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EXPERIENCE OF THE PROLONGED OPERATION AND MODERNIZATION OF AMMONIA PRODUCTION PLANTS AT "ACRON" JOINT STOCK COMPANY IN NOVGOROD, RUSSIA

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1. Historical background

The factory for the production of mineral fertilizers and products of organic synthesis was constructed in Novgorod in the sixties. The first product - methanol was produced in 1967.

In the seventies, the enterprise expanded rapidly in two directions:

- Ammonia and mineral fertilizers;
- Methanol, acetylene and products of organic synthesis.

Since the middle eighties, with economic and political reforms in Russia, the structure of production varied constantly. In connection with toughening of ecological requirements the production of sulfuric acid and NP were closed. At the beginning of the nineties, for reason of unprofitability, the plants producing acetylene and its derived products were closed. At the same time, the financial investment for increased capacity of ammonia, NPK, urea, ammonium nitrate, methanol and urea -formaldehyde resins and reliability of operation, and for competitiveness in the world and domestic markets were increased.

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[2] Director General

Table 1 - Current Operation

Production	Design capacity 000 t/year	Designers
Ammonia (2 units)	900 (2 units 450 each)	Design: TEC, Japan Process: KELLOGG, USA
Urea	360	Process: GIAP, Dzerzhinsky
Ammonium nitrate	900	Design: GIAP, Moscow
NPK	1100	Technology: Norsk Hydro, Norway Design: TEC, Japan
Nitric acid 1st stage (UKL process - 7-71)	600	Technology: GIAP, Dneprodzerzhinsky, Ukraine
Nitric acid 2nd stage (AK-72 process)	768	Design/Process: GIAP, Moscow
Methanol	1st stage 67.5; subsequent: 135	Revamp of ammonia plant: "Technogas-GIAP", Moscow
Formalin	180	Design: GIAP, Moscow
Urea-formaldehyde resin	80	Designer: GIAP, Moscow
Polyvinylacetate dispersion	10	Process: NPO "Plastpolimer", Russia
Liquid carbonic acid and dry ice	15	Design: Institute "Hyprochlorine", Moscow

A the enterprise of "ACRON" in Novgorod, there are two ammonia production each with design capacity of 1360 tons per day or 450 thousand tons per year at 330 days of operation per year. Both units were constructed under the contract with Toyo Engineering Corporation (TEC) and using the technology of Kellogg. The first unit (TEC-1) was put into operation in 1975, while the second (TEC-2) in 1979. With each unit of ammonia production, there is a isothermic storage tank with a capacity of 10 thousand tons. Between 1986-90, the complex revamping of TEC-1 under TEC was executed. At that time, the goal was to increase output of ammonium by 25% to 1710 tons per day. The decision was adopted at state level. The revamping of TEC-2 was executed not as an integrated one but by serial liquidation of bottlenecks with the incorporation of the most effective technology of Russian and foreign firms. All decisions on revamping TEC-2 were adopted by the management of the joint-stock company "ACRON".

During realization of works on revamping of both the ammonia plants, the experts of "ACRON" have investigated the offers of the world leaders in the field of technology, equipment and catalysts of production of ammonia. A stable business cooperation with the following firms was established:

- "Toyo Engineering" - Japan;
- "Haldor Topsoe" - Denmark;
- "Honeywell" - Russia;
- "ICI" - England;
- "Ammonia Casale" - Switzerland;
- "Yokogawa Electric" - Japan;
- "Manoire"-France;
- "Air Liquide" - France;
- "Hadson" - Italy.

Now both units are in good condition and steadily provide the enterprise with ammonia for processing into mineral fertilizers as well as for export.

2. Brief description of the technological process

Under the initial design, the TEC-1 and TEC-2 units are rather close; they can be presented by one basic flow diagram. The main technological stages are:

