WHAT EXPECTATIONS DOES THE CERAMIC INDUSTRY HAVE IN REGARD TO RESEARCH AND DEVELOPEMENT

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When analysing where in the whole field of ceramics to find the crucial points of research and development at colleges and scientific institutes in the last years, we find out that these are definitely in the fields of technical or high-performance ceramics. The aim is to improve the especially strong points of ceramic materials, such as temperature resistence, temper, compressive resistence and corrosion resistence, and put them at the disposal of industry and consumer. Here we want to remind some rather spectacular applications, such as the heat-shield of space-ships, rocketpoints, combustion chamber of engines, abrasion resistant jets, fire-proof auxiliary materials of highest strain and recently even ceramic supra-conductors.

In some extent, the expectations were far excessive and have given place to a more realistic estimation, particularely regarding the economic side.

However, also the traditional ceramics have gained by the new knowledge of those modern developments, and due to the economic meaning, it is anyway sensible to devote oneself to this field.

Also QUALICER addresses itself mainly to manufactureres and customers of the traditional ceramics. Therefore the following performances will especially regard dish-ceramics and sanitary ceramics and especially ceramic tiles.

The market for the traditional ceramics and particularly the construction ceramics is today a very discussed item, and the customer has especially in Europe a wide offer of national and international production, being thus able to make heavy demands on technical and esthetical quality as well as on the price. If a manufacturer wants to keep being able to compete and be economically successful, he has to keep pace with the partly revolutionary technical development, to modernize the factories and look for possibilities to improve every step of the manufacturing process. This starts with the raw material and does not end with the finished product, but as an integral system of quality-protection it has to cover production, logistics and customer service.

In the following we show where to find starting points for more works of research and development and to set up a modern system of quality-protection.

1.- RAW MATERIALS

In general we can say that due to rationalization of processes and the transition towards energy-saving combustion procedures the factors of staff costs and energy costs have been proportionally reduced, while material and capital costs have been increased. The ceramic raw material is thus changing from a commodity into a more and more valuable starting product being made increasingly high demands. Therefore some examples:

The high degree of **whiteness** of a raw material is becoming decisive for its utility in the industry of dishes. The increasing importance in the production of vitreous china of bone china and the herewith connected "withdrawal" from the traditional china manufacturing with the costly reduction progress makes this field of our industry highly receptive for the degree of whiteness of raw material.

The **capacity of liquefaction** of raw material is being aimed at where we try to influence the direct manufacturing process by high liter-weights, as in the sanitary ceramic industry, or at least the production of compression mass from dizzle towers, as in the tile industry. Costs and speed of the production processes are being decisively determined hereby.

In relation herewith is the search for **liquefaction additives** which influence the rheologic behaviour of ceramic mud in a way that the processing with high liter-weights becomes successful, taking into account the environmental compatibility of the mentioned additives.

One of the most important developments of the last years in the ceramic processing technique was the introduction of a quick combustion, for reasons of energy saving and a rational flow of material. This quick combustion makes high demands to the raw material and its composition. A very important claim to the raw material is a good **combustion behaviour**. Raw material with too high a content of carbon-containing blends have to be eliminated. They lead to the so called "black kernel" and affect in extreme cases the enamel by needle stitches.

A special problem is the claim of maintaining the **green-resistance** of the raw material, being both properties opposite to each other.

Quick combustion makes other demands to the applied enamel. This demand is made to those products which are being made by insight baking. However, this is the mostly used process of today. The enamel has to remain "open" until all the waste products have degassed; on the other hand the enamel has to react quickly in order to form a perfectly smooth surface.

The fact that also in the future we will have to work with natural raw material, - that is to say that for reasons of costs we won't be able to work with starting products that are clearly definite and constant in their chemical composition and mineral contents - requires special claims of the **raw material prospection.**

The aimed reduction of raw material and the **homogenization** of different components towards the starting product adecuate for the industry, is a demand to the raw material suppliers. It is clear that these demands have to be carried out at an economically justifiable price.

The following aspects seem to be equally important:

Through scientific research and development it should be possible **to clean** natural raw material by certain chemical and thermical procedures, from iron containing substances or carbon, or on the other hand, to enrich certain components in the raw material, as it is done in the processing of caoline, that is the enrichment of Al203, containing components in clay, which determine a big part of its positive properties.

At the same time we have to consider in the raw material winning that we should use all the substances in some way or another, **to reduce to a maximum waste products**, in order to protect the environment. An "over-qualification" of raw material has to be avoided.

2.- THE TREATMENT

The second field where we are expecting new knowledge is in the field of treatment. First it is necesary to mention **the mill technic** Here we can see a new and important development for the industry, which is the **fine-mill**. Although we are at the very beginning of this development, we already know that through the fine-mill there will be new possibilities with the **ball-mill**. In the processing of **enamel** we get a definite corn-spectrum and related with it, decisive quality-improvements, a reduction of the temperature of reaction, and finally the elimination of negative effects through impurities.

