiln preheater may be necessary.

It was then asked what was the replacement period for refractorys in the cyclon heat exchanger. The reply was between 10 and 20 years under normal working conditions.

Under what conditions is the installation of the Pyrorapid kiln recommended, was another question asked. The answer was that for cement raw materials which were uniform and for a uniform fuel which assures a short flame, a ratio of 1:10 could be used. The grindability of such a clinker was low and the mineralogical composition and the physical properties of such a clinker were good.

It was then asked whether the installation of the Pyrorapid kiln was recommended for all available raw materials. The author said no, each plant needed its own design. The diameter length ratio of the kiln for the different raw materials could be fixed between 1:10 and 1:15.

Finally it was asked if the material of the lifters in the rotary cooler was of high quality. The answer was yes, at the inlet part of the rotary cooler. Respective data had been published in Zement Kalk Gips.

Development of the Training Centre at Benghazi

Ahmed El-Dursi

The paper discussed the development of national skills to meet the increasing demand for skilled labour for existing works and future extensions and projects. It recommended the intensification of local experience to upgrade technical standards to raise productivity, undertake more elaborate tasks by enabling workers to follow recent technological trends of process improvement, cost reduction and industrial security.

The acquisition of further know-how was encouraged as well as the participation of students in reinforcement and development of industrialization facilities.

A survey conducted in the establishments belonging to the Heavy Industries Secretariat showed that the Centre was training a number of skills needed for these establishments in safety and laboratory testing.

Performance of volatile substances in the kiln and problems from high clinker temperatures in cement production

Wieslaw Kurdowski

The volatile substances,namely alkalis, chlorides, sulphates and heavy metals such as lead or thallium form inner cycles in the rotary kiln. If it is a "closed kiln" this will be a short kiln with suspension preheaters, the volatile substances may then form unfavourable build-ups in the inlet chamber, especially when chlorine content in the kiln feed is greater than 0.015%.

To reduce these disturbances partial precalcining can be used, and in borderline cases the by-passing of part of the gases must be introduced. The effectiveness of by-passing will be influenced by the properties of raw materials, namely by the content of sulphur and chlorine. Sulphur reduces and chlorine increases the volatility of alkalis. By-passing of the gases in conventional systems involves a considerable increase in heat and electric energy consumption. By-passing of the gases from the kiln with complete precalcining is much more economic because of the high content of volatile matter in the kiln gases. In this case, the heat consumption is small and amount to 5.4-7.1 kj/kg of clinker per 1% of by-passed gases.

Some negative problems can result from high clinker temperatures. Too high a clinker temperature, especially above 70°C, causes several problems in cement production, lowers its quality and leads to lumping of the material in the silos. To avoid these difficulties the appropriate clinker granulometry through special technological treatment, should be undertaken. In the case of insufficient cooling in the cooler, spraying water into the cooler or on to the clinker transporting devices should be employed. Water injection into the mill, utilization of grinding aids as well as increasing the amount of ventilation air also gives good results. Finally, the partial substitution of gypsum by anhydrite avoids the formation of hemihydrate and syngenite in the mill or in the silos. It is much better to install cement coolers than to suffer the consequences of high cement temperatures.

A question was asked whether the granulometric composition of clinkers in the function of alumina ratio shown in the figure was obtained by laboratory tests or were they clinkers from industrial kilns. In reply the author said that clinkers were from the industrial kilns and repeated tests were made to establish their granulometric composition.

Another question was on the limitation of water quantity which might be injected into the cement mills. The answer was that the positive influence of water on clinker grindability as well as on lowering cement temperature was shown in the figures. There were, however, special cases in which water spraying might have negative effects. When the clinker was rich in calcium sulphate the addition of water enhanced the formation of syngenite in the mill and the cement quantity would be lowered.

In some cases the concentration of water in the mill, especially for about half its length could occur.

It was then asked why there was a maximum SO_3 content in the kiln feed, and how and when water was added to the mill feed. In reply, the author said that the SO_3 alkali molar ratio had a great influence on alkali behaviour in the kiln. When this ratio was smaller than one, the addition of gypsum or anhydrite to kiln feed could have a positive effect. The sulphur could not be added in case of by-passing of the gases because it diminished the alkali volatility. When an excess of sulphur was present, the formation of anhydrite in clinker occurred.

With respect to the water question, water was first sprayed into the last chamber then to the first, and finally in both places.