- **Compression of natural gas** from 8,0 up to 43,0 kg/cm^2 G by the centrifugal compressor with the drive from the steam turbine.
- **Removal of sulfur compounds from natural gas**, including hydrogenation of sulphuric compounds with cobalt-molybdenum and absorption of hydrogen sulphide by absorbent based on ZnO. Parameters of the process: t = 370-400°C, P = 42 kg/cm^2 G.
- **Steam conversion of methane in the tubular furnace** (primary reformer). Parameters of the process: t = 800°C, P = 34 kg/cm^2 G, ratio H_20:C = 3.5:1.
- **Steam-air conversion of methane** (secondary reformer). Parameters of the process: t = 1100°C, P = 33 kg/cm^2 G.
- **Two-stage conversion of carbon oxide**. High-temperature conversion: t = 370-430°C, P = 33 kg/cm^2 G, low-temperature conversion: t = 200-240°C, P = 31 kg/cm^2 G.
- **Removal of CO_2 from the converted gas** by hot solution of potash, process "CARSOL": t = 70-100°C, P = 28 kg/cm^2 G.
- **Methanation**: t = 70-300-360°C, P = 26 kg/cm^2 G.
- **Compression of the treated synthesis-gas** from 25 till 330 kg/cm^2 G by centrifugal compressor.
- **Synthesis of ammonia**. t = 470-530°C, P = 240-300 kg/cm^2 G.
- **Cooling and storage of ammonia in isothermal tank** T = -33°C, P = 0,02-0,04 kg/cm^2 G.
- **The formation and distribution of steam**: at the ammonia unit steam is produced: P = 100 kg/cm^2 G and 40 kg/cm^2 G, which is used as the drive of steam turbines, and also in technological process. The formation of steam is performed mainly with the help of reaction heat of technological processes, and also from auxiliary and starting boiler.

3. Experience of operation. Statistics on output and energy consumption

The ammonia plants, TEC-1 and TEC-2, practically reached their design capacity - 1360 t/day immediately after commissioning. This was due to the following factors:

- Good design by Toyo Engineering
- High quality of the equipment made in Japan, Italy, Germany and some other countries;

- High quality of installation of the equipment carried out by Novgorod organization "Neftezavodmontazh" under the control of the Japanese experts;
- Good training of technological staff (operators).

In the seventies and partially in the eighties, under planned economy and with the low cost of hydrocarbons, the main requirement for ammonia plants was high volume of the product output. The product sales were guaranteed due to centralized planning. However, even under such conditions, seasonal reduction of production took place such as minimum consumption in winter months.

The problems of revamp of ammonia plants was exclusively under the control of the central bodies (Ministry of Mineral Fertilizers). The currency for purchase of the equipment and spare parts also was distributed by Ministry of Mineral Fertilizers. In view of the lack of currency, a signification portion of the spare parts was manufactured in USSR. In this case, the technology and workmanship of spare parts differed from the original ones, as a rule they were worse. This influenced the reliability of plant operation.

One of the weighty factors reducing the output of ammonia and other products, was restriction on the use of railway transport. Such a restriction was, as a rule, was connected to overloading of the railway for transportation of the harvest.

The total influence of all indicated factors is reflected in statistics of production of ammonia at "ACRON". (Schedule 1°). This schedule is easily divided into three time periods:

1981-1988: A rather stable production at a level of ~ 900 thousand tons per year.
1989-1993: Reduction of production to a level of ~800 thousand tons per year
1994-1998: Rise of production up to ~900 thousand tons per year.

The analysis of this schedule shows the production of ammonia at "ACRON" were affected by external factors:

1989's - Progressive deterioration of economic conditions in USSR
1993's - Establishment of the joint-stock company "ACRON".

Under the new economic conditions, which began to develop at the end of the eighties, and especially after 1991, the problem of cost reduction of production had become priority. The cost reduction in ammonia production had become one of main factors for successful competitiveness among the manufacturers of ammonia and mineral fertilizers in Russia and CIS. The reorientation on the external market has required availability of a reserve of capacity for insurance of losses during emergency stops, which statistically are probable, for the purpose of the unconditional fulfillment of the contracts. Thus, it was determined, that it was necessary to direct efforts of technical divisions regarding the revamp of ammonia plants on the following directions:

- Reduction of energy consumption per 1 ton of ammonia
- Increase of reliability of work of the equipment;
- Increase of capacity of units and expansion of the control range of capacity;
- Solution of a problem concerning the oil content in ammonia;
- Minimization of the expenses for revamping.

Proceeding from the set priorities, the character of the revamping of ammonia plants was determined as shown on the enclosed schedules.

Schedule 2.4: Daily production show the opportunity, guided by statistics, for long term operation of each unit of ammonia at high load. Certainly, such load was confirmed by the saleability of ammonia and nitric fertilizers.

