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QFD in new production technology evaluation

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Abstract

The large number of new technologies being developed means it is vital for organisations to make appropriate selections that will translate limited capital resources into maximum competitive advantage. However, a thorough economic evaluation of a technology requires considerable time and effort. This paper presents a tool developed from the techniques of quality function deployment. This tool allows a rapid evaluation of the feasibility of using the thixoforming process to manufacture products. The paper describes the semi-solid metal processing technology of thixoforming, the relevant quality function deployment techniques and the approach used to develop the tool. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Computer Aided Design, Computer Aided Manufacture, Computer Integrated Manufacture, rapid prototyping, high-speed machining, hot isostatic pressing and thixoforming are just a small selection of the many innovative technologies being promoted around the world. All of these technologies have the potential to provide manufacturing organisations with a competitive advantage over their competitors. The major difficulty though is in selecting and investing in the most suitable technology. Not only does an organisation have to make this selection accurately but also rapidly if it is not to lose the opportunity to an ambitious competitor.

Investment in many of these technologies involves a degree of risk, especially for those with few or no existing commercial applications. In these cases the lack of available process expertise means that investment in research and testing will be necessary to develop a stable and reliable process. For such a developed commercial application the benefits which have been attributed to the technology by its proponents may not appear as anticipated. There is therefore a need to ensure that this investment and development effort is not wasted on inappropriate technologies.

Investment appraisal techniques have been refined over a number of decades to provide a reasonable financial measure of the value of making an investment in capital equipment. Techniques used include Payback Period, Net Present Value and

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Internal Rate of Return. The benefits offered by these new technologies are not always directly quantifiable (e.g. increased process flexibility) and cannot be included in conventional financial appraisal approaches. Primrose [1] has shown how such benefits can be accurately quantified, but the level of detail required in such an accurate economic viability analysis requires a significant time and allocation of resources.

There is a need to subject these technologies to some kind of filter before an organisation commits itself to the requirements of an in-depth economic analysis.

Researchers in the Department of Engineering Materials at the University of Sheffield have been involved in the development of one such innovative manufacturing technology. The technology for the semi-solid processing of metals, also called thixoforming, has been available for some years. Although commercialised in Japan, the US and Europe it has yet to be commercialised in the UK despite the many benefits promised. A three year study on the "Exploitation of Semi-Solid Processing" was embarked upon to provide stimulus for this adoption. One of the key components of this work was a software package for potential users of the technology. This software "ThixoCost" was to provide facilities for carrying out a "Cost–Benefit Analysis" of the technology using a business process perspective, for the application circumstances of any user company. During the development of this software it became obvious that before the managers of a company were able to commit the resources necessary for gathering the cost data for such an analysis, they wanted an "expert" opinion on whether their particular products were likely to be suitable.

Part of the aim of the project became to analyse the experience held within the Thixoforming Research Group and incorporate it, in a structured way, into a decision making tool within the software, to offer users such an opinion.

Initially, the application of a neural net was considered. This could accept as inputs, measures of relevant attributes that characterise a product. The net could be trained with the details of existing commercial thixoformed products and those of products currently recognised as unsuitable. The small number of existing commercial users of the technology meant that the availability of such training data was limited and difficult to obtain, effectively preventing the use of this approach.

Quality function deployment (QFD) was therefore considered as an evaluation tool. This paper describes the process used to develop this tool and highlights its potential for application to technologies other than thixoforming.

2. Introduction to thixoforming

The opportunity for forming processes based upon semi-solid metal alloys was first recognised by Spencer et al. [2] while studying the unusual properties of vigorously stirred tin-lead slurries in the early 1970s. The microstructure of the stirred alloy comprises rounded particles of solid surrounded with liquid of a lower melting point, rather than the normal angular and interlocking dendrites (Fig. 1). This microstructure gives the material its thixotropic properties, i.e. when sheared the material flows but when allowed to stand it thickens.

Thixoforming is one member of the family of semi-solid forming processes and possesses characteristics of both casting and forging. The solid feed stock for thixoforming must be pre-treated, so that on heating into the semi-solid state the microstructure is spheroidal rather than dendritic.

A general thixoforming process cell incorporates four operations (Fig. 2):

1. A bar of thixoformable raw material is cut into appropriate slug lengths.
2. The slugs are heated in a controlled manner, using either an induction coil or a muffle furnace into a uniform "mushy" state.
3. The heated slug is transferred to the shot sleeve of a suitably modified die casting machine. Initially, the heated billet of material behaves like a solid, holding its shape unsupported and able to withstand the low stresses of handling. When the semi-solid material is subjected to shear stresses during injection into a die, it flows in a smooth laminar manner and accurately fills the die cavity.