What happened to UAN?

Five years ago the prospects for UAN were promising. A steady increase in demand and supply seemed to be certain, and many large-scale projects were discussed. In 2004 Uhde presented a “Mega UAN Concept” to meet the expected future market demands, making use of the then latest technological developments in the UAN production chain. But have these expectations been fulfilled? And are there any new technical developments which would support large scale production complexes or increase the economic or environmental feasibility? **Axel Erben** of Uhde GmbH reports.

What is UAN?

Urea ammonium nitrate (UAN) solutions are well established liquid fertilizers, particularly in North America, Western Europe and the former Soviet Union. North America is traditionally a market for anhydrous ammonia fertilization, however, transport and storage risks have increased insurance costs. Also, many of the existing UAN production plants are small in size and use an on-site surplus of ammonia and urea for additional production of UAN solutions, and can be expected to be replaced by larger scale facilities, as transport of UAN solutions is safe and fairly simple.

Due to the different nitrogen compounds contained in UAN solution this liquid fertilizer also has certain advantages concerning retarding effects and efficiency of fertilisation.

UAN solutions are typically produced from urea and ammonium nitrate solution plus water. They usually contain a corrosion-inhibiting agent, frequently ammonia but most commonly molybdenum or anionic surfactant containing agents. The UAN solution can then be stored in mild steel equipment. Common UAN solutions on the market contain 28, 30 and 32% N, but typically a 32% N quality is produced, transported and, if required, diluted only at the final destination.

The composition of typically marketed UAN solutions can be defined by two characteristics. The first is the temperature at which a UAN solution of the required nitrogen content will start to crystallise or “salt out”. The lowest salting out temperatures and densities of common solutions are shown in Table 1.

The 32% N solutions start to salt out at 0 to -2°C, a fairly low temperature. When stored in large tanks only partial salting out can be expected even in cold climates and without heating. When required, the salting out temperature can be significantly lowered by just adding water for long-lasting extreme temperature conditions (e.g. in Canada and Russia).

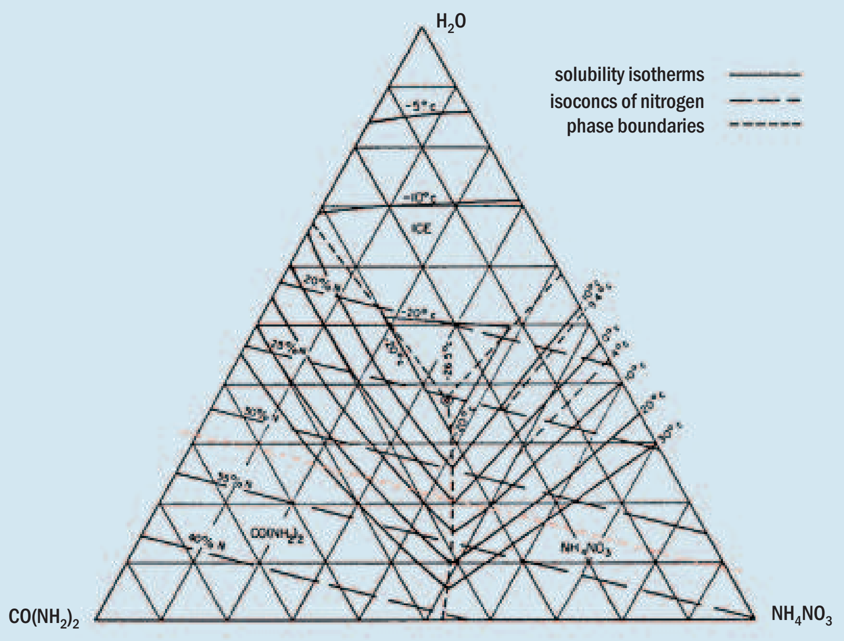
The second characteristic is the balance of the nitrogen sources. The amide nitrogen from the urea accounts for approximately 50% of the total nitrogen content, whereas the other 50% are contributed equally by the nitrate and ammoniacal nitrogen of the ammonium nitrate.

Figure 1 shows a 3-phase diagram for UAN solutions.