Schedule 3: General consumption of energy show the specific consumption of energy per 1 ton of ammonia (natural gas + electric power), fixed by statistics, for the same periods of time, as in the schedule of daily production. The specific consumption of energy, except the main costs, includes:

- Energy consumption for heating of pipelines and equipment by the stream tracers;
- Energy consumption for the storage of liquid ammonia in isothermal storage tank;
- Energy consumption for demineralization of water for the high pressure boiler (partially).

It is necessary to note, that the share of the electric power in the general energy consumption accounts for less than 0,1 Gcal/t, the rest of the general energy consumption is from natural gas.

4. Experience of modernization

4.1. Technical decisions made within the framework of the whole "ACRON"

4.1.1. The use of the "warm" liquid and gaseous ammonia

All production of ammonia according to the design was stipulated as the cooled liquid product with temperature, -33°C. However, for the purpose of energy saving, the experts of "ACRON" have developed the flexible system of supply of nitric acid and ammonium nitrate production from ammonia with various parameters:

- Cold liquid ammonia
  t = -33°C; P = 19-23 kg/cm^2 G;

- Warm liquid ammonia
  t = 5 to 10°C; P = 18 kg/cm^2 G; 25 t/h max.;

- Gaseous ammonia
  t = 80 to 100°C; P = 11-13 kg/cm^2 G; 25 t/h max.;
  t = 80 to 100°C; P = 5-6 kg/cm^2 G; 25 t/h max.;

The given system functions from the beginning of the eighties.

4.1.2 Use of the argon production plant

This plant extracts argon from the purge gases of ammonia synthesis cycle by deep cooling. The plant is capable of processing ~ 10 thousand nm^3/h of the purge gases and to return to the process of ammonia production ~ 5-6 thousand nm^3/h of the hydrogen fraction, and also ~1 thousand nm^3/h of the methane fraction.

4.2. Technical decisions implemented at the unit TEC-1

4.2.1 Replacement of radiant pipes of the furnace of primary reformer - 1990

The pipes of original delivery were made by "Kobe Steel" of a material KH-40, and had an internal diameter of 72 mm and wall thickness of 16-19 mm. These pipes were used for 15 years. During operation, there were leakages 16 times on weld seams in the heated zone of pipes, that has resulted in one complete emergency stop of the furnace; In other cases, there was an opportunity to continue operation with the help of special measures up to the nearest scheduled stop, or till the emergency stop of the plant for other reasons. The pipes produced by "Kubota" made of the material HP-Nb, internal diameter - 85 mm, wall thickness of pipes - 9-11 mm were re-installed. The increase of volume of the catalyst of the primary reformer was 40%. The measure was included into the project of revamping executed by "Toyo Engineering".

4.2.2 The "lateral" converter of low-temperature conversion of carbon dioxide with volume of loading of the catalyst of 36.5 m^3 was installed. The increase of volume of the catalyst HTK was 50%. It was executed in 1993. The measure was included into the project of revamping executed by "Toyo Engineering".

4.2.3 Revamping of CO_2 removal section - 1995

The reconstruction was made with the use of "Low Heat" technology. In this case, the equipment for boiling of semi-lean solution, ejectors, reflux boiler and other necessary equipment were installed. The measure was included into the project of revamping executed by "Toyo Engineering".

4.2.4. Installation of the "lateral" converter of ammonia synthesis - 1992

Parallel to the existing converter of ammonia synthesis, the additional convertor KOPEPTOP of ammonia synthesis was installed, with heat exchangers for heating of synthesis - gas and boiler water. Volume of the catalyst - 16 m^3, that corresponds to 44% of the volume of the main converter. The measure was included into the project of revamping executed by "Toyo Engineering".

4.2.5 Replacement of steam turbines - drives of the natural gas and air compressors - 1990

It was executed under the project of revamping by "Toyo Engineering" in order to provide for the increased productivity of compressors.

