# Tentative Research on Technologic and Economic Analysis of Application of γ-ray Analyzer and Raw Meal Quality Control System (Software) from Thermo Electron Corporation

Yao Xuming, Wu Xinxian, Wang Junmei, Fang Wan, Shen Xin

Preamble

Yunfu Tianshan Cement Co., Ltd has set up a 5000t/d clinker line in Yun'an County, Yunfu City, Guangdong Province; it adopts γ-ray analyzer and raw meal quality control system (software) from Thermo Electron Corporation, which changes the traditional thinking set on raw meal component control since the beginning of cement industry, simplifies the raw meal homogenization chain in new dry cement production, improves product quality, greatly reduces capital investment and operating costs and attains marvelous technical effects and good economic benefits.

Now we attempt to make a brief analysis on the raw materials, assay instruments, technical effect, investment and operating situation of this production line.

1. Use of raw materials with big composition differences

The four ingredients are adopted: two types of low-lime high-silica limestone with big and very big composition difference (the proportion of the two types in raw meal: approx. 92~96%), danby and iron ore.

1.1 Calcareous raw material (two ore points)

1.1.1 Shishan Limestone Ore

The deposit occurrence, located in the upper strata ($D_3t^c$) of Upper Denovian Tianziling Formation, is the type of littoral ~ neritic facies carbonate sedimentary deposit; single stratum lithology: carbonate rocks whose surfaces have sandy strips formed by horizontal differential corrosion, and grey, dark grey, locally light grey or grey black thin ~ medium bedded carbon filled with knife-chopping lines.

There are two types of ores, i.e., silt-containing limestone and siltstone. The mineral composition is mostly calcite (generally 88%~93%), followed by quartz (5%~8%) and a small amount of carbon, sometimes fine iron pyrite and white coarse-grained quartz found on the bedding surface. The structure is usually of crystal powder~fine-grained, thin~ medium-bedded, and locally thick-layer (ore surface has clear stratification, but no stratification is found on fresh surface)

Most calcite grains are anhedral or subhedral with average size of 0.02~0.05mm, some as big as 0.1~0.2mm. Quartz basically appears in a decentralized way, with local enrichment in the shape of small round package. The granularity is 0.02~0.03mm, and some can be as big as 0.1mm. Carbon is mostly distributed in the shape of particles or fine sesames, but some relative enrichment appears in sporadic lines and arranged in a directional way, sometimes filled in furrow lines or stratification.

Shishan Ore has a low content of CaO but a relatively high content of $SiO_2$ and $fSiO_2$; thus it becomes a source of calcium in raw meal, meanwhile used as silicon corrective; its chemical composition is shown in Table 1 below.

Chemical composition of Shishan Ore (%) Table 1

| Name of test sample | L.O.I | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | $Cl^-$ | TOTAL | f-$SiO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral rock, grand average | 37.89 | 11.72 | 0.96 | 0.85 | 47.01 | 0.76 | 0.154 | 0.021 | 0.17 | 0.0054 | 99.54 | 10.32 |

For single engineering average chemical composition homogenization and standard deviation (calculated via weighted thickness approach) for control section, see Tables 2.1 and 2.2 below.

Statistics (weighted) on boring data Table 2.1

| Bore No. | ZK001 | | ZK002 | | ZK101 | | ZK102 | |
|---|---|---|---|---|---|---|---|---|
| Length of test samples, M | 140.84 | | 68.52 | | 88.85 | | 99.75 | |
| Item | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ |
| Average, Ā | 46.21 | 12.04 | 45.08 | 14.21 | 47.41 | 10.98 | 47.18 | 10.41 |
| Standard deviation, S | 1.47 | 2.64 | 1.37 | 2.42 | 1.27 | 1.81 | 1.06 | 1.26 |
| $SCaCO_3$() | 2.63 | | 2.45 | | 2.27 | | 1.89 | |

Statistics (weighted) on notch data Table 2.2

| Prospecting Line No. | KCO(Line 0) | | KC1(Line 1) | | JK2(Line 2) | | JK3(Line 3) | |
|---|---|---|---|---|---|---|---|---|
| Length of test samples, M | 330.90 | | 182.70 | | 137.80 | | 114.30 | |
| Item | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ |
| Average, Ā | 46.81 | 12.21 | 46.92 | 12.01 | 47.71 | 11.24 | 48.48 | 10.23 |
| Standard deviation, S | 1.68 | 2.74 | 1.54 | 2.59 | 1.65 | 2.83 | 1.93 | 2.71 |
| $SCaCO_3$ () | 3.00 | | 2.75 | | 2.95 | | 3.45 | |

1.1.2 Dayanshan Limestone Ore

Deposit occurrence lies at the middle and upper strata ($D_3t^b$, $D_3t^c$) of Upper Denovian Tianziling Formation, mostly micritic limestone mixed with a small amount of argillaceous limestone and arenaceous limestone; argillaceous limestone is generally contained in micritic limestone, arenaceous limestone usually at the bottom of micritic limestone.

Micritic limestone is grey or dark grey, medium-bedded and locally thick-bedded configuration, micritic structure. The composition is mostly calcite (95%~99%), with dolomite (about 1%), quartz (1%~2%), a small amount of carbon and slime, trace amount of iron pyrite and limonite.The granularity of calcite is generally less than 0.01mm, and the micritic calcite is unevenly mixed with some sub-angular~subrounded terrigenous quartz with the granularity of 0.03~0.10mm.

Argillaceous limestone is grey, dark grey, grey black, thin~medium bedded shape with micritic structure. The composition is mostly calcite (90%-96%), quartz (approx. 1%-4%), a small amount of slime and carbon and a trace amount of iron pyrite. Micritic calcite is unevenly mixed with sub-angular terrigenous quartz, with the granularity of 0.02~0.10mm and only some secondary quartz may be 0.15mm. Most of these ores belong to Grade II.

Arenaceous limestone is grey or dark grey, with medium-bedded shape and micritic structure. The composition is mostly calcite, and sub-angular silt-sized terrigenous quartz (about 15%~28%). It is characterized by low-content CaO but high-content $SiO_2$. The content of CaO in those ores generally fails to meet the requirements of Grade II.