Table 1: **Properties of common UAN solutions at lowest salting-out temperatures**

N (wt-%)	Urea (wt-%)	Ammonium nitrate (wt-%)	Salt out temperature °C	Density kg/m³
32	35.4	44.3	-2	1320
30	32.7	44.2	-10	1300
28	30.0	40.1	-18	1280

Fig 1: **3-Phase diagram for UAN solutions**



Due to their characteristics UAN solutions have certain advantages over solid fertilizers:

Application

One of the advantages of nitrogen solutions is that they can be more uniformly applied to the field (mostly via various types of nozzles) than dry fertilizers. The mechanical spreaders normally used in dry fertilizer application tend to result in varying concentrations of nutrient over the field.

Nutrients

UAN solutions contain nitrate, ammoniacal and amide parts (Fig. 2). The nitrate part is readily available to the crop while the ammoniacal and amide parts have to be converted by soil bacteria first. This means UAN has immediate and retarded action components, resulting in a possibly higher N efficiency and added value for the farmer compared to single-acting fertilizers.

An additional advantage of solutions is that both pesticides and herbicides can be incorporated in the liquid solution and applied at the same time. In this way they can be injected into irrigation systems. Also secondary nutrients like sulphur and micronutrients (e.g. boron) may be added to the solution to be simultaneously applied to the field.

Transport and storage

Other advantages of nitrogen solutions include their relative ease of handling (no caking or dust problems) and they can easily be transported via pipelines or in barges or rail cars.

In comparison to granulated urea, UAN solutions have an even higher nutrient density. With a bulk density of approx. 760 kg/m³ and a nitrogen content of 46.2% granulated urea contains about 350 kgN/m³, whereas the figure for UAN-32%N solution is about 420 kgN/m³. Transport volumes are therefore some 20% smaller for the same amount of nitrogen, though the weight percentage of nitrogen in the fertilizer is lower.

The neutral pH (pH 7 or slightly higher) also make UAN solutions suitable for low cost storage, such as pit storage.

Safety

In recent years the safety issues of ammonium nitrate-based fertilizers have been reviewed thoroughly. Especially after the Toulouse accident, the fertilizer market reacted very sensitively with transport and import restrictions on AN. Though some fertilizer grades (e.g. CAN with 26-28% N) have proven to be quite safe, storage and transport of high N-containing AN fertilizers is still under discussion. UAN solutions combine the properties of AN fertilizer with an extremely high degree of safety.

Production and costs

Liquid effluents from a fertilizer complex are often a problem and may cause increased investment and operating costs for treatment steps. In a UAN complex these effluents can be discharged into the UAN solution without affecting the quality or safety of the product.

Additionally the investment and maintenance costs of a UAN mixing plant are much lower than those of a fertilizer granulation plant. Therefore the total investment is also lower than for a comparable solid fertilizer plant.

Demand for UAN plants

The world consumption of fertilizer nutrients is growing by approx. 2-3% per year. In 2004 it was expected that the market for UAN would grow at an even faster annual rate of 3-5% due to the ongoing discussions on AN safety and security issues and the direct use of anhydrous ammonia. In addition the relocation of UAN production to areas with lower gas prices was expected, since the main raw material for UAN production, ammonia, is produced predominantly from natural gas. This means essentially the replacement of small and medium size plants in the vicinity of customers by world-scale facilities close to the major gas fields. The total UAN consumption in 2004 reached approximately 11 million tonnes, for 2007 a production of 18 million tonnes was reported, representing more than 15% annual increase of the UAN market.

UAN technology

A complete UAN complex comprises an ammonia plant, a urea synthesis plant, a nitric acid plant and an ammonium nitrate neutralisation plant with a UAN mixing unit, Fig 2: **UAN nutrient makeup and crop availability**

