Kennedy-Wunsch Lecture 2016

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Developing processes for commercialisation-successes and roadblocks

24 November 2016.

The annual Kennedy-Wunsch Lecture has been delivered by pioneers, Professor Miles Kennedy, Professors Dick and Mary Earle and by eminent chemical engineers. When I was invited to give this year's lecture, I was surprised and humbled. I wish to thank the board of IChemE (New Zealand) for inviting me. It is an honour and a privilege to deliver this lecture.

Schooling in Ceylon/Sri Lanka

I attended Trinity College, Kandy, Ceylon from 1953 to 1963. In the last four years we studied subjects that were required to enter the engineering faculty of the University of Ceylon. I did not gain entry to the engineering faculty but obtained the consolation of entering the science faculty in 1964. In that year the university postponed the academic year to commence from 1st September in order to synchronise with the U.K. universities.

I filled the extra six months of waiting by accepting a teaching position in a government Central College which was set up to provide good educational facilities to less affluent rural students in the hill country of Ceylon. During this teaching assignment, one of my colleagues suggested I should apply for a Colombo- Plan scholarship in New Zealand which offered engineering. I applied for the scholarship, was interviewed at the Ministry of Education in Colombo and did not hear from the Ministry for six months. Then, while I was at the University of Ceylon, I was informed to leave for New Zealand within 5 days in early February 1965 to follow a course in electrical engineering.

New Zealand (1965 to 1971)

I recollect approaching Wellington airport on a TEAL flight from Sydney, and met by my student officer Don Richardson of the Ministry of Foreign Affairs and my accommodation was at the Peoples Palace, (Salvation Army) Hotel in Cuba St. Don informed me that I had been allocated to the University of Canterbury and accommodation would be at Warwick House. I found that Canterbury also offered chemical engineering. So, with the help of Don, I switched from electrical to chemical engineering. Why chemical engineering? Well I liked chemistry and also my chances of employment in Ceylon was higher. Chemical engineering was not taught at the University of Ceylon.

Arrival in NZ in 1965

Warwick House 1880 - 2011

My intermediate year in 1965 was an introduction to New Zealand. The course was at the old university buildings close to Warwick House. The students in this house were from all parts of New Zealand and many Colombo-Plan students from Asia and Africa. The first professional year was busy, and the "boiler lab test" and report was probably the first insight into practical chemical engineering.

Old Canterbury University buildings

Ilam Mushroom lecture theatre
1950 -2011

Seimon building 1965 - 2011

Chem Eng 1968

The Chemical Engineering Department was headed by Professor Miles Kennedy and had an impressive dedicated team: Tom Hagyard, Roger Keey, Arthur Williamson, Bill Stott, Brian Earl, Maurice Allen, and John Peet. Later John Abrahamson and Ian Gilmour joined as lecturers. The departmental staff had an immense influence on moulding my career. This was the place I learnt the basics and my introduction to process development.

After completing my B.E. I was encouraged to complete the M.E. which was a very enjoyable and interesting course. At the end of this course there was an insurrection and unrest in Sri Lanka and I was offered by both Professor Kennedy and Tom Hagyard to be a research assistant to develop a coal based carbon anode material which could be used at the Tiwai Point Aluminium Smelter which was being built. I was very fortunate to have been supervised by Tom Hagyard who taught me practical research into developing processes. His catchphrase was "the process is there-all you got to do is to find it!" A process was developed by carbonising Stockton No. 2. Coal which had low ash, grinding to a very fine powder and briquetting and calcining to form a carbon material that met the specifications of the imported carbon used to produce anodes.

I returned to Sri Lanka in 1971 and Ian Gilmour completed the project which included the design of a full-scale plant. The Tiwai Point Aluminium Smelter chose not to uses this new process but to stick with importing the "tried and proven" product from overseas.

Sri Lanka (1971 to 1974)

Although I had a contract to serve the government of Sri Lanka, and despite many interviews I was not offered any employment by government departments and state owned enterprises. After being unemployed for nearly three months, I was persuaded by a relative to seek a job with Walker Sons & Company Ltd. (Walkers) which was a large civil, mechanical and electrical engineering company. My interview with" Mr" Alan Hill the works manager was interesting. He looked at me and said "I will show you around". The workshops and offices covered fifty acres including the dry docks

After spending about an hour showing me around we returned to the office and I was asked by Mr Hill what I thought of the place? I replied I have never seen such a large and diverse engineering establishment. At this Mr Hill said, "at least you are honest, I have shown others around who had graduated from U.K. and they all said they had seen larger and better sites-they were lying, you know I am from England". Mr Hill looked like a Sri Lankan after having spent nearly 40 years in the Island! Few days after I commenced work he informed me "oh, I got just the job for you. I want you to visit Lever Brothers and look after their work." So, I went to Levers in Colombo and asked to meet the Engineering Manager. He was terse and informed me that Levers did not give any work to Walkers. I returned to the office and found out our Mr Hill had an altercation with the Managing Director of Levers and Walkers were not welcome at Levers. As a student, Tom Hagyard had mentioned to me, Joe Shantiapillai who was one of the very first Colombo-Plan students and had obtained First Class Honours as well as published a research paper with Tom. So, I asked to see Joe, who was the Commercial Manager at Levers. Joe was very nostalgic about Canterbury University and Tom and he gradually opened the door for me to carry out work for Levers. After about three months Walkers received many orders from Levers including the installation of a distillation plant for essential oils.

I was enjoying and learning at Walkers but I was not engaged in R & D in chemical engineering, which is what I wanted. I decided to apply for jobs in New Zealand.

In mid-1974, I obtained a position of a Chemical Engineer at Meat Industry Research Institute of New Zealand (MIRINZ). The Director was Norman Law who I later found used to work with Tom Hagyard at Booths Chemicals in the UK. MIRINZ Engineering Division had a number of chemical engineers: Doug Haughey (Head of Division), Keith Fleming and John Marlow, all from Canterbury and Brian Edwards from Auckland University and two from U.K. Universities. I found the environment excellent for R & D as other disciplines such as Biochemistry, Microbiology, Chemistry and Electrical Engineering were all at MIRINZ including excellent workshops. My first project was to concentrate animal blood by Ultrafiltration and this was interesting as Professor Miles Kennedy had introduced us to Membrane Processes in 1969 when the pioneers in the US, Loeb and Surirajan had discovered UF and RO membranes. The Dairy Research Institute had already tested many proprietary UF systems for whey and I sought advice from Kevin Marshall and met with Arthur Wilson of the Lactose Company of New Zealand and bought a second hand Dorr-Oliver UF unit for a pilot –plant which was installed at Hellaby, Whangarei. The UF plant concentrated blood to around 30% DS and was dried in the MIRINZ fluidized bed dryer (developed by Doug Haughey) to produce a soluble dried blood powder with an improved amino-acid profile when compared with conventional drying. The system was developed and licenced to Protech Engineering, Auckland (Mark Hirschfeld was the manager-a graduate from Canterbury Chemical Engineering Dept.). Protech installed two more systems in South Australia.

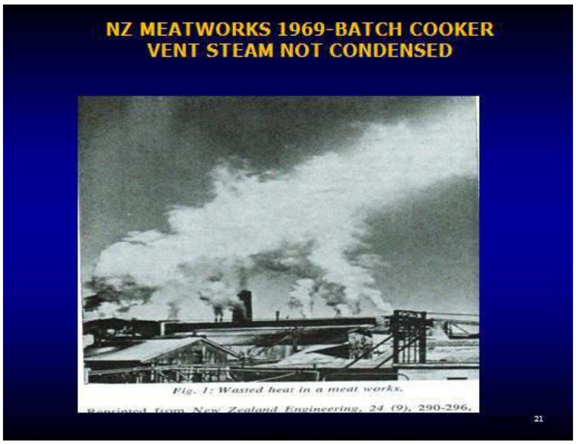
MIRINZ

Rendering of Animal By-Products

Rendering, the process of extracting and refining animal fats is the oldest recycling process practised over 2000 years. The Roman, Pliny the elder made the first written record of rendering when he described a soap made from goat's tallow and wood ashes. In the last 175 years rendering has developed as a global industry. Modern rendering systems are efficient continuous recycling processes that convert waste animal by-products to stable saleable products without harming the environment and ensuring that there is no danger to public or animal health.

