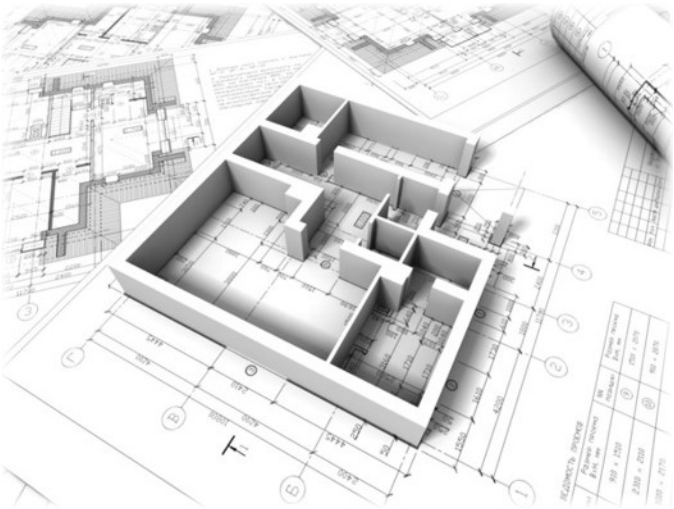
Understanding the Engineering Design Process

THE ENGINEERING DESIGN PROCESS has developed and evolved over time with new technology and knowledge. Basic principles are required for good design, and a series of constraints affect engineering design. The design process has a series of steps that allow for an efficient and organized process. The specifics can range from project to project. Yet with designs and new technology come risk. To ensure the safety of all those involved, risk analysis is applied, which includes understanding the problem, managing the risk, and maintaining effective communication.



Objectives:

1. Explain the engineering design process.
2. Identify the steps in the engineering design process.
3. Describe the risk analysis.

Key Terms:

brainstorming
design proposal
engineering design process
prototype
risk analysis
risk assessment
risk communication
risk management
specifications

The Process of Engineering Design

The **engineering design process** is a systematic problem-solving strategy that uses specific criteria and constraints to develop possible solutions. In general, it is used to solve problems to satisfy human needs and wants. Established design principles are used to evaluate existing designs. They are also used to collect data and information that can guide the design process.

ENGINEERING DESIGN PRINCIPLES

Many established principles are used to guide and evaluate the design process. Design is not just a random event. It is actually the result of a formal process. Design problems seldom arise in a clearly defined form. Characteristics of the final result may be known, but the actual design may be very open.

Design can be driven by profit motives and the market. In situations where this is the only criteria used, design solutions usually suffer. Typically, there are several design requirements, which can cause conflict among different parts. Some things may have to change to allow others to work better. What is valued more in the design will guide which parts receive more attention—the quality, the function, or the aesthetics of the design.

FIGURE 1. Sport shoe design is constantly checked and improved as a result of many factors.

Good design is the result of having a specific goal and guided research. Numerous factors need to be considered, so a lot of research may be required. Designs must also continually be checked, refined, and improved.

ENGINEERING DESIGN CONSTRAINTS

Many constraints exist in the engineering design process. One of the most important constraints is safety, which should always come first. However, the safest design is not always the cheapest, so some laws have been put in place to guarantee a certain level of safety. Of course, economic considerations are always a driving force in the design. This can be directed by the project funds, the product sale price, and the potential profits.

Reliability and maintenance are also important constraints on the design. The manufacturability—the ability to produce the design efficiently—can affect the design. Envi-

ronmental concerns and quality control may be additional constraints. Also, some of the most noticeable constraints are human factors. These are the ergonomics (how it relates to its user in its form and function) of the design.

Steps in the Engineering Design Process

There are essentially 12 steps in the engineering design process. To help organize these, they can be grouped into three stages: the initial design creation stage, the design and development stage, and production and distribution.

The steps in the design process are not always followed in the same order. In some cases, all the steps listed are not used in a design. However, there is almost always an initial stage (where the problem is defined and ideas are generated), a middle stage (where a certain idea is developed), and a final stage (where the item is produced). Some steps may need to be repeated more than once in the design process.

INITIAL DESIGN CREATION

In the first stage, the problem needs to be defined. This means finding out exactly what the design needs to accomplish (its purpose). Once this is known, a design proposal is developed. Basically, a **design proposal** is a written plan of action to develop a solution to a proposed problem. Once this is established, research and idea generation begins. Along with this, the criteria and any constraints that are going to affect the design are identified and explored. As this information is developed and established, all of the design possibilities are investigated.

