

Management of Technology Transfer in Developing Countries: Re-Engineering an Suitable Option for Iran

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Abstract. Technology management arrangements of developing countries vary from those of developed ones, and management of technology transfer during the recent years has been among the cases that has allocated the biggest mental disturbance of senior managers of engineering and manufacturing organizations in developing countries such as Iran. One of the questions that have always been raised is that how Iran can decrease its technological distance with that of developed countries in the shortest time and have a suitable share in the global business. This can be achieved through reverse engineering which includes any activities to determine how a product works or to learn the ideas and technology that were originally used to develop the product. It provides a systematic approach for analyzing the design of existing devices or systems. It can also be use either to study the design process, or as an initial step in the redesign process, in order to observe and assess the mechanisms that makes the device work or dissect and study the inner workings of a mechanical device.

Studying about countries like Iran which haven't obtained technology in the course of time, but have tried to encompass it at a point in time, shows that one of the best way to achieve technology transfer is the extensive application of reverse engineering method to determine how a product functions, its fabrication, and then develop it with respect to its own needs. Supervision for good execution of systematic reverse engineering process and the application of engineering tools and techniques in this process could have an appropriate impact on reaching technical knowledge of products in the shortest time possible and with minimum cost.

The aims of this study is to explain briefly the steps needed to manage the different strategies of technologies management, role of research and development in achieving them, as well as how to select appropriate reverse engineering strategies as a suitable way towards technology transfer in order that Iran can meet its own demand for new compatible industrial product in a cheaper way as well as market expansion, exporting purposes and, in one way or another, to overcome the imposed economic sanction against her by some countries. The result of this inquiries shows that, in short run, application of re-engineering method is one of the best solution to decrease technological gap from that of industrial countries and to meet its mentioned purposes.

Keywords: management of technology, developing countries, reverse engineering, research and development, production, technology transfer

1. Introduction

Management of technology in developing countries is different from those of first world ones. The requirement for skill in these countries is not growing from within, but somewhat cropping up from new wares imported from first industrial countries. Technological growth in addition does not consequence from inner data and research, but resulting upon the technology transmission from abroad. In these environments, technology management by customary way is barely effective. These are troubles facing some developing

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countries these days and as a consequence organizations controlling the technology management endure non compliance, then technological development does not trail an accurate trend.

Reverse engineering is the process of discovering the technological principles of a human (or non-human) made device, object or system through analysis of its structure, function and operation. It often involves taking something (e.g., a mechanical device, electronic component, biological, chemical or organic matter or software program) apart and analyzing its workings in detail to be used in maintenance, or to try to make a new device or program that does the same thing without using or simply duplicating (without understanding) the original.

Reverse engineering is applied for retrieving and specifying constituting elements of a product especially in case of lack of access to the primary designing and is used for maintenance, development and extension of the existing possibilities and re-engineering. It has its origins in the analysis of hardware for commercial or military advantage. The purpose is to deduce design decisions from end products with little or no additional knowledge about the procedures involved in the original production.

This method is an accepted strategy for developing countries. Degree of lack of technical information to protect production of a product is determined in this process. Then it is tried to achieve specific documents and maps in order to design the product by performing an integrated team work consisting of experts and researchers of various basic sciences along with suitable management and organization of research and development setting. It is tried to perform pattern-making and semi-industrial phases and product fabrication and production if necessary by considering properties, purposes and conditions of designing of products, national and common standards as well as covering of unknown points.

Research and development activities in generic concept have always two products: knowledge and technology. Role of research and development activities in creating technology is to the extent that the intellectual say technology is a product which has been produced in research and development factories.

Technology is the master key of development and the most powerful factor of economic revolution in societies. A complex combination of four elements is represented in atlas technology as below:

- Hardware and machineries
- Technical knowledge or information tools
- Abilities including human proficiencies and initiatives
- Technology management and organization including mechanisms that are needed to facilitate effective merging of the above elements. Now that importance of technology in national development and role of research and development in achieving technology have been illustrated technology life phases are mentioned.

