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PROCESS MODELLING FOR MANUFACTURING PROCESS SELECTION

Adil BAYKASOĞLU
Gaziantep Üniversitesi, Endüstri Mühendisliği Bölümü, 27310, Gaziantep, Türkiye

ABSTRACT
This paper explains and discusses the process modelling technique, which is accepted as a modern approach to improve performance of manufacturing and service industries. A case study, which was performed by the author to evaluate alternative manufacturing methods for a car component is explained and presented in the paper. It is shown that via process modelling it is possible to make good decisions for process selection in order to optimise product cost and cycle time.

Key words: Process modelling, process selection, simulation

ÜRETİM PROSESLERİNİN SEÇİMİ İÇİN PROSES MODELLEME

ÖZET
Bu makale, günümüzde üretim ve servis endüstrilerinin performansları artırmada modern bir yöntem olarak Kabul edilen proses modelleme tekniğini açıklar ve tartışır. Bir araba parçasının alternatif üretim proseslerini değerlendirmek için yazar tarafından bir uygulama çalışması gerçekleştirilmiş ve makalede açıklanarak gösterilmiştir. Bu çalışma ile gösterilmiştir ki, proses modelleme yöntemi kullanılarak ürün maliyetini ve üretim zamanını enazlayacak proseslerin seçimi doğrultusunda iyi kararlar verilebilir.

Anahtar Kelimeler: Proses modelleme, proses seçimi, benzetim

1. INTRODUCTION

In today's challenging production environments, managers are being asked to cut costs while maintaining or even increasing production and quality. This often requires organisations to dramatically change how they operate. Inefficient ways of doing production, that may have evolved over many years, must be streamlined to improve performance [1].

However, because of the difficulty in predicting the effect of major changes, such changes are often viewed as risky and avoided. But today's rapidly improving technology offers ways to test proposed changes before implementing them like *computer-based process modelling*.

The process modelling allows detailed analysis before incurring the risk of making major changes to existing processes or implementing new ones. Process models are used to facilitate an organisation's understanding of HOW it currently operates and WHAT it actually does [2]. To investigate the way in which business processes may be constructed and/or re-engineered, it is necessary to define what a process is. Moreover via process modelling it is possible to investigate alternative technology insertions to reduce product costs and manufacturing lead-time.

The synthesis of many approaches that companies and consultants used for Business Process Reengineering has resulted in the identification of a five stage composite methodology.

- Phase 1 Identify or create corporate, manufacturing and IT strategies.
- Phase 2 Identify key process(es) and performance measures.
- Phase 3 Analyse existing process(es).

- Phase 4 Re-desing and implement process(es)
- Phase 5 Monitor and continuously improve new process(es).

From the experiences, of practitioners it is evident that the majority of effort is expended in phases two and three of the methodology. In the main, these phases require the identification of process boundaries, and the construction of AS-IS process models for highlighting current situations [2]. Here the *process modelling* comes into play to speed up and direct the re-engineering efforts towards success.

The process modelling is already available in many leading European and US companies. But the development of methods to optimise production processes is still one of the core tasks of corporate planning. Furthermore, in view of dynamic markets and changing conditions companies have to be able to analyse and adjust their production processes on an ongoing basis.

This paper explains the process modelling to give the reader a deeper insight on what the process modelling is. A case study is also carried out using SIMPROCESS™ a state of the art process modelling and analysis tool to show usefulness of process modelling in selecting alternative manufacturing processes in discrete part manufacturing.

2. WHAT IS PROCESS MODELLING?

Process modelling is a sub-component of *enterprise modelling*. The objective of *enterprise modelling* is to develop a repository regarding organisational elements and functions that maps information objectives with business functions. This is accomplished through an exhaustive process that analyses and models the business to a level of detail sufficient to enable selection of appropriate technologies and design of specific information systems [3].