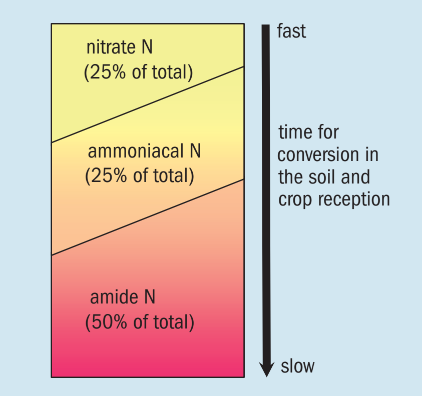
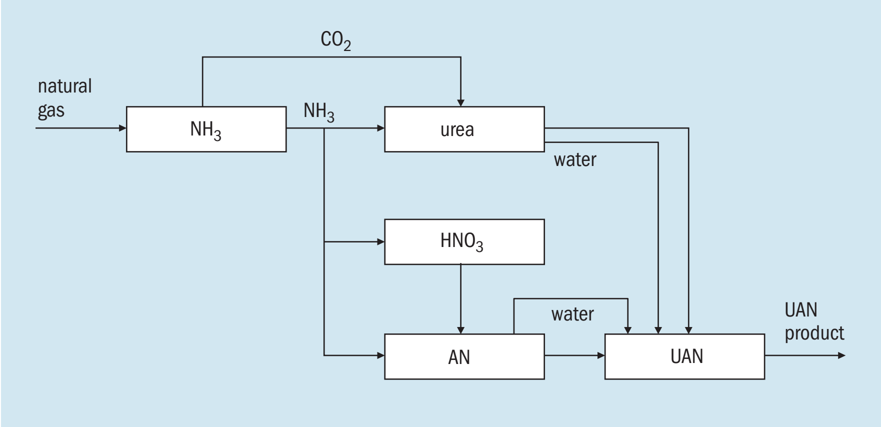


Fig 3: **Stand-alone block flowsheet for UAN production**



all being available from or through Uhde.

Two main flow schemes are realised in UAN production facilities. While the ammonia and the nitric acid technologies are independent of the different flow schemes, there are significant differences in urea and ammonium nitrate neutralisation technologies.

The first scheme (see Fig. 3) shows a stand-alone concept. Ammonia is utilised for urea solution and nitric acid production, with the acid and ammonia being feedstock for the AN neutralisation plant. The UAN is mixed from the urea solution, the ammonium nitrate solution and balance water (i.e. condensates from the AN solution or the urea plant).

For this alternative a total recycle urea technology is employed, which makes maximum use of the ammonia and CO_2 feed resulting in extremely low effluent figures. The ammonium nitrate technology is conventional neutralisation technology, such as the Uhde vacuum neutralisation process. The flow diagram for this process with UAN mixing is shown in Fig. 4.

This flowsheet is advantageous if urea solution is also used for other purposes like a urea granulation or melamine production plant. The ammonium nitrate plant can be of a simple and economical design, without jeopardising safety and environmental requirements. As the Uhde neutralisation generates extremely clean process vapours without any ammonia surplus, the excess condensate from the AN/UAN plant can be fed to the nitric acid absorption tower. Due to the total condensation of the process vapours the plant does not emit gaseous effluents.

The second scheme (see Fig. 5) refers to an integrated concept. While the ammonia and the nitric acid technologies are unchanged, the urea plant employs partial recycle technology. This means that the ammonia-rich dissociation gas after the high pressure synthesis loop of the urea plant is not re-compressed and fed back to the synthesis, but sent to the ammonium nitrate plant where it serves as ammonia feedstock. A typical composition