Also in the processing of compression-, **founding-, or pulling masses**, considerable improvements are to be seen with the **fine-mill technique**, for example also with the **ray-mill**. The homogenisation of not homogeneous starting products could be improved, whereby a revolution of the treatment procedures becomes possible.

In the fields where we work with **spray-dried compression masses** we have - being this an actual item - economical problems due to the need of energy for drying. An important reason for the introduction of the spray-drying process in this industry was the homogenization of the different starting materials. One could imagine that through the fine-mill a similarely good homogenization could be obtained. It is known that in Italy some manufacturers have gone back to the "old" form of treatment, which is milling and later moistening of the dry power. In order to obtain a good compression corn in the moistening **granulation** of the dry power has to be perfectly solved. We have already several starting points and expect further progressing. However we can't hide that there is still a long way to be gone to obtain a dry-treated compression corn equal to the spray-corn, at least for the field of high-quality products. In case the costs of energy should rise, that new way will become even more interesting.

3.- FORM-GIVING PROCESSES

In the last years there have been considerable improvements regarding machines and processes of the dry **compression technique**, so that it is no longer a problem to fix homogeneously and manipulably tiles of a size of 60 x 90 cm. At the moment, the development advances towards high load pressures - but that is not generally supported. On the one hand a **higher load pressure** brings a more stable product with a larger dimension constance. On the other hand products processed with a high pressure sometimes are more difficult to degas, that is to say, raw material with a high content of carbon doesn't suit for such a procedure.

An **exact steering** of the compression process with its different degasing steps still seems to be important. Also in this field the machine industry has made incredible progresses.

Far longer is the step in the **founding technique**. The **founding-compression procedure** in the fabrication of dishes, but also of sanitary ceramics shows a big step forward. The speed of fabrication, the quality of the manufactured pieces and the avoiding of waste forms mark this process. This field is still developping, and especially research and development of suitable form materials can still bring considerable impulses. Anyway, a revolution of the need of space in the processing for the working staff has already been achieved.

Refering to the process of **plastic shaping**, we have to mention the efforts towards a tension free shaping during the last years, which should be achieved by pressure distribution and mouth-piece design. The progress in this area is also considerable, even though we have to mention that in many cases empirical knowledge regarding pressure- and flow-behaviour of plastic masses have been considered instead of scientifical ones.

4.- TEMPERING AND BAKING

The third large area of the ceramic processing deals with tempering and baking of ceramic products. Here a big progress has been made in the field of traditional ceramics in the last years, towards quick baking. The baking time has been reduced by the factor 10 to 100. In the field of tiles and wall tiles we have reached a stage which seems difficult to improve. The energy consumption has been reduced by 70% to an amount of 500 kcal/kg. Modern kilns promise a value that could be 20% under these figures. The baking is carried out, except for the stationary rolls, where the product is being transported, without any baking auxiliary instruments, and the quality of products has much improved in relation to the constance of baking colour, the product dimensions and the technical properties.

However, three points of this procedures still remain unsolved. Firstly, we can't obtain the traditional **red and orange-red colour-tones** of unenamelled ceramic products. The baking time of the quick baking process is likely to be too short to develop enough ferric trivalent silicates for these colours. Secondly, the procedure is limited to relatively thin tiles and wall-tiles. **The 18 to 20 mm thick tiles**, needed for highly charged floors can't be fabricated in this process due to heating and cooling problems. And thirdly, in the **field of particularly gleaming decorative tiles**, the possibilities existing in the single firing process, are still limited. For all three points, there could be interesting developments.

The fabrication process in the field of **sanitary ceramics** and in the fabrication of dishes, have indoubtedly gained by this **development**. Also in these fields first quick baking processes have been carried out. But there are still many technical steps to be developped. The resistance to temperature changes has to be improved for these processes. Also the automatation of the flow of material is not as easily to solve as in the field of tiles. The weight charge of the relatively heavy sanitary ceramic pieces on a roll requires particular materials. The starting points are offered by the processing of reaction bounded SiC-products.

5.- FULL AUTOMATATION OF THE PROCESSES

Throughout all the processing steps until sorting and packaging, due to the rise of staff costs in the last 30 years, the industry wants to automatize these processes fully. Thereby a new field of research and development is being addressed to, which has been covered up to now, by suppliers of machines and kilns. With the application of **process-calculators and computers** in the last years, this effort has experienced a new dimension. Data processing of the production in the different steps, feed-back and early detection of failures have improved these processes in the industry. However, especially in this sector, there are still many wishes unsatisfied. **Using times of machines of 60% to 70%** seem to be enough, but considering the high capital costs, they are not satisfying.

