

## **Personal CV - a written painting:**

When looking back on many years engagement in industrial materials research, I am not far from designing my self as a generalists. Any how, it has been a joy full time.

Being a young geologist being on fieldwork in Greenland and Norway was somewhat romantic. Besides tenting in the summer in the artic nature doing geological and geophysical work, there was also room for being an amateur ornithologist and botanist. Also when jobbing in Godhavn on the Disco Island of Greenland. Here boat and dog sledging was added to mountain roaming, allowing continued interests in geology and geophysics in free time. My interest for metals and their preparation was initiated because I found interest in studying the telluric iron found in many places on Disco.

During my employment at F.L.Smidth & Co my experience in preparation and microscopy was transferred to the examination of industrial minerals and products, and none the less cement clinker.

In the period from 1971 to 1986 I experienced a high degree of freedom in the research team under the leadership of cand.scient.Vagn Johansen, in the fertile period when the company believed in the necessity of research.

After 16 years of employment in the chemical department I found myself searching for a company with a more direct connection to costumers and the market, and I joined Struers A/S, learning here among other things about marketing, production and the art of writing manuals.

Working with material science in my own business has been equal amusing and sometimes exciting. To mention selected subjects there has been development of a glass with fluorescent properties, and a glass produced from melting of ash from sewage slurry and industrial mineral waste (Carbogrit). A surprisingly new subject became composting needed as a pre treatment of slurry when utilised in the Carbogrit production. This was not a subject I imagined to study as a young geologist (Shit happens)

## **The private life.**

I have been happy to bring up 6 children (5 boys and a girl) with two wives. None of have found interest in education in natural sciences: Carpenter, composer, mathematics/datalogy, marketing, smith and technical student. The 4 eldest have settled with family and 7 grand children have until now been born.

I have been much engaged in the Danish Society for Material Technique (DFfM), thus president in 14 years. It has been challenging to prepare seminars and short courses together with engaged members of the committee.

In the Danish Society Fathers for Support of Children and Parents I placed a lot of engagement in 11 years of which 7 as president for the local committee in Copenhagen and later as national president. It was a busy learning time together with clever and engaged free time workers to run this organisation with need for counselling, education courses and official representation in medias, to mention some main issues.

## **Equipment and analysis:**

Consulting 650: dkr/h

Laboratory work: 400 dkr/h

Microscopic Asbestos analysis: 300 Dkr. pcs.

## **Microscopy:**

Polarizing microscopy, reflected light microscopy, sample preparation for Scanning Elektron Microscopy (SEM).

## **Præparation:**

Cutting of metallic and mineralogical samples. Diamond drilling of stone, refractories etc.

Preparation of samples for microscopy – thin section and polished samples.

Crushing (disc mill)

Machine sieving

Drying, pyrolysis and incineration

## **Methods of Testing**

The Micro Wear Test (MWT)

Sand blasting test

Selected chemical analysis.

## **Abrasive wear - Consulting and testing**

The MWT (the micro wear test) has been developed in a period from 1972 to 1980 in F.L.Smith & Co, mainly as a result of own investigations. Further 1989 to 1990 the MWT was put commercial at Struers A/S using the a slightly modified Abrapol 2 model produced by this company.

In 1992 an adequate theory for abrasive wear testing has been developed and a testing equipment (The Labormat) has been constructed in accordance. The details are thoroughly described in the brochure: LABORMAT, Basic Concepts and Machine Design, and also in publications (see also reference list of supplying publications).

The construction is based on a new analysis of the relative movement between two rotating discs pressed against each other at controlled pressure and relative velocity.

By means of the MWT it is possible to compare the abrasive properties of much different materials as f.i. steel, ceramics, rubber, paint, CVD coatings, plasma spray coatings, welding, natural stone, composites etc.

This equipment has been extensively used in testing abrasive wear during the last 15 years. (see list of tested wear parts and abrasive). A large amount of abrasive wear data have been compiled originating from testing of more than 300 wear parts and 40 abrasives. It has been proven that the MWT might be used to predict the wear at full scale conditions, provided the physical conditions are known.

Abrasive wear testing may be required from Fundal Consult for any individual type of material and abrasive, and at customer request tested at conditions approximately equivalent to full scale conditions, including erosive wear (sandblasting).

The MWT is fast and applying as little as 100 g of abrasives and 3x1 cube centimeter of wear parts. A test may be finished within 5 hours when instant control of abrasive properties is needed.

## **The LABORMAT shortly described:**

- The relative velocity may be chosen in the range from 1.0 to 7.5 m/sec.
- The hydraulically controlled pressures may be chosen in the range 20 to 1400 kPa. The pressure range is equivalent to an average apex pressure in the range from 10-1000 MPa when applying the standard fineness.
- The two principal forces (relative speed and pressure) may be resolved to angle of incidence and thus applying the testing results at sandblasting conditions.
- It is equipped with a standard sample holder for 3 standard embedding sizes, 20, 27 and 40 mm.