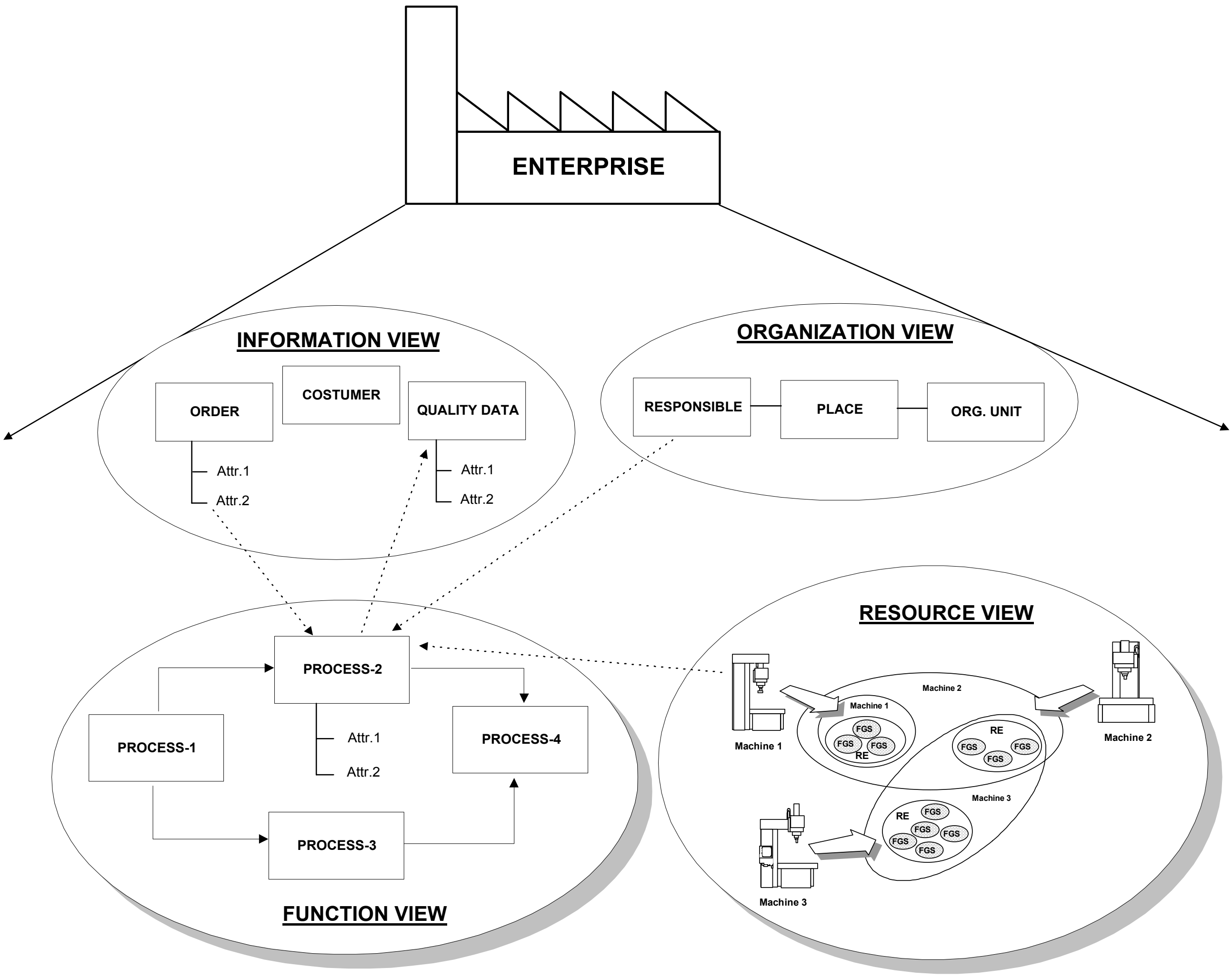

Figure 1. The process modelling within the enterprise modelling

An enterprise can be viewed from various perspectives depending on the kind o information required. Usually this is of the type, what work is going to be done, who will take the decision etc. An enterprise has *informational*, *organisational*, and *functional* and *resource* based content. Figure 1 indicates some of the views that an enterprise has. The process modelling can be related to functional view where activities are carried out within processes and resources consumed to accomplish activities.

The goal of the process modelling is to create a ***simplified*** but ***useful*** model of a business enterprise. The enterprise can be an entire company or a particular division of a company or a related set of departments.

The purpose of the process modelling is generally to achieve the following:

- Determine the ***bottlenecks***
- Determine ***non-value adding*** activities
- Devise ***revisions*** to the process to improve performance
- Generate ***alternative*** process designs and select the one, which gives best results
- Provide cost ***justification*** to planned alternatives
- Establish performance ***targets*** etc.

The process modelling can also be considered as a useful prerequisite of process re-engineering. In order to speed up and carry out the process modelling activity effectively, it is highly recommended by the practitioners to use a computer-aided integrated tool. Several tools are available in the market for this purpose each having different level of sophistication and capability. Reference [4] presents a good review and analysis of these tools. As a guide, it is suggested that such tools should presents the following capabilities in an integrated manner in order to realise the most of the benefits of process modelling (see Figure 2):

- Process mapping,
- Simulation
- Activity based costing (ABC).

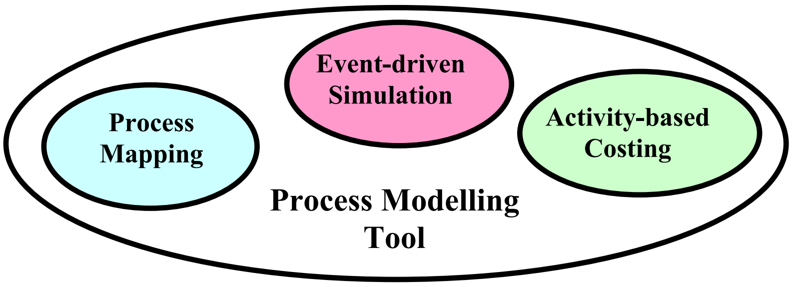

Figure 2. Components of an integrated process-modelling tool

The process models are generally constituted from three main building blocks, namely:

- Processes
- Resources
- Entities (flow objects)

These building blocks also bridge ABC with dynamic process analysis.

The **ABC** embodies the concept that a process consists of activities that convert *inputs* to *outputs*. The process modelling manifests this concept, and builds on it by organising and analysing cost information on the *activity* basis.

A ***process*** represents behaviour that may require some amount of time to be performed. The ***resources*** represent the objects that are needed to perform a task. The ***entities*** flow through and, possibly, are transformed by processes. An overall framework is shown in Figure 3, which depicts the practice of the process modelling, how the process models can be generated and seamless integration of its components.

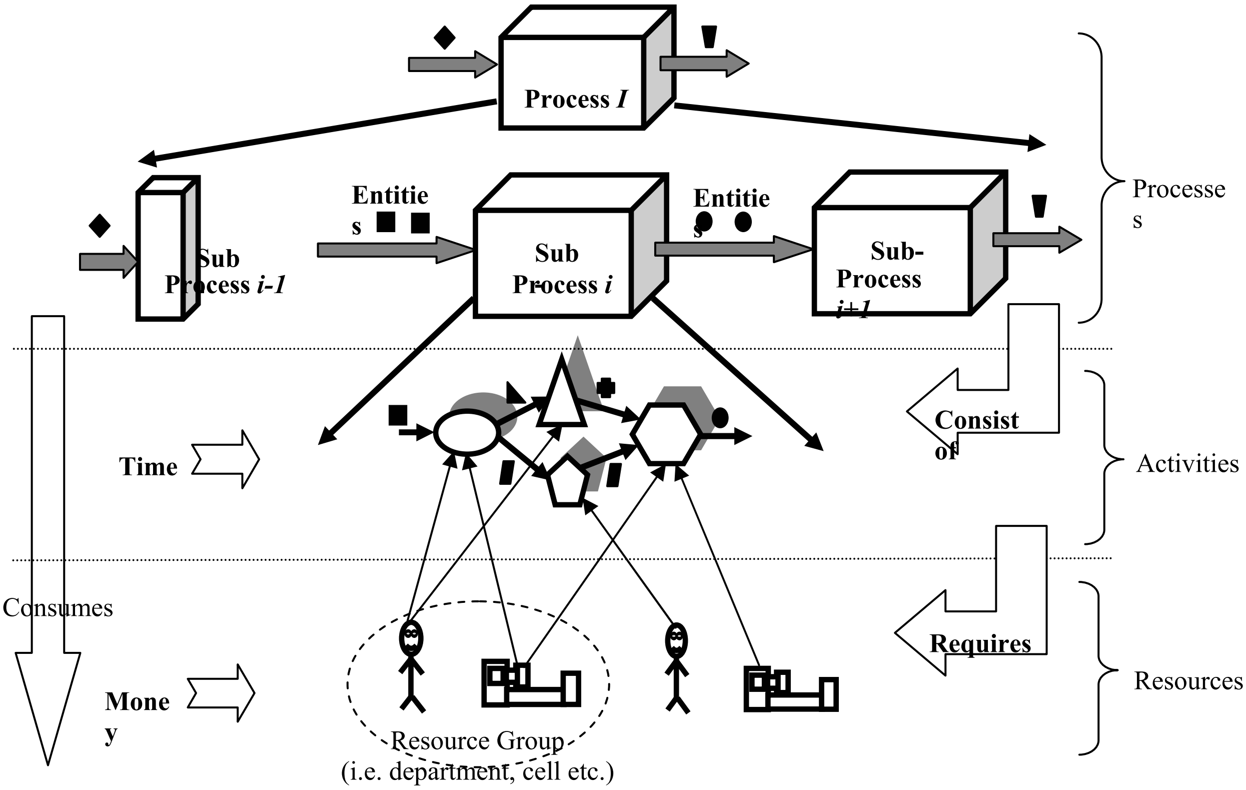

Figure 3. Process modelling framework

There are generally four main steps to model a process.