The average content (calculated on weighted thickness of test sample) of chemical compositions for ores throughout the mine field is shown in Table 3 below.

Chemical composition of Dayanshan Ore (%) Table 3

| L.O.I | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 39.51 | 5.81 | 1.55 | 0.77 | 49.15 | 1.37 | 0.44 | 0.03 | 1.15 | 99.77 |

For single engineering average chemical composition homogenization and standard deviation (calculated via weighted thickness approach) for control section, see Tables 4.1 and 4.2 below.

Statistics (weighted) on boring data Table 4.1

| Bore No. | ZK101 | | ZK102 | | ZK201 | | ZK202 | | ZK203 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Total length of test samples, M | 150.21 | | 24.5 | | 90.39 | | 109.80 | | 77.00 | |
| Test Sample No. | 1~44 | | 1~7 | | 1~25 | | 1~39 | | 1~25 | |
| Item | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ |
| Average Ā | 47.62 | 6.85 | 47.85 | 8.69 | 33.31 | 28.10 | 46.97 | 8.64 | 46.01 | 7.83 |
| Max | 53.89 | 22.43 | 52.88 | 17.12 | 51.93 | 46.40 | 53.56 | 45.05 | 53.21 | 18.25 |
| Min | 36.26 | 0.36 | 41.09 | 2.64 | 19.19 | 4.20 | 16.17 | 1.41 | 37.07 | 2.01 |
| Standard deviation S | 4.58 | 6.35 | 4.31 | 5.45 | | | 7.59 | 9.17 | 4.18 | 4.03 |
| $S_{CaCO_3}$() | 8.18 | | 7.70 | | Temporarily not for use, so no statistics | | 13.55 | | 7.46 | |
| Remark | | | | | | | | | | |

Statistics (weighted) on notch data Table 4.2

| Prospecting Line No. | KC1 (Line 1) | JK2 (Line 2) |
|---|---|---|

| Total length of test samples, M | 105.00 | | 192.30 | |
|---|---|---|---|---|
| Test Sample No. | 1~33 | | 1~66 | |
| Item | CaO | $SiO_2$ | CaO | $SiO_2$ |
| Average Ā | 46.97 | 8.45 | 48.82 | 6.10 |
| Max | 53.12 | 36.85 | 54.34 | 35.40 |
| Min | 18.97 | 0.90 | 13.79 | 1.03 |
| Standard deviation S | 6.13 | 6.68 | 6.29 | 6.61 |
| $S_{CaCO_3}$() | 10.95 | | 11.23 | |

Both Shishan limestone and Dayanshan limestone are of low-lime and high-silica type, but considering their purpose and management convenience, they are named as “high-lime low-silica” limestone and “low-lime high-silica” limestone respectively based on their slight differences.

### 1.1.3 Information on quality of limestone for production

Information on quality of limestone for production Table 5

| Time | 2006 | March | | April | | May | | June | | July | | August | | September | | October | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ore name | Item | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ |
| Shishan Limestone Ore | statistic quantity, N | 22 | | 31 | | 22 | | 17 | | 22 | | 17 | | 31 | | 27 | |
| | Average, X | 43.36 | **16.04** | 43.73 | **15.22** | 44.79 | **14.63** | 44.86 | **15.10** | 45.50 | **14.22** | 46.12 | **13.45** | 45.48 | **14.09** | 45.17 | **13.96** |
| | Max | 45.08 | 19.55 | 45.66 | 22.13 | 46.28 | 16.43 | 46.36 | 16.63 | 46.66 | 16.01 | 52.26 | 18.08 | 48.16 | 21.34 | 48.48 | 19.30 |
| | Min | 40.98 | 13.53 | 39.74 | 12.33 | 43.43 | 12.08 | 42.47 | 13.25 | 44.58 | 12.14 | 43.77 | 3.50 | 41.08 | 10.75 | 41.05 | 10.07 |
| | Standard deviation ,S | 0.93 | 1.38 | 1.14 | 1.77 | 0.76 | 1.09 | 0.93 | 1.20 | 0.52 | 0.99 | 1.49 | 2.48 | 1.66 | 2.20 | 1.67 | 2.28 |
| | $S_{CaCO3}$ | 1.66 | | 2.04 | | 1.36 | | 1.66 | | 0.93 | | 2.66 | | 2.96 | | 2.98 | |
| Dayanding Limestone Ore Mining Area 1# | statistic quantity, N | 18 | | 29 | | 6 | | 16 | | 11(Caiying Ore) | | 16 | | 28 | | 8 | |
| | Average, X | 44.65 | **10.68** | 45.04 | **10.18** | 44.46 | **10.57** | 42.98 | **12.46** | 51.22 | 3.37 | 46.23 | **9.12** | 45.57 | **9.90** | 46.03 | **8.44** |
| | Max | 48.46 | 15.35 | 48.92 | 18.42 | 49.47 | 13.88 | 47.22 | 18.27 | 54.51 | 5.53 | 50.33 | 12.88 | 49.06 | 15.77 | 49.79 | 12.18 |
| | Min | 41.28 | 6.87 | 37.64 | 6.37 | 41.70 | 5.74 | 37.45 | 7.63 | 48.34 | 0.48 | 43.01 | 5.86 | 40.34 | 5.22 | 42.23 | 5.23 |
| | Standard deviation ,S | 2.19 | 2.35 | 2.50 | 2.95 | 2.92 | 3.11 | 3.07 | 3.25 | 1.97 | 1.70 | 2.05 | 2.07 | 2.31 | 2.63 | 2.41 | 2.45 |
| | $S_{CaCO3}$ | 3.91 | | 4.46 | | 5.21 | | 5.48 | | 3.52 | | 3.66 | | 4.13 | | 4.30 | |
| Dayanding Limestone Ore Mining Area 2# | statistic quantity, N | 12 | | 24 | | 9 | | 4 | | | | 20 | | 30 | | 8 | |
| | Average, X | 45.97 | **9.10** | 44.79 | **9.60** | 42.44 | **12.77** | 47.28 | **6.08** | | | 47.34 | **6.58** | 44.70 | **10.06** | 44.63 | **10.51** |
| | Max | 49.92 | 17.78 | 48.79 | 14.71 | 47.01 | 18.50 | 48.35 | 6.85 | | | 50.87 | 14.26 | 49.06 | 20.64 | 49.16 | 15.90 |
| | Min | 38.64 | 5.12 | 40.06 | 5.01 | 36.86 | 6.82 | 45.70 | 5.23 | | | 39.82 | 4.44 | 36.94 | 5.92 | 39.23 | 4.82 |
| | Standard deviation, S | 3.34 | 4.13 | 2.24 | 2.36 | 3.28 | 4.16 | 0.97 | 0.57 | | | 2.32 | 2.28 | 2.66 | 3.17 | 2.95 | 3.22 |
| | $S_{CaCO3}$ | 5.96 | | 4.00 | | 5.86 | | 1.73 | | | | 4.14 | | 4.75 | | 5.27 | |

