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Industrial maintenance: a discipline in its own right

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ABSTRACT: The economic importance of industrial maintenance was encountered for the first time after the Second World War. Today, it has fallen in the league of a few measures to reduce the cost of production and the lifecycle cost of the physical assets. This has led to increased demand for maintenance specialists in industry. Some universities and tertiary institutions have responded to this need by starting postgraduate programmes in industrial maintenance, but there is still a clear need for more such institutions to do so. When designing such a programme, the interdisciplinary nature of industrial maintenance should always be kept in mind. Industry, especially at the local level, should be closely involved in designing, developing and running this type of programme, thereby keeping the programme always relevant to industry, as well as exposing students to the application of the theory taught in the classroom. In this way, students' interest levels can be kept alive in what they study. It will also facilitate a smoother transition of students from the university into industry as an employee.

INTRODUCTION

Maintenance came into focus as a necessary industrial activity that was closely associated with production only after the Second World War. Prior to this, maintenance activities, repairs or replacements were only carried out when a machine broke down, ie a maintenance strategy or operate-to-failure was followed. It was rational to do so as these machines were over-designed, moved slowly, were operated and maintained by the owner, and wore out slowly and predictably.

In the aftermath of the Second World War, large sized plants sprang up. They had more complex machines and more mechanised production process. Huge capital became locked up in these large plants. At the same time, the cost of capital continued to increase. The failures of machines led to high unavailability and became costly. This prompted the invention of preventive maintenance as a maintenance strategy [1].

In the 1960s, a study commissioned by the Federal Aviation Agency (FAA) in the USA to investigate the efficacy of preventive maintenance for civilian aircrafts found that preventive maintenance was not cost effective. Moreover, there were parts and components for which there were no effective form of preventive maintenance.

This led to the establishment of Reliability-Centred Maintenance (RCM) [2]. It shifted the focus from preventive maintenance to condition-based maintenance. This triggered active research in the methods and techniques to discover the condition of machine and components. Condition monitoring systems started being available on the market in the 1970s and used in industry. Research in this area continues today [3]. The 1980s saw the development in decision support tools such as expert systems, designing for reliability and maintainability, and new thinking in the management of the workforce [4].

THE ECONOMIC IMPORTANCE OF MAINTENANCE

Manufacturers are working continuously to decrease the cost of their products and increase the quality of it in order to survive in a fiercely competitive marketplace. At the same time, increasing the mechanisation and automation of the production process is proving a failure as it is costly. Even if a machine continues to operate, but is in a bad condition, it would produce bad quality products [5][6].

The process has seen maintenance emerging from nowhere up until the late 1940s, to the top of the league of the measures to reduce the cost of production in the 1980s [4]. Some examples help prove this point. In 1968, the Ministry of Technology in the UK commissioned a study to find out the status of maintenance in the British manufacturing industry. Its findings were as follows:

- The total direct cost of maintenance was approximately £1,100 million per annum;
- The improved productivity of maintenance staff could have led to a reduction of maintenance costs of around £250 million per annum;
- Better maintenance could have saved about £300 million per annum of lost production caused by unavailability [7].

In 1988, the British manufacturing industry spent £8 billion in maintaining direct production systems, while US airlines spend $9 billion every year on maintenance [8]. The cost of maintaining military systems could be as high as 70% of the total lifecycle costs [9]. The cost of maintenance is estimated to be 15-40% of the production cost [10]. It is 60% of the total lifecycle cost of the production systems [11]. One of the world's largest oil companies is saving more than £10 million a year at its UK site because of smarter maintenance decisions at all levels [12].

MAINTENANCE EDUCATION

There is a clear need for maintenance specialists in industry. In order to meet such a need, some institutions of higher learning have responded by offering postgraduate courses [13]. Most of these courses have a strong emphasis on technology. Indeed, most of these courses have been initiated by faculty who have a background in mechanical engineering. However, these courses are offered as interdisciplinary subjects. It requires inputs, not only from engineering and technology, but also from management and microeconomics (see Figure 1). Within these areas, specialists with narrow specialisations in different areas are needed under one roof. These areas need to be integrated.