STEP-1: Create the Process Model
- Firstly determine the activities and processes, and link them using connectors to define process flow.
- Secondly define the entities and resources used in the model.
- Thirdly customise the behaviour of the model and create a realistic model by populating it with the correct data.

STEP-2: Simulate the Process
- Select the performance measures of interest: cycle time, utilisation, activity costs etc.
- Define the type of reports to be generated

STEP-3: Analyse the Results

STEP-4: Evaluate Alternatives
- The primary purpose of the process modelling is to evaluate alternative processes. This can be achieved by defining *Alternative sub-process constructs* of a process.

3. CASE STUDY

In the present case study alternative-manufacturing methods for a *Hydraulic Lift-Control-Valve Actuating* of a car is investigated. First, the present production system is modelled and analysed using SIMPROCESS. Then two alternative production methods, which replace several existing processes and modify several other existing processes of the current process chain, are examined for possible process insertion.

The assembly drawing of the product is shown in Figure 4. But it is possible to have several minor design modifications in relation to alternative production processes (i.e. if casting is employed for lever, there may not need to drill a hole on lever for the pin etc.)

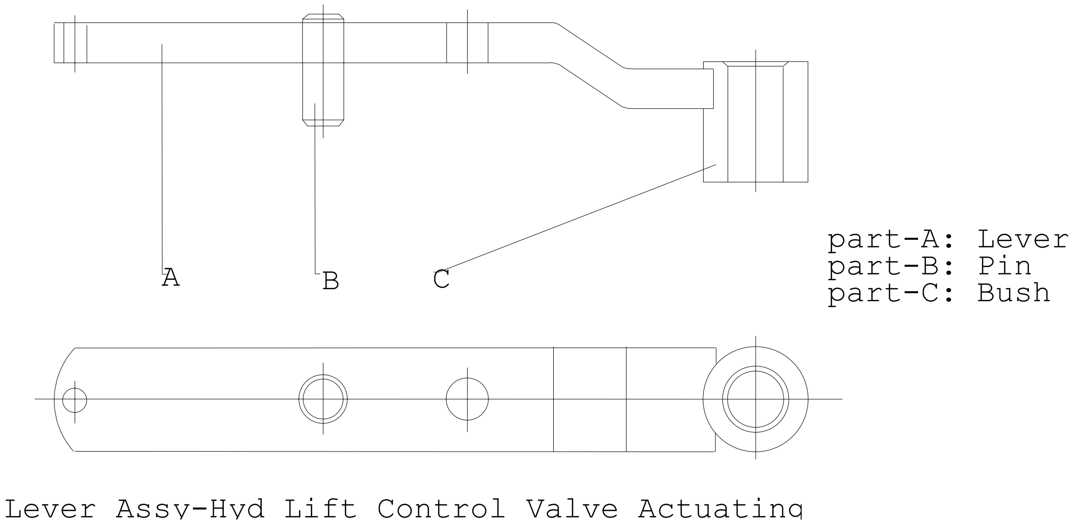

Figure 4. Assembly drawing of the product

The production system is divided into three main processes, namely; *order generation*, ***production*** and *delivery* (see Figure 5).

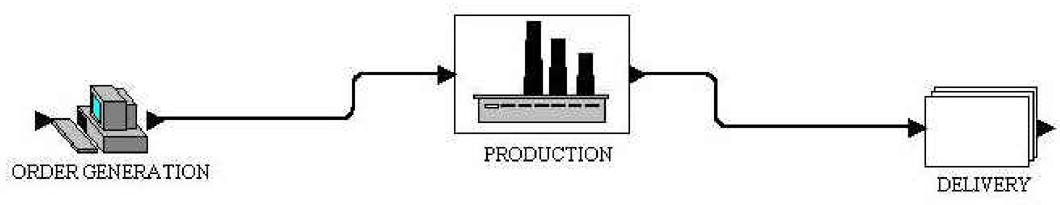

Figure 5. The process model (Top level-1st level in the hierarchy)

The main concentration in this case study is on the *production* processes. The order generation process generates raw-material orders based on the selected manufacturing processes and demand data. Figure 6 shows order generation activities for the current process chain. Similar models are generated for the alternative process chains, which are not depicted here. The delivery process simply disposes the produced products. The developed models are populated with *cost*, *time*, *resource*, *schedule* and other data by using capabilities of SIMPROCESS.

The *current process chain* is mainly composed of metal removing processes (*Material Preparation, Pressing, Turning, Welding, Drilling, Heat Treatment, and Quality Control*). In comparison to proposed alternative process-chains, it contains more machining activities and more material handling. The current process route and several examples from corresponding activities within the processes of current process-chain are presented in Figures 7-10. The cost report in a graphic form for the current process chain is shown in Figure 11. The cycle time in the current process chain is found 10.56 minutes.