Another question was on how to avoid cement lumping in the silos when calcium carbonate was added to the mill feed. The answer was that limestone addition could only slightly diminish the cement temperature because of its relatively low temperature and some humidity.

Finally, it was asked if there were some plants in the world using anhydrite to regulate setting. The author replied that in Belgium, one plant used 80% anhydrite and 20% gypsum.

Grindability and burnability of oolitic limestone

Abd El Rahim Marei
and
Kaissar M. Hanna

Oolitic limestone played a strange role in burning the raw mix because of its unique physical property, i.e. texture. It was worthwhile to study its thermal behaviour and grindability.

The differential thermal curve of this type of limestone showed that there was a reaction with an endothermic peak at 130°C which could be attributed to the loss of humidity. Other weak effects with endothermic peak temperatures at 691°C and 739°C might be due to the hydrooxylation present in small quantities of clay minerals. Strong effects with an endothermic peak at 980°C is due to the dissociation of calcite into CaO + CO_2.

The total loss in weight during heating from 25°C to 1,000°C of the oolitic limestone was 42%, represented in three temperature regions on the DTG and TG curves in the temperature regions as follows:

(a) From 25°C to 525°C with a weight loss of about 2.0% due to loss of moisture content;

(b) From 525°C to 805°C with a weight loss of about 3.9% which could be attributed to the loss of the structural hydroxylation present in small quantities or due to the contamination of small amounts of magnesite or dolomite;

(c) From 805°C to 1,000°C with a weight loss of about 36.4% which could be attributed to the liberation of CO_2.

Grindability tests were carried out on two kinds of limestone (white and brownish oolitic limestone) of approximately the same chemical composition but with different hardnesses. The difference of hardness range is due to the presence of calcareous cementing material of the white type. The white limestone developed, at all grinding times, represents a greater surface area and finer material than the brownish oolitic limestone. This result could be because the cementing material was more grindable than the spherical and oval ooids as attrition took place at limited points on these ooids. It was found also that both rounded and oval oolites could escape the attrition action of the grinding media and they could be considered as a part of this grinding media.

The thermal behaviour of oolitic limestone on the raw mix could be summarized as follows:

(a) Loss of humidity, endothermic with a peak temperature at about 130°C;

(b) Dehydroxylation of clays, endothermic with a peak temperature at 525°C to 535°C;

(c) Deomposition of carbonate, endothermic with a peak temperature at 743°C, 756°C and 940°C for the dolomite and calcite respectively;

(d) Reaction between lime and clay to form belite with an exothermic effect with a peak temperature ranging between 1,230°C to 1,250°C;

(e) Liquid formation followed by completion of cement compounds in three phases represented by an endothermic effect between 1,290°C and 1,340°C (clinkering temperature);

(f) On cooling, an exothermic effect is indicated at 1,230°C + 2°C due to the crystallization or molten phase.

The factors affecting the burnability (lime saturation factor, fineness, burning temperature) of raw mix were taken into consideration in the investigations. The results showed that raw mixes containing the white oolitic limestone were more easily burned (because of the free lime and insoluble residue content of the burned raw mixes) than the brownish oolitic limestone, i.e. white limestone had a higher reactivity in combination with the acidic oxides. The investigation results revealed also the importance of fineness, especially for the brownish limestone in burning cement raw mixes. The raw materials should be fine enough to bring the reactions to completion. The results also showed the marked difference in the reactivity behaviour of the brownish oolitic and white oolitic limestone at a relatively low lime saturation factor. The white oolitic limestone showed a higher reactivity than the brownish oolitic limestone.

The evalution of cement burning technology in rotary kilns and the development of refractory kiln lining

Peter K. A. Kurpiers

Although cement has been manufactured for over 150 years, its production in the first half of that period was confined to low-capacity shaft kilns. When the rotary kiln was introduced towards the end of the last century, it was first provided with the same simple form of fire-clay bricks lining (with a 40-42% alumina content) as already used in the shaft kiln. With the subsequent introduction of larger kiln units, especially of pre-heater kilns, the demands made upon the refractory lining became so much more severe that it necessitated further development of the high-alumina brick and the use of basic grades of refractory in the high-temperature zone in order to ensure satisfactory capacity utilization of the kiln installations.