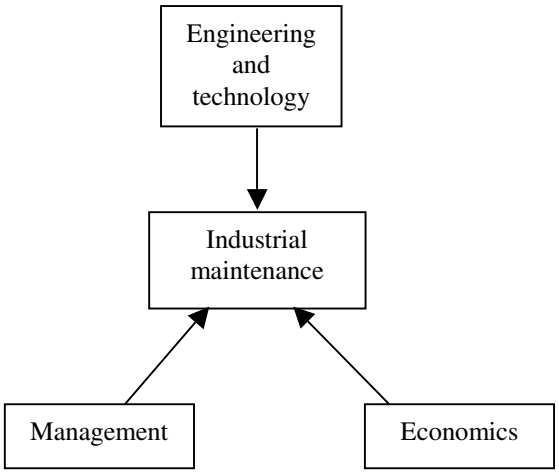

Figure. 1: The interdisciplinary nature of industrial maintenance.

In the mid-1970s, a concept called *Total Productive Maintenance* (TPM) evolved in Japan [14]. This aims at zero breakdowns, zero losses and zero defects. It advocates total participation, autonomous small group activities and motivation management. The concept was so successful in Japan that it quickly spread to industries in the West. More and more industries in the West, as well as China and other countries, are trying to implement it. Along with many success stories, some failures have also been reported and the reason for failure has been traced to the failure of management [15][16].

The cost of maintenance consists of two elements, namely the cost of resources and the cost of unavailability. This is illustrated in Figure 2.

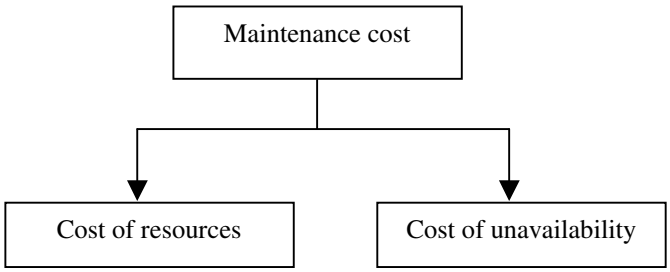

Figure 2: Cost classification of industrial maintenance.

While the cost of unavailability is the cost of loss of production due to machine not being available for production, the cost of resources consists of mainly the costs of workers and materials, especially spare parts. The laws of economics govern the decision of what kinds of spare parts and in what quantity they are to be stored. The same is valid for the storage of raw materials and other inputs needed for production. Even in the procurement of the plant and machinery, the concept of lifecycle costing (LCC) is being increasingly utilised. Finally, identifying which maintenance strategy to apply when more than one option is available is also governed by the laws of economics.

Studies in Sweden have shown that the interest of the young in engineering education is declining [17]. Social sciences are attracting most of the students and engineering the least [18]. This scenario should not be different in other western countries. One reason seems to be that the youth find engineering dry and boring. Therefore, it is important that the theory taught in the classroom is related to practice. Therefore, actual case studies from industry should follow the theory and students should be encouraged to work on industrial projects. The experience of the author in this respect has been rewarding [19].

THE DESIGN OF THE PROGRAMME

A teaching programme in industrial maintenance should be at the postgraduate level for students who hold a bachelor degree in engineering/technology. In order to be relevant, it should be designed in collaboration with industry. In particular, industry at the local level should be closely involved. Figure 3 proposes a model to develop such a programme. A Programme Advisory Committee should be formed with people from the university and industry. It should consist of those people who can decide on, and respond to, needs and take a decision on the running of the programme.

In the next step, a Programme Executive Committee should be established. This Committee should frame the courses and run the programme. Student feedback should be a regular feature for each course. Finally, at the end of their education, students should be asked for feedback regarding the whole programme. The programme should be evaluated, say, after it has been run three times by the Programme Advisory Committee (see Figure 4).

The Programme Advisory Committee should consider the feedback provided by the Programme Execution Committee, students and industry. Based on this feedback, it should decide if the programme should continue or if it needs more support. Indeed, does the course need a change of focus or orientation, etc? Such an approach has several advantages. Students gain exposure to applications of the theory presented. Students also have the possibility of carrying out their major project in industry, thereby increasing their chances of getting jobs with the industries involved, as they will find these students immediately useful without them requiring additional training.

The level of industrialisation differs from country to country. It differs from region to region within a country as well. Often, regions have the concentration of a particular type of industry. The level and sophistication of the content of courses will depend upon the level and the sophistication of the industry around. The involvement of industry, particularly local industry, will help to ensure this.