Life cycle of each technology includes the following phases:

Designing phase, introduction phase, growth phase, maturation and saturation phase and stagnation phase

2. Application of Reverse Engineering

Reverse engineering is one of the methods by which companies applied to accelerate their product evolution process. This method in the developing countries like Iran, that are not so advanced in terms of product and technology designing knowledge as compared to that of the developed countries, is a response to increase designing capability and accelerate the evolution process, and further can be applied in the following circumstances:

- Interoperability.
- Lost documentation: Reverse engineering often is done because the documentation of a particular device has been lost (or was never written), and the person who built it is no longer available.
- Product analysis. To examine how a product works, what components it consists of, estimate costs, and identify potential patent infringement.
- Digital update/correction. To update the digital version (e.g. CAD model) of an object to match an "as-built" condition.
- Security auditing.
- Acquiring sensitive data by disassembling and analyzing the design of a system component.
- Military or commercial espionage. Learning about an enemy's or competitor's latest research by stealing or capturing a prototype and dismantling it.
- Removal of copy protection, circumvention of access restrictions.
- Creation of unlicensed/unapproved duplicates.
- Materials harvesting, sorting, or scrapping.
- Academic/learning purposes.

- Curiosity.
- Competitive technical intelligence (understand what your competitor is actually doing, versus what they say they are doing).

Learning: learn from others' mistakes. Do not make the same mistakes that others have already made and subsequently corrected.

2.1. Benefits and Achievement of Reverse Engineering

Reverse engineering examine how a product works, what components it consists of, estimate costs, and identify potential patent infringement. Some of re-engineering achievements are discuss below:

- Create the capability and technical-technological reinforcement of fabrication through recognition and perfect perception of the product (gaining technical knowledge of the product) and create self-confidence in engineers and experts of industry in confronting with industries and internal technologies
- Possibility of designing a timely product at the level of international standards by discovering of new methods of product development and improvement to satisfy customer's needs like better performance, adding characteristics and eliminate deficiencies of the product. Also satisfaction of needs of the market like changing or improving of the technology or reduction of costs
- Creating of potential ability for attraction to transfer advanced technologies
- Training of the required specialist force in strategic industries
- Establishing of systematic steps to help perceive and document designing and its process
- Possibility of competitive modeling to understand competitors' products and better development of one's own products
- Possibility of performing reverse engineering by means of obtained technical knowledge through reverse engineering

2.2. Example of Reverse Engineering

A typical workflow in reverse engineering could involve scanning an object and recreating it. These steps are illustrated below.

Step 1: A cloud of points taken from scanned data using a digitizer such as a laser scanner, computed tomography, or faro arms.

Step 2: Convert the point cloud to a polygonal model. The resultant mesh is cleaned up, smoothed, and sculpted to the required shape and accuracy.

Step 3: Draw or create curves on the mesh using automated tools such as feature detection tools or dynamic templates.

Step 4: Create a restructured spring mesh using semiautomatic tools.

Step 5: Fit NURBS surfaces using surface fitting and editing tools.

Step 6: Export the resulting final NURBS surface that satisfies accuracy and smoothness requirements to a CAD package for generating tool paths for machining.

Step 7: Manufacture and analyze the part for physical, thermal, and electrical properties.

3. Strategies to Obtain Technology and Products

Reverse engineering is no longer just about bringing old technology back to life. It's also about using that technology as a launch pad into the future. There are different ways to obtain technology as an industrial product that each country uses them in all industrial grounds given to its scientific and industrial structure and degree of self-reliance in sciences and techniques grounds, degree of access to required exchange resources, internal raw material, kind and quality of specialized forces and international and regional political relations. Important kinds of strategies to obtain the new product and the intended technology are cited in the following:

- strategy of innovation and designing to product production through research and production activities
- technology development strategy
- copy making and reverse engineering strategy
- technology selection, transfer and domestication strategy
- effective utilization of possibilities and the existing technology strategy
- strategy of factory purchasing and production process in the form of perfect delivery

- strategy of purchasing the intended product and technology

3.1. Technology

Technology is constitutes three transformation powers.

- Procreation power or transformation power of scarce resources and capital into knowledge
- Transformation power or transformation power of knowledge into an exchangeable product with economic value
- Exchange power or transformation power of the product into money.

Thus three exchangeable elements of technology are knowledge, work (machine) and product.