The tremendous increases in kiln size which occurred between 1960 and 1970 demanded new developments from the refractory industry, particularly with regard to the thermomechanical behaviour of the basic lining, especially in the transition zone. Higher demands have now in part been met by developments that have taken place in refractory brick technology. With preheater kilns equipped with secondary firing systems, or such kilns designed from the onset as precalcining kilns, it has once again become possible to attain kiln utilization factors of around 90%.

An active exchange of views and information between kiln constructors, kiln operators and suppliers of refractory materials was an important prerequisite for attaining maximum economy in the operation of high-capacity rotary kilns.

It was asked if it were possible to conserve energy by choosing the right quality and size of bricks. In reply it was said that insulating bricks were necessary in the calcining zone, and 50% Al_2O_3 in transition zone 2.

Another question was on problems of alkali attacking the kiln. The answer to this problem was that alkali-resistant semi-insulating bricks with low Al_2O_3 content should be used in the calcining zone; and magnesite bricks with low CR_2O_3 content in the hot zones.

The Holderbank training centre approach

Klaus Alexander Kayatz

The paper discussed the importance and need for maintenance workshops to maintain the productivity level of the assets, plant and equipment. The human assets, however, the important factor in production, were comparatively neglected in many industries.

In "Holderbank", the management was convinced that individual training centres in each cement factory were a prerequisite for success. It was not so much the physical establishment of a training centre, but the organized training activities.

Holderbank had developed a comprehensive system of training modules which covered all aspects of training, technical as well as managerial, and which were geared to all levels of the organizational hierarchy. The objective was for all supervisory personnel to become instructors in the in-plant training organization.

In response to a question on selection of persons to be trained, it was stated that aptitude tests, intelligence tests etc. were conducted in the case of staffing of a new plant; management then recommended those who had potential for promotion and who needed upgraded training.

Another question was asked on the effectiveness of incentives for performance and training success. In reply the author said that if people, particularly the young, considered their future, a career etc. they would be motivated to undergo training. To become a trainer for their own working group and colleagues gave them prestige and this was a further strong incentive.

Finally, a question was asked on the selection of people to become trainers. The reply was that basically, the person must have a natural talent which could be developed further by learning to apply training methods. In general, every successful manager had the capability of being a good trainer, because a large part of his or her work was instructing people in their work.

Pollution and electrostatic precipitator problems

Abdelatif Goma

The following is an outline of the discussion on dust pollution in the cement industry and on various types of dust filters.

(a) The principle of the electrofilters;

(b) The main component of the electrostatic precipitator:
- Gas distribution system
- Discharge electrodes
- Rapping systems
- High voltage rectifier and control circuit

(c) Factors which affect and control the electrostatic precipitator:
- Dust resistance
- Gas distribution
- Size of discharge and collecting electrodes
- High tension valve and regulating system
- Evaporative cooling tower, dew point and gas humidity
- Degree of insulation electrofilter
- Degree of heating of high tension insulators
- Quantity of false air

(d) Main problems of electrostatic precipitators in Libyan Cement Company factory:

- High resistance of gases, dust build-up in water spray nozzle, wet material in cooling tower.
- Relatively high amounts of false air
- Effect of high temperature on the support frames of electrofilters.
- Corrosion in discharge electrodes

Present state of basic refractory lining of the sintering zone

Erwin J. Koetter

Under present-day technical conditions only bricks which consist mainly of magnesite or dolomite have sufficiently good chemical resistance to the action of cement clinker and liquid alkali phases at sintering zone temperatures. Dolomite bricks, however, possess good durability only in the zone where a stable coating is picked up by the lining and only if no gypsum for "sulphatization" is added to the raw meal.

Magnesite and magnesite-chrome bricks with good creep properties (i.e. calcium silicate-bonded bricks) behave better against stresses, caused by restrained thermal expansion or to kiln shell deformations, than so-called direct-bonded and therefore "rigid" magnesite bricks. These latter bricks merely offer some slight advantages over calcium silicate-bonded bricks against overheating and/or infiltration by liquid phases from the clinker. Present-day bricklaying techniques cannot as yet fully cope with the considerable thermal expansion of these bricks. It should be considered in each individual case, depending on the special operating conditions, which type of basic brick should be installed in the transition zone 1, the sintering zone or the outlet zone.

The avoidance of cement aggregation in the Libyan Cement Company's storage silos

Ali Fathi
and
Abd El Rahim Marei

Serious problems in the operation of the packing plant operated by the Libyan Cement Company are caused by the formation of cement lumps and clogging of cement silos. This makes it difficult to load cement in the bagging section.