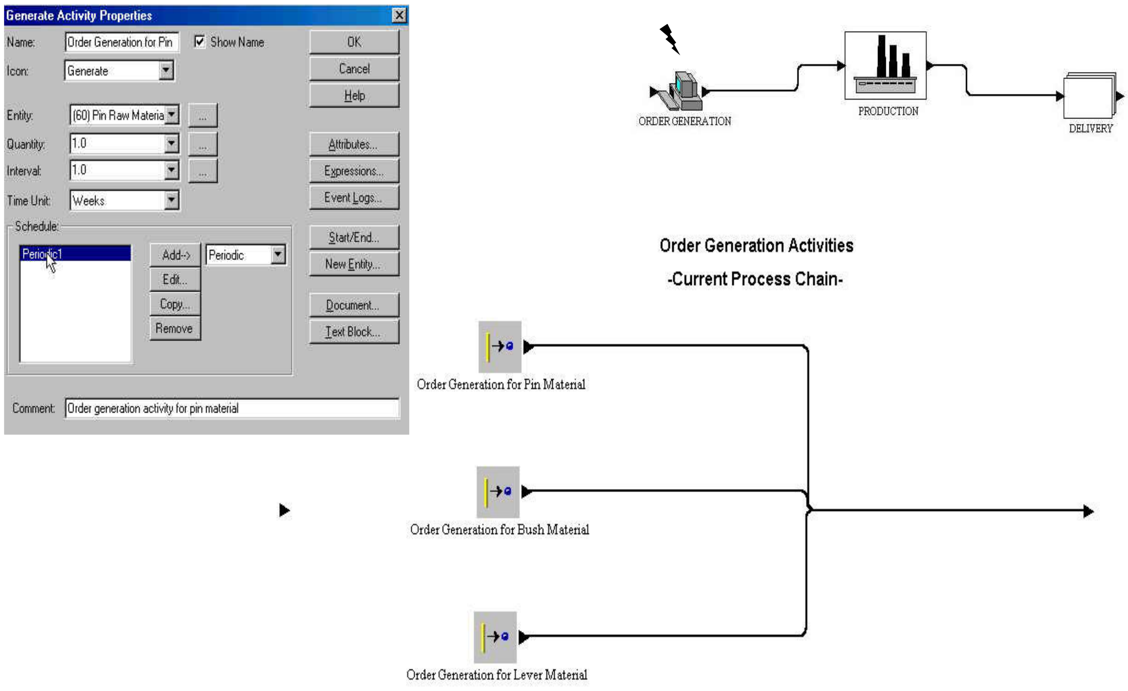

Figure 6. Order generation activities for the current process-chain

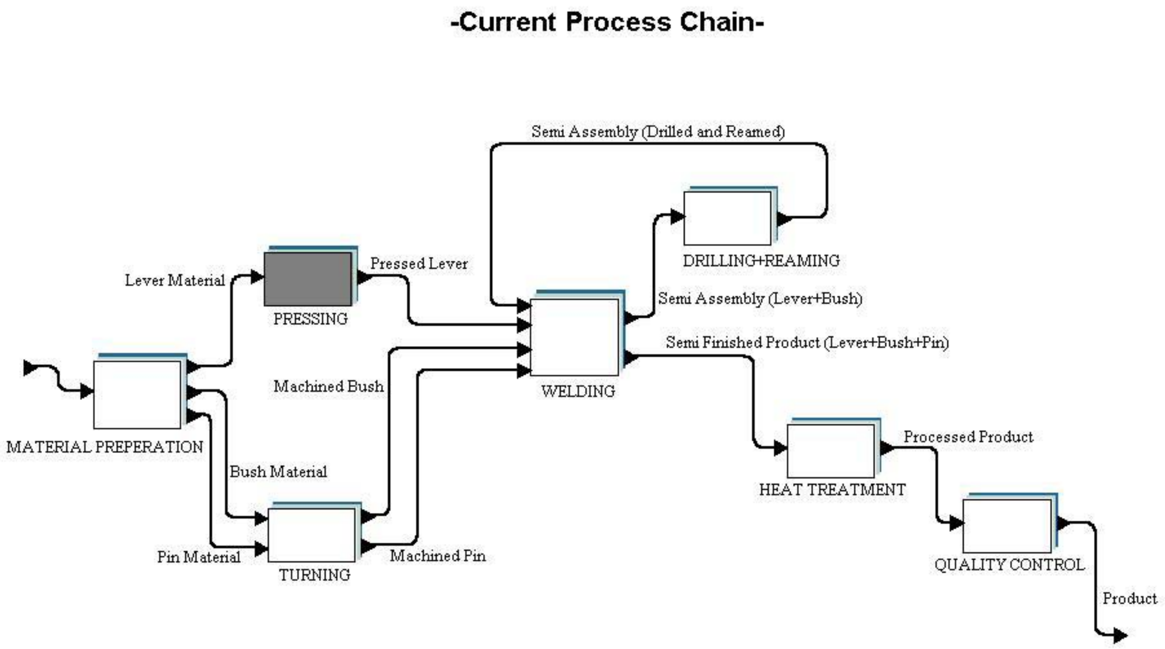

Figure 7. Current process chain

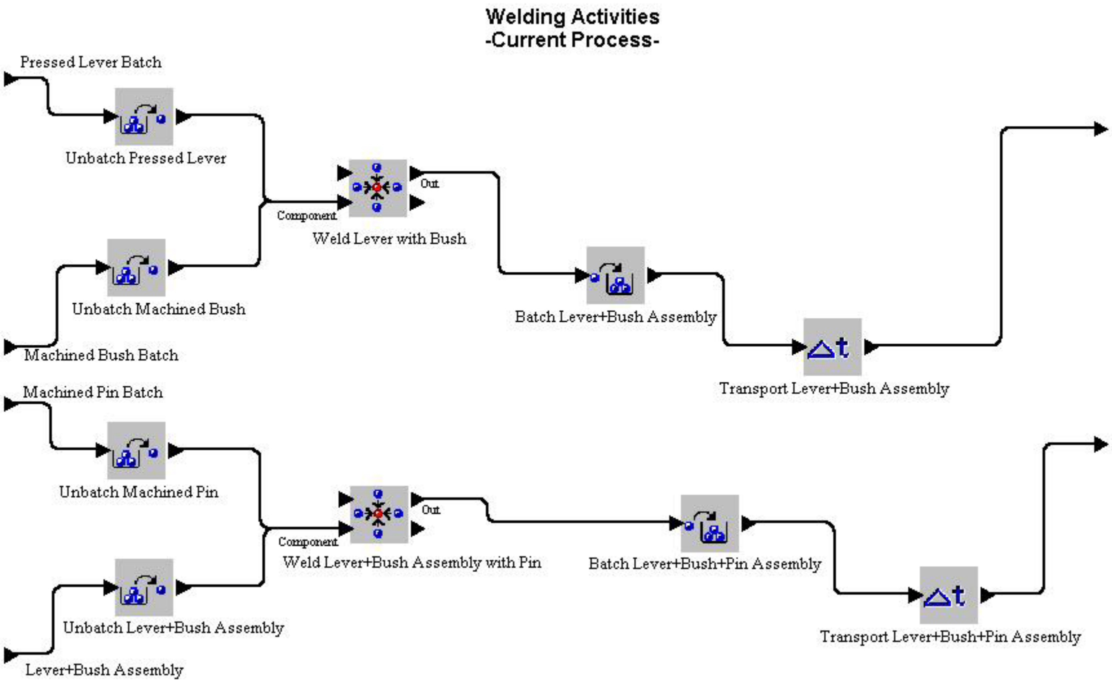

Figure 8. Current process chain for welding activities

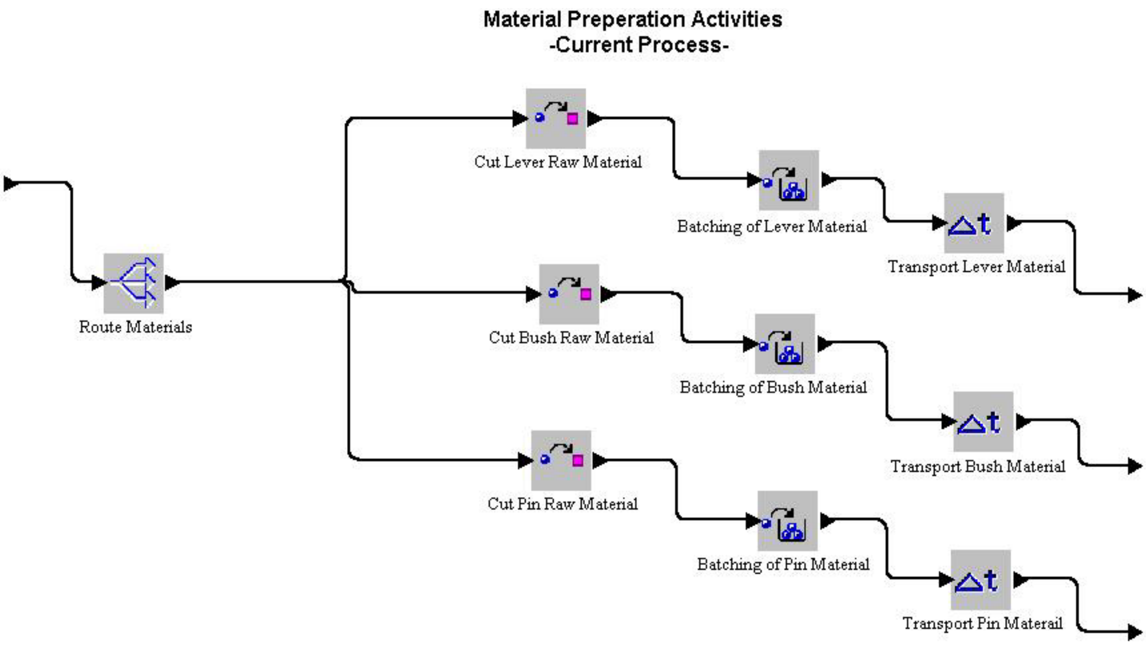

Figure 9. Current process chain for material preparation activities

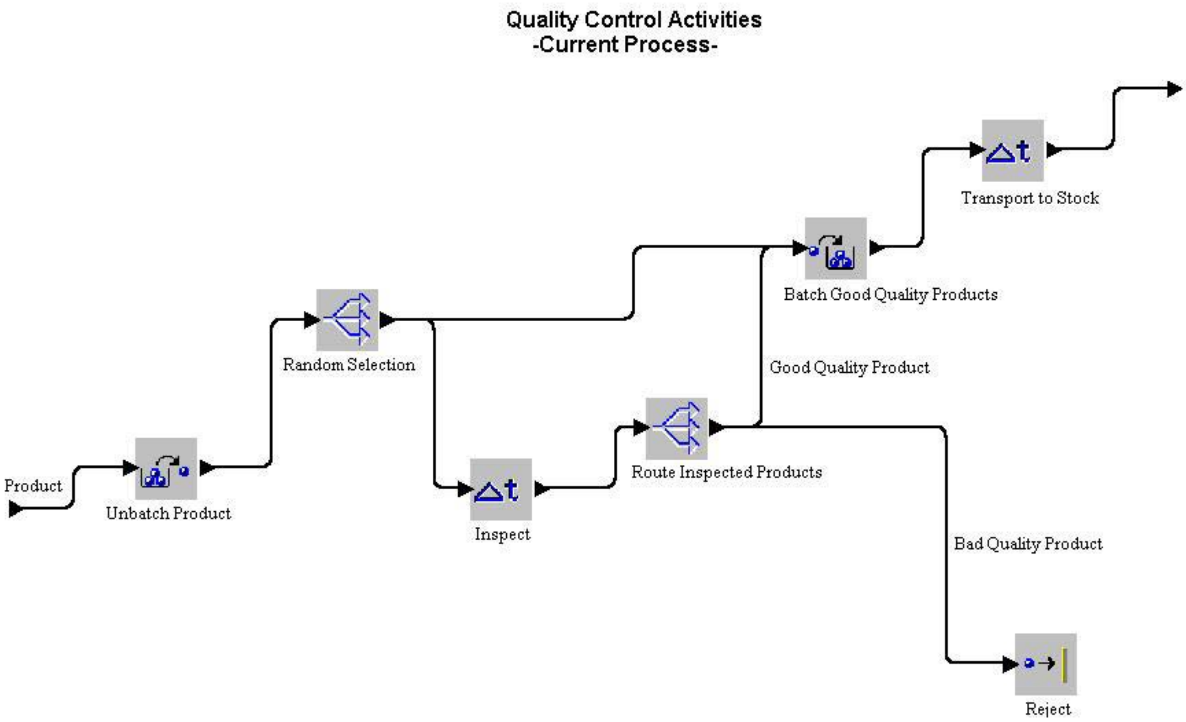

Figure 10. Current process chain for quality control activities

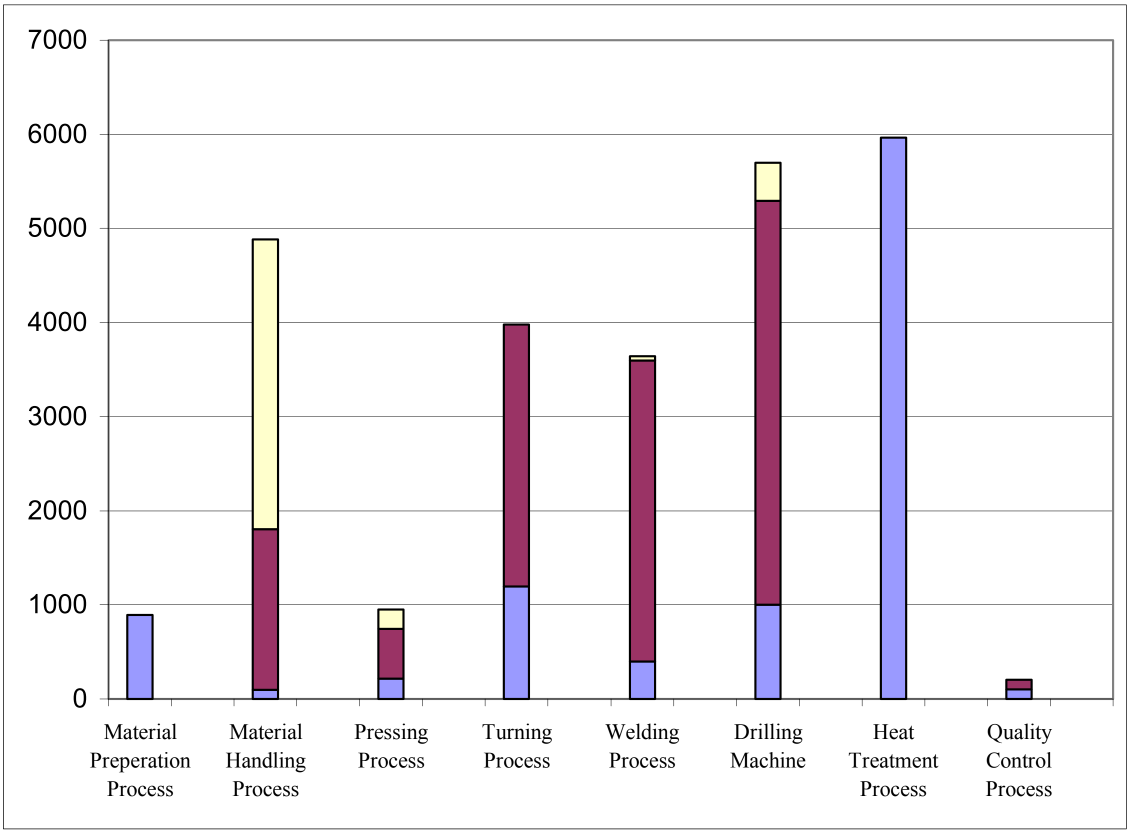

Figure 11. Cost of each process for the current process chain

In order to improve the existing process chain, two alternative feasible candidate process chains are proposed (Modelled by using SIMPROCESS). In the ***first alternative process*** chain, ***Pressing*** process is replaced with ***Forging*** process and Lever and Bush are forged as a single part. Therefore, the number of machining activities are decreased. The first alternative process route and examples from corresponding activities are presented in Figures 12-13. The ***Heat Treatment*** and ***Quality Control*** activities are the same in both process routes. Therefore they are not remodelled. The cost report in a graphic form for the *first alternative process chain* is shown in Figure 14. The cycle time in the *first alternative process chain* is found 9.5 minutes. As can be seen the cost and cycle time performance is slightly improved (i.e. cost from 8 pounds to 6.26 pounds, cycle time from 10.56 minutes to 9.5 minutes).