Technology from one side has the ability of knowledge procreation and from the other side it converts such knowledge into an exchangeable and valuable product in the production and working domain, hence it will finally be converted into financial power in the exchange process.

In this era, management is defined as the ability that could create an active relation among three factors of procreation, production and market. Figure 1 shows the regulating process of this complex field called the technology management.

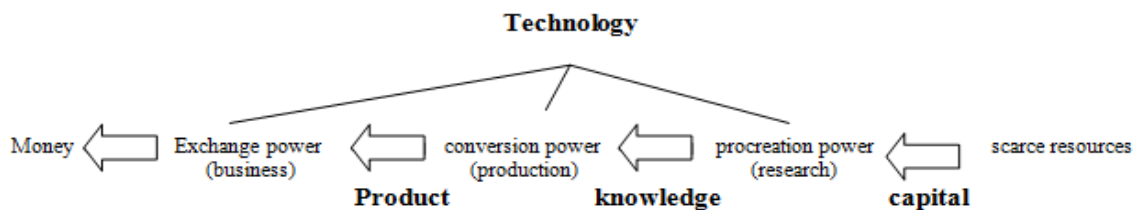


Fig. 1: Process of Technology Management

3.2. Selection of Appropriate Strategy

One of the strategic decision-makings in order to achieve a product or technology is to select the most appropriate access method. Such decision making depends strongly on the growth and development phase of that product or technology (in the cradle of formation and emergence and evolution of that technology), for instance if a technology is in the introduction phase in its emergence cradle (the primary country), taking action to achieve that through technology transfer is an unreasonable act. Also if a product is in the stagnation phase in its emergence cradle and a superior technology has replaced it taking action to achieve the first product through the same strategy would be a hazardous act.

Essentially taking action to transfer technology about those products that have traversed the introduction phase in their emergence cradle and are in the growth phase is more reasonable for developing countries. In this case a developing country's action to achieve the same product or technology through research-production strategy will be an uneconomic and unreasonable act unless purposes like reinforcing technical and scientific bases of the country are proposed that choosing this strategy won't be desirable again. Whatever the evolution degree of a technology prior to the stagnation and abolishment phase is higher; strategy of purchasing a product and technology would be more cost-effective.

The intended strategy in this paper is in accordance to technological needs of developing countries like Iran and the compensation of this technological gap by developed countries with the highest speed is reverse engineering strategy where its methodology is as follows:

4. A Methodology for Reverse Engineering

Reverse engineering includes any activity you do to determine how a product works, or to learn the ideas and technology that were originally used to develop the product. This method in the developing countries like Iran that are not so advanced in terms of product and technology designing knowledge as compare to that of the developed countries is a response to increase designing capability and accelerate the evolution process.

Establishing a reasonable and systematic method to determine the degree of lack of technical information to protect production of a product and then perform an integrated team work to complete such information is related to a set of operations that are occurred in the process of reverse engineering. A level of the required technical information that its shortage must be specified and eliminated is called technical data package.

In spite of delicacy and the need to high accuracy in reverse engineering, reduction of time of operations is a very important issue in this regard. In other word reverse engineering is a systematic approach for analyzing the design of existing devices or systems. You can use it either to study the design process, or as an initial step in the redesign process, in order to do any of the following:

- Observe and assess the mechanisms that make the device work
- Dissect and study the inner workings of a mechanical device
- Compare the actual device to your observations and suggest improvements

Before you decide to re-engineer a component, be sure to make every effort to obtain existing technical data. For example, you can proceed with reverse engineering if replacement parts are required and the associated technical data is either lost, destroyed, non-existent, proprietary, or incomplete.