4.2.6 Implementation of the frequency control of the operation of air coolers fans - 1994

It was executed in connection with complete failure of positioners for control of the rotary blades of fans. The current frequency regulators with power of 22 and 37 kw produced by "Telemechanics", France were used. The payback time due to the saving of electric power was than 1 year. **The given work was made parallel on units of ammonia TEC-1 and TEC-2.**

4.2.7 Installation of additional air condensers for steam, ammonia, air coolers for air and gas. Installation of an additional recycle - 1993-1997

According to the project of revamping executed by "Toyo Engineering", on a part of fans for air cooling, the replacement of electric motors with the increase of capacity from 22 up to 30 kw was made. The replacement of one interstep air cooler of the synthesis - gas compressor was made by the additional interstep air cooler of the air compressor. Additional water condensers of ammonia and steam were installed.

Under the project of GIAP, the additional air condenser of ammonia and three sections of air condensers for steam were installed. The additional recycle with capacity of 2000 m^3/h of water was installed. The works allowed the increase in possibilities of the heat exchange equipment by ~ 30% and to ensure the operation of the unit with high loads.

4.2.8 Installation of "dry" gas seals on the centrifugal ammonia compressor - 1995

The installation of "dry" seals on the compressor by "Hitachi-Pignone" was conducted in connection with necessity of large replacement of the worn out pumps, steam turbines and primary devices in the seal oil system of the ammonia compressor. The discharge of ammonia to atmosphere through oil traps has decreased more than by 100 tons per year. The "dry" seals are manufactured by "EG and G SEALOL", USA. The concentration of oil in ammonia had decreased from 2,0 mg/l up to 0,1 mg/l within 1 year and is at the limit of accuracy of a technique for its determination.

4.2.9 Installation of "dry" gas seals on the centrifigal compressor of natural gas - 1996

The installation of "dry" seals on the compressor by "Hitachi-Pignone" was conducted in connection with necessity of large replacement of the worn out pumps, steam turbines and primary devices in the seal oil system of the natural gas compressor. The discharge of the natural gas to atmosphere through oil traps has decreased more than by 100 nm^3/h. The "dry" seals are manufactured by "Grace Engineering", Ukraine.

4.2.10 Complete replacement of coils of the auxiliary boiler - 1995

The given work was conducted in connection with deterioration of the condition of coils of the boiler after a failure in 1993. For replacement, the coils from a unit, unfinished for economic reasons, of ammonia plant AM-76 (USSR-Czechoslovakia) were used. After realization of replacement of coils of the boiler, its efficiency and steam-generating capacity have increased.

4.2.11 Installation of additional coils for steam-gas mixture and process air in convection zone of the furnace of the primary reformer - 1997.

The given work was conducted with the purpose of increasing the surface area of coils for steam-gas mixture and process air. The measure was included into the project of revamping executed by "Toyo Engineering". The surface area of coils for steam-gas mixture has increased by 40%, process air, by 13%, that has allowed to optimize a thermal load in the primary and secondary reformers.

4.2.12 Replacement of the "top" control system of the ammonia plants - 1997

The replacement was made in connection with the large wear of the secondary current devices installed in the central control room of ammonia plant. The distributed control system TDC-3000, produced by "Honeywell" was installed. This work has allowed to reduction up to a minimum the number of false stops for the reason of instruments and to improve the controllability of the process.

4.2.13 Revamping of the process air compressor - 1998

The revamping of the compressor manufactured by "Hitachi" was included in the project of revamping executed by "Toyo Engineering". The revamping was made by replacement of rotors and flowing parts of compressors of high and low pressure. A reducer also was replaced. The realization of the given work has allowed to increase productivity of the air compressor from 52 thousand to 65 thousand nm^3/h and to ensure the operation of the ammonia production at a high load. Excess air from the compressor of process air now is directed to NPK production, where due to its use the electrical compressor of air is stopped.

4.2.14 Replacement of packing in absorbers and regenerators of CO_2 removal systems - 1985-1998

Originally, in CO_2 removal equipment the irregular packing of a saddle "Intalox", made from unburnt ceramics was used. This packing has been appreciably leached by the potash solution. It resulted in caking of packing layers, increase of resistance of devices and deterioration of operation of CO_2 removal system. Silica dissolved in a solution was deposited on cold surfaces of the heat exchange equipment. For replacement of the ceramic packing from 1985, the packing of in the form of Pall rings and Intalox saddles, made of high density polypropylene are used. This packing has a density more than the working solution and preserves the mechanical strength up to the temperature of 140°C.

