As my lifetime of active support for the pump industry approaches its end, two issues arise for which I offer my not-unbiased views. Both need advance planning. In a period of economic uncertainty perhaps this is the time for action.

A structured technical training based on compatible school and industrial apprenticeship environments is an essential starting point. I put on record a method particularly appropriate to the pump industry, developed long ago by others, that has proven to be the most successful in maximizing the intellectual outcome for the able few whilst also developing the competence of the many support engineers needed to service basic activities.

I then share my observation that structural improvements in the worldwide transport of goods, the increasing accessibility of electrical grid power-supply systems and the long-awaited availability of low-cost, variable-high-speed electric motor drives will, at some time soon, bring about new challenges in the global marketing of centrifugal pumps. I suggest it is timely for manufacturers to ensure that current methods of centrifugal pump design and manufacturing will meet future needs.

Technical training

A proven methodology

My engineering education was gained at Newton Heath Junior Technical College, Manchester, UK, where, from 13 to 15 years of age, I found pattern making replaced the woodwork of my earlier school and engineering workshop replaced metalwork. Engineering drawing was a core activity. When the time to leave approached, the school arranged an informal visit to a local engineering firm that offered an apprenticeship. This gave an opportunity for the firmly planted seeds of engineering interest to flower.

On 1 September 1952, I entered the world of work as a technical apprentice with pump manufacturer Holden & Brooke Ltd of Manchester. In the next three years I completed nine months in the fitting shop where centrifugal pumps of many configurations were assembled. These included vertical in-line and end-suction pumps (Figure 1), split-casing, multistage (ring section) and suspended vertical pumps. This was followed by six months in the pump test department. Later, at my request, I completed three months in the fitting shop at Pearn Works (Holden & Brooke had incorporated Frank Pearn & Co Ltd) where I helped build reciprocating pumps – both steam and electrically powered (Figure 2). All this
was in addition to 18 months of basic engineering training that included the machine shop (six months) and foundry (three months). So I had by age 18 a strong grasp of all the hands-on skills needed in pump manufacture.

My apprenticeship finished with lengthy periods in offices engaged in production planning and contracts (sales) followed by the drawing office and the design office.

Such early hands-on experience was not an obstacle to afterwards completing graduate and postgraduate university studies or from subsequently pursuing an interest in centrifugal pump technology through lengthy periods at G&J Weir (design & research), Crane (pump division technical manager) and CEGB (head of Pumps & Water Turbines Group).

Of course, engineering today demands different design and manufacturing skills. The base should now be a progression from shop-floor experience that, if possible, was in addition to 18 months of basic engineering training that included the machine shop (six months) and foundry (three months). So I had by age 18 a strong grasp of all the hands-on skills needed in pump manufacture.

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Of course, engineering today demands different design and manufacturing skills. The base should now be a progression from shop-floor experience that, if possible, includes welding technology and the use of plastics/composite materials, to an understanding of the computerized methodology needed in stock control, machine programming, stress analysis (e.g. pump casings) and fluid-flow analysis.

Observations
It is important to make training specific to the needs of the pump industry. A general engineering apprenticeship equips the trainee for employment generally. However, a pump industry apprenticeship makes a knowledge of pumping products an advantage in a recipient’s CV and this in turn makes staying in the industry more likely. The long-term pay-back can be significant.

A further advantage of an early starting age that became apparent to me in later life is the fact that a 15, 16 and even a 17 year old youth can be practically ‘invisible’ when observing those arguing the business of the day in the industrial workplace. For me, one placement included receiving a surprising first-hand appreciation of the skills of a trade union shop steward in the workplace. After 18 and certainly by 20, a perceived maturity excludes apprentices from this informal experience of shop-floor management skills.

Practical training needs to encompass a wide range of skills. Three-month modules require a considerable investment by the provider. However, in my experience, having a more-than-superficial appreciation of manufacturing processes has clear benefits in meeting company or organization objectives.

After completing practical training I went to university. It was evident to me that my relatively in-depth engineering experiences, when compared to those of my peers, conferred on me considerable advantages. For them, the norm after leaving school was to become apprentices with very large organizations in which experience was typically gained in two-week modules, many of which were in a training school. These very short, concentrated periods devoted to learning manufacturing techniques and processes were soon forgotten if not used.

Recommendations
To those responsible for training and apprentice schemes, I commend a structured learning in pump engineering based upon apprenticeships that include:

• general workshop practice totalling at least 12 months;
• pump fitting and pump testing together with other pump-orientated activities totalling at least 24 months. This could include accompanying field service staff and/or sales staff on visits to potential clients.

Hands-on product experience is essential. Multiples of three months are suggested for each area of training. No need to hypothesize about this structure – it clearly works.

Pump design and marketing

The need for change
The changes in centrifugal pump design in the past 60 years have, by and large, been incremental and driven by innovations to meet particular specialized needs. This has led to a fragmented approach based, for many applications, on the limitations associated with using the synchronous speeds of the ubiquitous electric motor drive. Typically, standard pumps with numerous pump casings for each branch size have been matched to need by the use of a reduced impeller diameter. Keeping a full impeller diameter and matching need using a belt drive has been an alternative. Both these routes produce an excessive and costly manufacturing inventory.