Approximately 30% to 45% of the animal is processed in rendering plants. By-products processed in rendering plants contribute significantly to the profitability of meat-processing operations. The rendering process separates the raw material into tallow, meat and bone meal and water, all three are re-usable.

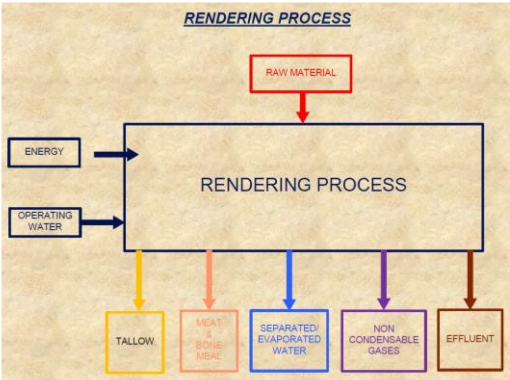
Tallow is used to produce edible fats (margarines) soap and detergents, biodiesel and animal feeds. Meat and Bone Meal which is high in protein (40% to 65%) is used as a feed additive for chicken and pigs. In addition the bone is extracted and gel-bone is produced for producing edible gelatine.



NZ Meatworks 1969

Mixed abattoir raw material

Raw material, bones



Rendering process

Modernizing NZ Rendering Plants

The return from rendering which processed 30% to 45% of the animal was below 10% of the value derived from rest of the carcass. Without rendering, large quantities (typically 50t/day to 300 t/day) pathogenic, putrefying waste material would have to be disposed. Around 1975, New Zealand rendering plants had the following problems:

- Energy intensive
- Production costs –largely unknown
- Poor quality tallow and meat and bone meals
- Salmonella contamination of meat and bone meals
- Odourous, noisy, dirty and unpleasant working environment
- Plants treated as waste treatment plants rather than processing plants producing safe, stable, quality products.

Around 1971-1973 period, MIRINZ had undertaken evaluating the semi-continuous Centrimeal system (phase separation in batch cookers followed by indirect steam heated dryers). This system was developed by Alfa-Laval, Denmark. A pilot plant was evaluated at Horotiu by Jones & Loo (1973). Mass balances were determined on an extensive number of trials with different raw material compositions in terms of water, fat and fat-free solids. Heat transfer correlations were produced and were similar to the research carried out in Australia by CSIRO (Herbert & Norgate, 1971).

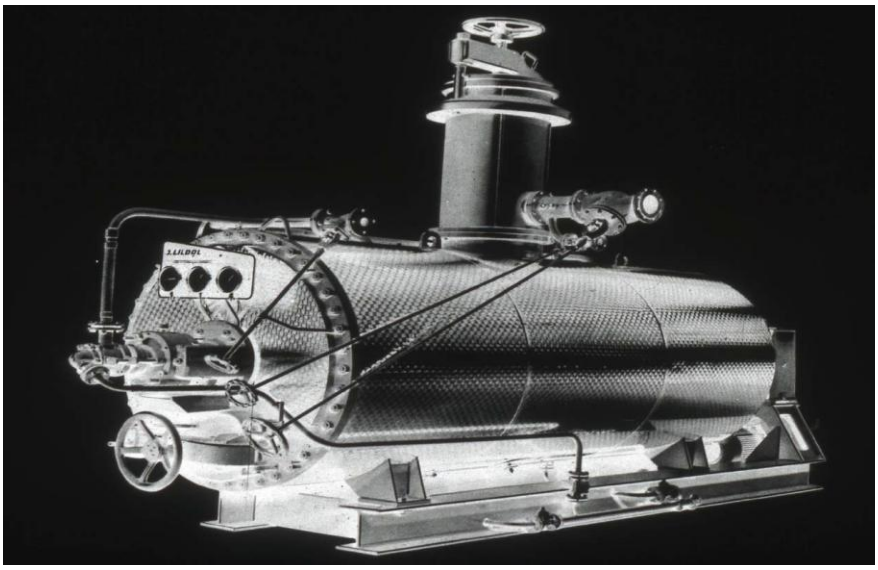
One significant conclusion from the MIRINZ and CSIRO research was that during the rendering process there was a phase inversion from mainly water being the solution to fat becoming the solution for the solute of meat and bone meal (protein). In addition, up to the inversion point heat transfer was proportional to the heat input and condensing of the evaporated water but past the inversion point, heat transfer was diffusion controlled. Thus, it was apparent that the batch and continuous high temperature rendering processes that were prevalent in Australasia were not ideal processes and were not designed based on chemical engineering principles.

Products from Rendering

Products from Rendering

Norman Law, called me one day and gave me a direction: "I want you to survey the different rendering processes in New Zealand and Australia, and on a scientific and cost basis select the best process for New Zealand conditions. Rendering plants should be like dairy factories …" I was given a team of three technicians and an industrial engineer. Our team was supported by analytical chemists and microbiologists.

The objectives of the survey carried out from 1976 to 1979 were to determine: causes of Salmonella contamination and how to sterilize meat and bone meals; effects of processing on product quality; production costs and to select the best rendering process for New Zealand.



Dry batch rendering cooker

We carried out surveys of five rendering plants in meat works: two of these plants used the conventional batch, dry, high temperature rendering process; one had a Keith continuous, dry, high temperature rendering process which was relatively new technology; one was the Centrimeal semi-continuous, wet rendering process (new technology) and the final was a Pfaudler low temperature process operating in Australia (new technology).

Rendered products are introduced into the food chain as tallow, meat and bone meal and blood meal. These are components of feed rations for poultry and pigs. Salmonella is a vegetative organism and is destroyed when subjected to say, 95 Deg C. for 6 minutes. Spore formers such as Clostridia perfringens and Bacillus are heat resistant and thus require are more rigorous time temperature regime such as 121 deg C for 15 minutes .These temperature regimes were applied by a "pressure cook" at the end of the cooking/drying cycle.

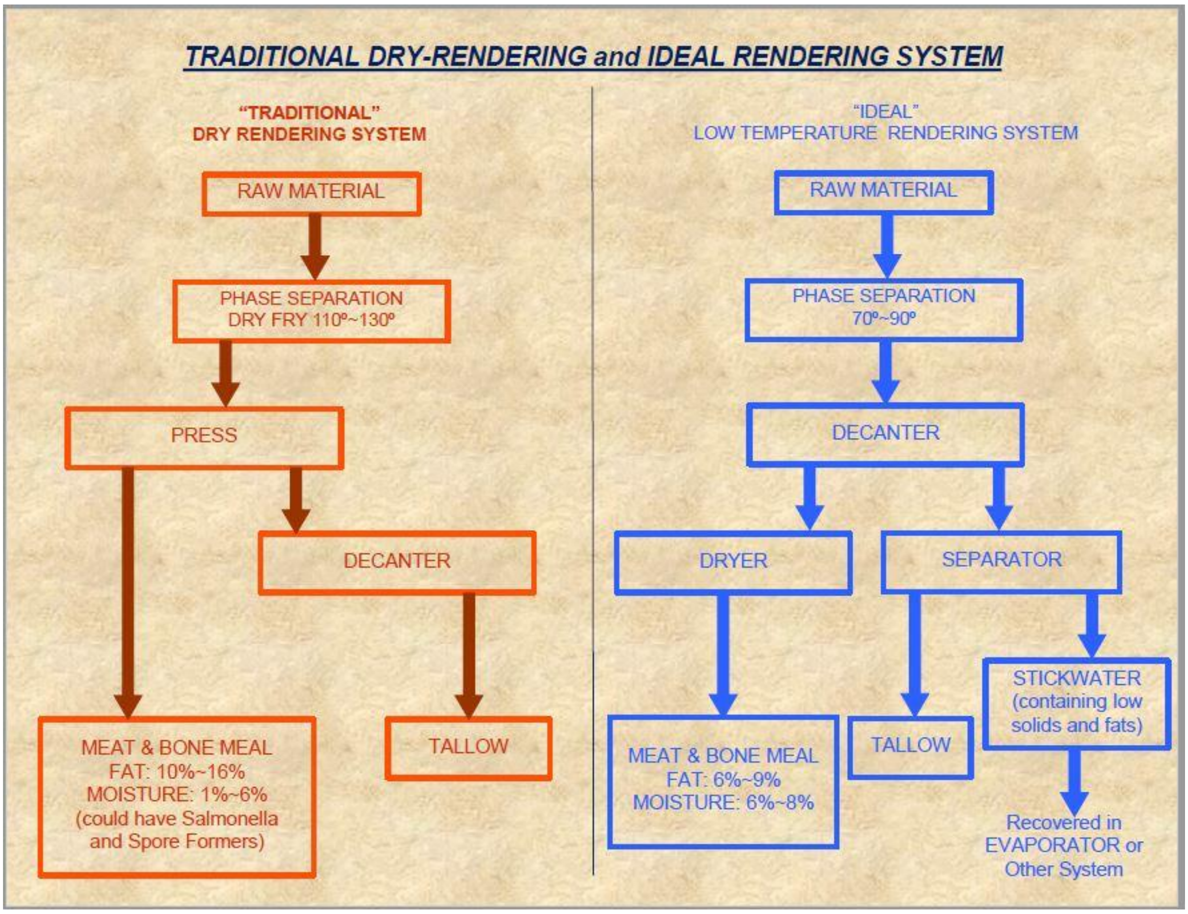
A very important objective of the surveys was to check whether Salmonella and spore formers were present in meat and bone meals. Finished products were sampled for testing. After the first survey, we duly took the samples back to MIRINZ and handed over to our microbiological colleagues. They found that despite the application of a pressure cycle of 3 bar for 20 to 30 minutes, spore formers were present in significant numbers. Initially, the microbiologists thought that there would have been contamination during sampling. To verify this the microbiologists themselves undertook to take samples after ensuring that the sampler was heat sterilized in a Propane flame. The results did not change-spore formers were present. This led to research the cause of the problem and it was found that at the end of the cooking/drying process the moisture content was well below 10% and it was at this stage the prescribed pressure cycle was applied.