(Continued)

| Time | 2006 | November | | December | | January, 2007 | | February | | March | | April | | May | | June | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ore name | Item | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ | CaO | $SiO_2$ |
| Shishan Limestone Ore | statistic quantity, N | 22 | | 27 | | 24 | | | | | | | | | | | |
| | Average, X | 47.40 | **10.86** | 47.65 | **10.94** | 47.31 | **11.74** | | | | | | | | | | |
| | Max | 49.03 | 15.78 | 49.20 | 14.23 | 48.94 | 15.39 | | | | | | | | | | |
| | Min | 45.21 | 8.64 | 45.38 | 8.26 | 44.77 | 9.02 | | | | | | | | | | |
| | Standard deviation ,S | 1.02 | 2.02 | 0.91 | 1.56 | 1.06 | 1.80 | | | | | | | | | | |
| | $S_{CaCO3}$ | 1.82 | | 1.625 | | 1.89 | | | | | | | | | | | |
| Dayanding Limestone Ore Mining Area 1# | statistic quantity,N | 15 | | 20 | | 22 | | | | | | | | | | | |
| | Average, X | 46.27 | **9.00** | 47.02 | **7.55** | 47.38 | **7.04** | | | | | | | | | | |
| | Max | 52.24 | 14.87 | 49.75 | 13.03 | 51.06 | 13.15 | | | | | | | | | | |
| | Min | 41.12 | 3.20 | 42.46 | 4.12 | 42.69 | 3.34 | | | | | | | | | | |
| | Standard deviation ,S | 3.15 | 2.91 | 1.75 | 1.97 | 2.31 | 2.79 | | | | | | | | | | |
| | $S_{CaCO3}$ | 5.63 | | 3.125 | | 4.125 | | | | | | | | | | | |
| Dayanding Limestone Ore Mining Area 2# | statistic quantity,N | 15 | | 22 | | 20 | | | | | | | | | | | |
| | Average, X | 45.41 | **9.33** | 46.23 | **8.36** | 45.72 | **8.87** | | | | | | | | | | |
| | Max | 51.46 | 24.59 | 50.01 | 13.22 | 48.69 | 14.31 | | | | | | | | | | |
| | Min | 32.43 | 4.22 | 42.22 | 4.00 | 39.31 | 3.81 | | | | | | | | | | |
| | Standard deviation ,S | 4.56 | 4.95 | 1.90 | 2.33 | 2.32 | 2.82 | | | | | | | | | | |
| | $S_{CaCO3}$ | 8.14 | | 3.39 | | 4.14 | | | | | | | | | | | |

1.2 Silica-aluminum raw material (shale)

Deposit occurrence of Doubaping Shale lies at Triassic – Jurassic Xiaoping Formation ((T3r - Jl)[a]), mainly composed of dark grey, grey black danby and white-grey mudstone. Its physical properties are as follows:

Dark grey, grey black danby

Mineral composition is mostly clay minerals, followed by silt, including carbon and a small amount of iron substrate; carbon is mostly distributed along bedding surface. It is of argillaceous texture, schiefer structure, with single-layer width of 0.5~1.5cm.

White-grey mudstone

The predominant composition of the ore is clay minerals, including a small amount of clay, iron substrate, and it is of argillaceous texture and massive structure. The ore has good viscidity and plasticity. These ores are mainly distributed at the upper portion of ore deposits with limited quantity.

The above two types of ores, characterized by low silicon and high aluminum, are the right choice for preparation of raw meal by our company.

Chemical composition of danby(%) Table 6

| | L.O.I | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | $Cl^-$ | TOTAL | SM | AM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. | 12.03 | 63.04 | 31.58 | 12.20 | 0.32 | 0.92 | 2.91 | 0.29 | 1.79 | 0.0093 | | 1.95 | 10.10 |
| Min. | 4.99 | 46.78 | 22.22 | 1.00 | 0.26 | 0.29 | 1.98 | 0.11 | 0.02 | 0.0019 | | 1.20 | 2.01 |
| Average | 10.48 | 51.95 | 25.67 | 7.43 | 0.29 | 0.74 | 2.32 | 0.19 | 0.98 | 0.0069 | 100.05 | 1.58 | 5.15 |

1.3 Iron ore

Its chemical composition is generally as follows:

Chemical composition of iron ore (%) Table 7

| L.O.I | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 9.13 | 39.43 | 3.08 | 45.60 | 0.47 | 0.25 | 0.20 | 0.14 | 1.72 | 100.02 |

1.4 Anthracite

Imported anthracite from Vietnam is used.

