〔特別招待講演〕

MANAGEMENT PROCESSES FOR INNOVATION IN JOINING TECHNOLOGY*

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Innovation is the key to improved business performance. The paper discusses management processes which help to improve creativity in staff and bring new ideas to the market in the area of joining and related technologies. The success of these approaches is illustrated by two case histories.

Companies need a management style which has a strong concern both for individuals and for the commercial exploitation of ideas. Creativity is enhanced if individuals feel that their ideas can be quickly developed and exploited, and that there is personal recognition for success as well as an opportunity to stay with the development.

Innovation is most likely when key individuals have a detailed knowledge of industry needs along with current best practice and operational constraints.

1. Introduction

This paper is about management of technical innovation for better business performance. For many years Japan has constantly sought change and new technical advances. As an example, the European Patent Office has reported recently that the number of patent applications by Japan in 2000 was 436,000, this comparing with 297,000 for the USA and only 24,500 for the UK.

Technical innovation is at the heart of my own organisation which I believe has been successful over many years in inventing as well as developing a number of new joining and related technologies. Table 1 shows some of TWI's world firsts over the last 40 years.

The purpose of this paper is to discuss various management issues which relate to innovation in companies. Factors influencing creativity in staff will be discussed and two case histories will be used to illustrate TWI's general approach. The paper will introduce TWI's innovation pipeline, and finally, lessons learned will be summarised.

Table 1 : Examples of TWI World Firsts

- CTOD concept & defect acceptance methodology
- Generalised fatigue design rules for welded joints
- Long range ultrasonic technique for pipelines (Teletest®)
- Fast axial flow CO₂ lasers
- Gas assisted laser cutting
- Synergic MIG welding
- High power electron beam welding
- Friction stir welding

It is useful to start with a definition of innovation. It is a process best described as doing something in a new way. This may involve an incremental or a step change, but in either case the result has a successful commercial outcome. There may be an invention at the heart of the innovation but this is not essential. There are three main steps in the innovation process. The first concerns encouragement of staff to be creative, the second concerns the planned development of ideas with good market potential, and the third deals with exploitation through customers.

2. Creativity

The importance of encouraging creativity in staff needs to be stressed to senior and junior managers. The managers must explain to all their staff that creativity is an expectation of any job. However, step changes in a technology are usually delivered by staff with a strong inclination to invent and there are only a few of these in any organisation. For example, 8% of TWI staff have filed for a patent once, but only 0.5% of staff have filed 6 or more times.

A new technical idea is usually generated by a single person in a company, but the route this idea takes will depend on which route is seen as easiest. This should be the official route but this could be seen as slow and tedious if company bureaucracy is too high. If this is the case, the idea may be dumped by the individual or it might be leaked outside the company through personal contacts or by publi-

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cation. In both cases the company loses the idea.

How do we find creative people ? Psychometric tests have proved useful to TWI. The Belbin team test is one form of test which can reveal staff who are particularly good at developing new ideas, but of course these ideas must then be communicated effectively to peers and management. Some creative people may be technically brilliant but not able to communicate easily. Acceptance of new ideas by management is also a critical step and management have to pay careful attention to developing a close and regular interaction with creative people. Technical opportunities can be lost if creative individuals feel they have been unfairly treated by management at any stage.

3. Case Histories

Friction Stir Welding is a TWI patented process which was created in 1991. It is a solid state joining process initially developed for aluminium alloys. In the last few years it has seen extensive exploitation in the rail transport, aerospace and automotive sectors. The development process from first idea through to exploitation is shown in Table 2. The duration for the whole process to first exploitation was about 5 years. This is seen as particularly fast and the exploitation route in this case has been by licensing for use of the process in manufacture. TWI has nearly 70 licensees at present.

Teletest® is a long-range ultrasonic technique for surveying pipework and pipelines, and was conceived in 1984. The process relies on injecting low frequency ultrasound into a pipeline. Up to 30 metres can be surveyed from a single test point and the process is capable of detecting metal loss down to 3% of pipe wall cross-section. Currently it is being used around the world for road crossings, for pipelines with insulation, for risers and for chemical pipework. The development process for Teletest® has taken 13 years from the first original thought, and the process is shown in Table 3. TWI has set up a subsidiary company as the exploitation route for this product, offering

Table 2 FSW development process

• Original thought   • Anarchic research   • 6 month exploratory project leading to patent   • 3 year Core Research Project   • 6 year Joint industry project   • Exploitation by licensing

Table 3 Teletest® development

• Original thought   • Anarchic research   • 6 month exploratory project   • 3 year Core Research Project   • UK Government and EC projects   • Subsidiary company formed

a pipe inspection service as well as sales of equipment.