The low moisture content hindered the heat transfer to the centre of the product particles and being a lipid rich phase at the end of the process spore formers were protected by the lipids (Gill, Lowry & Fernando, 1978). This work was later verified by the Danish Meat Research Institute. The Pfaudler, Low Temperature process was found to destroy Salmonella and spore formers due to small particle size (15 mm to 20 mm) and the drying of meat of bone meal in a water-rich phase and not a lipid rich phase.

Until the undertaking of the rendering surveys the New Zealand and Overseas market regulations were based on time/temperature within the processing vessel and not that at the centre of the product particle. Particle size was also not defined and as such the regulations had not taken into account the mechanisms of heat and mass transfer. This changed after the publication of the research paper above.

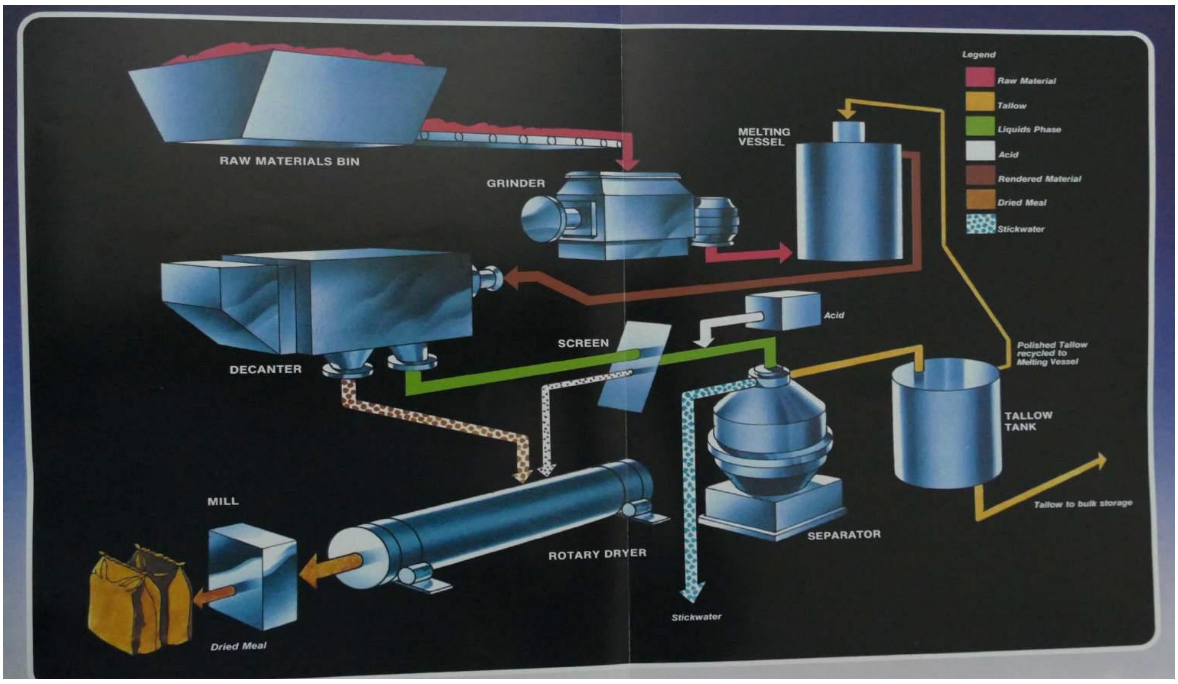
The overall conclusion of the surveys was that none of the systems that existed and surveyed suited New Zealand conditions. Based on achieving high quality products and low operating costs and microbiologically safe products the Pfaudler system showed potential but there were inherent problems- a complicated process for rendering around 95 degrees C. Also, there was high wear in raw material grinders, pumps and conveying equipment. The addition of pressurised direct steam into the rendering vessel produced large quantities of "stick water" which not only reduced yields but also produced high strength effluent.

The next step was MIRINZ developed a low temperature rendering system by overcoming the problems that were encountered in the Pfaudler system. Approval was given for a budget of around $30,000 (equipment only) and the development of the MIRINZ Low Temperature Rendering Plant (MLTR) from bench-scale to pilot-plant scale was completed in one year 1979/1980, (Fernando, 1982)



Comparison of Rendering systems

The rendering vessel was designed as a continuous stirred tank reactor (CSTR) and heating with steam at 5.5 bar was carried out in a coil. The residence time in the Rendering Vessel (RV) was 3 to 6 minutes compared with conventional high temperature processes that required 20 to 40 minutes. Using tallow as a recycle medium ensured that the mixture in the RV was predominantly fat thus reducing the emulsification of water when the speed of agitation was 750 rpm (which gave rapid heat transfer). A residence time of 3 to 4 minutes and controlling the temperature to 95 Deg C, and a raw material particle size of below 15 mm ensured the destruction of Salmonella.



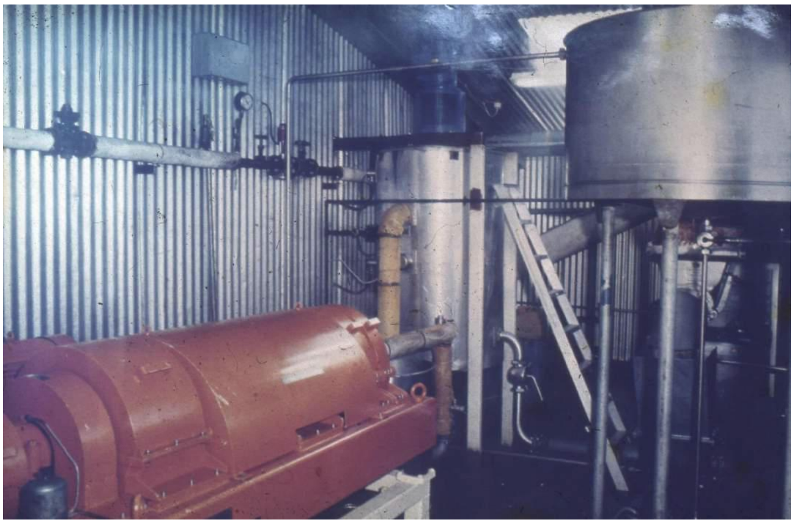
MLTR Flow sheet

Other advantages of the MLTR were: Due to the low temperature, colour from grass and other impurities were not "fixed" in tallow; both tallow and meat and bone meal could be separately sterilized; moisture content of meat and bone meal could be controlled to 6% to 8% specification and not over dried; the process could be designed to produce either edible or inedible products; modular; required less steam; plant had a compact footprint; products were free of Salmonella and spore formers, as effective time temperature regimes were applied in the rendering vessel and also in the dryer.