KHD chemical laboratory determined the phase composition of some samples radiographically. X-ray tests revealed the presence of small amounts of hemihydrate in addition to gypsum.

Other cement factories in a similar position proposed avoiding chemical reaction that might result in lump formation:

(a) By lowering the alkali content;
(b) Lowering the aluminate content by adding iron oxide to the raw mix;
(c) Relacing the gypsum partly by anhydrite;
(d) Bonding the alkalis by sulphate up to 70% in the raw mix;
(e) Lowering the cement temperature to 60%

They also recommended improving the physical conditions:
(a) By adding grinding aids to the cement;
(b) Adding limestone during cement grinding;
(c) Painting the inner silo wall;
(d) Modifying the cement silo design to include greater aeration and more outlets.

Limestone was added to the cement during grinding. The results were negative. The clogging of cement silos was removed mechanically. As a preventive measure the storage capacity was limited to 40

Tests were also carried out to investigate the behaviour of some types of additives on the flowability of cement.

Laboratory results showed the following:

(a) Limestone

No wide range of differences from previous work in large-scale production;

(b) Limestone associated with high-quality gypsum

When limestone was associated with high-quality gypsum good results occurred when using 30% of the amount of gypsum. The compressive strength of cement mortar increases, however, and the cement showed better flowability;

(c) Ethylene glycol

Ethylene glycol was used in percentages of 0.02, 0.4, 0.06, 0.08, and 0.01. The grinding was continued for 20, 30, 40, 50 and 60 minutes respectively;

It was found that the fineness increased by increasing the time of grinding for all percentages. The critical figure was 0.06%;

(d) Using commercial additives (HEA)

The same procedure as used with ethylene glycol was followed.

The results were encouraging, especially when dealing with fineness, compressive strength and flowability. The critical figures used was also 0.06%.

Iron oxide is the final additive being tested in the laboratory. The Libyan Cement Company intends manufacturing sulphate-resistant cement and will produce large quantities of this raw material.

The modernization of packing plants with automatic truck-loading equipment and palletless shrink-wrapping lines

Gernot Schäfer

The building materials industry has concentrated its past efforts on economic planning of its production capacity; as a result the opportunities remaining in these fields for improving efficiency are largely exhausted. The enlargement of production units and the automation of the process control mean that the number of personnel required in the production area can be notably reduced. More personnel were employed in the packing and loading areas than in all other production departments. Modernization was then undertaken in the packing and loading departments. This led to the departure from conventional machinery and the gradual introduction of more efficient systems.

The breakthrough in the modernization of packing plants in the last 10 years was brought about in principle by three machine systems which were developed by the machinery industry and the cement manufacturers. These were the development of automatic bag-placing systems for high-capacity rotary packers, the development of machinery for automatically loading bags on to trucks and the further development of palletizing technology in conjunction with palletless shrink wrapping for producing large packages without wooden pallets.

The automatic bag-loading machines which palletize on to vehicles are known as the Autopacs. The Autopac loading machine series is available in three models:

Autopac II for loading open vehicles from above

Autopac III for loading closed vehicles and containers from the rear

Autopac V for loading closed vehicles with laterally collapsible walls from the side

Loading machines of the Autopac type have come to be regarded almost as standard equipment in new plants. At the beginning of 1982, approximately 120 Autopac-type machines were in operation or ready for shipment or commissioning in Cantral America, Europe, the Middle East, North Africa, North America and South America.

The purpose of palletless shrink wrapping of palletized bag stacks is to produce large packages which can be transported safely, are capable of being stacked one on top of the other, are packed watertight and can be stored outside and do not have the disadvantages associated with the use of pallets.

The films used for palletless wrapping of bag stacks are thermal shrink films, e.g. special plastic films which shrink when heated and subsequently cooled, thereby surrounding the package securely. Because of the particular advantages of polyethylene over other thermal plastics, PE-film can be regarded as the standard shrink film with a thickness of about 150-200 my.

Film consumption per bag stack is determined by the packing method as well as by the stack dimensions. Two packaging methods are available: the Beumer flat film process and the Beumer Konterpac process.