In both case histories, the route taken by the first idea was similar and this leads to the concept of a 'pipeline' for ideas and their subsequent development, which is discussed in the next section.

4. TWI's Innovation Pipeline

Figure 1 shows TWI's schematic pipeline for innovation, which essentially models the continuous flow of ideas from a 'fuzzy front end' through to consolidation and development and finally to exploitation. The front end of the pipeline is termed 'Idea Capture'. Throughout this first phase there must be a light touch from management. Anarchic research should be encouraged which means that management knows little about what is being researched.

The next stage is some form of exploratory project for the best ideas. These projects should be formally recognised by management and ideally supported by a mentor who talks regularly to the creator of the idea. In this period a director or senior manager can speed up the development of the idea and the appointment of such a person is recommended. The idea creator should have a full awareness of the opportunities which could arise from a technical breakthrough. This comes from a thorough knowledge of the technical subject areas, as well as current best practice, customers needs and the technical barriers in the area in question. As an example, some market drivers and technology needs for the electronics, photonics and sensors sector are shown in Fig. 2.

The 'consolidation and development' phase of the innovation pipeline involves planned development through different types of research project either funded internally

Fig.1 TWI's Innovation Pipeline

Drivers

- Reduced environmental impact
- Miniaturisation
- Harsher environments
- Higher speed/frequency/power
- Cost reduction

Technology Needs

- Electronic packaging reliability
- Photonics packaging
- Higher T device materials
- Biodegradable materials
- Pb-free soldes
- Agile manufacturing
- Nanoscale joining

Fig. 2 Market drivers and Technology

Fig. 3 Innovation Pipeline-Exploitation Options

or funded by industry. Patents must be strengthened and the market demand for the idea continually tested. This is also the time for a first business case to be developed and the risks of exploiting the project assessed. A stage-gate approach to the management of patents and intellectual property is very important in this phase.

The third and final phase of the pipeline is 'exploitation'. TWI uses a well-known chart which examines the combined effects at risk and the attractiveness of the market, shown in Fig. 3. Typically, TWI encourages exploitation by projects and publishing, or by the subsidiary company or licensing route. High risk exploitation does not normally feature in TWI's portfolio although occasionally a partnering arrangement has been used if the intellectual property is shared.

5. Some Lessons For Management

A key issue is the management of 'creativity'. Managers need to try and inspire staff to produce something special for the company. This can be helped by ensuring that Director or Senior Manager encouragement of creative individuals is in place. Time and opportunity for creative staff to do their thinking and exploratory work must also be arranged. In TWI's experience, creative staff do not wish to be burdened with commercial project pressures and deadlines. Management must then ensure that there is a relatively low level of bureaucracy for the development of good ideas, otherwise as explained earlier, the idea may be leaked or dumped. Finally, there needs to be personal recognition of creative staff by management for success, and the idea creator must be allowed to stay with the development and exploitation if he/she wishes.

Another issue is management control of patents and intellectual property. Here TWI has found that stage gate approaches are ideal and the typical stage-gates are shown in Table 4.

Finally there is an important aspect of style which describes management's view of its primary activity. At one extreme, it may be driven strongly by production, operations and the bottom line financial performance or, at the other extreme, it may be driven by its concern for individuals and people. Figure 4 shows TWI's grid in which inno-

Table 4 : Stage-gate Management at TWI

Gates/ Stage	Main Question
1	Should the idea be funded? <i>Proof of concept stage</i>
2	Preliminary protection? <i>Proof of feasibility stage</i>
3	Is full protection warranted? <i>Develop commercialisation stage</i>
4	Is invention commercially feasible? <i>Proceed with Exploitation stage</i>
5	Maintained each year? <i>Mature product stage</i>

Fig. 4 Management Style for Innovation

vation space is seen to occupy that part of the grid where management has a strong concern for both production and people. If one of these concerns is dominant then either there is no energy for invention or there may be an invention but no exploitation. Management sets its own style and if it wishes for innovation then it has to put its energy equally into both of the axes of the grid.

6. Conclusions

- Innovation is most likely when directors have a high level of concern for both production and individual creativity.
- Creativity should be an expectation of the job, success leading to personal recognition by senior management.
- Creative people must perceive easy exploitation routes for ideas and opportunities to stay with the subsequent development.

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