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SUGGESTIONS FOR INCREASING STANDARDIZATION OF AMMONIA PLANT CAPACITIES AND EQUIPMENT *

by

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The benefits of increased standardisation of ammonia plants lie in many areas. It is the purpose of this paper to identify and to assess the value of standardisation in each of these areas. For this paper only ammonia plants using the steam reforming of either naphtha or natural gas will be considered, although many of the conclusions could very well apply to partial oxidation plants.

USING PROCESS DESIGN STANDARDISATION TO REDUCE THE COST OF PLANTS.

While the benefits of cometition between various designers is recognised as being essential to ensure that each new generation of plants is more economic than the previous it is still possible to have a degree of standardisation which would be to everybody's benefit.

If the majority of projects were for a few sizes of plant, it would reduce considerably the background work that each designer has to do to present a bid likely to obtain the contract for him. It would also remove the situation where one contractor wishes to bid a plant slightly smaller and another a slightly larger plant because that was the only way that they could complete their bids in time. Now, even for a standard plant output, it is possible to have considerable variation in the size of parts of the plant due to the nature of the feedstock, the temperature of the cooling water and other climatic features.

For any plant size there are generally four broad groups of feed-stock which affect both the size of parts of the plant and the extent of the ancillaries. These are Naphtha, LPG, associated gas and light dry natural gas. Apart from the liquid nature of naphtha and LPG the front end of the plant from the Reformer to the CO_2 Removal unit has to be 10 to 17% larger than when handling a light natural gas.

Consequently, it is unlikely that a contractor would like to offer one standard plant for both liquid and gaseous feeds which he slightly stretched for one feedstock and slimmed down for the other. No, it is much more realistic to make a split between liquid feedstock and gaseous feedstocks so that designers can have two basic designs which can be adapted easily to other liquid or gaseous feeds without introducing very much uncertainty into estimates developed for a standard specification.

The effect of cooling water type and temperature upon a standard design can generally be limited to a very few areas. The most sensitive is the refrigeration duty, particularly on the higher pressure loops. This is affected in two ways, the refrigeration load generally increases quite considerably, while the condensation pressure of the refrigerant also rises. The two effects taken together can mean that the power of the refrigeration compressor and the size of the refrigeration condenser can double for something like a 20°C rise in the design cooling water temperature. As the temperature of cooling water increases the condensing pressure of steam turbines rises causing two effects. It increases the quantity of steam required to drive compressors, but this steam flow has a much reduced volume at the exit of the turbine. This could result in a physically smaller machine being satisfactory for the higher power. The other effect of a higher cooling water temperature is that the interstage temperature of all compressors is higher, resulting in more power. The combined effect of all these changes is, that the power requirement of an ammonia plant of 1000 MTPD can vary by about 5 MW for a change of 20°C in the cooling water. After allowing for the reduced vacuum this could mean an increase of 30 te/hr in the steam production which might change from 210 to 240 te/hr.

The effect of this extra steam production on the ammonia plant can be minimized by completely separating the generation of auxiliary steam from the waste heat derived steam which is almost completely independent of the cooling water temperature. There is no way of minimizing the effect of cooling water on the refrigerator system, so it is necessary to recalculate this area for each project.

However, even here the contractor can easily be prepared by previously considering a range of temperatures and producing design variations for each of them.

Even the effect of sea-water cooling can be minimized by certain solutions. The conventional alloys for sea-water service, brass and cupronickel, are also attacked by ammonia. For this reason a secondary cooling circuit is best used for most of the coolers, particularly the compressor intercoolers. If the sea-water temperature is below 30°C then the secondary circuit can also be used for the ammonia loop cooler and the refrigeration condenser, leaving only the steam turbine condenser to use sea water directly. Consequently, the use of sea water generally reduces to the same effect as using hotter cooling water since the secondary cooling system normally operates 5 to 8° above the sea water temperature.