Anthracite industry analysis (%) Table 8

| Mad | Vad | Aad | FCad | Qnet.ad(Kcal/Kg) |
|---|---|---|---|---|
| 0.43 | 6.80 | 29.86 | 62.90 | 5372.53 |

Chemical composition of coal ash (%) Table 9

| L.O.I | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | TOTAL | SM | AM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| - | 58.59 | 26.28 | 6.82 | 0.70 | 2.63 | 1.00 | 0.50 | 0.20 | 96.72 | 1.77 | 3.85 |

2. Typical raw meal control method in pre-calcining kiln

The history of cement industry is a continuous pursuit of improved product quality and reduced consumption; quality plays a vital role. Homogeneous composition of raw meal directly impacts on the quality of clinker. The “Technological Management Criterion of Kiln with Precalciner” , formulated by China, requires that the proportion of $S_{CaCO3}$ , one of raw meal fed into the kiln, shall be not bigger than 0.20%, which is close to the requirement of chemical analysis on error (for error requirement concerning analysis of raw meal CaO: 0.25% for the same test room, 0.40% for different test rooms); for every 1% increase in $CaCO_3$, there will be about 13% in $C_3S$, and about 11.5% reduction in $C_2S$.

2.1 Makeup of “homogenization chain”

Quality homogenization of raw meal prepared in pre-calcining kiln is achieved through “homogenization chain”, which means that homogenization is realized throughout all the technologic links for raw meal preparation. A complete raw meal homogenization system consists of four indispensable links, i.e., matched mining and transportation of raw material quarry, pre-homogenization and storage of raw materials, blending control and adjustment for raw mill, homogenization and storage of inbound raw meal. The said four links forms the raw meal homogenization chain, which is necessary for guaranteed homogeneity and stability of inbound raw meal; every link has definite functions: pre-homogenization storage yard for storage and homogenization of lumpy materials, homogenization coefficient H=5-10, the standard deviation of $S_{CaCO3}$ in limestone out of storage yard shall be ≤1.0%; under the condition that multiple raw materials come into the mill, QCX system ensures that the standard deviation for each outgoing raw meal shall not be bigger than that of incoming raw material, i.e. it is guaranteed that the outgoing raw meal $S_{CaCO3}$ shall be ≤1.0%; homogenization of raw meal is finally achieved in the raw meal homogenization silo with the help of gravity homogenization by side wind and atmospheric agitation by central wind, homogenization coefficient H=5-10, i.e., meeting the requirement that the standard deviation of $S_{CaCO3}$ in inbound raw meal $CaCO_3$ shall be ≤0.20%. The approximate homogenization proportion of each link during raw meal preparation is shown in Table 10.

Function configuration of homogenization system Table 10

| Name of each link | Average homogenization cycle (h)* | Standard deviation of $CaCO_3$ | | Homogenization effect $S_1/S_2$ | Proportion of homogenization work completed (%) |
|---|---|---|---|---|---|
| | | Feed $S_1$(%) | Discharge $S_2$ (%) | | |
| Quarry | 96~168 | | 2~10 | | ≤10 |
| pre-homogenization storage yard | 2~8 | 2~10 | 1~3 | 3~6 | 35~40 |
| Raw mill | 1~10 | 1~3 | 1~3 | 1~2 | 0~15 |
| Raw meal homogenization silo | 0.5~4 | 1~3 | 0.1~0.4 | 4~15 | 40 |

*operating time required for raw meal (raw material) of each link to attain the target value of discharge (standard deviation )

Technological and economic significance of raw meal homogenization system is: relatively low power consumption to make inbound raw meal reach technical requirements.

2.2 Technological requirements for building of pre-homogenization storage yard

During the study on composition of raw meal homogenization chain, the first concern is the storage method of limestone; for a single limestone mine, $S_{CaCO3}$≥3, the building of pre-homogenization storage yard can be considered. The results of geological statistics on the above two ore points (i.e., Shishan and Dayanshan) show: the average geological grade for Shishan, CaO=45.05-48.48%, $SiO_2$=10.23-14.21%, given the ore dilution rate of 2~4%, estimated grade of mined ore: CaO≈44-46%, quite low; $S_{CaCO_3}$=1.89~3.45, not too big, but $S_{SiO_2}$=1.26-2.83, coefficient of variation $CV_{SiO2}$= 12.13~26.49%, a big fluctuation. The average geological grade for Dayanshan Ore: CaO=46.01-48.82%, given the ore dilution rate, the expected grade of mined ore: CaO≈45-47%; calculated $S_{CaCO_3}$=7.46~13.55, a drastic degree of change seldom seen; the ore grade in Dayanshan is not much higher than that of Shishan. The reason that Dayanshan ores are adopted is that the ores in Dayanshan has a relatively low content of silicon. For production in such a mine, homogenization is required. For these two mines, a design unit will surely adopt a pre-homogenization storage yard.

Lime stones from these two limestone mines come together into the pre-homogenization storage yard for homogenization, equal to pre-mixing. It requires that these two types of limestone shall be crashed and stored separately; meanwhile, it is also required that the storage yard should be installed with controllable fixed-amount feeding and systematic sampling devices, fast analytic instrumentation and feedback control and feedstock proportioning methods; large sampling stations prevalent overseas are usually installed with X- fluorescent analyzers, γ-ray analyzer and storage quality control system (software); only in this way can the composition of materials going out of the storage yard remain basically stable. Based on the amount of materials that a pre-homogenization storage yard can hold, the yard can be divided into 5~10 sections for control, e.g. for a rectangular pre-homogenization storage yard with a total capacity of 50000t, each section may have a capacity of approx. 5000~10000t; through standard sampling and analysis, the information on discharge composition for that section is obtained, and the proportion and amount of materials coming into the next section will be automatically calculated through control program; the control logic is to gradually reduce the deviation between composition of existing materials in the stack and the respective target value by changing the proportions of materials coming into the stack so as to make the composition of the whole stack reach or near the target value. Table 11 is an example of composition control and adjustment in a large pre-homogenization storage yard.

