SYSTEMATIC MACHINERY AND EQUIPMENT SELECTION (SYMES)

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Mention was made in the article 'Systems Analysis' (Vol. 16, No. 1) of the 'Systematic Machinery Selection Concept'. The following article shows how this concept has now been developed and, within the limits of security, what is intended.

The Aim

The aim of systematic machinery and equipment selection (SYMES) is to establish a policy which will govern the future selection of much of the machinery for the Fleet in the light of the financial, industrial and manpower resources likely to be available and of the prevailing strategy.

If this policy is established and implemented there will be a gain in ship availability and a much more effective use in terms of ship design, operation maintenance, refitting and repair, of whatever money and civilian or naval manpower can be found or deployed. Some initial increase in first cost of equipment may be involved but the overall cost in the long term will fall.

Factors Affecting the Development of this Policy

The Future Naval Building Programme

The significant features of the future naval building programme, which includes classes of ships to be ordered up to 1975, are:—

(*a*) The large variety of ship types

(*b*) The wide range of power requirements

(*c*) The relatively small numbers of each class.

In total the programme includes nearly 100 shaft sets of machinery for about a dozen classes of ship all with different requirements; unless strictly controlled, the variety of machinery design will proliferate beyond the capacity of headquarters staff to check each properly.

One of the foundations of SYMES is that the machinery requirements of the whole future building programme (as far as they can be foreseen) will be considered together. This will encourage a steady production programme for the machinery units selected and will offer an opportunity of exchanging units if for any reason one element of the future programme receives higher priority than another.

The Attitude of Industry to Naval Machinery Orders

Naval machinery that has no commercial outlet and unless ordered in large numbers will not attract the best efforts of industry. In any case naval machinery business, generally, is not very profitable and apart from a few firms traditionally supplying the Navy, there is no great competition to enter it.

Design and Development Time

The period between Final Board Approval of a design and invitation to tender is usually too short for the design and building of a new prototype and does not permit the exhaustive shore testing which is so essential if the high reliability necessary to the Fleet is to be guaranteed.

Increased Endurance

Successive Staff Requirements are asking for longer endurances at higher speeds, reflecting the changing international scene, As the number of overseas bases is reduced, so warships will need to stay at sea longer and have higher passage speeds to reduce deployment times.

Increased Mobility

The usage of frigates and destroyers is now comparable with that prevailing in World War II and with reducing shore support facilities outside the United Kingdom this places an even greater emphasis on the need for reliability and mobility.

Reduction in Afloat Manpower

The overall manpower bearing figures are likely to fall slowly but steadily. Due to demands from industry, and other factors, it is possible that engine-room ratings recruitment will not keep pace with wastage. This together with the need to improve the sea/shore ratio of these ratings, means that engine-room complements must be reduced. Another important factor is that since the crew occupy at least one-third of the ship's available space, a reduction in complement will reduce the size and therefore the cost of the ship.

Reduction in Cost

The National Plan shows a Defence expenditure pegged to its present level. With the increasing complexity and hence cost of new weapons, this constant figure will result in the ability to buy less and less ships when replacement of existing ships has to take place, unless savings in unit cost can be made. Thus it is important to use machinery of low first cost not offset by subsequent high running costs and where weight and space requirements are low (so reducing hull costs) while still retaining sufficient ruggedness for the marine environment.

Noise

Both from the point of view of possible detection by the enemy and to increase the effectiveness of a warship's own sonars, noise of machinery and hull must be decreased.

Headquarters Effort

It is unlikely that there will be any increase in headquarters staff, rather the reverse.

Essential Principles of Systematic Machinery and Equipment Selection

Naval machinery policy must be based on plant which offers some and if possible all of the following capabilities:—

(*a*) *A Degree of Standardization.* Standardization will allow concentration of effort in all fields of manpower and material expenditure, not least of which is in the training and maintenance personnel. This standardization must be rigid enough to prevent a host of minor variations in design that inevitably are proposed and which themselves can absorb as much effort as a new design.

(*b*) *Maximum Use of Commercial Designs.* As extensive use as possible must be made of machinery which either has been or is being developed by industry for commercial use. By this means MOD(N) expenditure on development work will be reduced and naval orders can take advantage of the cost savings achieved by sharing large production runs.

The cost to the MOD(N) for the development of a major piece of equipment, which has only a naval use, is becoming prohibitive. Another advantage of using such designs is that MOD(N) can benefit from the commercial incentives to produce a reliable and robust product.

(*c*) *Simplification of Control.* Wherever possible the use of sophisticated and involved controls is to be avoided. The aim is to use machinery and systems that are self-regulating without the use of multi-loop control systems. This will lead to reductions in watchkeeping, maintenance and setting-to-work tasks.

(*d*) *Low Specific Fuel Consumption.* The longer endurances at higher speeds can only be achieved by improvements in fuel usage rates. In addition, since fuel is still the largest logistic item, lower fuel consumption will lead to reductions in afloat logistic support.

(*e*) *Overhaul and Maintenance by Replacement.* The ability to remove machinery and equipment from the ship for repair and major maintenance will not only reduce turn-round times but will allow a large part of the engine-room department workload to be done by shore or depot-ship based personnel and so lead to reduction in complement. An essential of this method is the provision of clear access trunks and planned removal paths in the machinery spaces.