A more **flexible design of the processing ways** is another aim. The wish for a differentiation of products in such a pretentious market tries to avoid the mass series. However, the desired small series disturb the highly automatized process due to frequently converted equipments. A corresponding demand is therefore a high automatation with **quickly converting equipments**. Several machine manufacturers offer already interesting solutions.

6.- ENERGY USE

Considering the need of energy in ceramics, one should take into account that the simultaneous need of thermal and electrical energy correspond in an almost classical way to the **power-heat-coupling**. Explaining one could say that the power-heat-coupling basically is an installation for the production of electrical energy, where compulsorily big amounts of thermal energy are being produced, which can be used as process energy. In ceramics, spray-tower-installations are offered, and the heat needed to dry the mud is won from a **power-heat-coupling-installation**, and the electrical energy can be used for the production. Such installations work with an effect of 80% to 90%, while classical plants have an effect of 35% to 38%. It is easy to understand that there is a potential

way of saving energy, which concerns for example Villeroy & Boch. A first installation is running since over two years, and a second one very successful, since half a year. The capital backflow times for such investments are three to three and a half years.

7.- PRODUCT PROPERTIES

The last years' improvements concerning technical qualities and decoration possibilities are considerable. However, there are still some restrictions demanding further development in this field:

The problem of **lead enamels** is known to all of us. The question of garbage grinding is in several ways put to the manufacturer. Lead enamel garbage is considered as special garbage.

When pulling down old kiln installations, samples are taken and different kiln areas where throughout many years of processing, lead has been accumulated, are as well considered special garbage. When using dishes, an increased demand for low lead contents can be seen. The newest claims on the US market which also for us is quite important, is a lead content of zero. This means, that we have to regard the production of lead-poor or lead-free enamels, without losing the much appreciated properties of lead enamels. The way of solving this problem in research and development is not yet clear.

Another question, we are concerned about, are the **mechanical properties** of ceramic products. We reach high values in the field of pressure resistance. The pull-traction resistance values are lower and the unyieldingness also called strike-tenacity, of ceramic materials is for this application many times a disadvantage.

New ideas propose a **fibre reinforced** formation of ceramic materials. First results have brought astonishing improvements of properties, However, we have to mention that we have to carry out these processes at justifiable prices. There are still development works to be done regarding the blending of such fibres in ceramic masses.

Product properties where we are only at the beginning of their ceramic development, have also to be mentioned.One problem is the **frost recistance** of ceramic tiles. Apparently the actual test-processes don't correspond enough to the practical needs. More over we know that not only the porosity, that is the capacity of absorbing humidity, in its absolute figures, gives a reasonable indication about the frost resistance. Pore size and distribution play an important roll. We have not succeeded so far, to quantify the results and make a clear statement about whether a product resists many changes of frost-defrost or not. It seems to be that modern processing procedures have rather negative influences regarding frost resistance. The industry expects the development of a suitable test procedure and then products which resist this type of strain.

8.- QUALITY PROTECTION

The increased expectation of product quality requires generally the construction of a **quality-protection-system.** In this connection, the responsibles for production as well as for the laboratory are looking for safe, quick and definite supervision and test methods, beginning with the raw material until the finished product, including the application technique.

By means of **suitable test procedures,** deviations from the norm can early be detected automatically, in the production process, and by feed-back of the informations, corrections can be carried out in time. This is very important as otherwise, with today's high performance installations, big amounts of low-quality goods or rejects are being accumulated.

But also methods that allow definite statements about the expected **behaviour of ceramic materials in the praxis** are very important, as herewith we work against later claims, eventually avoiding high claim costs and a loss of image.

For the factory worker a possibly permanent, regular readyness for action of his high performance production aggregates play an important roll. It should be refined by **self-diagnosis-installations** permitting thus a quick intervention at the right spot.

For research and development there is a large and paying field of action regarding methods and test apparatus.

Besides the mentioned aspects for starting points of **research and development** work serving especially to quality, we have to mention the **basic attitude towards** the expression **"quality"** in a company.

Doubtless, **quality** is today considered a decisive factor in the conscience of our society in private as well as in public life.

In our company the enterprise-clue is being reflected in the following **wording**:

We guide along our customers' wishes.

Of course the conscience of quality has always played an important roll in the company, but the therefrom resulting behaviour came forth rather "on need" and uncoordinatedly. Only in the last time scientific knowledge, the elaboration of methods, the need of protecting complex and dangerous systems, and last but not least the worldwide open competition for the customers' favour have placed into the foreground the expression of quality and everything connected with it.

There is basically one answer in three steps to this challenge:

1. The elaboration of an extensive analysis and realization of all factors connected with the expression of quality.

Only a few words regarding this aspect:

- Quality is defined as extensive usefulness, that is to say, the final aim is the hundred percent fulfilment of the customers' need regarding products and services.