An example of lists showing chemical composition of pre-mixing material stacks in a rectangular pre-homogenization storage yard Table 11

List of results on materials of the fifth layer

| No. | Weight (t) | L.O.I | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | $CL^-$ | KH | SM | AM | SR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50000 | 36.72 | 12.07 | 1.73 | 1.34 | 44.74 | 1.35 | 0.99 | 0.12 | 0.57 | 0.009 | 1.225 | 3.93 | 1.29 | 6.98 |
| 2 | 20000 | 36.70 | 12.00 | 1.70 | 1.30 | 44.70 | 1.30 | 1.00 | 0.10 | 0.60 | 0.009 | 1.233 | 4.00 | 1.31 | 7.06 |
| 3 | 5000 | 36.57 | 12.33 | 1.77 | 1.37 | 44.54 | 1.35 | 1.01 | 0.12 | 0.56 | 0.009 | 1.191 | 3.93 | 1.29 | 6.97 |
| 4 | 25000 | 36.67 | 12.07 | 1.71 | 1.31 | 44.67 | 1.31 | 1.00 | 0.10 | 0.59 | 0.009 | 1.225 | 4.00 | 1.31 | 7.06 |
| 5 | 25000 | 36.77 | 12.07 | 1.75 | 1.37 | 44.81 | 1.39 | 0.98 | 0.14 | 0.55 | 0.009 | 1.226 | 3.87 | 1.28 | 6.90 |

List of results on materials of the sixth layer

| No. | Weight (t) | L.O.I | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | $CL^-$ | KH | SM | AM | SR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50000 | 36.72 | 12.07 | 1.73 | 1.34 | 44.74 | 1.35 | 0.99 | 0.12 | 0.57 | 0.009 | 1.225 | 3.93 | 1.29 | 6.98 |
| 2 | 25000 | 36.67 | 12.07 | 1.71 | 1.31 | 44.67 | 1.31 | 1.00 | 0.10 | 0.59 | 0.009 | 1.225 | 4.00 | 1.31 | 7.06 |
| 3 | 5000 | 36.95 | 11.69 | 1.69 | 1.29 | 45.03 | 1.35 | 0.96 | 0.12 | 0.59 | 0.009 | 1.277 | 3.92 | 1.31 | 6.92 |
| 4 | 30000 | 36.72 | 12.00 | 1.71 | 1.31 | 44.73 | 1.32 | 0.99 | 0.11 | 0.59 | 0.009 | 1.234 | 3.97 | 1.31 | 7.02 |
| 5 | 20000 | 36.72 | 12.17 | 1.76 | 1.38 | 44.76 | 1.40 | 0.98 | 0.14 | 0.54 | 0.009 | 1.214 | 3.88 | 1.27 | 6.91 |

List of results on materials of the seventh layer

| No. | Weight (t) | L.O.I | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | $CL^-$ | KH | SM | AM | SR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50000 | 36.72 | 12.07 | 1.73 | 1.34 | 44.74 | 1.35 | 0.99 | 0.12 | 0.57 | 0.009 | 1.225 | 3.93 | 1.29 | 6.98 |
| 2 | 30000 | 36.72 | 12.00 | 1.71 | 1.31 | 44.73 | 1.32 | 0.99 | 0.11 | 0.59 | 0.009 | 1.234 | 3.97 | 1.31 | 7.02 |
| 3 | 5000 | 36.10 | 11.44 | 1.65 | 1.26 | 45.22 | 1.34 | 0.94 | 0.13 | 0.61 | 0.009 | 1.313 | 3.93 | 1.31 | 6.93 |
| 4 | 35000 | 36.77 | 11.92 | 1.70 | 1.30 | 44.80 | 1.32 | 0.99 | 0.11 | 0.59 | 0.009 | 1.245 | 3.97 | 1.31 | 7.01 |
| 5 | 15000 | 36.59 | 12.41 | 1.80 | 1.43 | 44.60 | 1.42 | 1.00 | 0.14 | 0.51 | 0.009 | 1.199 | 3.84 | 1.26 | 6.89 |

List of results on materials of the eighth layer

| No. | Weight (t) | L.O.I | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | $CL^-$ | KH | SM | AM | SR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50000 | 36.72 | 12.07 | 1.73 | 1.34 | 44.74 | 1.35 | 0.99 | 0.12 | 0.57 | 0.009 | 1.225 | 3.93 | 1.29 | 6.98 |
| 2 | 35000 | 36.77 | 11.92 | 1.70 | 1.30 | 44.80 | 1.32 | 0.99 | 0.11 | 0.59 | 0.009 | 1.245 | 3.97 | 1.31 | 7.01 |
| 3 | 5000 | 36.35 | 12.71 | 1.82 | 1.42 | 44.25 | 1.36 | 1.04 | 0.12 | 0.53 | 0.009 | 1.145 | 3.92 | 1.28 | 6.98 |
| 4 | 40000 | 36.72 | 12.02 | 1.72 | 1.32 | 44.73 | 1.32 | 0.99 | 0.11 | 0.59 | 0.009 | 1.231 | 3.95 | 1.30 | 6.99 |
| 5 | 10000 | 36.72 | 12.27 | 1.79 | 1.43 | 44.78 | 1.45 | 0.98 | 0.16 | 0.51 | 0.009 | 1.203 | 3.81 | 1.25 | 6.85 |

Remarks on the above serial numbers:

1 – total weight of a single stack and the target value on chemical composition of pre-mixing materials;

2 – the amount and chemical composition of existing materials in the storage yard before this unit (material layer) materials are stacked;

3 – the amount and chemical composition of stacked materials in this unit (material layer);

4 – the amount and chemical composition of stacked materials in the storage yard after this unit (material layer) materials are stacked;

5 – the amount of materials that need to be stacked and chemical composition target value of materials.

The pre-homogenization storage yard is quite costly and occupies a large floor area. Plus necessary sampling, analytic and mixing control devices and facilities, capital investment for such a yard will be quite large.