Reverse engineering initiates the redesign process, wherein a product is observed, disassembled, analyzed, tested, "experienced," and documented in terms of its functionality, form, physical principles, manufacturability, and ability to be assembled. The intent of the reverse engineering process is to fully understand and represent the current instantiation of a product

5. Difficulties and Challenges of Technology Management in Iran

In industrial countries, to deliver a market requirement typically a new technology and innovation is initiated, which needs investment from study to manufacturing stages, the funding gains earnings in return for advertising the new products and this cycle is endlessly repetitive. In countries like Iran, a market requirement is created after monitoring foreign products rather than on the foundation of local demands, and as a consequence importing foreign technology is unavoidable. In view of the fact that the imported technology in the majority cases is not located on a suitable seat, it compels large extra costs and requires the ability to compete with foreign merchandises. So venture capital investments in such technologies usually are not cost-effective and government has to be paid the necessary capital from oil funds. In such circumstances, researching activities are presently ornamental and some times have no connection to the real needs of the industry. Figure 2 shows the difference:

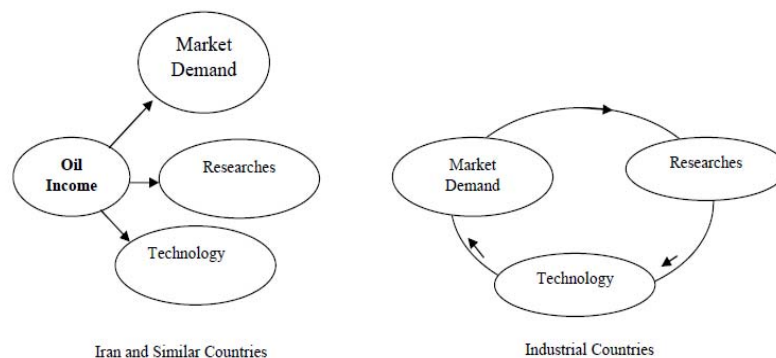


Fig. 2: Market requirement differences between Industrial and Oil rich countries

6. Conclusion and Suggestions

Reverse engineering initiates the redesign process, wherein a product is observed, disassembled, analyzed, tested, "experienced," and documented in terms of its functionality, form, physical principles, manufacturability, and assemblability. The intent of this process step is to fully understand and represent the current instantiation of a product. Based on the resulting representation and understanding, a product may be evolved, either at the subsystem, configuration, component, or parametric level.

Reverse engineering is one of the ways to achieve technical knowledge. Existence of samples of the product is the necessity to execute this method that is considered as the basis of research project. We resort to projection of technical information through product's disintegration in this method in order to achieve technical knowledge that is idiomatically called defaktage. The relevant experts consider characteristics, purpose and conditions of designing of the product in this process and try to make and produce the product according to their common and national standards and cover unknown and passive points of the problem with intelligence and expert studies and researches without being involved in technical details and designing of the product from the beginning. Perhaps we can call reverse engineering as deliberate copying of a product, the method that many countries in eastern Asia and Europe implemented practically after the Second World War and now are among the developed and industrial countries.

Anyway precious experiences that wear obtained in the recent decade by support of the governmental on different issues and products in the country all confirm productivity and helpfulness of this strategy in response to the needs of the country. The interesting point is that internal experts find the necessary self-confidence and technical effrontery in confronting with foreign experts in technology transfer phase. It is

obvious that conditions of total attraction of technology transfer phases, recognizing technical and scientific blind spots of internal industries and trying to eliminate them, correct directing of technology transfer, consulting with authorities for decision making and conclusion of production and participation contracts with foreign companies and so on will be provided.

Reverse engineering is used in various hardware and software fields including overcoming the deficiencies or extending capabilities of the existing devices, preparing repair parts and establishment of maintenance and repairing centers for advanced devices as a tool for learning, a tool for making new and adaptable products that are cheaper than the current products in the market as well as a tool for competition and enhanced efficiency of utilized software. Specifically it is important in the computer.

Aside from that reverse-engineering is used for many other purposes such as a learning tool; as a way to make new, compatible products that are cheaper than what's currently on the market; for making software interoperate more effectively or to bridge data between different operating systems or databases; and to uncover the undocumented features of commercial products

Lastly in Iran since the government has the vital position in the economy, it takes on the responsibilities of developing national technological hierarchies and therefore market systems cannot work effectively. Consequently, the Iranian government ought to try to diminish its allocation in economy and on the other hand, sustain development of domestic technologies. The Government's most imperative obligation here is researching technology, development of systems and chain-work and be acquainted with the missing links. If not, mechanisms required for implementation of the chain would not be created and therefore technological projects and research would remain incomplete.

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