A market for readily-transportable 2 kW to 2,000 kW variable-speed pumps running up to 12,000 rpm exists. The introduction of a low-cost, variable-speed pump drive – that avoids the complexities of gears and fluid couplings etc. by separating out the source electrically by a variable-frequency supply up to 200 Hz – would transform the market. Developments in electrical and electronic engineering mean that this could come soon. The electrical solutions tried to date fail the ‘low-cost’ test. For electrical equipment manufacturers this prize is too great to miss.

Some very-low-powered (less than 1 kW), variable-speed pumps have found niche market places. High-powered (5,000 kW plus) variable-speed pumps based on slip-ring motor/gearbox or fluid-coupling/gearbox combinations have been used for many years in the power supply industry. The mid-power range identified here – where most industrial applications reside – is ready for a change. Just as the pumping ‘dinosaurs’ of the early
20th century, the reciprocating pumps, have been driven to near extinction by electrically driven centrifugal pumps so, for many applications, a product line based on fixed speed 50 or 60 Hz motors is heading for a similar demise.

When new, low-cost, variable-speed centrifugal pump design variants enter the market they will almost certainly dominate the market sector for pumps absorbing power in the 2 kW to 2,000 kW range. To understand why this is so consider the following:

1. Variable-speed centrifugal pumps substantially reduce operating costs for most applications.
2. The marketplace for selling (and manufacturing) pumps is increasingly global. Worldwide competition means that products easily transportable by air freight have a significant advantage. High-speed centrifugal pumps have a substantially reduced physical size and weight. Consequently, the essential performance-determining elements, the hydraulic performance unit (HPU), can be placed in a single readily-transportable package (Figure 3).
3. Worldwide air transport and rapid international rail links bring second-day delivery within reach for most users. For all users, within-the-week delivery is achievable. Return-to-base packaging permits rapid replacement (or upgrading). Module replacement rather than on-site repair increases the likelihood of a positive outcome, reduces pump outage time and provides commercial logic for the pump user.

What meets future market needs best?
In my view, the basic requirements for a new pump concept are:

- competitive pricing with a worldwide seven-day delivery capability;
- reduced inventory and maximum use of ‘production line’ manufacturing methods;
- a compact design to permit air transport;
- flexibility – to accommodate future pump-drive variations.

For each manufacturer the argument and the outcome are different. Existing areas of market presence, manufacturing machinery/technology limitations, design resources and permissible capital outlay will all be different. In well-run companies the debate on future markets is always ongoing. It will take time for most manufacturers to be able to offer pump speeds up to 12,000 rpm in the form of air-freight packaged pumps. The need is to decide if a major product design change should take place and, if so, when work on it should start.
To provide a basis for discussion, I outline my choice as a preliminary design concept (Table 1 and Figure 3), taking into account core requirements and identifying design issues where choice exists. This is just one of the possible ways forward.

Observations
1. Vertical in-line pumps have a significant advantage in reducing the effect of pipe forces on shaft alignment especially when, as is usually the case, the driving motor does not have an anchor point. They are least affected by external flooding (e.g. in basements).

2. Most industrial applications are covered by a pressure containment rating of 16 bar. It is prudent to anticipate a possible future requirement for pressure retaining components to be rated at 40 bar. At the concept design stage it is possible to ensure that, whilst pump casings etc. are different, the hydraulic performance modules within them are interchangeable. The principal pipework installation dimensions should also be identical.

3. Variable high-speed pumps allow the number of common parts to be maximized. 4. Centrifugal pumps need to be protected from unacceptable cavitation. The margins on net positive suction head (NPSH) needed to avoid loss of performance and cavitation erosion with certainty were developed last century. Avoidance of cavitation surging at low flowrates is less exact. With multistage pumps – particularly high-energy variants – the pressure pulsations appear to be abrupt. From what little evidence is available, cavitation surging in vertical in-line and split-casing pumps seems to be more benign.

5. Mechanical shaft seals fail if a liquid film is not maintained between the stationary and rotating surfaces. In a stationary pump, the density difference between air or trapped vapour and the pumped liquid means that such gases rise to the highest point. Vertical in-line designs are potentially the most vulnerable.

Recommendations
As always, a strategy that meets market needs is required. The changing marketplace means now is the time for manufacturers and designers to review firstly the goals and secondly the timescale for implementation. Procrastination brings closer a parallel to the downfall of the reciprocating pump manufacturers of yesteryear. Being ‘well-engineered’ is no guarantee of market suitability. Growing market forces will eventually undermine the option of staying in the comfort zone of the status quo.

Pump manufacturers are recommended to review the additional market opportunities that are emerging as a result of expanding worldwide rapid transport systems. In parallel with this, it is prudent to review the changes in product design and the in-house technology capability necessary to be successful in a market favouring low-cost variable-frequency electric motor drives up to 12,000 rpm in the 2 kW to 2,000 kW range.

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