Over the past few years the majority of large ammonia plants supplied outside of Western Europe and the United States have been for 1000 and 1350 MTD regardless of the feedstock. The next most common size to be offered has been 900 MTD, particularly in association with naphtha feedstock. Consequently, it would appear that as far as size is concerned 900 - 1000 and 1350 MTD would represent standard sizes acceptable to most designers with a bias in favour of 1000 and 1350 MTD.

When ammonia plants are associated with a Urea plant there emerges a problem with natural gas based plants since there is not enough process derived CO_2 to convert all the ammonia into Urea. There are several ways that this can be done without affecting the standardisation of ammonia plant sizes and flowsheet arrangements. The easiest is to make arrangements to export the surplus ammonia production. The next easiest is to design the ammonia plant without regard to the Urea plant at, say, 1000 MTD all through and to design the Urea plant for about 1600 MTD of Urea. The surplus ammonia synthesis gas would then be used for fuel in the Reformer. This problem does not of course arise with very heavy associated gases or with liquid feedstocks.

USING STANDARD PLOT AREAS AND INTERNATIONAL PIPING STANDARDS TO REDUCE COSTS.

A very large saving can be made in the design costs of ammonia plants if the designer can always bid according to his standard layout. In these circumstances it should be possible to use a large member of the standard isometrics in the new plant. This not only reduces the engineering hours but considerably improves the quality of the initial cost estimate where fixed prices are required.

The savings due to using identical isometrics from job to job can be entirely lost if the client is unwilling to accept the piping standards both for the design basis and material that are normally offered by the designer.

Generally, the cost of land is very low compared with the cost of engineering an ammonia plant and it should be relatively easy for most clients to accept the designers normal plot plan. Piping and fittings are available worldwide in almost any of the major international standards.

One factor which tends to complicate piping specifications is that several countries have widely different legal standards for steam piping. Since steam itself has no knowledge of international boundaries it should be possible to arrange an international specification which ought to be acceptable to the legislators of most countries.

STANDARDISATION OF SPECIFICATION FOR VESSELS AND HEAT EXCHANGES.

These two areas of plant design which represent a large proportion of the plant cost show some benefits by being built to similar standards. Generally, conformity to various standards has little effect on the overall dimensions but can have a considerable effect on weight and cost. Accordingly, the piping design may only be very slightly affected by the adoption of different national vessel codes, but the structures and foundations may be greatly affected.

The designer will have to do a considerable amount of work at the estimating stage to convert his standard design to a new national standard and since these items are very expensive a considerable time must be allowed for him to obtain quotations for fixed price type contracts. For engineering only contracts the designer will still require a reasonable time to familiarise himself with the new standards and their effect on his design and procurement costs.

Very few countries have legislation concerning the use of vessel standards and it should be possible for most clients to allow the contractor to bid in the most appropriate standard which may not always be the same as the contractor's standard for all vessels. For example, any vessel or heat exchanger which has to be purchased in the client's own country to minimize foreign exchange costs should, of course, be specified to the code most familiar to the local fabricators.

STANDARDISATION OF ELECTRICAL AND INSTRUMENT SPECIFICATION.

Many countries have very well defined national standards for electrical machines and installations. Often these are backed by legislation. Fortunately, the effect of changing the electrical specification has little effect on other areas of the plant. However, the application of certain standards can have a considerable effect on both capital and engineering costs.

Instrumentation is an area of rapid technological development, particularly on the control side. Normally, clients allow the designer to offer either his own preferred supplier, or impose on him one on which the client has decided to standardise. The latter situation may have an effect on engineering and cost, and may produce a credit problem if the equipment is not available from the country supplying the contract finance.

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Mechanical equipment is often designed to comply with certain national or international standards. This is, however, more of a guarantee of quality than of interchangeability. The only way that mechanical items can be interchangeable is for the process conditions to be almost identical. This means that at the present machinery may be interchangeable from one plant to another, especially if each plant is designed by the same organisation. However, even for identically sized plants from the same designer, it is often the case that the machinery will differ from plant to plant, even when the same standards are specified and the two plot plans have the same overall dimensions.