The replacement of the ceramic packing was made parallel at ammonia plants TEC-1 and TEC-2. Packing is manufactured by the joint-stock company "Uniset", Moscow. In 1997, the bottom layer of CO_2 absorbers instead of the irregular packing as an experiment, the regular packing made by "Peton", Russia, was installed. The operation of CO_2 removal system was appreciably stabilized, especially during the starting period.

4.2.15 Use of effective catalysts

As it is known, the use of good catalysts and their timely replacement are the most effective energy saving measure in production of ammonia. The good operation of catalysts of reformer and of CO conversion at one ammonia plant can give a daily increase in output by 30-60 tons without the additional costs. Therefore "ACRON" tries to use the best catalysts that are being available in the market, despite their high price. The careful technological control of the operation of catalysts is performed with the purpose of achieving peak efficiency and extension of their service life. On the unit TEC-1 the effective modern catalysts are now used.

- High-temperature CO conversion, manufactured by "Haldor Topsoe" - loading in 1995;
- Primary reformer - a shape with 4 apertures, manufactured by "ICI Katalco" - loading in 1998.

In 1999, the following will be loaded:

- The catalyst of secondary reformer, manufactured by "Haldor Topsoe";
- The catalyst of ammonia synthesis, manufactured by "ICI Sinetix".

On the unit TEC-2, the effective modern catalysts are now used:

- High-temperature CO conversion manufactured by "Haldor Topsoe"; loading in 1994;
- Secondary reformer - a shape with 4 apertures, manufactured by "ICI Katalco" - loading in 1998.
- Synthesis of ammonia, manufactured by "Haldor Topsoe"

On the unit TEC-2 in two loadings of catalysts - for the secondary reformer and the low temperature CO conversion, the original loading device of a design of engineer Mr. Klyonov, The Boreskov's Catalysis Institute Novosibirsk is used. This device provides uniform density of loading of the catalyst on the whole area of reactor due to its dispersion with an air jet. The collection of statistics on the work of catalysts is now conducted, which are loaded with the help of the Klyonov's device.

4.3. Technical decisions implemented on the unit TEC-2 - in the chronological order

4.3.1 Replacement of the "top" control system of the ammonia plant - 1990

The replacement is made in connection with the large wear of the secondary current devices installed on the central control room of the ammonia plant. The decision was accepted at the level of Ministry of Mineral Fertilizers. The distributed control system TDC-3000, manufactured by "Honeywell" was among the first four similar systems installed in USSR. This work has allowed to reduce up to a minimum the number of false stops due to failure of the instruments and to improve the controllability of the process, and also to accumulate the experience of work with the distributed control systems.

4.3.2 Installation of "dry" gas seals on the centrifugal ammonia compressor - 1993

This work was conducted in connection with the necessity of the large replacement of the worn out pumps, steam turbines and primary devices in the seal oil system of the ammonia compressor. The discharge of ammonia to atmosphere through oil traps has decreased more than by 100 tons per year. The "dry" seals are manufactured by "EG and G SEALOL", USA. The concentration of oil in the ammonia product has decreased from 2,0 mg/l up to 0,1 mg/l within a year and is at the limit of accuracy of a technique for its determination. This installation of "dry" gas seals was the first one among the technical enterprises of CIS, and on compressors of ammonia of a similar class - the first one in Europe. During implementation of these seals, the unpleasant details of behaviour of demountable cases of the compressor "Hitachi-Pignone" were revealed, and in order to overcome the consequences of it, the engineers of "EG and G SEALOL" and of "ACRON" have developed the special devices and schemes which are now widely used.

4.3.3. Installation of "dry" gas seals on the centrifugal compressor of natural gas - 1995

This work was conducted in connection with necessity of large replacement of the worn out pumps, steam turbines and primary devices in the seal oil system of the natural gas compressor. The discharge of the natural gas to atmosphere through oil traps has decreased more than by 300 nm^3/h. The "dry" seals are manufactured by "Grace Engineering", Ukraine. This installation was the first implementation of "Toyo Engineering". Due to the successful start at "ACRON", and also due to a low cost price, the firm "Toyo Engineering" has won the market in the CIS with this class of "dry" seals.