Transfer of MLTR technology to Industry

The Director of MIRINZ in 1980 was Lester Davey and he and I travelled to Christchurch to address the senior management of Waitaki N.Z. Refrigerating Ltd, to obtain support to transfer the MLTR technology into a meat works. After listening to me extolling the advantages of the MLTR I was asked how much it would cost to install a demonstration MLTR system. My reply was a budget of $250,000 and this was abjectly rejected –they were not prepared to risk money on essentially a system unproven in a meat works situation.

We were disappointed by the decision which we never expected as Waitaki was a proponent of the MLTR development as they had very old rendering plants that required renewal. My Director stated "let us approach Graeme Lowe" who was New Zealand's Businessman of the year 1977 and was instrumental in delicensing the New Zealand Meat Industry in 1980. Very shortly we met with Graeme Lowe at his Pacific Beef Ltd, Hastings. I described the MLTR and Graeme listened without one interruption for nearly 45 minutes. His one and only comment at the end was "sounds good". Nothing happened for another 2 or 3 weeks and then I had a call from Graeme at MIRINZ. He said, "actually I need the MLTR at Pacific, Hastings, but my chief engineer prefers an overseas technology from Alfa-Laval. Never mind, you can install the plant at our Hawera works. My chief engineer at Hawera, Harvey Schultz will contact you for details, I am off overseas for a holiday!" This was excellent news. In two days Harvey Schultz arrived, studied the pilot-plant at MIRINZ, asked a lot of questions and took the drawings of the proposed full-scale equipment and within a few days informed that he had found how to retrofit a 5t/h MLTR into his Batch Dry Rendering plant. With Harvey's enthusiasm and "anything is possible" attitude, we proved the MLTR system on bovine raw material.



Supporter of MLTR MLTR Demonstration plant Hawera 1979

The next challenge was to prove the MLTR on bovine and ovine material and this was achieved due to the support of Owen Paris, Group Engineer of Southland Frozen Meats Ltd and John Agnew Chief Engineer at Mataura. Like at Hawera a 5t/h MLTR was retrofitted to the old Mataura rendering plant. Barry Kidd of Alfa-Laval, New Zealand assisted us and continued to supply the centrifuge packages for many MLTR plants.

In 1981, MIRINZ licensed the MLTR process for Australasia to three reputable engineering companies: IST Consolidated Ltd., MacEwans Machinery Ltd and Protech Engineering Ltd. (Protech) The selection of the licensees was based on the first two companies being active in the rendering industry and offering proprietary equipment and the third had already obtained a licence from MIRINZ to design and market the MIRINZ Fluidized Bed Drying System for blood.

MLTR Brochure

The Manager of Protech's Process Engineering Division, Mark Hirschfeld (from Canterbury) approached me to manage the commercialization of the MLTR for Protech and I accepted in 1983.

From 1981 to 1986, the New Zealand Meat Industry installed either retrofits or new MLTRs at eleven sites. Seven of these were supplied by Protech and two by MacEwans Machinery Ltd and two by IST Consolidated Ltd. Protech also were successful in installing two plants in the UK: a retrofit in Cumbria and a Greenfield plant in Wales.

Introduction to Entrepreneurship

When we were developing the MLTR at MIRINZ, Andrew Taylor a young and enthusiastic engineering technician often asked me whether rendering plants "made money". I said "yes "and he suggested "why don't we build one?" I informed him that we needed raw material. Andrew being a budding entrepreneur, found a small sheep boning operation in Mt. Maunganui that sent their boning waste material to Waikato By-Products in Tuakau. Andrew took me to meet the owners of New Zealand Primary Processors Ltd (NZPPL) who had a sheep processing plant at Mamakau and boning at Mt. Maunganui. Mike Giles who was the Managing Director and his brother Barry Giles (Director) and other shareholders including The Saudi Capital Corp. showed an interest and within a few months we installed a small rendering plant in which Andrew and I were shareholders in a joint venture. So, in 1983, I left MIRINZ, joined Protech and was also an investor in a small rendering plant.

As we could not afford to purchase a continuous steam jacketed dryer designed in Europe we were forced to develop our own continuous direct fired dryer. Andrew and I started the initial trial at my home using a 5 litre empty Fresh-Up can rotating on four ball bearings and using my wife's hair dryer as the heat source!.

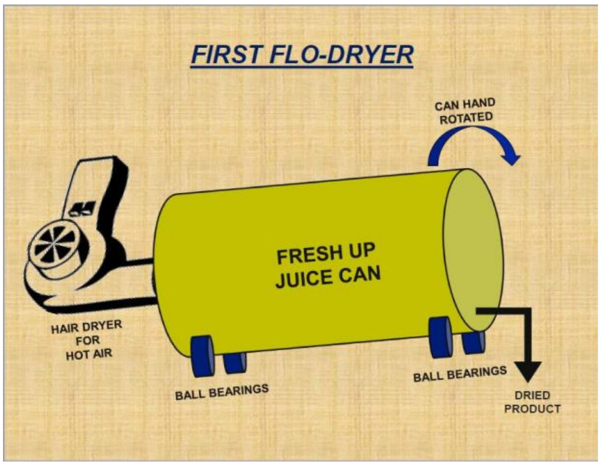


Table Top Model

The data we gathered was sufficient for us to build the very first Flo-Dryer with an evaporation of 250 kg/h in 1983. Direct-fired rotary driers were used in the USA in the Pfaudler rendering process and in low temperature rendering plants producing gel-bone for producing photographic quality gelatine as used by Eastman Kodak. (Presently, there is a growing demand for gel-bone which is required to produce photographic material for medical scans and capsules for medications).

Conventional direct-fired dryers were not energy efficient as a large quantity of air was used to convey the product in the dryer and this resulted in a large heat loss in the exhaust. The large quantity of air increased the non-condensable gases in the dryer exhaust which resulted in the requirement of large heat transfer areas to condense water evaporated in the dryer. In addition, odour control equipment required to treat the non-condensable gases were large in size and thus expensive.

In the Flo-Dryer design, I reduced the conveying air by a factor of two to three and this increased the thermal efficiency and conventional shell and tube condensers could be used to condense and cool the evaporated water and the odourous non-condensable gases could be economically treated in afterburners or biofilters.

Mike Giles and his brother Barry Giles and other Directors of PPL were very supportive to commercialize the Flo-Dryer with Mike coining the word "Flo-Dryer". Mark Hirschfeld inspected the

Flo-Dryer at PPL and agreed to include the Flo-Dryer in the Protech MLTR package. A separate company, Flo-Dry Technology Ltd (FDT) was set up for the manufacture of Flo-Dryers.