CONCLUSIONS

The economic importance of industrial maintenance has increased to such an extent that there is a clear need for

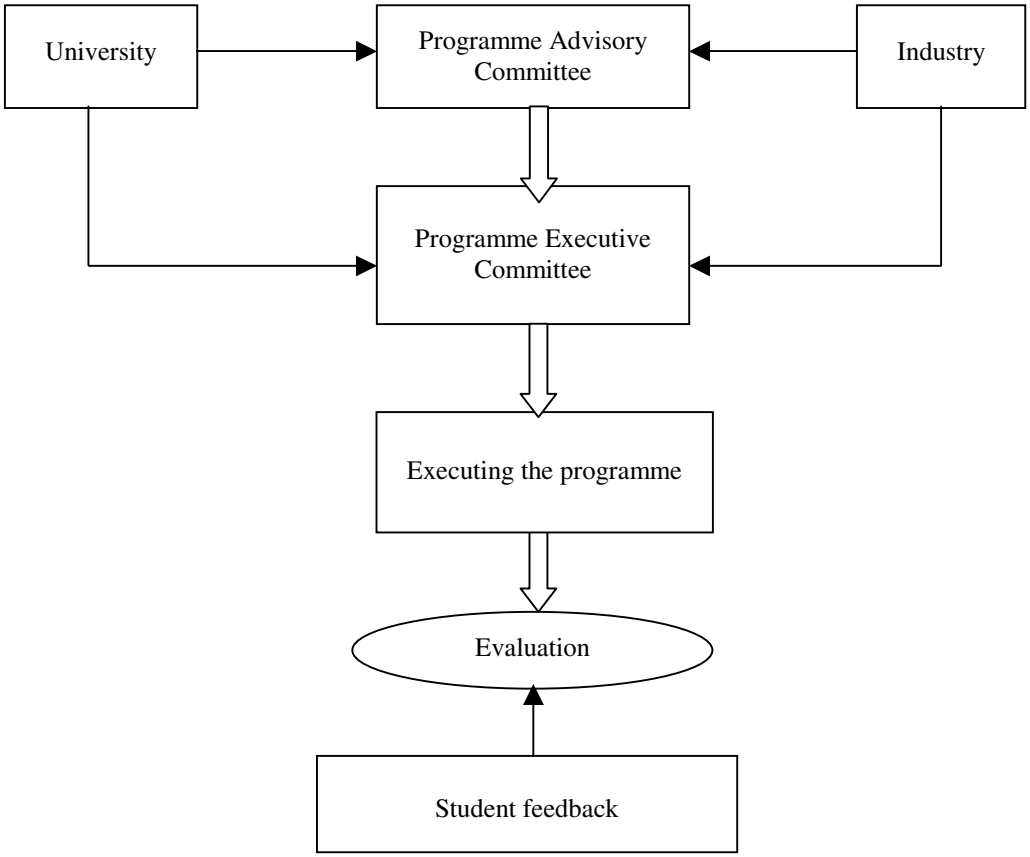

Figure 3: Proposal for a teaching programme in industrial maintenance.

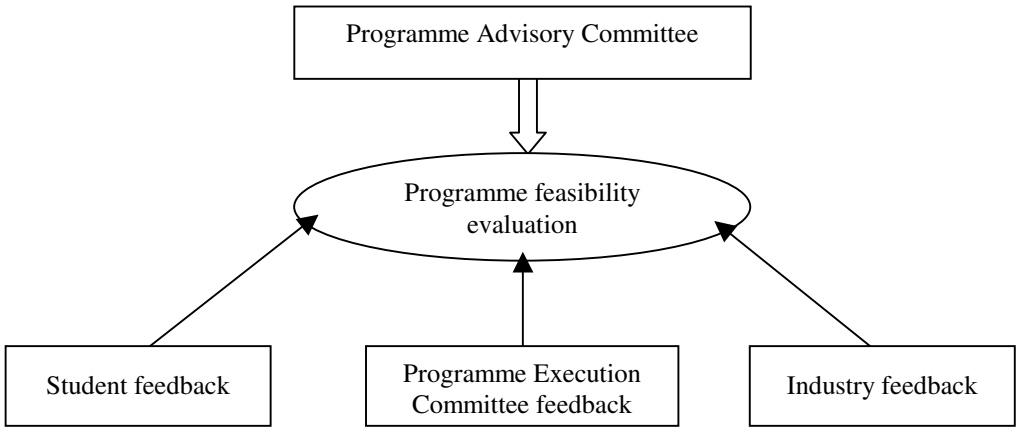

Figure 4: After the programme has run three times in continuity.

specialists. Therefore, it is imperative that more institutions develop such postgraduate programmes in industrial maintenance. When doing so, they should also keep in mind its interdisciplinary nature. Industry should be closely involved in the design and execution of such a programme so that the programme remains relevant.

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