The explanation of the use of different machinery on otherwise identical plants is either due to the normal restrictions of price and delivery or because of the financing provisions. The problem with most machinery is that different vendors may have widely different physical solutions to the same set of process conditions. As the total price of machinery is very high and the highest single cost item is usually a compressor, the designer is under intense pressure to choose machinery according to price rather than similiarity of size and interchangeability between various sites. In fact rarely are machinery spares interchangeable between several vendors except ancillaries like bearings and instrumentation.

The costliest spares on an ammonia plant are the spare rotors of compressors and turbines. Most vendors of this type of machinery work from standard frame sizes with a certain amount of detail tailoring to suit the actual situation. However, this detail tailoring of impellors, in particular may mean that very few rotors for the same compressor frame size are exactly interchangeable. To be interchangeable, it is essential that plant capacity and climatic conditions should be very close.

[illegible]

The items that [illegible] plants are generally [illegible] the parts [illegible] readily and cheaply [illegible] pump and [illegible] packings, oil filters, [illegible] controller [illegible]. The next category of spares are those likely to require occasional replacement like seals, bearings, [illegible] and [illegible]. There is a reasonable probability that some of these items will require attention at frequencies of [illegible] a year. Those that are expected to require this [illegible] of attention are normally, either provided with on line replacement facilities, or with installed spares, as is the case with the process pumps.

Other parts of the plant are likely to require attention at the annual or biannual shutdown. Among these are reformer tubes, catalyst, heat exchanger tubes, fan bearings, refractory and contacts. Vessels and other equipment often has to be inspected, but generally no action is required for several years, if at all.

The majority of expensive maintenance incidents are those which happen without warning. Of these, the most expensive relate to machinery. These, however, rarely take much time to sort out, due to the policy of buying spare rotors and internal parts of all the expensive machinery. Much more expensive, in terms of lost production and expense of the repairs, are failures of vessels and the pressure parts of heat exchangers, since spares are not held for these and repairs are often difficult and time consuming even with the resources and assistance of a good fabricator.

The cost of machinery breakdown incidents can only be reduced by pooling spares, where possible, with other operators, so that the amount of non-productive capital can be drastically reduced. As we have seen the likelihood of spare machinery parts being interchangeable is increased if most plants are the same size; flowsheet conditions are similar and operators have equipment from the same machinery vendors. Now new machines are constantly being introduced and it is obvious that developments in terms of better value for money and higher efficiencies must be encouraged. However, both manufacturers and operators should benefit if designers were encouraged to standardise on [illegible]. Most machinery producers already themselves standardise frame sizes to minimise their casting and forging inventory. Unfortunately the same standardisation does not extend to the shafts and impellors. As we saw in earlier paragraphs, this is not entirely the fault of the designer, since climate, elevation and cooling temperature and medium affect the detail design of the compressors.

Around the world some ten major ammonia plants are ordered every year. Purchasers of new plant should investigate the possibility of pooling spares with any operator of similar equipment in any part of the world. With modern transport few places are more than three days apart.

CAN 'U.N.I.D.O.' HELP TO REDUCE OPERATORS COST BY STANDARDISATION.

In the area of contractors bidding costs UNIDO can help by encouraging developing countries to adopt the standards of one of the major industrial nations. This is not an attempt to impose technological colonisation, since the alternative is either for countries to write a new set of standards, or to take bits from various standards and synthesize them into a new distinctive standard. This last technique appeals to many countries who feel it produces the best of all worlds. Generally, it results in complete confusion. Even some European countries are prone to this error. One H & G plant was designed to the German code, on the clients instructions, but during erection the national boiler authority decided it would extend its code to include the boiler on this plant which worked at a higher pressure and temperature than had been previously used in the country. The result was that a boiler system which satisfied the clients enquiry and would have been acceptable in West Germany had to be modified before it was allowed to start up.

One area which can cause high risk to a designer is where the national standards allow for discretion on the part of the inspection or certifying authority. If this discretion allows for substitution of the enquiry standards by the advice of the inspector which may be backed by law, the designer may have to take excessive financial risks. Situations have occured where H & G have found the certifying authority of one country not accepting the weld factors allowed by the contractual standards. In cases like this clients should make designers fully aware of these possibilities before they submit their bids.