Flo-Dry Skid Dryer

The Early Flo-Dryers

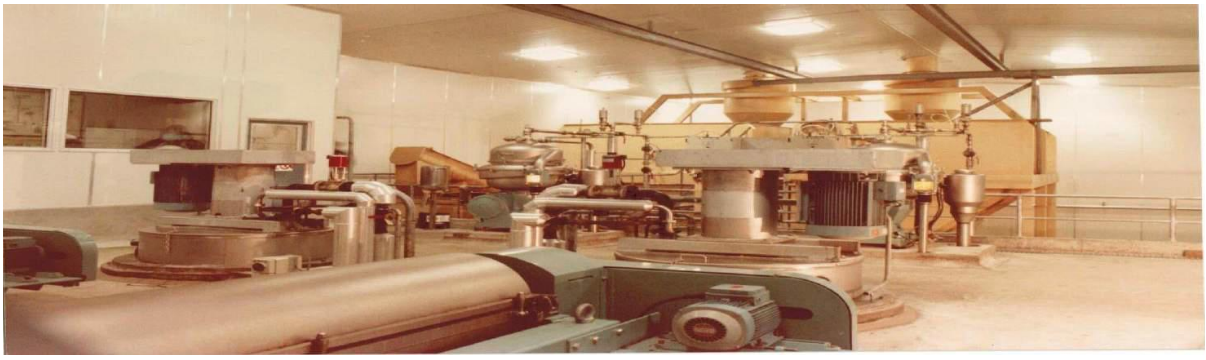
Peter Egan had already converted his Advanced Meats rendering plant to a MLTR. One afternoon he phoned me and said “I want a completely new 5 t/h MLTR for lamb material and I need a price tomorrow!” I had to rush the quote to him and I was summoned for a meeting at his Gisborne office the very next day. He informed me that “time was of essence and we had about 6 months to commission the plant at a greenfield plant in Waipaukarau that he was setting up to produce “ready for oven” lamb roast for Bernard Mathews UK and it had to be operational on the 1st of May 1985. I informed him that to meet the tight schedule, he had to buy the first Flo-Dryer and give me a deposit immediately. He replied, “I will have your guts for garters if you miss the deadline!” and then he threw his cheque book at me and said “write down the amount of the deposit you want”. I returned to Auckland and handed the cheque for around $400,000 to Mark Hirschfeld who was surprised and pleased but reminded me that we needed to have a signed contract soon. Well, we never signed a contract. The plant was built on time and on budget. Peter himself was the project manager, living at the site and assisted by Basil Wakelin of Morrison Cooper.

Peter Egan supporter of MLTR Advanced Meats, Gisborne, Advanced Foods, Waipaukarau (1985) Greenlea Meats, Waikato

Peter was a hard taskmaster but fair and loyal. Even though we did not have a written contract he settled all our claims for additional work – his word was his bond.

Advanced Foods 1985

The Auckland City Abattoir located in Otahuhu was selling their rendering raw material to Auckland By-Products and were interested to install a MLTR with a Flo-Dryer to render bovine, ovine and porcine raw material. The general manager Bob Turnbull, chief engineer Max Jamieson and rendering by-products manager Alan Von Tunzelman were very meticulous in carrying out due diligence and Alan even brought a load of "woolly" hocks and face pieces to check how the wool was handled in the Flo-Dryer at PPL. Protech won the public tender to install the MLTR at ACA in 1985 with a Flo-Dryer.



MLTR Plant 1987

MLTR Plant 1987

MLTR Plant 1987

MLTR Centrifuges

MLTR Plant 1987 - Dryers

MLTR for Edible Products

Around 1984, the New Zealand Meat Board had a huge stock of frozen mutton. Larry Stenswick of Wattie International Ltd had learnt of the MLTR and asked me whether we could build a completely edible MLTR plant to produce edible mutton tallow and quick frozen, defatted high protein meat as a food ingredient for products like dim sim and pizza toppings. This edible plant was designed from scratch and was built in the Meat Hall of Wattie Industries in Gisborne. It was unfortunate that The New Zealand Meat Board, withdrew support for this project once the mutton mountain disappeared. In all probability if the plant operations were continued, "Edible Rendering "would have been a success in New Zealand and waste from boning room material (which by definition is edible) would have added value to the Meat Industry.

Edible MLTR Plant 1986

Adding value to Tallow

Around 1985, the high prices of tallow from $1000/t dropped to the normal market values of around $ 300/t and this immediately put PPL in a loss situation. The only way to turn the venture into a profitable situation was to “add value to inedible tallow” and produce margarine-grade tallow and better still to refine, bleach and deodourise (RBD) tallow for edible purposes such as for frying fish and chips. Through dire necessity, we devised a crude RBD plant by using carbon black to deodourise tallow and sold the RBD tallow at around $1000/t. I can recollect bringing boxes of 25 kg RBD fat, which was branded “Silver Chef” and dropping them off at various fish and chips shops in Auckland.

Joint Venture with AFFCO

Around 1987, Affco purchased NZPPL and thus our joint venture shareholders were replaced by AFFCO. The CEO of AFFCO, Max Toy, appointed Larry Stenswick as the Managing Director of PPL. I had first worked with Larry building the edible rendering plant for Wattie International. Larry was a visionary and he convinced me to leave Protech and open an engineering office in Auckland for Flo-Dry Technology, not only to sell the Flo-Dryers but also to design and build MLTR rendering systems. Also, he visualised the concept of building, operating and transfer (BOT) of MLTR plants similar to what PPL had accomplished: small on-site automated rendering plants and adding value to end-products. We had a strong interest in this concept from the USA, but unfortunately AFFCO was cautious and we could not progress.

The AFFCO board however, accepted Larry’s proposal to replace the very old AFFCO rendering plant at Horotiu with a Greenfield new MLTR plant of 15 t/h producing margarine –grade tallow and inedible tallow which was built by FDT. In 1988, this was a state-of-the- art rendering plant and served as an excellent reference plant in years after for sales of plants in New Zealand, Australia and India.

The edible fats and oils business of PPL grew rapidly thanks to Larry’s visions of having strong branding and paying attention to quality. Frying fats with brand name “Silverchef” followed with “Friday” as a premium frying fat (which is still a market favourite). Very soon, PPL was producing specialized frying fats for McDonalds and KFC and other large potato chips manufacturers. It was apparent that the potential of the RBD oils and fats dwarfed the income from the small rendering operation. We were very fortunate to have employed Mark Caddigan who was a colleague of mine at MIRINZ, as the Managing Director of PPL. Mark was very well versed on the technical aspects of rendering and soon picked up the technology of further processing fats and oils and cultivated excellent business relationships. It is largely due to his excellent ability and hard work that the business grew and today operates as Bakels Edible Oils Ltd (BEOL) with a turnover of $ 150 million and employing 130 people and is the leading edible oils refinery in New Zealand.

Bakels Product

Recently Mark celebrated his 30th anniversary on joining PPL and being the MD of PPL and BEOL. He informed me with a smirk that one senior staff member of MIRINZ castigated him for considering to join PPL which was described as “tin pot outfit started by Fernando & Taylor!

Flo-Dry 1987-1998

Destruction of Spore Formers and Bovine Spongiform Encephalopathy (BSE-Mad Cow Disease)

The Ministry of Agriculture and Fisheries (MAF) required scientific proof that the Flo-Dryer destroyed spore formers. Destruction of spore formers was a necessary requirement to export meat and bone meal to certain markets.

Firstly, the drying process of meat and bone meal in a Flo-Dryer was mathematically modelled by Keey & Langrish (1991). This model was verified by inserting time/temperature indicating sterilizing indicators (used to validate sterilizers in hospitals).

Based on the above results, MAF then issued a set of conditions that validated the Flo-Dryer of producing meat and bone meal free of spore formers. Sterilization parameters for meat and bone meal were defined in terms of: Particle size, fat to protein ratio, inlet temperature and outlet gas temperatures and the humidity inside the dryer. This was the first instance when heat sterilization in rendering operations was specifically defined in terms of the size and composition of the raw material and dryer operating variables.

The Flo-Dry MLTR system produced meat and bone meal which could be separated into gel-bone (used for edible and pharmaceutical soft gel caps) and a high protein meat and bone meal. As the gel-bone was purchased by Nitta Gelatine, Japan it was necessary to prove that the Flo-Dryer exerted the time/temperature regimes prescribed by EU to ensure that the BSE organism if present could be destroyed. Once again we had to seek the assistance of Professor Roger Keey who modelled the drying of gel-bone in a Flo-Dryer. This model validated that the dried gel-bone underwent the time temperature regime required by the EU.

The occurrence of BSE in 1986 in the UK, prevented the sales of further MLTR systems in U.K. and In Europe as meat and bone meal could not be used for animal feed and adding quality to rendered products was not necessary.

Flo-Dry Engineering Ltd (FDE).

In 1990, AFFCO decided to divest in non-core business activities and the AFFCO shares in PPL was sold to Bakels NZ Ltd. The FDT shares were bought by me and my wife and we set up Flo-Dry Engineering Ltd (FDE).

Due to the excellent reference of the Horotiu MLTR plant we quickly received orders from Lake View Farms Ltd, Levin and a large Greenfield plant for Rockdale Beef Ltd, NSW, and Australia through a group of consultants Meateng in Melbourne.

