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# Research into the engineering application of reverse engineering technology

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**Abstract**

Based on previous research on reverse engineering (RE) technology, the engineering application of RE is explored in this paper. The application environment of RE is built with coordinate measurement machine (CMM) and CAD/CAM software. Taking a core die of the inlet of a diesel engine as an example, this paper describes the processes of RE, from object digitization, CAD model reconstruction to NC machining. Measurement data are acquired by scanning the physical object using a three-dimensional CMM. Through processing of measurement data, the authors succeed in creating a CAD model of the die and machining the die, gaining a good result.


*Keywords:* Reverse engineering; Product development; CAD/CAM

## 1. Introduction

Nowadays, competitive pressure has reached the point, where rapid product design and optimization need to be embraced within the product development cycle. A short lead-time in product development is strongly demanded to satisfy needs, resulting from the globalization of manufacturing activities and the changes in market requirements. In engineering areas such as aerospace, automotives, shipbuilding and medicine, it is difficult to create a CAD model of an existing product that has a free-form surface or a sculptured surface. In these cases, reverse engineering (RE) is an efficient approach to significantly reduce the product development cycle.

RE refers to the processes in which designers acquire a design concept of a product from digitization of a physical model, and create the CAD model to realize approximation to the physical model: the model created can be reused, modified and optimized [5]. By RE technology, the geometric shape of an existing part or product is measured. Based on this measurement data a complete and complex CAD model is created. RE has two key technologies, i.e. digitization of a physical model and creation of its CAD model.

## 2. Working processes of RE

Differing from the traditional design idea and method, RE technology enables one to start a design from an existing product model by combining computer technology, measurement technology and CAD/CAM technology. RE has been of interest in many different branches such as automotives, shipbuilding, electronics, and medicine. It is often used in cases such as the following [3]:

(i) Where a prototype of the final product has been modeled manually and therefore no CAD model of the prototype exists, e.g. clay model in automotive industry.
(ii) Where a CAD is introduced in a company and all existing products must be modeled in order to have a fully digital archive. Particularly, the CAD model of a complex shaped part is modeled because it is difficult to create its CAD model directly.
(iii) Where complex shaped parts must be inspected and therefore the RE model created will be compared to an existing CAD model.

The RE process can principally be seen as a process chain that is composed of three main operations as follows [5]:

(i) *Digitization of the object*: The three-dimensional shape of the product is acquired by any appropriate measurement method.

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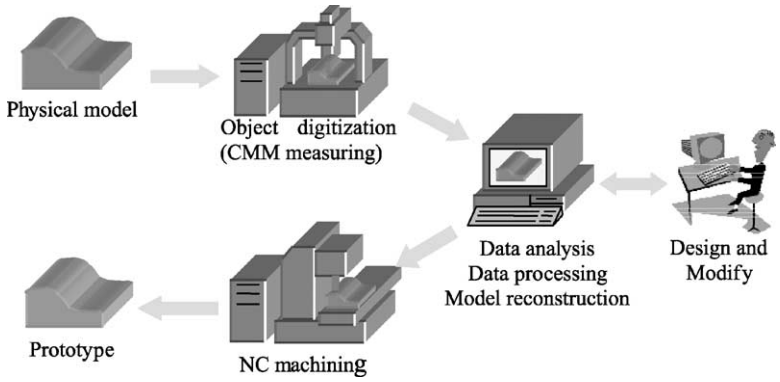


Fig. 1. Working processes of RE.

(ii) *Processing of measured data*: The three-dimensional data acquired is processed in order to fulfill the requirements of the following operation.
(iii) *Creation of a CAD model*: A complete CAD model of the product must be built in order to represent all relevant data of the product.

Fig. 1 shows the working processes of RE. The whole process of RE should be computer aided.

## 3. Engineering application of RE

Based on principle of RE technology mentioned above, the authors applied RE technology in the design and manufacturing of the die of a diesel engine. Taking the core die of the inlet of a diesel engine as an example, this paper describes the RE processes, from object digitization, CAD model reconstruction to NC machining.

The inlet is the key part in a diesel engine. It influences the characteristic of the diesel engine to a great extent. Because the inlet has very complex shape (see Fig. 2), it is difficult to create a digital model of the inlet, as well as to manufacture the core die of the inlet. The authors have therefore taken it as an example to research the engineering application of RE technology.

Fig. 2. The 3D model of the inlet.

### 3.1. Environment of RE

The environment of RE is a local area network (LAN), which is built with two work-stations, two NT work-stations, three sets of PC, a coordinate measurement machine (CMM) and three NC machines. The hardware platform uses level disposition of work-stations and PCs. The main application software utilized is the Unigraphics CAD/CAE/CAM integrated system and KUM measurement software provided by the zess company. The operating systems utilized are HP-UX 10.2 on work-stations and Windows NT on PCs. Fig. 3 shows the environment of RE. With computer network, the RE processes, i.e. object digitization, processing of measurement data, creation of a CAD model, and NC machining, are realized in a integrated environment on computers.

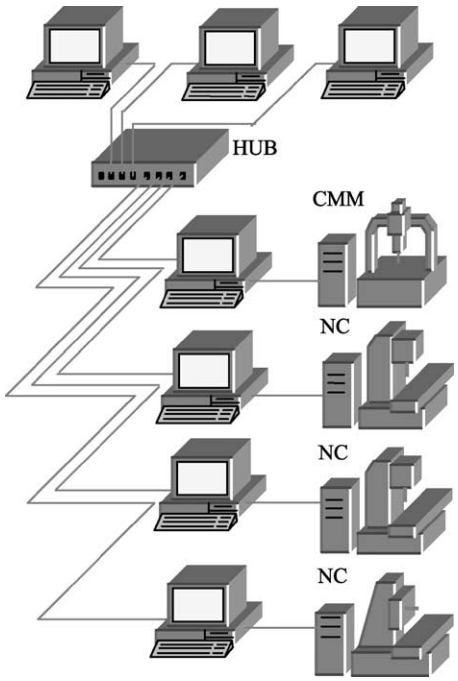


Fig. 3. Environment of RE.