After significant exploration has been completed, a specific approach is selected. Throughout all of these stages, brainstorming strategies are used. **Brainstorming** is the spontaneous creation of ideas. Typically, it is done in a group and involves sharing ideas that are all written down, responded to, and developed further.

FIGURE 2. Great ideas sometimes come about during the brainstorming process.

DESIGN AND DEVELOPMENT

Once a specific design is selected, design and development can begin. The selected design is more thoroughly developed, and all of its requirements are studied and explored. At this point, a **prototype** (a working model used to test a design concept) can be made. In some cases, it

can be made of a different material or to a smaller scale. The prototype can be used to study various functions and effects of the design in real space.

The design is then tested and evaluated, which is typically done according to the specifications given by the designer and by the codes. The **specifications** are written descriptions of exactly how something should be built, installed, and manufactured. They can include the final quality required in the design and steps to insure this level of quality. In most cases, after evaluation and testing, the design is refined even more.

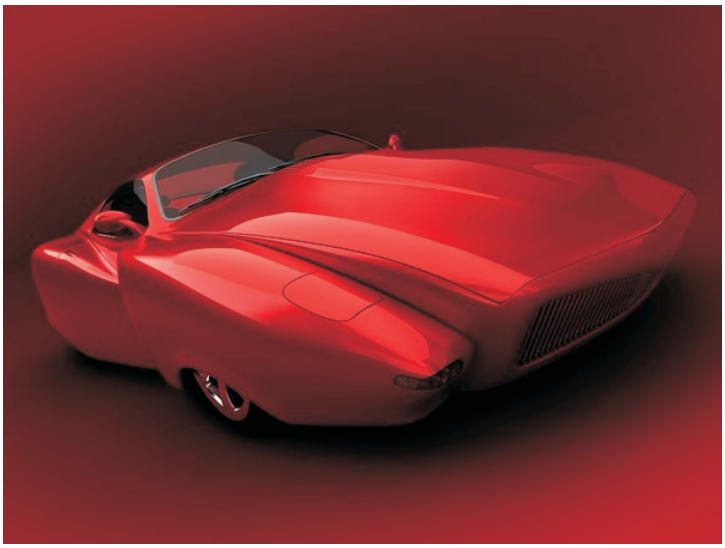


FIGURE 3. A prototype, such as for a car, is part of the design process.

PRODUCTION AND DISTRIBUTION

Then the solution is produced. This can include the actual creation or making of a design. All of the information needed, including the product, can be distributed to its final location. Information and results can be communicated and exchanged.

Risk Analysis

Risk analysis is used to minimize the likelihood of unwanted side effects of a new technology. These can be obvious and may be direct or indirect; they happen as a result of something over time. Risk analysis is made up of three processes: risk assessment, risk management, and risk communication.

RISK ASSESSMENT

Risk assessment involves identifying sources of potential harm. It requires assessing the likelihood that harm will occur. It also involves asking the question, "If harm does occur, what are the consequences?"

RISK MANAGEMENT

In **risk management**, the risks identified in the risk assessment that require management are evaluated. The necessary plans and actions required to ensure that those risks are controlled are implemented.

RISK COMMUNICATION

Risk communication requires an interactive dialogue between stakeholders, risk assessors, and managers. Communication is extremely vital in any risk situation. Everyone involved needs to have information regarding what is known about the object of concern and what is going on at all times. Risk communication allows for all people and processes to be actively informed at all times.

Summary:

The engineering design process involves a specific strategy to solve problems. It relies on a series of design principles and design constraints. These can range and vary from project to project. There are a series of steps in the engineering design process that have evolved. All of the steps are not always used, or they may not be used in the same order. However, the main ideas behind the steps are always carried out to some degree. This insures an organized project and a well-designed solution. There can also be a lot of risks involved in engineering design. Risk analysis can be performed to limit and control the risk.

Checking Your Knowledge:

1. What are three engineering design constraints?
2. What are three steps in the engineering design process?
3. What is brainstorming?
4. What are design specifications?
5. Name two principles that help guide the design process.

Expanding Your Knowledge:

Risk analysis can be applied to many aspects of your life. Look at some of the activities you go through daily or weekly, and analyze the risks. Identify what they are, how they can be avoided, or ways to manage them. Then share this information with everyone involved in that activity.

Web Links:

Risk Management

http://www.rmmagazine.com/

Design Principles

http://www.raeng.org.uk/education/vps/pdf/design_principles.pdf