## 2.3 Raw meal homogenization silo

Newly-built factories adopt continuous homogenization silo or multi-flow homogenization silo: a typical continuous homogenization silo is a mixing silo developed by Germany-based C1audius Peters and its improved homogenization silo; multi-flow homogenization silos include central room homogenization silo by Germany-based IBAU, FLS CF(Controlled Flow) Silo, Germany-based Polysius Company's multi-flow homogenization silo (MF Silo), NC-type multi-flow homogenization silo by Nanjing Cement Design and Research Institute, TP-type multi-flow homogenization silo by Tianjin Cement Design and Research Institute, etc. In these silos, no temporary correction or adjustment is made on the composition of raw meal in silo. Instead, the fluctuation range on composition of outgoing (stock-in) raw meal is minimized through raw mill control system. Therefore, to make the composition of outgoing raw meal up to standard, the composition of incoming raw meal must be controlled near control indexes; in addition, it shall be guaranteed that average composition of incoming raw meal reach or near the control indexes within a specific time interval, which is called allowable fluctuation range for homogenization silo. Such a range depends on the internal structure and homogenization capability of the silo, usually 4~6hrs. When such a silo is used, the composition of outgoing raw meal must be controlled in strict accordance with allowable fluctuation range for the silo, i.e., grinding head and mixing materials must be strictly controlled.

The above silos share similar working principles. Characteristics of TP-type multi-flow homogenization silo are as follows:

The roof of silo adopts overflow raw meal distributor, which has inner cylinder and outer cylinder. The wall of inner cylinder has many round holes, and on the upper portion of bottom of outer cylinder are 6 discharge holes for distributing raw meal to air conveying chute to put raw meal into the silo horizontally.

The bottom of the silo is installed with large cone structure to form more reasonable civil structure; mixing chamber is installed outside the silo to reduce plenum area within the silo.

The annular space between silo wall and cone structure is divided into 6 big discharging zones and 12 small plenum zones. Each plenum zone inclines toward discharging opening, and the inclined surface is installed with plenum box for filling gas to each zone in turns; pressure-relief cone is installed at the upper portion of discharging zone to reduce the pressure in the discharging zone.

When gas is filled into a specific zone, funnel flow is formed at the upper portion, and meanwhile multiple layers of raw meal are incised to produce axial mixing of raw meal flow in the silo.

Two symmetric discharging openings at the centre of silo carry out discharging operations. Outbound raw meal will be transported through manual, pneumatic and electric flow control valves to metering bin, which incorporates material mixing, weighing and feeding. This bin with weight sensor consists of inner cylinder and outer cylinder; the wall of inner cylinder has holes. According to the principle of communicating pipe, raw meal entering outer cylinder of metering bin will exchange with raw meal entering inner cylinder and the raw meal will be discharged after being mixed in inner cylinder.

Through calibration, power consumption for raw meal homogenization and aeration in TP silo is 0.25 kwh/t raw meal, $S_{CaO}$ (for raw meal entering the kiln) ≤0.25%, homogenization coefficient H=3~5, the raw meal empting rate can be as high as 98~99%.

As a weak link in the whole "homogenization chain", a homogenization silo undertakes the biggest proportion of homogenization work. However, because many devices and pipelines are involved and its operation is subject to various external factors, it is required that suitable silo type shall be chosen, construction quality shall be guaranteed, and due attention shall be paid to routine and regular check and maintenance during normal production so that the homogenization silo can perform its due functions.

## 2.4 Problems with conventional raw meal homogenization chain

Corporate management and staff quality restricts the establishment, improvement and operation of homogenization chain. In reality, the homogenization chain of some domestic enterprises is not complete, mainly shown in the following aspects:

Complicated raw material mines. Due to insufficient input or limited technology in geological work, mineralization model cannot be established, thus causing such problems as disorderly mining and unreasonable matching.

Due to unsound mixing mechanism for materials coming into pre-homogenization storage yard, pre-mixing cannot be realized or the pre-mixing effect is not good.

Not many enterprises have complete QCX quality control systems and actually make inputs; most of them regard X-fluorescent analyzer as an “analyzer” instead of a control software; what is worse, because of the failure to take effective measures to get rid of mineral effect and particle-size effect that affects the analytic accuracy of X-fluorescent analyzer, some discard X-fluorescent analyzer, thinking it is inaccurate in terms of analysis.

Design, installation, maintenance and management of homogenization silo are sometimes not in place, so the ideal homogenization effect fails to be reached.

## 3. Use of γ-ray analyze and the new concept of raw meal quality control

### 3.1 Introduction of γ-ray analyzer and raw meal quality control system (software) – decisive factor for the implementation of the new scheme

Even since cement industry emerged about 100 years ago, raw meal quality control has always relied on the mode of sampling analysis at mill end and proportion adjustment at mill beginning; thus creating various “sampling theories” aimed to reduce quality deviation between samples and overall production as well as “fuzzy control” to make up for inaccurate adjustment arising from long-period delay (about 1 hour).

The analytic technology of prompt neutron activation γ-ray analyzer was first developed by Thermo Electron Corporation in 1983. With such technology, the chemical composition of lumpy substance can be accurately analyzed for an instant. The said company later developed γ-ray analyzer and raw meal quality control system (software), which was successfully applied to raw meal preparation in cement plants. The unique strengths of this system was shown since it was applied:

First of all, it does not damage test samples; it can accurately analyze 200mm lumpy materials barely acceptable to vertical mill, completely overcoming the impact of particle effect and mineral effect on analytic accuracy of X-fluorescent analyzer widely used in cement plants;

All raw materials can be conveyed by belts for its analysis, which belittles any “sampling theory”;

Raw meal quality control system (software) can complete the work of adjusting inbound raw material proportion at intervals of minutes, making the fluctuation of outgoing raw meal composition reach the control level of incoming raw meal issued by “cement industry”, changing the traditional feed backward control to feed forward control and solving the century-old problem concerning raw meal control in cement industry.

It has such outstanding advantages, but expensive price restricts its popularity. With time going by, this system continued to be improved. In 2003, the fifth-generation product was released. Since it was not very expensive like initial stage, it gained rapid popularity in the US. At the beginning of the 21st century, it was applied in some cement enterprises in China. In addition, its price continued to decrease, now almost one third of its original price. Through several technological exchanges and studies, we decided to order CBX1 γ-ray analyzer and raw meal quality control system (software). The γ-ray analyzer has good accuracy and precision in terms of material analysis (see the paper on acceptance); ground raw meal can meet the levels shown in Table 12, and can meet the basic requirements on materials entering the kiln.