The capacity of the palletless shrink-wrapping lines, known as Beumer Paketpac lines, is 60-70 packages per hour. Whereas in the cement industry lines with reduced capacity are generally unacceptable, lower hourly output is not unusual with special products. There are two possibilities for reducing machine expense and required building space. On the one hand, parts of the line can be run in reverse operation, on the other, some components can be passed through twice by running the line according to the circulation principle. The capacity of the line working by the reversing principle is about 15-20 packages per hour. The capacity of the line using the circulation principle is around 30 packages per hour.

Installation of refractory lining and some associated problems

Eckard Josef Hobrecht

Factors affecting brick life include:

Mechanical stability of the kiln shell

Inlet construction

Discharge and construction

Tight bricking of the kiln lining is another important factor influencing the brick life. Various methods are used:

Screw jack method

Glue method

Bolting method

Centre method

After lining has been installed, the heating-up procedure has an affect on the life of the brick work. Operating conditions are responsible for short brick life only if temperature and chemical composition of the kiln feed are completely outside the set standards.

In the following discussion a question was asked on the safety of the glueing method. In reply it was stated that the glue had sufficient strength that with proper cleaning of the shell and proper workmanship no risks were involved. No accidents had been known to have occurred.

It was explained that the insulating layer had a backing brick in the burning and transition zones. Insulating layers with high insulating efficiency were too soft to keep the upper lining in a stable condition. Insulating layers with higher cold crushing strengths had almost no insulating effect, it might even prevent coating formation.

Further questions elicited the facts that:

(a) Relative movements between tyre and kiln shell could be measured with devices developed by Holderbank and Ciment Obourg;

(b) Normal deformations had no significant effect on the lining. Deformations in the tyre area caused substantially higher ovality and lining damage;

(c) Distortion of the lining in a limited section might also affect the adjoining part of the lining.

Cement terminals and new developments in the packing plant

Hans Georg Lowag

Over the years a strong demand for the construction of cement terminals had been experienced. In many cases great importance was attached to the fact that the terminals could easily be dismantled and re-erected elsewhere. Local harbour regulations often prohibited the construction of permanent plants, and this resulted in the erection of floating terminals, in which modernized ships or barges served as cement silos. For designing and constructing such terminals, local circumstances must be taken into consideration when arranging for plant equipment. Terminals which handle over 1 million tons of cement per year require the latest state of engineering. This could also be used in the construction of packing plants within cement works. A calculation in 1981 based on costs in Iraq, showed that the distance between the cement works and the terminal should be no more than 65-80 km. When planning a terminal, not only should the packing into bags be taken into consideration, but also the installation at a later date of bulk loading.

Attention should also be paid to loading into Big-Bags. For lorry-bag-loading, stern-loading machines with manual operation, as well as automatic lorry loaders, can be introduced. In those cases, where bagged cement is being exported or is being stored in the open air for a considerable time, fully automatic palletizing devices with subsequent palletless shrink wrapping have proved successful.

In the stationary terminals the material fed to the hopper takes place over a pneumatic conveyor, belt plants, bucket elevators or vertical screws. The cement storage hoppers can be designed in steel or concrete. The silo discharge of the Ibau design guarantees a complete and reliable discharge and in addition offers the possibility of arranging the packing plant beneath the Ibau cone. This silo system is also economic as far as building costs are concerned.

The following developments for packing plants can be installed in terminals as well as in plants within the cement works:

(a) Automatic bag applicators. These are used according to the bundle or roller system in connection with rotating packing machines but also in connection with stationary packing machines. Existing packing machines can also be fitted with this automatic bag-applicator system after modification. Automatic bag applicators also contribute to the fact that the effective output per packing point is being increased and that employee costs are being reduced;

(b) Roto-Packer 4000. As with nearly all sections of the cement works a great improvement has also been made in the packing plant during the last year with regard to the increase in output per packing point. The Roto-Packer 4000 of 200 t/h, consists of the successful component parts of more than 1,000 Roto-Packers. The special feature of this model is that it has 12 spouts, and releases on to two discharge belts. Each discharge belt conveys 2,000 bags/h, so that two belt systems can be fed simultaneously. When employing an automatic palletizer for 4,000 bags/h both belt plants can be brought together.

Automatic bag applicators can be used in conjunction with the Roto-Packer. The installation of a Roto-Packer 4000 has the advantage that only one material feed is required. In addition, only one filter plant, one spillage return and a considerable smaller building are needed compared to two normal Roto-Packers with the pertinent conveyor elements. The total costs are also considerably reduced.