The SYMES Policy

The purpose of SYMES is to derive a minimum range of machinery which most closely follows the principles as given above but which also allows sufficient flexibility to enable the Staff Requirements to be met without introducing severe weight and space penalties. Such a policy will not in every case give the smallest machinery layout nor the most efficient plant for a particular requirement. This policy, however, will enable the Ship Department to fulfil its correct function and will lead to greater effectiveness of the money and manpower available to the MOD(N) as a whole. Not least of the advantages of this policy will be to improve the conditions of the engineering staffs afloat.

Application of SYMES to Main Machinery

The types of main propulsion plant that will be available in the next ten years are set out below with a brief summary of each against the yardsticks given above.

Steam Turbine Machinery

This machinery has proved nearly impossible to standardize, rarely uses commercial designs and is anything but simple. Long term prospects for simplifying the basic system and reducing numbers of components are unlikely to pay off during this time-scale. Its advantages at present are in its flexibility of power transmission and its ability to be designed for very high powers.

Gas Turbine Machinery

At powers needed for propulsion the gas generators will only become available in types and sizes adopted by the air engineering industry. These will always be few in number due to the large cost of development. However, these generators with their simple power turbines do satisfy most of the requirements previously mentioned under the heading 'Essential Principles of SYMES'. Fuel consumption can now be comparable with steam turbine machinery, and overhaul intervals are adequate. The only present serious disadvantage is that it is non-reversing.

Medium and High Speed Diesel

These engines are now available commercially in designs which meet the naval requirements. The main disadvantage of all Diesels is that they are inherently noisy and therefore produce the most difficult noise reduction problems. Diesels can be designed to reverse.

Nuclear Power

The main advantages of nuclear power lie in its unlimited endurance and in the reduction of space needed for uptakes, fuel tanks, etc. Although the present reactors are tied to steam machinery with all the inherent disadvantages, nuclear power engineering exerts a discipline of reliability and attention to detail from which the steam plant can benefit.

Transmission

Main gearing designs are not included in SYMES. This is because the gearing determines the position of engines relative to propeller shafting and freedom to 'tailor' gearing to ship design needs must be retained.

Application of this Policy to Auxiliary Machinery

The factors leading to the SYMES policy for main propulsion machinery apply just as forcibly to auxiliary machinery. Here the aim is to produce a short range of equipment in each of the following categories:—

(*i*) Electrical generation

(*ii*) Auxiliary steam raising plant including waste heat recovery

(*iii*) Refrigeration plant

(*iv*) Air conditioning plant

(*v*) Distillation equipment

(*vi*) Fire pumps

(*vii*) Air compressors.

At most, three sizes for each type of equipment will be sufficient. The principles to be followed in the selection of these ranges will accord as closely as possible to those given previously under 'Essential Principles'. Some suitable units are

already in the Fleet or under development. The remaining ones to complete the range will be drawn from available commercial designs wherever possible but some development for naval use will be needed.

Research and Development

It is an axiom of the SYMES policy that all research and development must lead to machinery and equipment which will more closely fulfil the SYMES principles than do these plants which exist today.

Broadly, research and development will fall into two categories:—

(*a*) That leading to improvement of existing designs, and

(*b*) That leading to entirely new equipments to replace those in the present approved stage.

All future submissions for research and development expenditure will be related to the provisions and principles of SYMES policy.

Contractual and Financial Implications of SYMES

There are certain inescapable contractual and financial implications of SYMES and the most important of these is the impact on competitive tendering.

Competitive Tendering

If competitive tendering based on first cost is strictly applied to naval machinery, a proliferation of types will result. This carries the risk of inadequate design and development, uneconomic production, poor quality and reliability, extra work at headquarters, and formidable logistic difficulties. It is therefore envisaged that while contracts for design of SYMES range items should be let on an initially competitive basis, selection of the successful tender should be governed by estimates of 'through cost' as far as this is possible. The contracts should also be stated for periods of time, rather than covering specific ships or Classes as at present. Successive orders within these periods would be subject to agreed price variations, as has been usual in the internal combustion engine field since 1950, when the first of the Admiralty Standard Range engines was introduced. Provided the engineering of the future Fleet is looked at as a single continuing problem and not as a series of separate ones, this change presents no insurmountable difficulties. Indeed once fully introduced it would allow the increasingly attenuated headquarters staff to divide machinery proposals into a series of well established groups and subject each to an annual or biennial review which would result in a systematic selection of machinery and equipment to supplement or replace obsolescent items in the SYMES ranges which would then be exhaustively tested ashore before final acceptance into the ranges.

Ship Costs

The SYMES policy will lead in some ship designs to marginally larger machinery compartments than would result from the use of machinery individually designed for each class. This extra space may lead to a small increase in hull cost but this would be offset by reductions in first-of-class costs and in the first cost of machinery for each ship.

Development Costs

Inevitably, with SYMES there will be a need for development and extensive shore testing in order to ensure unit reliability before introduction into the Fleet. By concentrating on fewer units, development testing can be more detailed and exhaustive, leading to an increase in research and development cost effectiveness.

Machinery Spares

The SYMES policy will decrease the number of component types in the Fleet while increasing the number of each type. This will lead eventually, as SYMES machinery spreads through the Fleet, to a substantial reduction in spare-gear costs.

Conclusion

It is concluded that only by the adoption of SYMES can the available headquarters effort produce satisfactory designs for the future naval building programme. Furthermore SYMES will lead to higher availability of ships machinery at less maintenance cost and to reductions in manpower ashore and afloat.

These advantages will lead in some designs to marginally larger ships, but this will not result in a significant increase in overall cost.

The cost effectiveness of research and development expenditure will be improved.