4.3.4 Installation of radial packing in the ammonia synthesis column - 1994

The work was made under the contract with "Haldor Topsoe", which had won the tender. The replacement of packing in the ammonia synthesis column was performed at the time of replacement of the ammonia synthesis catalyst and replacement of the failed internal heat exchanger of the synthesis column. After start-up and till now the synthesis column works perfectly. Even with a capacity ~ 1500 t/day, the radial packing has a large reserve for the possible load. The analysis of operation of the ammonia plant TEC-1 with two parallel axial columns (volume of the catalyst - 52 m^3) and TEC-2 with one radial column (volume of the catalyst - 39 m^3) show, in case of the same ammonia output the radial column provides the pressure in the synthesis section lower than ~ 20 kg/cm^2.

4.3.5. Replacement of radiant pipes of the furnace of primary reformer - 1997

The pipes of the initial delivery were manufactured by the "Kubota" of a material HK-40, and had an internal diameter of 72 mm and thickness of a wall ~ 19 mm. These pipes were used for 17 years. During operation, there were leakages on weld seams in the non-heated zone of pipes three times and on the border between HK-40 and alloyed steel, once at the bottom collector. The indicated leakages 4 times have caused an emergency stop of the furnace of reformer. The pipes manufactured by "Manoire Industries", France, of the material Manurite XM, internal diameter - 85 mm, thickness of the pipe walls - 9-11 mm are again installed. The increase of volume of the catalyst of the primary reformer is 40%. This consignment of pipes in delivers of the company "Manoire Industries" is the first complete consignment of radiant pipes, 100% of the welded seams of which are executed with the help of an electronic beam.

4.3.6 Installation of additional air condensers for steam, ammonia, air refrigerators for air and gas. Installation of an additional recycle - 1991-1996

Under the project of GIAP the additional air condenser of ammonia and three sections of air condensers for steam were installed. Under the project of the Novgorod division of GIAP, the additional section of the air condenser of ammonia was installed and the complete replacement of interstep coolers of the air compressor was made. This work has allowed to increase the heat exchange surface areas of the indicated equipment by 30-40% and considerably to increase the reliability of their operation.

4.3.7 Revamping of the process air compressor - 1998

The revamping of the compressor by "Hitachi" was made by replacement of the rotors with more effective ones, in a combination with a small modernization of the flowing part of both cases of the compressor. A reducers also was revamped. One of the conditions of fulfillment of revamping was the maintenance of the stable operation of the compressor in a wide range of loads without use of bypass. The revamping was executed by "Turbotech Lodz", Poland. The realization of this work has allowed to increase the productivity of the air compressor from 52 thousand up to 61 thousand nm^3/h and to ensure the operation of the ammonia plant with a high load. The excess air now from the process air compressor is directed to NPK production, where due to its use, the electrical compressor of air was stopped.

4.3.8 Other ways of energy saving

The technical decisions allowing to reduce up to a minimum quantity the amount of purge gases, directed for burning are implemented on both units of ammonia. This has enhanced the status of the know-how of "ACRON".

4.3.9 Reduction of NOx emissions with flue gases

The reformer furnaces of ammonia plants are the main source of NOx emissions to atmosphere. In connection with the rigid attitude of the environmental protection units on both ammonia plants, the systems of homogeneous removal of flue gases ensuring the removal of 60 to 70%. The process was developed by the Gubkin's Institute in Moscow, the design was executed by GIAP, Moscow. In the combination with measures on reduction of burning of the purge and tank gases in the furnace of the primary reformer, the homogeneous removal provides the NOx content in flue gases at a level of 60-80 mg/m^3.

6. Problems and prospects of both ammonia plants

6.1. Problems

- Replacement of the worn out waste heat boilers;
- Repair of steam turbines have erosion of a stator;
- Replacement of "busy" pipelines - at exit from ammonia synthesis column and of steam pipes P = 100 and 40 kg/cm^2 G;
- Replacement of a significant part of positioners and of pipes around the regulating valves;

- Implementation of the new element base TDC-3000 at TEC-2;
- Rejuvenation of the staff of operators.

6.2 Prospects

They include problems and decisions with a greater or smaller degree of readiness:

- Reduction of ratio H_2O:C = 3,2:1;
- Use of activators AKT-1, or LRS-10 for the potash solution;
- Modernization of the convection zone of the reformer furnace in order to decrease the temperature of the existing flue gases;
- Increase of a possible load up to 1600-1650 t/day;
- Modernization of the gas condensate treatment system with its short recycle to reformer process;
- Use of "dry" gas seals in synthesis - gas compressors;
- Joint production of ammonia and methanol TEC-2 due to the use of the existing "lateral" ammonia synthesis column;
- Reduction of energy consumption for production of ammonia up to the level of 8,5-8,7 Gcal/t.