Fig 4: **Uhde AN neutralisation with UAN mixing**

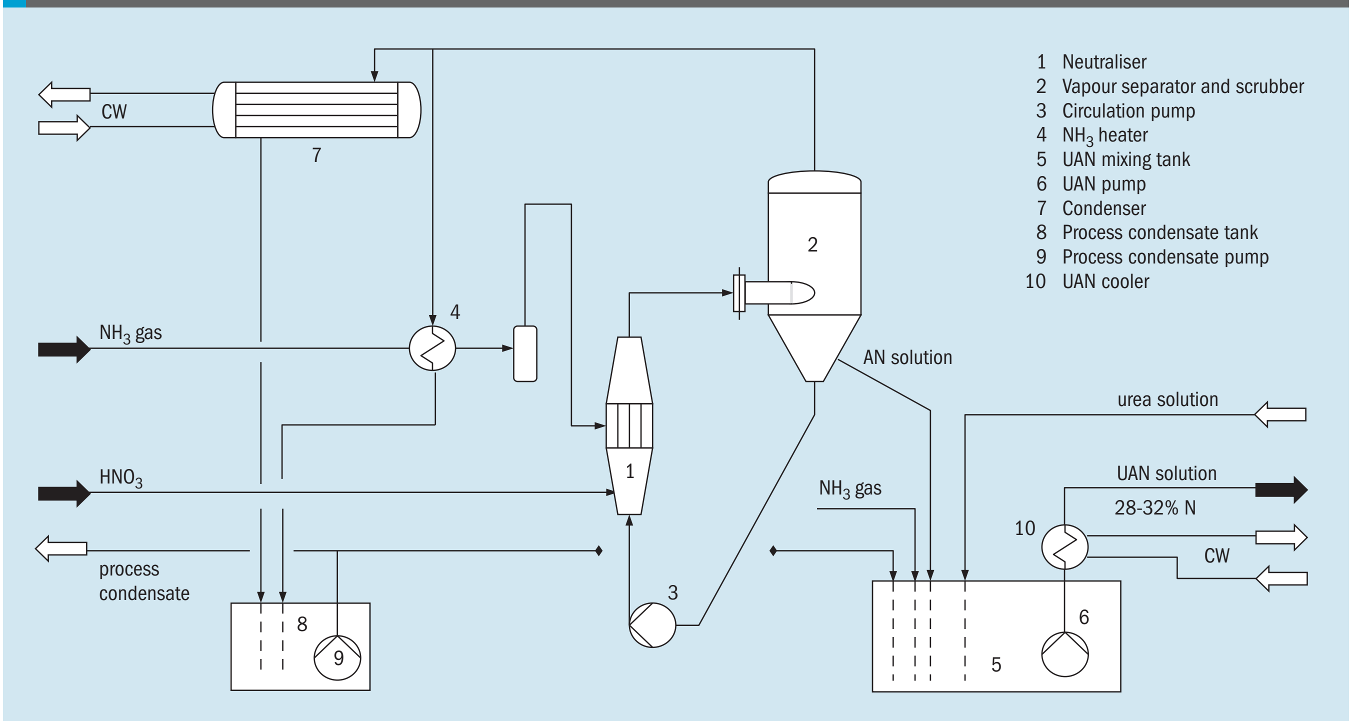
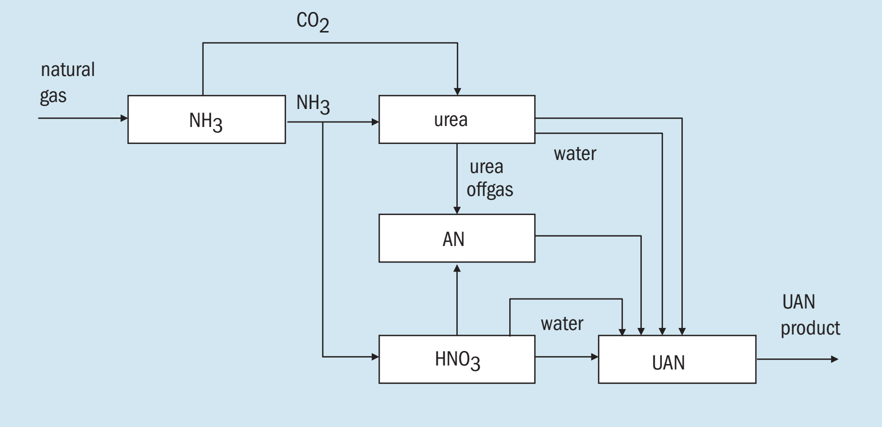


Fig 5: **Integrated flow scheme for UAN production**



of this urea off gas is 40 wt-% NH_3, 40 wt-% CO_2 and 20 wt-% H_2O. Due to the high amount of inert CO_2 the ammonium nitrate technology chosen is a natural circulation neutralisation. The ammonia contained in the off gas is reacted with nitric acid, while the CO_2 is taken off with the resulting process vapours in the vapour separator. The inert CO_2 leads to ammonia entrainment and partial condensation, so that the ammonia gas has to be removed in a scrubber before the CO_2 can be vented (Fig. 6).

Compared to the conventional AN neutralisation plant the urea off gas neutralisation contains more equipment, leading to higher investment costs. However, this is more than compensated by significant savings in the urea synthesis plant, which consists of a minimum amount of high pressure equipment and a low pressure desorber.