In 1993, we had a potential Australian client, Joe Catalfamo from the Tasman group, who visited and observed the Rockdale plant. He looked at the plant and said "your plant is clean, simple and easy to understand" come to Melbourne tomorrow. Joe ordered a plant for his Melbourne site and stated that he had already paid a deposit for one of our competitor's plant. Joe has been a very good client of FDE and purchased two more plants as well.

We continued to supply the Australian market and a total of ten, FDE MLTR plants were installed and there is at least one installation in each state.

MBL Adelaide, Evaporator 2011

India

One of our equipment suppliers, Weiler & Co; USA, recommended us to Allana Sons Ltd (Allana), India's largest export meat processor who required rendering plants. I duly followed up the inquiry and was informed that Allana headquartered in Mumbai required 6 rendering plants. I was surprised and thought "how can India have a bovine meat industry?"

On further discussions I was convinced that this company which processed buffaloes was a credible client especially when I found that the Allana Group that was operational in India and the Middle East and purchased substantial quantities of sheep meat from PPCS, Dunedin. Allana sent two of their technical managers to discuss the projects and were impressed by the plants we showed in New Zealand and Australia. Later it transpired that Allana had extensively visited rendering plants in Europe and had decided to purchase the Alfa-Laval Centribone rendering system. The Chairman, Irfan Allana was focussed on obtaining the best available technology for his Indian Meat Empire.

Within a few weeks we had another visit from the two technical managers accompanied by Irfan Allana, himself. After the due diligence was done, Allana ordered two plants each of 5t/h capacity and insisted that the total plant including the drives, valves, piping, instruments and electrical MCC etc. had to be supplied from New Zealand and we had to install at their Indian sites using local contractors hired by us. The first two Indian plants were packed in 14 containers and we had to follow extensive documentation required by the Indian Government and 18 months after shipment (containers were held in the port for nearly 6 months) we installed and commissioned both plants successfully. For my staff the exercise was an adventure! Nigel Von Tunzelman was a young engineer and was keen to undertake the role of our site engineer in India. Obviously, neither Nigel nor I were aware of the nature of what laid in front of us. Power cuts were regular. Safety was unheard of. Schedules and urgency were not recognized by the local workers whom we had to hire.

As soon as we completed the first two plants, we received the second order for two more plants and it was evident that Flo-Dry from New Zealand was the preferred supplier. We supplied 9 plants to the Allana group and a further 4 plants to other Indian Meat Processors. Flo-Dry was the leading supplier of rendering plants to India and the Indian Meat Industry.

In 1999, Flo-Dry received an award from New Zealand Trade & Industry for exports to India.




Allana, India, 1995

Allana, India, 1998

Allana, India 2011

Export Award 1998

Japan

After the success in India, we explored the Japanese market that had no Low Temperature Rendering.

Our Japanese agent Hiroshi Nagakawa worked tirelessly and secured the interest of Fuji Kagaku a large family owned rendering in the outskirts of Tokyo which operated an old batch and continuous high temperature rendering systems. Our Japanese client spent nearly a whole year carrying out due diligence on our technology including visiting plants supplied by us in New Zealand and Australia. At every plant they visited they insisted that they themselves be allowed to take samples of products for analyses in Japan. So, finally after many meetings in Japan (and hundreds of servings of cold and hot green teas), we succeeded in obtaining e order for a 30 t/h Flo-Dry MLTR system. This was the largest contract we had ever secured. That day was the 10th of September 2011 (the day before 9/11). On the same day Japan announced the detection of BSE in Japan.

So, after nearly 18 months of negotiations, at least a dozen redesigns of the plant and many visits to Japan, we had to accept that BSE had ruined our business in Japan and 18 months of hard work had come to nothing.

PVL Proteins Ltd

In 1993, the Auckland City Abattoir was privatised and the rendering plant was set up as separate company, PVL Proteins Ltd (PVLP). This was a joint venture between Auckland Meat Processors Ltd and PVL Ltd (Michael and Barry Giles and Tissa Fernando).The joint venture continued until 2005. Alan Von Tunzelman was and is still the General Manager. The original MLTR plant was installed by Protech in 1985. This plant was expanded in capacity and additional processes: Afterburners with heat recovery, DAF and biofilters were installed by Flo-Dry, to meet resource consent requirements. In 2012 PVLP, received a 30 year resource consent. Alan Von Tunzelman has supported the MLTR and the Flo-Dryer based on its performance and assisted me to secure a number of sales in the UK, Australia and India.

PVLP Auckland 1993-2005

Recuperative After Burners PVLP Auckland 1994

The After Burners at PVLP replaced a bio-filter the Auckland Abattoir had originally installed in 1985.This biofilter was the first biofilter to be designed to treat the exhaust gases from a Flo-Dryer. As the cost of operating afterburners were high FDE designed their own biofilters. In this design the effects of pressure drops due to rain were evaluated using the Carmen Kozeny equation. As a result the FDE biofilters were larger in volume. Around 40 FDE biofilters have been installed attached to Flo-Dryers in rendering plants and sludge drying plants as well as treating odour from waste water treatment plants.

WBP Tuakau Biofilter - 1998

Tahuna, Dunedin Biofilter, 2009

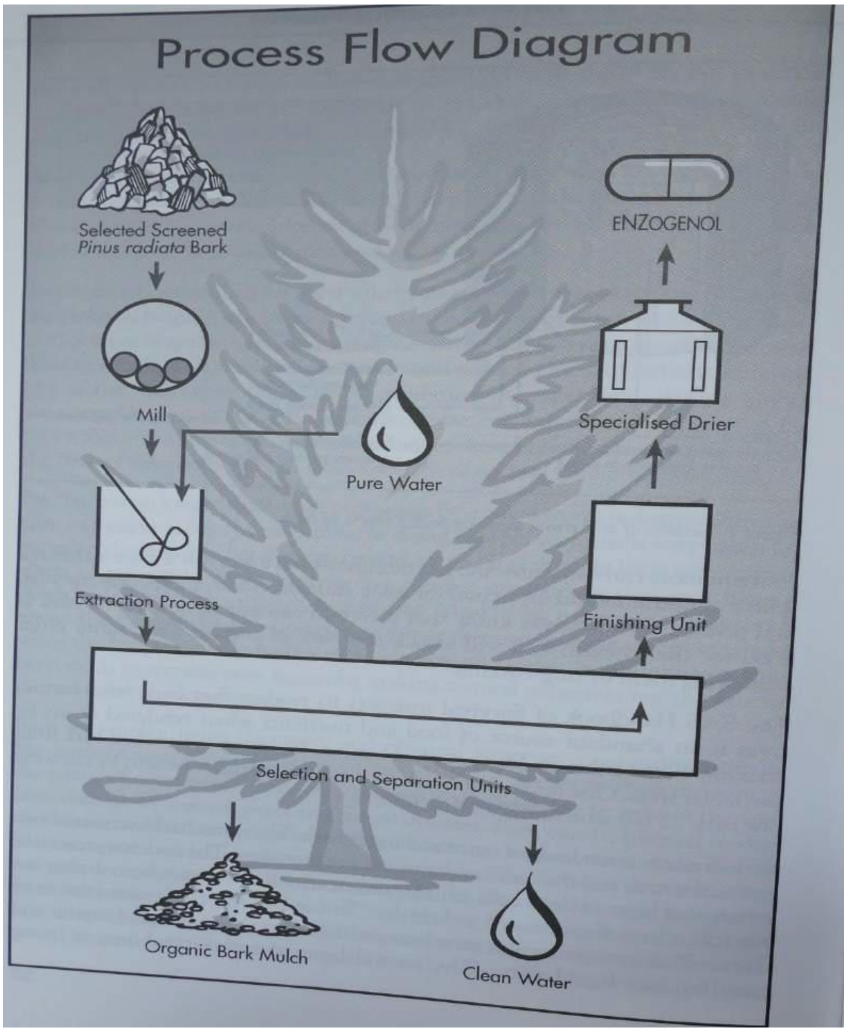
NPDC Sludge Dryer Biofilter 2000

Enzogenol

I suggested to my business partners, Michael and Barry Giles that we should invest in R&D and investigate producing high value chemicals from tallow.