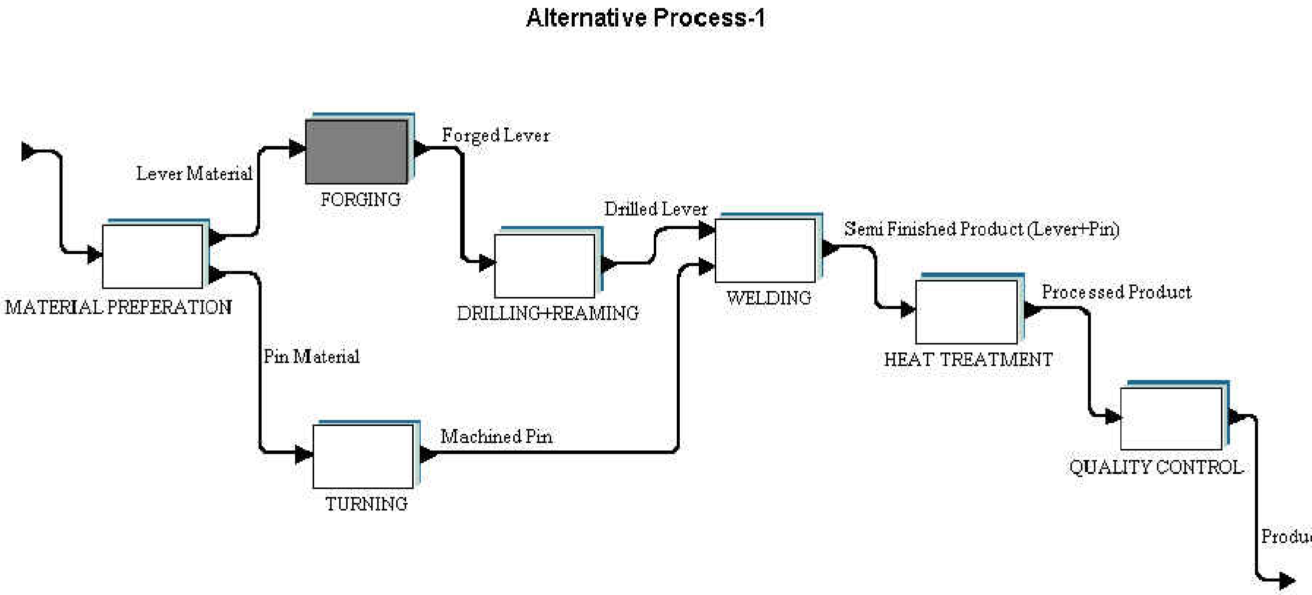

Figure 12. The first alternative process chain

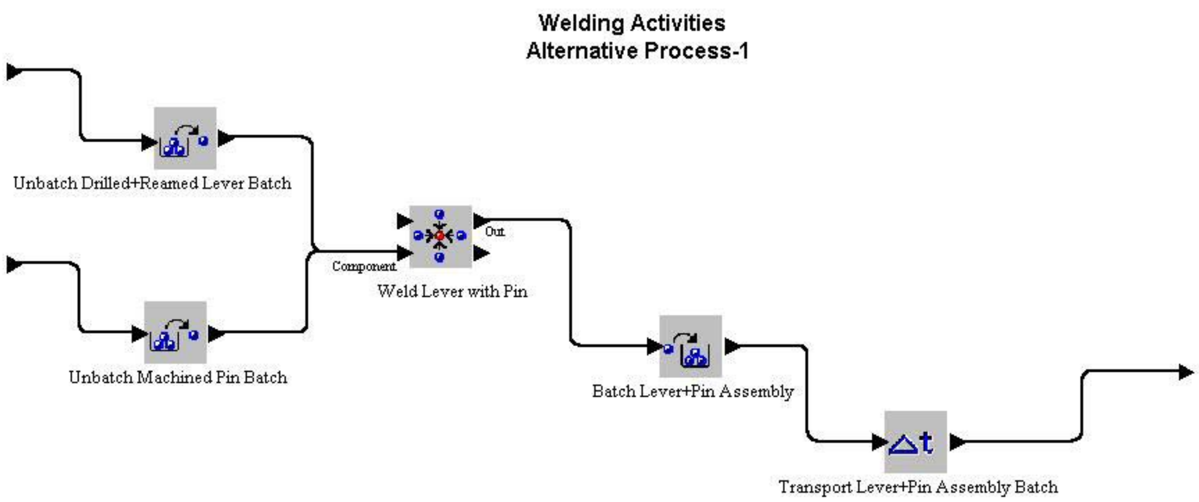

Figure 13. The first alternative process chain for welding activities

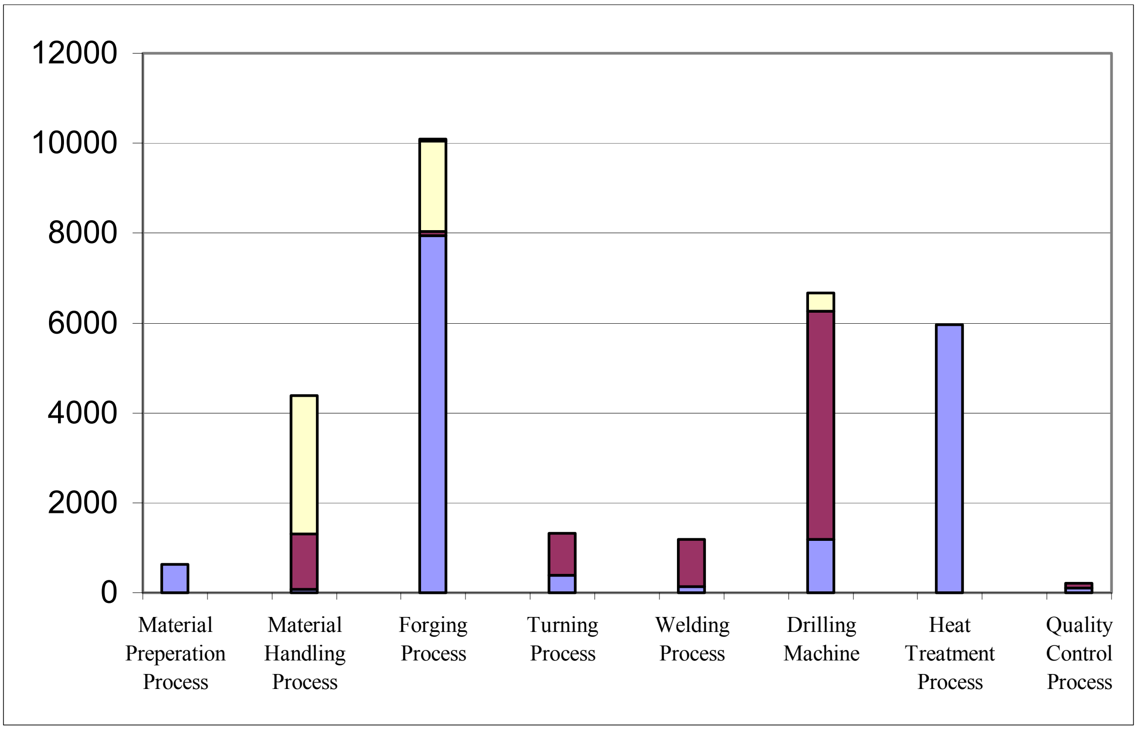

Figure 14. Cost of each process for the first alternative process

In the *second alternative process chain*, ***Material Preparation***, (*Forging* or *Pressing*), ***Turning*** and ***Welding*** processes of the previous two process chains are replaced with a ***Casting*** process. All three components of the product are casted as a single part and the holes are finished. ***Heat Treatment*** and ***Quality Control*** processes are the same in all process chains. In this case, the total numbers of activities are radically reduced. The second alternative process route and the example activities are presented in Figures 15-16. The cost report in a graphic form for the *second alternative process chain* is shown in Figure 17. The cycle time in the *second alternative process chain* is found 3.68 minutes. As can be seen the performance is much better than the previous two process chains (i.e. cost from 8 pounds to 3.7 pounds, cycle time from 10.56 minutes to 3.68 minutes).