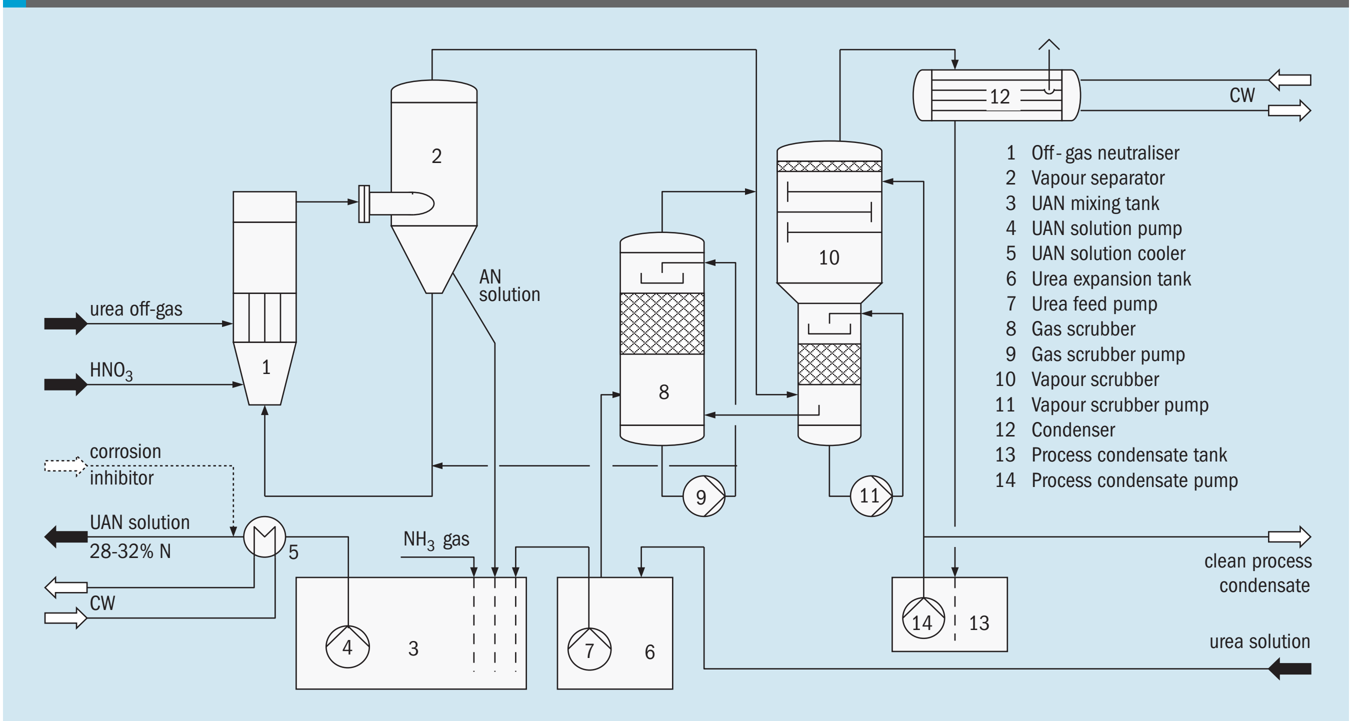
The disadvantage of this integrated concept is the lack of flexibility. The urea and the AN/UAN plants are directly linked, so that the neutralisation has to immediately follow the operational variations of the urea plant. The streams of urea solution and ammonia in the off gas are well balanced, so that an offtake of urea solution for other purposes (e.g. for urea granulation or prilling) is not possible. Figure 7 show a flowsheet for urea synthesis for a partially integrated UAN plant.

UAN projects

Despite the very positive prospects, the steep increase in UAN consumption and several large-scale projects (especially in Trinidad), only a few UAN projects have been realised since then as new, added nitrogen projects. Large UAN capacities were created by re-configuration and revamp projects in existing nitrogen fertilizer plants. Among them are small reconfiguration projects like the UAN plant of Abu Qir Fertilizer Company, Egypt, where existing capacities of urea and ammonium nitrate solution were used to mix UAN solution with a capacity of 1000 t/d of UAN-32. A similar project is ongoing in Ain Sukhna, Egypt, also without generating additional nitrogen output.

The only large-scale project being realised is the MHTL UAN plant in Point Lisas, Trinidad, which is currently under commissioning. The complex consists of an 1,850 t/d ammonia plant (KBR), a 2,080 t/d urea solution plant (TEC), a 180 t/d melamine plant (Eurotecnica), a 1,520 t/d dual-pressure nitric acid plant (Uhde) and a 1,925 t/d AN solution plant, producing 4,300 t/d of UAN-32 as final product. Due to the dual use of the urea solution (for melamine and UAN solution) only conventional technology is applied. This means that the urea plant is a total recycle plant with the ability to receive the off-gas from the melamine plant and that

Fig 6: **Uhde urea off-gas neutralisation with UAN mixing**



the AN/UAN plant is of a standard Uhde vacuum neutralisation design.