Three of us took a proposal to Professor Brian Earl in 1997, but we found that there was not much interest. After the meeting, I met Ian Gilmour in the lift. I informed Ian that we wanted to invest some money into R&D and he stated that he had an interesting project to extract anti-oxidants from pine bark. We held a meeting with Ian in the Air New Zealand lounge at the Christchurch airport and decided to invest in this interesting project. Very soon we funded Ian to contract a student to extract the anti-oxidants from pine bark and then concentrate by the use of reverse osmosis and freeze dry on a lab-scale. The dried pine bark extract was tested by Dr. Kelly Duncan who conducted a mice trial that proved that the extract was safe and prolonged life (Duncan, 1998)

A commercial plant was established in Auckland in 1999, and the pine bark extract branded "Enzogenol" was produced and marketed by Enzo Nutraceutical Ltd which was headed by Larry Stenswick. In 2005, I sold my shares to my partners and the manufacturing plant was moved to a purpose built new facility in Paeroa where it continues to operate and serves both the domestic and international market.



Process Flow Diagram

Enzogenol

Municipal Sludge Drying

Around 1998, the Wellington City Council sought a design and build solution for the dewatered sewage sludge from Moa Point. Barry Giles who lived in Wellington was contacted by Nova Gas who at that time was extracting landfill gas from the site.

Barry, suggested that FDE could use a Flo-Dryer to dry the sludge. After some pilot-trials in Auckland, FDE bid for the drying of sludge and using the dried sludge as a fertilizer. The other option was composting with green waste which had several inherent problems as was outlined to the Wellington Council, by Paul Lowe, and eminent consultant from the U.K. His concerns and warnings were not heeded by the council, and the composting plant was chosen (shut down after 10 years).

We were disappointed but another door opened and in 1999, the New Plymouth District Council opened a tender for a thermal sludge drying system. FDE won this tender against Andritz of Austria (the leading sludge dryer supplier in the world at that time). This plant was commissioned in 2000 and the dried product “Bio-Boost” was sold as a fertilizer.

In 2001, we installed a plant for Hutt Valley Water the capacity of which was double that of New Plymouth. By 2011, we had installed a total of six plants (three in New Zealand, two in Australia and one in South Korea).

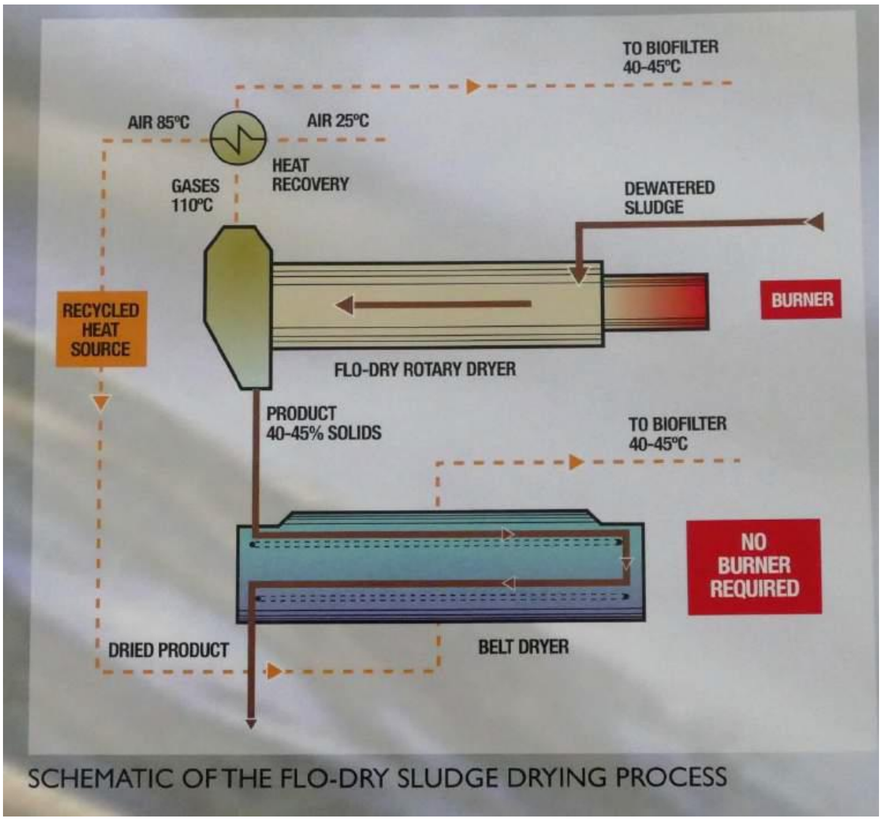
Two Stage Sludge dryer (enersaver2)

Dewatered sewage sludge (biosolids) varies from 12% DS to 35% DS depending on the sludge and dewatering process. For drum drying (direct-fired rotary dryer) it is necessary to add recycle to artificially increase the DS to around 70% to 75% DS before entering the dryer. This requires around 300% to 400% recycle of dried sludge which increases energy consumption, wears out conveying equipment and the dryer and produces dust which could cause explosions. The reason for the recycle is that around 40% to 45% DS, the sludge passes through a plastic “sticky” stage which balls up the sludge and the recycle artificially maintains the DS above the sticky stage.

A typical drying curve of thermal sludge indicates that up to the transition point of approximately 45% DS, heat transfer is controlled by the amount of heat input and well suited for drum drying. After 45% DS, in the plastic stage of sludge, heat transfer is diffusion controlled and belt drying is appropriate.

So, I thought why not have a drum dryer followed by a belt dryer? So, we built an enersaver2 demonstration plant at Watercare Services Ltd, (Watercare) Mangere, and proved the concept. I decided to invest in the demonstration plant as Watercare had a planned budget to install a full-scale sludge dryer. However, just as when we proved the enersaver2, Watercare purchased Puketutu Island to place the biosolids from the Mangere plant.

5 Installations



Flo-Dry Enersaver2

Demonstration Plant - First Stage Flo-Dryer

Demonstration Plant - Second Stage Belt Dryer

The results of the drying trials proved that there was an energy saving of at least 20% and a granular product without dust was produced which proved to be stable under long term storage without being susceptible to spontaneous combustion. This system was the Flo-Dry enersaver 2 technology.

The technology was selected by the Jinhe Municipal Council, South Korea, and two enersaver2 lines were installed in 2013 and is operating. The energy saving of this plant was 30% when compared with drum drying or belt dryers.

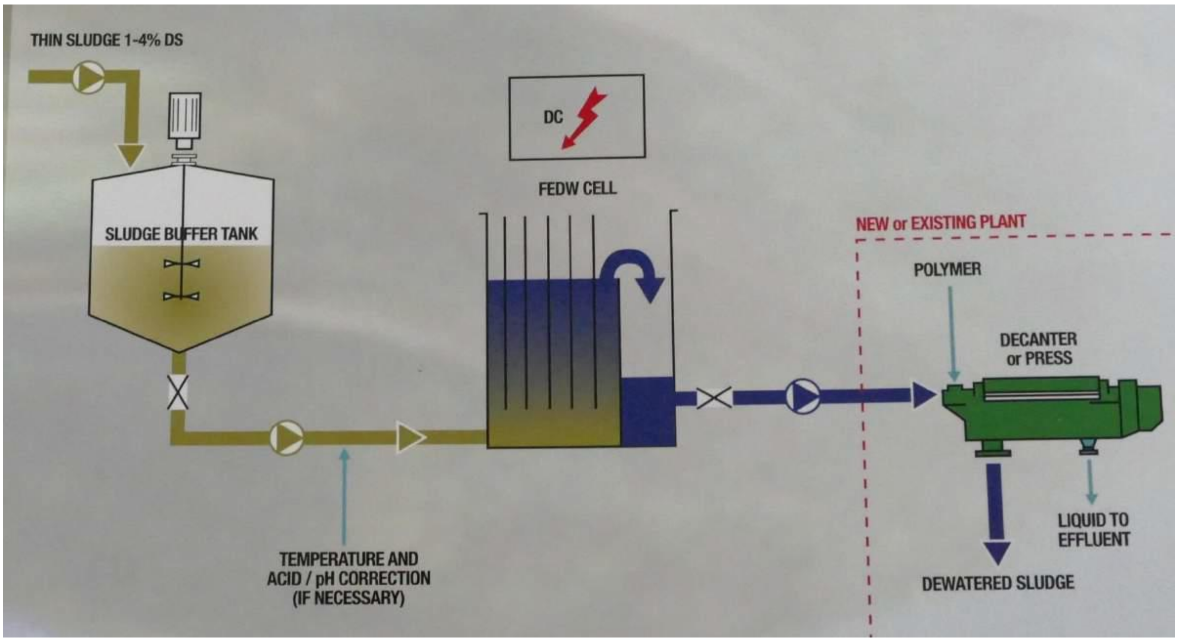
Enersavers2 - Jinhae Municipal Sludge Dryers, South Korea 2013

Electro-dewatering of Sewage Sludge

Dried sewage sludge is used as a fertilizer and also could be used as a fuel such as in cement kilns and thermal power plants. However, net energy (energy in dried sludge less energy required to thermally dry sludge) is usually negative and the sludge drying process is not sustainable. The reason for this is because dewatered sewage sludge has usually, 80% to 85% water that has to be evaporated. If the dewatered sludge that is say 20% DS (dry solids) is dewatered to 30% DS, then the amount of water to be evaporated is reduced, and this reduction could tip the scales for the process to be sustainable.