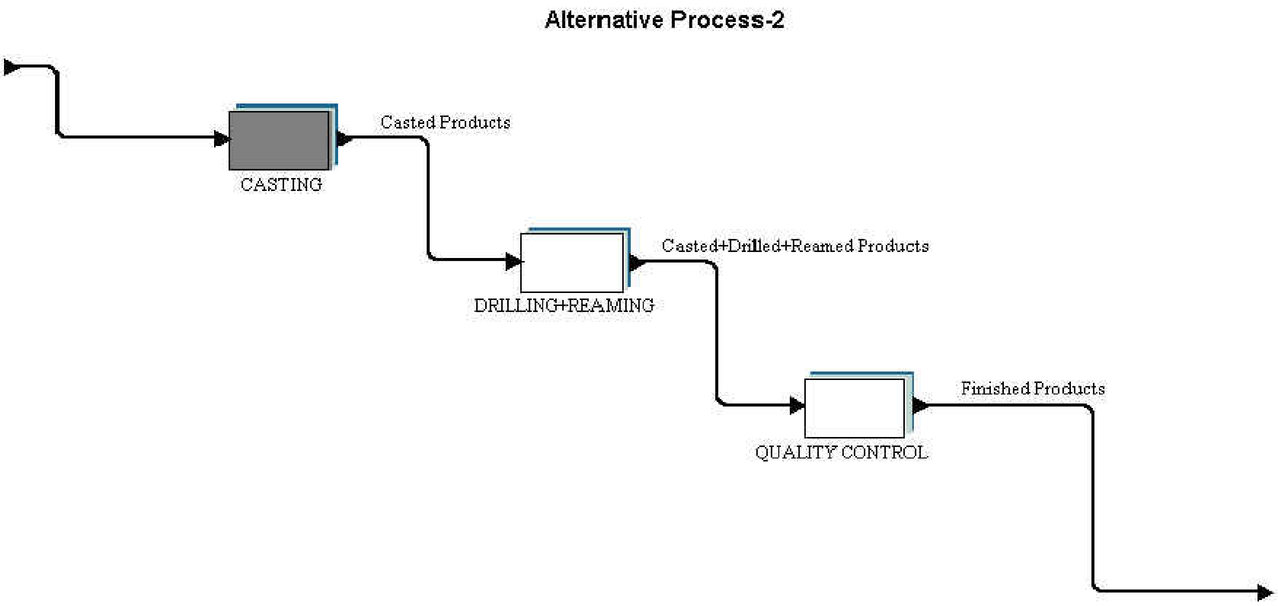

Figure 15. The second alternative process chain

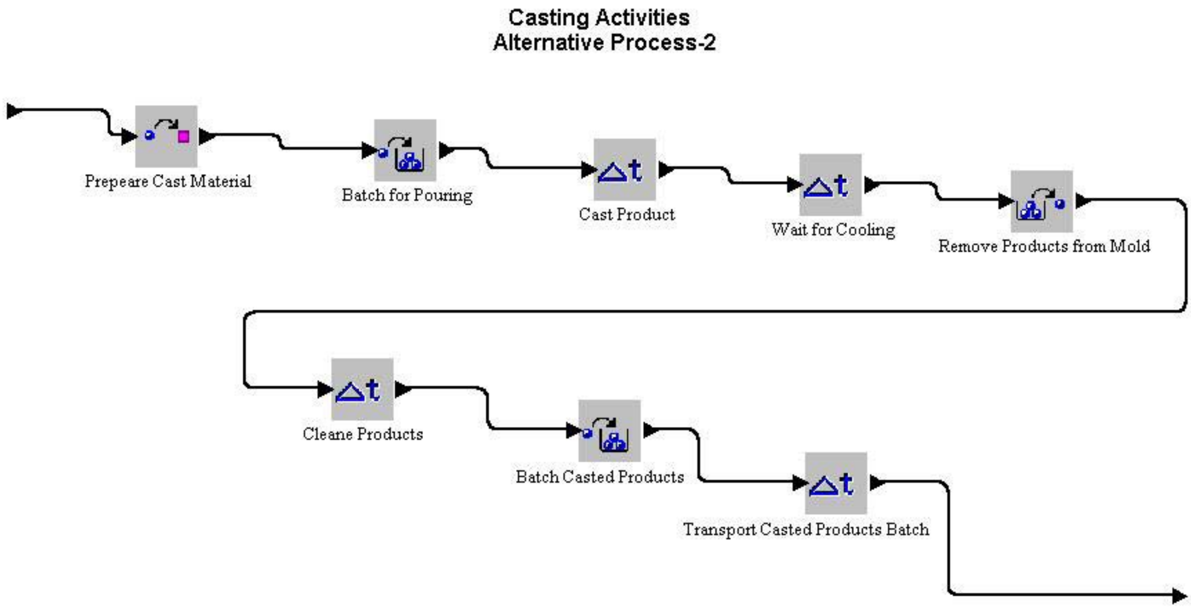

Figure 16. The second alternative process chain for casting activities

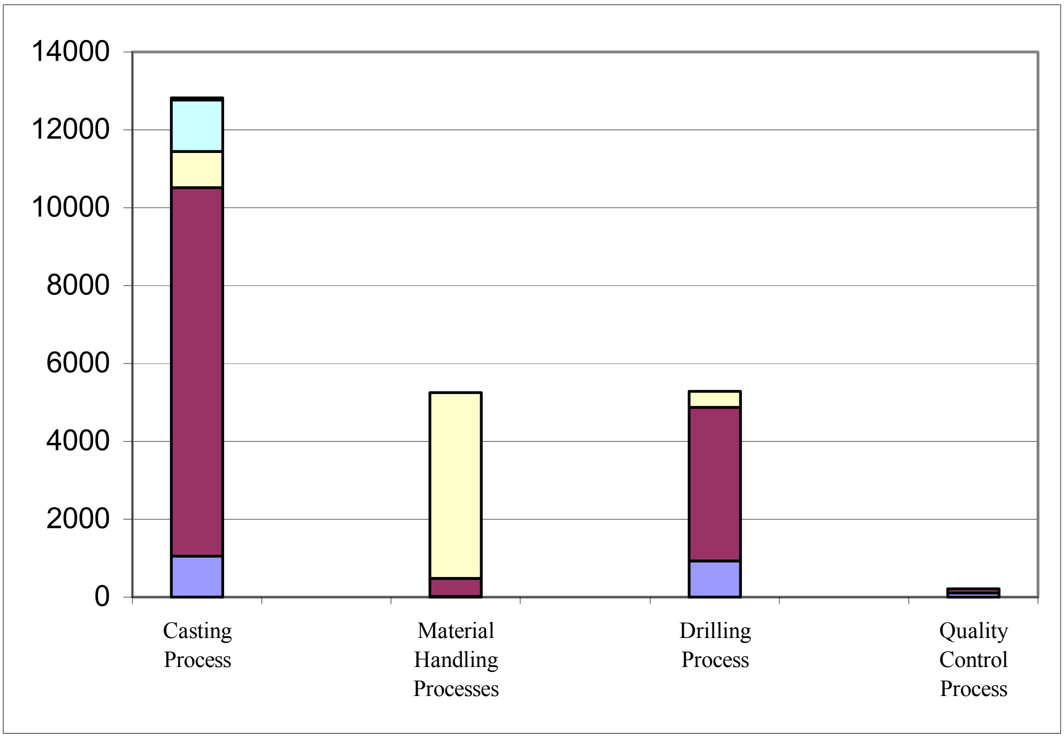

Figure 17. Cost of each process for the second alternative process chain

The overall comparisons of all three process-chains are presented in Figure 18. The second alternative process chain is found as the best performing one.

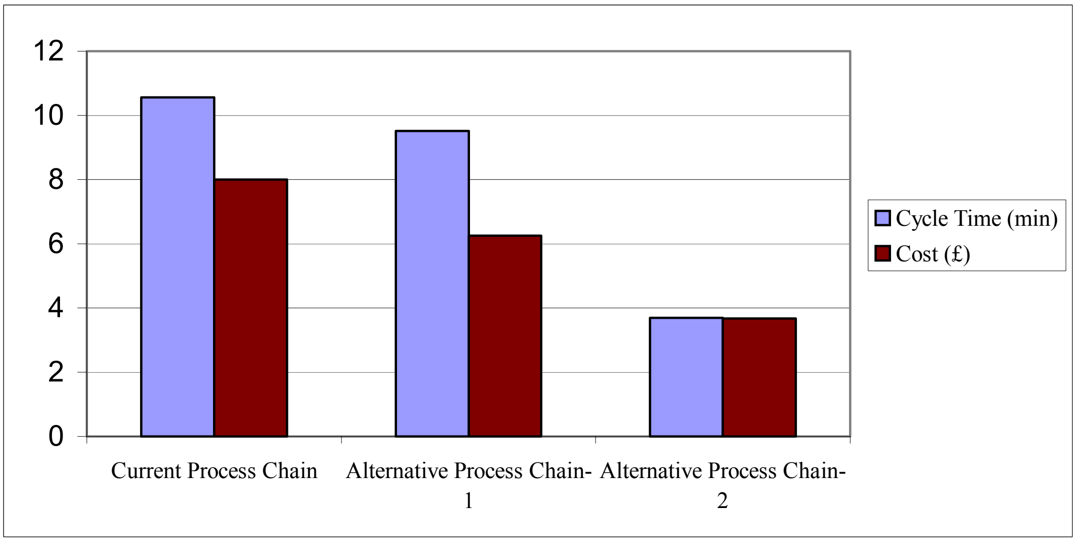

Figure 18. The comparison of alternative process chains

4. CONCLUSIONS

Nowadays, the importance of the process modelling for improving performance of the production systems is being well understood in the industry. Because, it enables effective re-engineering studies, by helping the determination of inefficient links in process chains, the evaluation of alternative design, etc. The process modelling (although it was not commonly referred as the process modelling) was in the manufacturing arena in several simple forms in the past, like manually mapping processes, activity-flow-diagramming etc. But these are all static analysis approaches and require long and complicated manual work and make small contributions to process evaluation-improvement and can not present dynamic nature of production processes. Today's advanced technology created solutions to dynamic process modelling and a discipline named as process modelling is emerged. Via process modelling, it is possible to generate dynamic process models, which can be used as a process map (also requirement of ISO 9000 certification). These process maps may include alternative process designs for the whole process-chain or a section of process chain. It is possible to dynamically simulate the developed process maps to obtain several performance measures of the process. This helps in determining inefficient links in the process-chain. Moreover, several advanced the process modelling tools made a seamless integration of Activity Based Costing (ABC) with process mapping and simulation. This enabled effective product and process costing a very important issue, which is vital in any organisation. It is the author's observation that although its vital importance, the process modelling is still not undertaken by many companies in Turkey and Europe.

This study explains the process modelling and presents a real case study performed by the author in The Nottingham University, UK. It has been observed that by the help of the process modelling, performance of a process-chain can considerably be improved.

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