Though the UAN capacity of this complex is large, it does not reach the capacities which would be reasonably possible while still employing a single line ammonia plant. With the "Mega UAN Concept" it was investigated what would be the effect of making use of the maximum referenced single-line ammonia technology, which is represented by the Uhde dual-pressure ammonia plant SAFCO IV with 3,300 t/d. The full conversion of this ammonia would result in the production of 8,400 t/d UAN-32, with the nitric acid and the ammonium nitrate plants being of dual-line design (Fig. 8).

In spite of advantages in indexed capital cost such a complex has not yet been projected. The reasons for this are and include limited access to natural gas reserves or lack of interest in venturing from standard granular urea production into a product, which is not such an important commodity. Further, the decrease in trade and production of straight ammonium nitrate due to safety and security concerns has not occurred to the expected extent, with less need for UAN solution as a safe substitute for straight AN.

UAN solution does have its advantages, including at large scale. However, with large granular urea projects continuing to be realised, and large UAN production capacities which have recently been added through re-configuration projects, investment into large integrated complexes is challenging, but definitely presents an interesting alternative to the norm. ■

Fig 7: **Urea synthesis for partially integrated UAN plant with Stamicarbon Urea200Plus™ pool reactor technology**

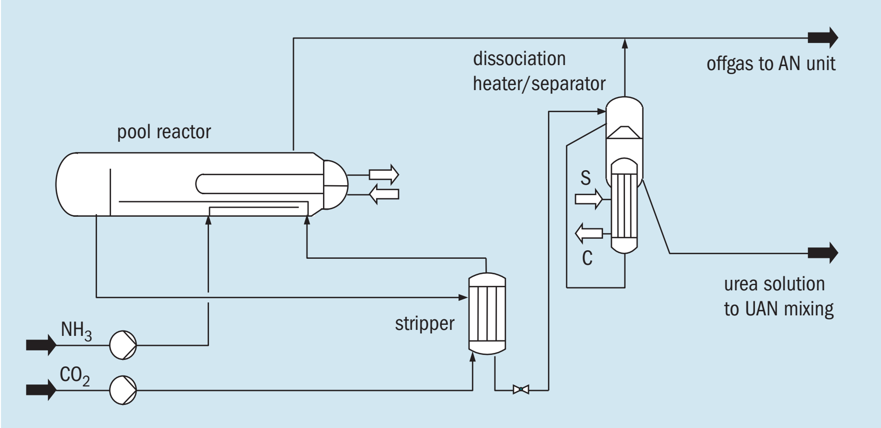


Fig 8: **Indexed capital cost per t/d of plant capacity for various UAN capacities**

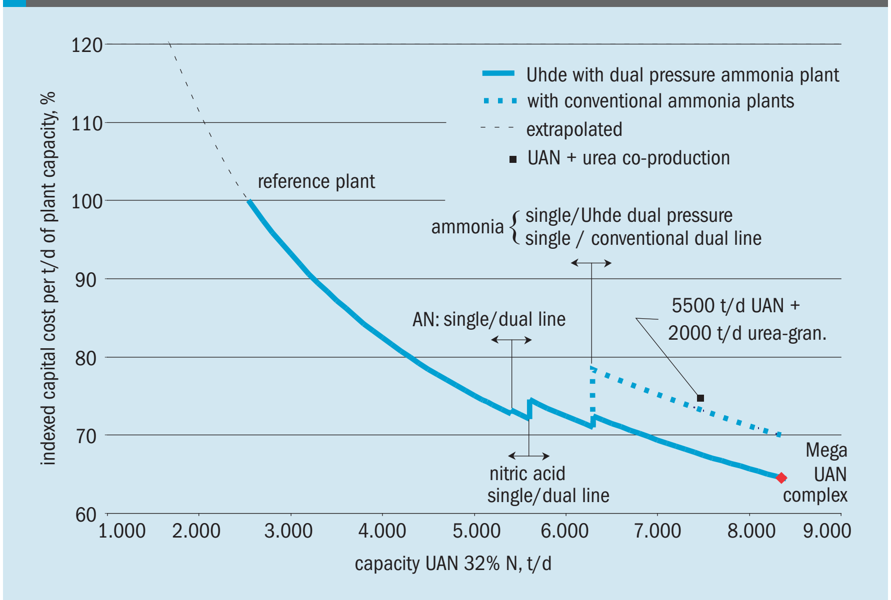


Fig 9: **PDMS model of the nitric acid and UAN plants for MHTL Trinidad**

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