As an example we mention the supply of **overglazed cants of tiles** (especially wall-tiles), allowing a clean and sharp formation of cants and edges in the coating without costly auxiliary constructions and without the extensive cutting of jollies on the spot. The floor-tiler only has to take into account the choice of the required tiles with one or more overglazed cants, from a normal package.

- The efforts and attempts in order to achieve the aims of quality, **pay** (costs/yield-proportion), they are even **essential** in today's economic environment.

2. The elaboration of the different modern methods and adapting to the conditions of each company.

- Knowledge on the different modern methods, adapting them to the conditions of each firm.

- Analysis of the connexions of the different influencing factors for quality, being a useful guidance-instrument DIN ISO 9000 - 9004.

- Basic aiming of the quality requirements by advanced **thinking and prevention**, that means action instead of reaction (control).

3. Choice and introduction of quality-protection-methods in the enterprise.

- Carrying out of the planned way of proceeding in a psycologically perfect form. It is necessary to create in all the company a new, positive attitude towards quality, a venture that requires much time, patience and especially personal efforts of the leading staff.

With the creation of **a quality-protection manual** authorized by the company's management, a basic information for the proceeding in all quality fields is given. The carrying-out depends on the responsibility of the leading staff and is supervised by the **quality-control responsibles** who have a more extensive formation in quality-questions.

Towards the exterior the quality-protection-manual means a base for **certification** of the processes and products by qualified auditors. A corresponding testate provides the client an additional security for all the promised qualities of the product.

In France there are certain attempts in the tiling industry to certify the products and their use properties since 1985. They have resulted in the **NF -UPEC** certification, based upon French and European norms.

This certification which serves as customer's protection, is firstly optional, but for the manufacturer it becomes compulsory from the moment on in which he decides to go through this test. He has then to proof several **quality-protection measurements**:

- The organisation of the production process on all steps regarding quality control.
- The periodical supervision by suitable and official auditors.
- The denomination of all products authorized to have the mark NF - UPEC.
- Bearing of the corresponding supervision costs.

With this certification we obtain:

- Facilities for the product choice of professional and not professional customers, due to the performance certification.
- Comparison of different products for the desired application field.
- Maintenance of the good image and mark-character of the certified products.

In the field of **sanitary ceramics** there is an analogue proceeding of certification for national and international products.

Villeroy & Boch have obtained the **NF - UPEC** certification for all possible products.

On a European level (CEN) the conditions for the technical licence and placing of an **EC-mark** are being elaborated. It will depend on a balanced proportion between required effort and yield.

If in spite of all the foreseen measurements there were a **claim**, the quality-protection-system with its computerized documentation is able to track the way from the customer until production which enables us to obtain an improvement of production conditions as well as a base for an objective, quick and satisfying processing of claims.

9.- ENVIRONMENTAL PROTECTION

Finally a few words regarding the aspect of **environmental protection**: Everything we do in research and development, has to include the aspect **of environmental protection.** We have to count with increasing demands in this connection, which will rise even more in the coming years.

We have to pay special attention to:

- using as few as possible raw material
- recycling of all wastes which we cannot avoid,
- feed-back of small percentages of the recycled, valuable raw material in the processing potential.
- keep down the electrical and thermical energy, required for the process.
- avoid as much as possible "waste", as exhaust gas, sewage and noise, and where they cannot be avoided, we should muffle (the noise), clean (exhaust gas) and feed back into the process (sewage),
- the products we make should be free of environment injuring properties and should be eliminatedat the end of their life-cycle, without affecting the environment.

At the moment the **question of packaging** is being discussed. In Germany we aim towards a solution with very little packing material and the required one should be recyclable:

- The **packing cardboard** is used in the paper industry by means of a collecting system; the therefrom resulting costs are added to the purchasing price.

- **Package foils** are being fabricated only from polyethylene and is also recycled.

- As **paletts only** pool-paletts will be used, furnished with a pledge in order to be given back to the cycle.

The demands of **environmental protection** can be reduced to one sentence: **The product itself and the process that leads to the product, its use and its later garbage grinding should not affect the environment.**

With our ceramic products we have a really good chance to succeed in a future and maybe even more environment-conscious world, in comparison with other comparable products, e.g. plastic.

This special "quality" is almost an obligation for traditional ceramics, as one of the oldest materials used by humans, which we should conserve and underline.

10.- SUMMARY

We provide an outline about the starting points for research and development works in the traditional ceramic industry, by which further progresses for a rational and safe fabrication-process, material and energy-saving procedures and further improvement of the ceramic products can be achieved. Hereby we analyse the different production-steps, beginning with the winning of raw-material, and ending with the packing.

We especially insist on the consideration and security of viewpoints of quality, as well as on the demands of environmental protection.