ТЕС -1+ТЕС-2.

График 1.Суммарная выработка аммиака(т/год)

Schedule 1. Total output of ammonia (t/year)

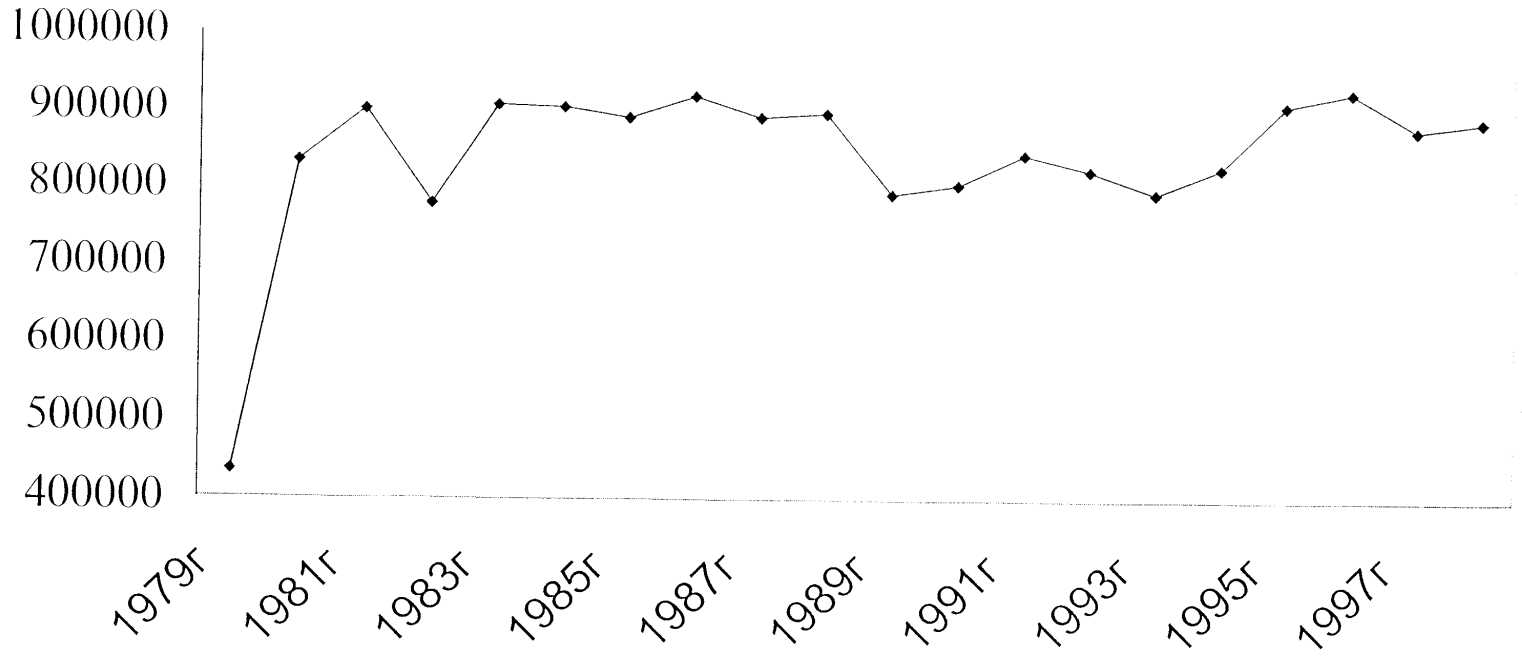


График 2. ТЕС -1. Максимальная суточная выработка (т)
Schedule 2. TEC -1. Maximal daily output (t)