(c) Belt control weighers for automatic weight correction. By installing a belt weigher in conjunction with a bag discharge belt, weight accuracy is considerably improved. An impulse on the belt weigher results in an automatic weight correction on the mechanical weighers of the Roto-Packers. Tests show that 95% of all filled bags lie within ± 200 g. In countries where calibration is compulsory, only the belt weigher needs to be calibrated, not the Roto-Packer.

"WARTAS" - An automatic control and information system for inspection and maintenance

Wilfried Droste

Modern cement plants which frequently reach outputs of more than 3,000 t/day include some 4,000 main and secondary installations. This means that more than 20,000 inspection or maintenance orders have to be carried out; sometimes several times per week or month.

An organization which relies primarily on the capability and the qualifications of its staff and utilizes a manually operated system will realize that a huge quantity of instructions are necessary. This will result in a choice of what has to be done, so in fact one third of the checking can often be neglected.

To guarantee continuous and economic production, KHD Humboldt Wedag AG has developed the "WARTAS" system, a maintenance and inspection time schedule-issuing system which benefits from the advantages offered by electronic data processing.

WARTAS includes functions for:

Maintaining approximately 4,000 installations

Administering about 20,000 maintenance orders

Administration of spare parts stock-keeping

Personnel organization

Preventing downtime expenses

Guaranteeing delivery obligations

For these operations, WARTAS software has been made up of various extension modules:

WARTAS-10 T for timely calling of preventive checking and service jobs, by calender or machine operating time

WARTAS-10 S for spare parts stock-keeping

Extension module 2; this combines the above modules and plans the spare parts availability in accordance with requirements given by the maintenance orders

Extension module 3; this also considers the availability of service staff.

The user is offered several advantages by installing these modules one after the other. The system grows with the experience of the staff.

Annex I

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Annex II

LIST OF PAPERS AVAILABLE TO THE FORUM

"WARTAS" - An automatic control and information system for inspection and maintenance Wilfried Droste	ID/WG.379/1
Trends and developments in dry raw material and clinker grinding P. Tiggesbaumker	ID/WG.379/2
Modern clinker burning systems M. Dürr and P. Golitsch	ID/WG.379/3
Criteria for the selection of grinding mills Helmut Wuestner	ID/WG.379/4
Development of rotary kilns with the Humboldt preheater Rudolf Kuhs	ID/WG.379/5
Grindability and burnability of oolitic limestone Abd El Rahim Marei and Kaissar M. Hanna	ID/WG.379/6
Performance of volatile substances in the kiln and problems from high clinker temperatures in cement production Wiesław Kurdowski	ID/WG.379/7
Oolitic limestone for use in the cement industry in North Africa Abd El Rahim Marei	ID/WG.379/8
High-alumina cement as a building material Kessete Gabre Kidan	ID/WG.379/9
Background Paper - Establishment of factories for the production of lime pozzolana cement O. Grane	ID/WG.379/10
The avoidance of cement aggregation in the Libyan Cement Company's storage silos Ali Fathi and Abd El Rahim Marei	ID/WG.379/11

UNIDO assistance to development and consolidation of cement industry in the developing countries — ID/WG.379/12

C. Rydeng

The modernization of packing plants with automatic truck-loading equipment and palletless shrink-wrapping lines — ID/WG.379/13

Gernot Schäfer

Present state of basic refractory lining of the sintering zone — ID/WG.379/14

Erwin J. Koetter

Cement terminals and new developments in the packing plant — ID/WG.379/15

W. Haschke

Mining methods and advantages of using hydraulic excavators — ID/WG.379/16

Raymond J. Bonnkirch

Conditions necessary for establishing new cement plants — ID/WG.379/17

Jacques Hoffmeyer

Cement training centres — ID/WG.379/18

K. A. Kayatz

The development of the cement industry in the developing countries — ID/WG.379/19

C. Rydeng

Annex III

COUNTRY PAPERS*

Algeria	Abdellaoui Benyoucef
Angola	Joao Mawungo
Chad	Nadjihabe Eloi and Zozabe Issaya
China	Fang Run and Li Jing Xing
Democratic Yemen	S.A. Al-Ammari and Awad Saeed Bin Ghouth
India	D.P. Narajan
Iran (Islamic Republic of)	Esmail Habib Ollahzade
Libyan Arab Jamahiriya	Ez El-Din Abd El Rahman Al-Ghedomsi
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Annex IV

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