- A squiggy allows testing with any abrasive slurry in the whole range of parameter settings using about 30 g slurry for each test run
- The duration of testing time is 20 s and any figure is the calculated average of at least 3 runs times 3 samples in the same sample holder.
- The abrasive wear index measured always has a standard deviation less than 10%.

Standard abrasives comprises a mineral series with increasing hardness 300, 600, (1050), 1200, 1800 and 2400 Vickers hardness number) and with standard fineness. Abrasives on request are normally prepared also to standard fineness equal to all particles less than 0,2 mm and with a sieve residue equal to 35% on 0,09 mm.

Documentation on the LABORMAT is available as well as a manual for the MWT.

## **Curriculum vitae**

PhD. from University of Copenhagen 1968 in geology and geophysics.

In 1962 study of geophysics and geology at the University of Bergen, Norway.

Geological field work:

- 1961 Greenland (Kryolitselskabet Øresund A/S)
- 1963 Greenland ((Kryolitselskabet Øresund A/S)
- 1965 Northern Norway (Sydvaranger A/S)
- 1966 Finmark, Northern Norway (Geological Survey of Norway)
- 1967 Finmark, Northern Norway (Geological Survey of Norway)

## **Employment:**

Meteorological Institute of Denmark, Geophysical Observatory, Godhavn, West Greenland 1968-70. The work comprised control, observation and daily calibration of the geophysical equipment ( magnetic, seismic, northern aurora and climate station). Field measurement of the local vertical magnetic intensity in order to prepare change of the observatory site. Geological study of the natural occurring telluric iron in basalt in the west of Godhavn. Established a petrographic laboratory and comprehensive petrographic analysis of iron basalt samples.

## **F.L.Smidth & Co A/S, Chemical Research 1971-86**

Responsible for chemical-mineralogical R&D with emphasis on the method of microscopic, optical as well as electron microscopy. A laboratory for preparation of micro sections was established and conducted. Besides general assistance in characterizing of raw materials for cement clinker production, also varying failure analysis of f.i. refractory materials applied in rotary kilns and preheater cyclones and other problems in connection with cement clinker production was investigated.

A method for characterizing and analysis of plastic clay for production of light weight aggregates (LECA) was succeeded. A sintered product based on fly ash of coal schist tailings named OCASIT was developed. Other large projects were examination of high temperature corrosion, and the ground of the micro wear test (MWT), later to be finished through Struers A/S and at Fundal Consult, was founded. In the Middle East a number of geological field mapping of limestone and adjusting materials for cement production was carried out.

## **Metallographic Department, Struers A/S, 1986-90.**

Engaged as an engineer in development of new products (f.i. a preparation microscope and a micro hardness tester) and specialist in geological, concrete preparation and quantitative microscopy. The concept of micro wear test (MWT) was introduced on the market, and in this context participating on the behalf of Struers in a project supported by Nordisk Industrifond (Nordic Industrial Fund). The other participants were Sandviken Rocktools, Sweden and SINTEF, Norway. In the project period several full scale wear tests were correlated to the MWT on Danish industrial sites.

## **Fundal Consult, 1990. Laboratory for material research.**

The laboratory has been engaged a comprehensive consulting work for Scandinavian mineral industry, and among the most important and consists the application of the MicroWear Test. Asbestos examination and determination has become a frequent task in the laboratory.

**Outstanding investigations in material research:**

- Development and test production of fluorescing glass intended for use in road surfaces (Kroghs A/S)
- Investigation of a process for production of cast magnetite ( Bergsøe Anticorrosion/Borup Jernstøberi)
- Development of a wear resistant coating for F.L.Smidth to be implemented at the LKAB site in Northern Sweden. The MWT test (se below) was applied to temporarily to control that coating of the inside walls of 350 m<sup>2</sup> exhaust pipes.
- Responsible for investigation in a melted glass blasting product (Carbogrit) on the basis of ash from sewage slurry and mineral waste. (RGS90)
- Investigation in full scale industrial composting technique.
- Investigation in a laboratory method for removal of phosphor ions in waste water on the basis of absorption by magnesium hydroxide or anhydrite. The method has been named metasomatose but not yet applied in full scale.
- Appointed in 5 cases at Danish courts as a technical estimator.
- Received Rendan Prisen in 2001 for investigations in environmental improvement and recycling.
- A comprehensive study of the asbestos impoverishing on roofs when exposed to high pressure rinsing of asbestos roofing (Eternit) on single house top (Dansk Byggeri).

**Publications, costumers and materials tested: See the Danish section**