A novel technology Flo-Dry Electro- Dewatering (FEDW) was developed to condition the thin sludge typically 1%DS to 3%DS and then subjecting to the normal dewatering process of the plant (centrifugal decanting or pressing). The FEDW process enhanced the dewatering of the sludge and reduced the polymer consumption. Typically DS of the dewatered sludge was increased by 20% to 50% and polymer consumption was reduced by 10% to 30%.

Demonstration Plant - Dried Sludge Product



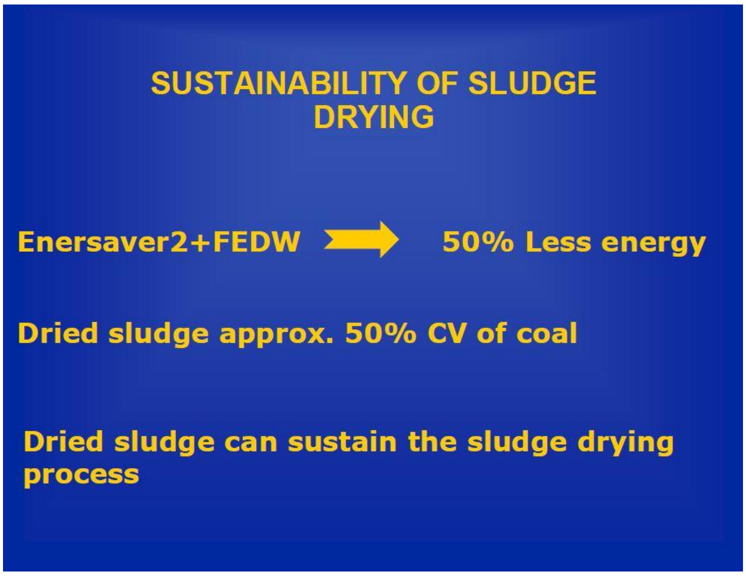
FEDW Module in Sludge Thickening Process

Flo-Dry Electro Dewatering (FEDW)

One FEDW full-scale module was installed in a sewage treatment plant in Korea.

Sustainability of sewage sludge drying

My idea of developing the Enersaver2 and FEDW systems was energy savings were around 50%. This not only reduced the operational costs but also ensured the system was safe of fire and explosion hazards and the process was sustainable and contributed to the reduction of greenhouse gases.



Biodiesel from Tallow

Around 1977, there was an "oil shock" New Zealand motorists had to have one carless day a week. The government set up the Liquid Fuels Trust Board (LFTB) to investigate to convert tallow methyl esters (biodiesel) and the rationale was that at least a portion of the diesel required on farms could be produced from tallow. A report (LFTB, 1983) investigated the feasibility of converting tallow to methyl esters but did not progress as the "oil shock" receded. Around 2005, the subject of converting tallow to biodiesel became prominent as a method to reduce greenhouse gas emissions. The labour government encouraged the production of renewable fuels and we developed the Flo-Dry Reactive Distillation Process in anticipation of the government's impending legislation requiring 5% of diesel fuel to be derived from tallow. The legislation was passed but The National Party won the 2008 election and the biodiesel mandate was quashed. The result was ourselves and four other companies who had invested in in either producing biodiesel or spent substantial sums of money in planning and project development suffered losses.

Our biodiesel process was developed from lab-scale to a 10,000 litre/day demonstration plant. This to my knowledge is the only commercial-scale, oils and fats to biodiesel process using reactive distillation in the world (Fernando, Bhagat & Earl, 2008). I obtained the valuable services of Brian Earl who designed the reactive distillation system and it was a very interesting project. The plant remained as a demonstration plant from 2008 to this year and is now packed in a container to find a use in a country that has mandated biodiesel.

Reactive Distillation Biodiesel Process Biodiesel from Tallow

Team FDE

In 1990, I started FDE with Mike Kurvink a graduate mechanical engineer from Canterbury and he is still working for the company. We employed chemical, mechanical and electrical engineers along with CAD draughtsman and technical officers. Without their professionalism, enthusiasm I could not have achieved the success of developing a number of processes and then commercializing these.

Profits from FDE and shareholdings in rendering companies allowed new processes to be funded internally.

FDE was sold to Haarslev A/S of Denmark in 2011, and the business continues as the Australasian/Oceania branch of a global company.

Flo-Dry Team

Conclusion

As a practising chemical engineer, I have been fortunate to have been associated with the development of eight processes out of which seven were developed to a commercial stage. These processes were installed in New Zealand, Australia, U.K., India and South Korea.

I encountered roadblocks: BSE (Mad Cow Disease) ended the sales of MLTR systems in the U.K. and Japan. The enersaver2 and FEDW developed to make sewage sludge drying sustainable was not supported in New Zealand. The Reactive Distillation Biodiesel technology could not be commercialised due to change in Government policy.

The MLTR technology and the Flo-Dryer, were successful with many installations in New Zealand, Australia, U.K. and India. The acceptance of the technology and establishment of “working plants” in New Zealand was a vital factor that enabled us to secure markets overseas. In addition, the flow-on industries created from the MLTR: Edible fats and oil processing (Bakels Edible Oils Ltd) and Flo-Dry Engineering Ltd resulted from research that was initiated by MIRINZ. Closure of MIRINZ which served our second largest export industry was short sighted.

The most rewarding technology for me personally, was the development of the Enzogenol process. I am convinced that product which I have been taking for the last 18 years has controlled my diabetes-I have been free of any other medication for 21 years.

When I visited Denmark in 1979, on a study tour for MIRINZ, I visited one of the leading spray dryer manufacturers in Denmark. I asked them how many of their spray dryers were in Denmark and they replied “only one, we use our grey matter to export our technologies overseas.” There are about 29 Niro spray dryers in New Zealand. Countries like Denmark and South Korea places a value in the development of new technologies for the export market. They accomplish this by supporting home-grown technologies in the domestic market and if the local technology is as good as the imported technology, the home-grown technology is preferred. In South Korea, opinions of processes are sought from Universities and their endorsements are considered in public tenders. I wish New Zealand also had similar structures to Denmark and South Korea.

Looking back, it was an exciting, enjoyable and rewarding experience over 42 years to put into practice a number of unit operations and chemical engineering principles I studied at University. I found as Dr. Tom Hagyard stated “the process is always there, all we have to do is to find it”.

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Questions and Discussion

John Wright: If there is a global demand for gelatine from bone, does the New Zealand rendering plants produce gel-bone?

Tissa Fernando: Very little, there is only one plant producing presently. There used to be around three plants previously.

John Wright: Why is that?

Tissa Fernando: Management have not correctly analysed the profitability of producing gel-bone and enriching the protein content in meat and bone meals.

Adrian Dickison: Why don't meat processors recognise the potential benefit of gel-bone etc.?

Tissa Fernando: For the last decade or so, there is no centralised R&D agency that would have had the capability of evaluating the potential of gel-bone etc. MIRINZ was the leading meat research organisation in the world and unfortunately accountants shut it down. This was very short sighted. Unlike the Dairy Industry, the Meat Industry has no planned R &D.

Tim Dobbie: Colombo-Plan students have made a significant contribution to both New Zealand and their home countries.