Guaranteed Fluctuation range of ground raw meal Table 12

| Clinker rate | Guaranteed standard deviation (σ) | Expected (possible to reach)standard deviation (σ) |
|---|---|---|
| LSF | 3 | 2 |
| SM | 0.15 | 0.1 |
| IM | 0.18 | 0.1 |

$$\sigma = \sqrt{\frac{1}{n-1} \bullet \sum_{i=1}^{n} (x_i - \mu)^2}$$

Where:

$n$ - number of samples, here it takes 30

$x_i$ - one of n analysis values

$\mu = \frac{1}{n} \bullet \sum_{i=1}^{n} x_i$ - average analysis value

With the introduction of γ-ray analyzer, the production line has been simplified as follows:

3.2 Limestone stored in silo

The two types of limestone used are separately stored in two φ18×40m silo for storage and mixing with combined storage capacity of nearly 20,000t, meeting the needs of the plant for 3-day consumption. People may have the following question – without a pre-homogenization storage yard, the homogeneity requirements of raw mill on materials entering the mill can be met?

We make analysis form the relationship between control cycle and material quantity: for a conventional pre-homogenization storage yard, material quantity for 6~10 days is stored for each stack. In general, a mill makes adjustment once every hour, material stack can guarantee the stability of ore composition for 144~240 hrs (cycle). For a 5000t/d production line, it means the storage of 46000~77000t. If the adjustment to mixing proportion of raw materials entering the mill is made once every minute, the time to ensure the stability of ore composition during the same cycle (144~240hrs) is shortened to 2.4~4.0 hrs. For a 5000t/d production line, the quantity of materials for this period of time is as much as 900~1500t; we use the said two types of limestone, the proportion is approximately 2:1, with more Shishan ores used for more composition stability; for Dayanding Mine, 300~500t ores (sedimentary rocks) may not change very greatly if it is well controlled after being transported to the factory.

3.3 Experiments on reduction of volume and air injection amount of raw meal homogenization silo

Because design lags behind research, our company has to adopt the φ22.5×62mNGF homogenization silo designed by Nanjing Cement Design and Research Institute for the 5000t/d production line. But we resolutely reduced the height of the silo from 62m to 50m, effective storage capacity from 24000t to 16000t with the storage period of 2 days. The capacity of conventional homogenization silo is the quantity for 3 days. In general, raw mill makes adjustment once every hour; “quantity for 3 days” means 72 layers in the condition of full silo; thus the question appears: “a smaller silo can ensure the stability of composition of raw meal entering the kiln?”

The capacity of our ATOX50 vertical mill is 450t/h. Generally, it makes adjustment once every hour. The thickness of each material layer is about 755mm (packing density of raw meal is 1.50~1.75t/m$^3$), for six layers, it means 4530mm. So it is difficult to keep good aeration status in the storeroom and conduct orderly homogenization as to such thick material layers under the effect of side wind. That is the reason why “a homogenization silo is hard to play the role of homogenization"; after the use of γ-ray analyzer, an adjustment to the mixing proportion of raw meal is made every one minute, and within one hour, 60 layers of materials with thickness of 13mm (very thin) will be formed in the silo; in case of one adjustment every six minutes, the thickness of material layer is only 78mm (very shallow), which facilitates homogenization.

According to a famous industry expert, the periodic fluctuation in composition of raw meal is the result of superposition of sine waves in various frequencies and amplitudes, and it can be developed according to the Fourier series in periodic function. He also points out that the homogenization capability can be evaluated through the specific value $\varepsilon$, the ratio of fluctuation amplitude of incoming and outgoing raw meal in a homogenization silo, as follows:

$$\varepsilon = k \, . \, A_1 / A_2$$

$$= k \, . \sqrt{1+V^2} = \kappa \, . \sqrt{1+(2\pi F T_R)^2}$$

Where,

$A_1$、$A_2$ - amplitude of fluctuation for composition of incoming and outgoing materials for a homogenization silo;

$K$ - factor;

$V$ - dimensionless quantity, $V = 2\pi F T_R$ ;

$F$ - fluctuation frequency for composition, i.e. the times of fluctuation centering on target value in a unit time;

$T_R$ - average time when the raw meal stays in the silo.

The formula determines the relationship among homogenization capability, fluctuation frequency and dwell time. From the formula, under the same condition of pneumatic mixing, if the frequency of fluctuation in composition of raw meal entering the kiln is very big, or the dwell time of raw meal in the silo is very long, the homogenization effect is better. Obviously, the extension of dwell time of raw meal in the silo requires enlarging the effective volume of the silo, thus increasing capital investment, which is unwelcome; therefore, controlling and improving the frequency of composition fluctuation of raw meal is the most economically effective way, which we have achieved.

After γ-ray analyzer was put into operation, aeration by silo-bottom discharging and plenum box, central mixing room and agitating bin has been weakened. Now our company has shut down a Roots blower, but the homogeneity of raw meal got improved.

At present, raw mill has few mechanical faults, and its operation rate is close to that of kiln system; if the capacity of raw meal is big but has a very low operation rate, it will surely lead to a thick layer of "return ash", which quite differs from raw meal in terms of chemical composition. Such situation is bad for calcination. But considering the issue of avoiding peak time and operating at lean period in our country in terms of power consumption, we did not further reduce the volume of the silo.

4. Technological and economic analysis of new scheme

4.1 Technological effect

4.1.1 Homogeneity of chemical composition of raw meal

After γ-ray analyzer was installed in the raw meal preparation system of our company, it passed instrumentation static analysis repeatability, static analysis precision, dynamic analysis precision and the assessment on raw meal quality control system (software) in a short time, and the standard deviation of outgoing raw meal in terms of three rates reached the requirements: $S_{KH}$=0.01, $S_{SM}$=0.07, $S_{AM}$=0.04 (for more information, see 2007 China Cement Phase * Acceptance Report), and it surpassed the three-rate control standard ($S_{KH}$≤0.02、$S_{SM}$≤0.1、$S_{AM}$≤0.1) issued by cement industry. The expected target set by Thermo Electron Corporation was attained and feedstock supply was guaranteed for stable production.