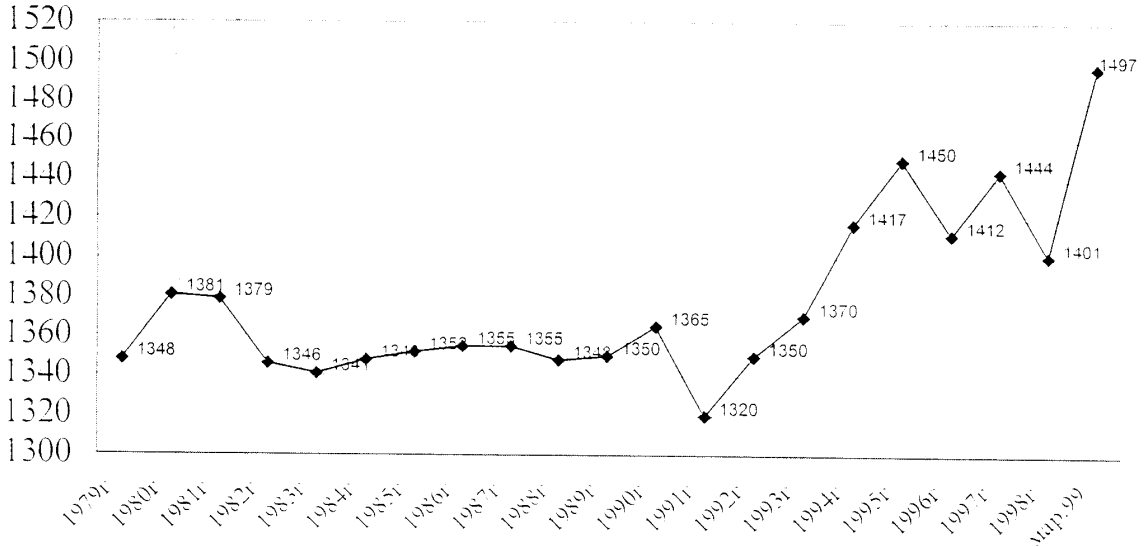
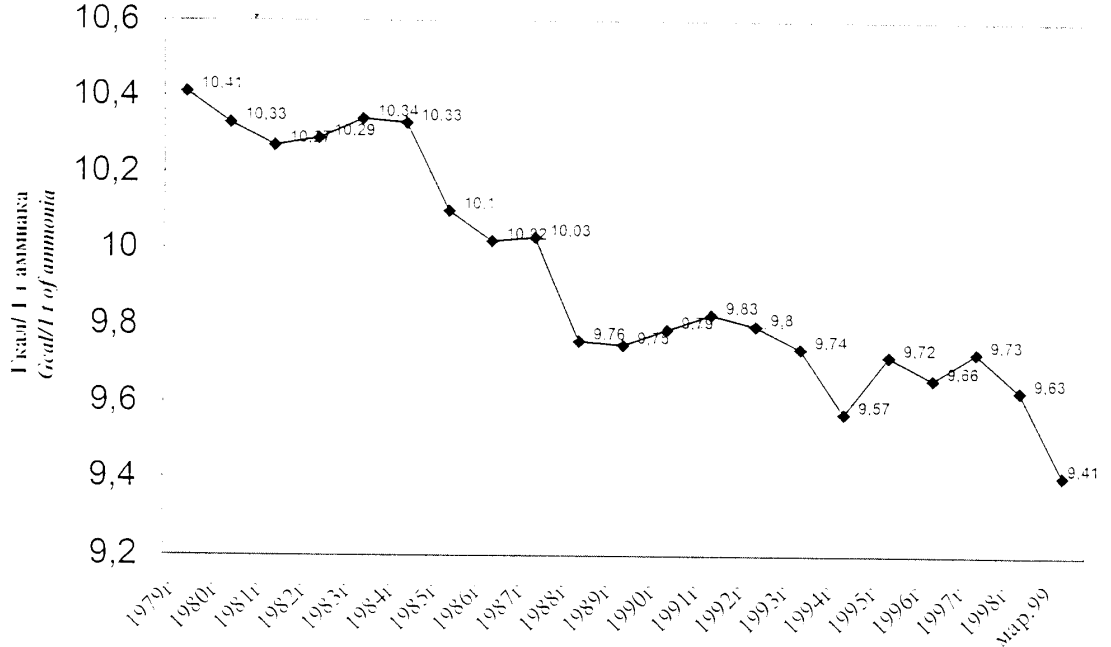


График 3. ТЕС -1. Общее потребление энергии на 1 т аммиака
Shedule 3. TEC - 1. Total energy consumption per 1 ton ammonia



SCHEMATIC DIAGRAM OF AMMONIA PLANT "TEC"