Many developing nations are quite happy to adopt the standards of one of the industrial countries who have spent a vast amount of money producing and developing their standards. UNIDO could usefully encourage other countries to adopt one of these existing standards or even to advise the operator to allow the contractor to use his own national standards which are generally completely acceptable to organisations like Lloyds and Bureau Veritas.

THE EFFECT OF ENVIRONMENTAL AND SAFETY REGULATIONS ON INCREASED STANDARDISATION.

Environmental and Safety Regulations can have considerable effects on the design of a plant. Noise considerations can result in a doubling of the size of air coolers. Most emission regulations have only a small effect on the battery limit plant but many of course have a big effect on the design of the effluent treatment facilities.

As effluent, noise and safety regulations become more severe most plant designs at the moment have been developed so that they are capable of meeting the requirements of over 90% of clients. It is the few others who can cause big changes by insisting on very onerous regulations governing such things as, wide separation between those parts of the plant handling liquid hydrocarbons from those handling light gases, noise levels below 70 dB at the battery limit, wider separation of all fired heaters and extremely low levels of sulphur and nitrogen oxides in the flue gases.

Regulations in these areas are generally in their infancy and there is a tendency for nations to adopt the most exacting regulation in force at any part of the world. In some locations H & G have been presented with water discharge regulations of such severity that once river water was extracted it could not be allowed to flow back into the river again without having most of the original dissolved solids removed.

Because of the infancy of these regulations this is an area where UNIDO could lead in the preparation of internationally acceptable standards which could allow for certain necessary national variations which would be published along with the enquiry for the new plant. Most contractors are only too willing to design a plant to meet any regulations because more work is required as the regulations become more severe. However operators must be aware of the very high cost of implementing some regulations.

CAN 'U.N.I.D.O.' INFLUENCE FLOWSHEET CONDITIONS.

It should be very easy for UNIDO to recommend to operators a limited number of large plant sizes particularly when there is a World Bank or similar involvement. However other flowsheet conditions require a different approach. The whole essence of competition between different designers is that each believes his flowsheet represents the optimum for either the majority of situations or he tailors it to what he believes is the optimum for each situation. The present designs of most contractors are fairly well known to clients and to other contractors. It is in the area of major development that most secrecy exists.

UNIDO could study these existing flowsheets and see whether different designers would be willing to make small changes so that the conditions for machinery in particular could be more similar even if not identical. If these recommendations were implemented it is likely that compressor vendors would sell many more nearly identical machines. In these circumstances one suggestion is for operators to finance a pool of spare parts at the compressor vendors works which would be sufficient to assemble and despatch within a period of about one week a sufficiently similar rotor to the one needing replacement so that performance would only be affected by two or three percent. Another suggestion mentioned earlier is that as the number of identical compressors in service increases that operators of these machines regardless of their position in the world should pool their spares. UNIDO could help by assisting in establishing a standard system of paperwork so that these pooled spares could be shipped and cleared by customs quicker than is generally the case.

Either of these suggestions for reducing the inventory of very expensive spares should have worldwide application in both developed and developing countries.

CONCLUSIONS.

We have seen that a reduction in the number of large ammonia plant capacities, the widespread adoption of already established design standards and the employment of gentle pressure on designers by UNIDO to reduce the variation in the flowsheet conditions particularly for compression will be of great benefit to both contractors, compressor vendors and operators.

UNIDO can assist in the formulation of national regulations concerning environmental and safety aspects so that these are as uniform internationally as possible. Since most countries are only just beginning to look at these this is a particularly hopeful area for international co-operation. However to increase the likelihood of its recommendations being accepted a reasonably rigorous set of regulations is likely to be most successful.

In all of its efforts UNIDO must adopt the role of persuader and co-ordinator. It should employ a small technical team who can advise operators new to the fertilizer field on the most suitable way to cover the selection of standards for any new project. It could also work closely with the certifying authorities in many countries encouraging the adoption of codes and standards which are already acceptable in most parts of the world.

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