4.1.2 Physical properties of clinker

Currently, the production for rotary kiln is stabilized at 5700~6000t/d with service rate of 95%, and the quality of clinker has also improved.

Change in clinker quality before and after using γ-ray analyzer Table 13

<table>
<tr><th colspan="2" rowspan="2">Item</th><th rowspan="2">Water consumption for standard consistence (%)</th><th colspan="2">Setting time (min)</th><th colspan="3">Folding strength (MPa)</th><th colspan="3">Compression strength (MPa)</th></tr>
<tr><th>Initial setting</th><th>Final setting</th><th>1 day</th><th>3 days</th><th>28 days</th><th>1 day</th><th>3 days</th><th>28 days</th></tr>
<tr><td rowspan="2">Before using γ-ray analyzer</td><td>Average, X</td><td>23.80</td><td rowspan="2">126</td><td rowspan="2">155</td><td>3.8</td><td>6.0</td><td>9.5</td><td>16.3</td><td>32.4</td><td>58.2</td></tr>
<tr><td>Standard deviation ,S</td><td>0.41</td><td>0.30</td><td>0.28</td><td>0.51</td><td>1.40</td><td>2.19</td><td>1.25</td></tr>
<tr><td rowspan="2">After using γ-ray analyzer</td><td>Average, X</td><td>23.60</td><td rowspan="2">127</td><td rowspan="2">180</td><td>3.9</td><td>6.5</td><td>9.9</td><td>16.8</td><td>34.2</td><td>61.3</td></tr>
<tr><td>Standard deviation, S</td><td>0.11</td><td>0.28</td><td>0.30</td><td>0.32</td><td>1.01</td><td>1.64</td><td>1.10</td></tr>
</table>

4.2 Economic effect

4.2.1 Reduction in capital investment

Investment comparison between the scheme using γ-ray analyzer and raw meal quality control system and the conventional scheme using pre-homogenization storage yard is shown in Table 14.

Investment comparison between the scheme using γ-ray analyzer and the conventional scheme using pre-homogenization storage yard Table 14

<table>
<tr><th rowspan="2">No.</th><th colspan="2">γ-ray analyzer scheme</th><th colspan="3">Conventional scheme using pre-homogenization storage yard</th></tr>
<tr><th>Item</th><th>Fund (ten thousand yuan)</th><th>Item</th><th>Fund (ten thousand yuan)</th><th>Remarks</th></tr>
<tr><td>1</td><td>2-φ18×42m limestone silo</td><td>2×290=580</td><td>2-φ5m crashing and mixing bin</td><td>2×40=80</td><td>Lumpy materials mixing</td></tr>
<tr><td>2</td><td>γ-ray analyzer</td><td>400</td><td>φ80m round pre-homogenization storage yard</td><td>1193</td><td>Price of Liyang Plant completed</td></tr>
<tr><td>3</td><td></td><td></td><td>pre-homogenization storage yard, covering an area of 30 mu</td><td>30</td><td>Ordinary land price</td></tr>
<tr><td>4</td><td></td><td></td><td>φ10m mixing limestone silo</td><td>70</td><td>Batching station storeroom</td></tr>
<tr><td>5</td><td></td><td></td><td>φ5m high-lime correction silo</td><td>40</td><td>Batching station storeroom</td></tr>
<tr><td>6</td><td></td><td></td><td>X- fluorescent analyzer</td><td>80</td><td></td></tr>
<tr><td>Total</td><td></td><td>980</td><td></td><td>1493</td><td></td></tr>
<tr><td>Remarks</td><td colspan="2">Including the purchase of γ-ray analyzer, radiation source, quality control system (software), expenses arising from application for relevant import and export rights both home and abroad, instrument transportation, customs exit and entry inspection, environmental acceptance handling fees, 4 million yuan in total.</td><td colspan="2">Excluding expenditures on capital investment on sampling station required for pre-mixing, equipment purchase, hardware and software for mixing material control via γ-ray analyzer and relevant handling fees.</td><td></td></tr>
</table>

### 4.2.2 Reduction of Operating Expenses

The total installed capacity of stacker machine in pre-homogenization storage yard is approximately 300KW. If it is calculated on operating rate of 0.5 and 320 working days within one year, then the reduction in power consumption is:

$Q_d$=0.5×300×24×320=1152000KWh;

If one 45KW Roots blower is reduced in the raw meal homogenization silo, then electricity saving is:

$Q_L$=45×24×320=345600KWh ;

Total electricity saving:

$Q_Z$=1152000＋345600=1497600KWh.

Based on Guangdong's average electricity fee of 0.7 yuan/KWh, annual reduction in operating expenses is:

RMB=0.7×1497600=1048320 yuan

The reduction in operating expenses is related to the scale of an enterprise. The bigger the scale is, the bigger reduction in operating expenses there is.

## 5. Outlook

The application of γ-ray analyzer and raw meal quality control system (software) ensures that the homogeneity of ground raw meal meet the requirements before being fed in the kiln. This "all in one step" approach simplifies the system control, and is quite suitable for current domestic management mode and thinking pattern. In terms of production technology, it will surely bring about changes in material homogenization and storage methods - "homogenization chain" being now widely used might be weakened or replaced, pre-homogenization storage yard will not play a rather big role in homogenization as before. If there is always a sufficient supply of raw materials, pre-homogenization storage yard, which requires a big floor area and expensive equipment, can be canceled. Therefore, the floor area of and capital investment by an enterprise can be reduced, and power consumption by such a yard is unnecessary as well; before the new application, raw meal homogenization silos tend to operate under tremendous pressure, and few of them have achieved good homogenization effect. After γ-ray analyzer and raw meal quality control system (software) is put to use, such a silo only has buffer function with homogenization function greatly reduced, and the volume and power consumption of the silo can be reduced too. A new concept of raw meal homogenization is yet to be improved; The research on the mechanism and specifications of raw meal silo suitable for this new technology is already on the agenda, and it is likely that a small silo will be adopted or such a link may be eliminated in the future; a new round of technological innovation is already under way, which is an undisputable fact.