LABORATORY MANUAL

SUBJECT: MECHANICAL SYSTEM DESIGN

[SUBJECT CODE: 402048]

CLASS: B.E. MECHANICAL
YEAR: 2011-12

APPROVED BY:

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VALIDITY UP TO: ACADEMIC YEAR 2013 -14

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List of Experiments

FACULTY: PROF. M. M. SAYYAD
SUBJECT: MECHANICAL SYSTEM DESIGN
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1. Design of pressure vessel

The design project consists of two imperial size sheets drawn with 3D/2D CAD software- one involving assembly drawing with a part list and overall dimensions and the other sheet involving drawings of individual components, manufacturing tolerances, surface finish symbols and geometric tolerances should be specified so as to make it working drawing. A design report giving all necessary calculations of the design of components and assembly should be submitted.

2. Assignments:
   
i. Design review of any product for aesthetic and ergonomic considerations.
   
ii. Analysis of any product using reverse engineering.
   
iii. Failure mode and effect analysis of one product.
   
iv. Concurrent Engineering.

Prof. Mannan M. Sayyad
[Subject In-charge]
1. **DESIGN PROJECT**

**TITLE: DESIGN OF PRESSURE VESSEL**

**SCOPE OF THE PROJECT:**
The design project consists of two imperial size sheets to be drawn with 3D/2D CAD software- one involving assembly drawing with a part list and overall dimensions and the other sheet involving drawings of individual components, manufacturing tolerances, surface finish symbols and geometric tolerances should be specified so as to make it working drawing.

Students are required to be submitted a design report giving all necessary calculations of the design of components and assembly.

**PRE-REQUISITES:**
Basics of Strength of Materials, Metallurgy, 2D/3D modeling, etc.

**PRESSURE VESSEL CALCULATIONS:**
Students are supposed to take reference of any standard reference book from the list provided in the Reference Books.

**SAMPLE DRAWINGS:**

![Sample Drawings](image-url)
2. ASSIGNMENTS

Assignment No. 01
Design review of product for aesthetic and ergonomic considerations

Although industrial and product designers are keenly aware of the importance of design aesthetics, they make aesthetic design decisions largely on the basis of their intuitive judgments and 'educated guesses'. Whilst ergonomics and human factors researchers have made great contributions to the safety, productivity, ease-of-use, and comfort of human-machine-environment systems, aesthetics is largely ignored as a topic of systematic scientific research in human factors and ergonomics. There are two major questions need to addressed: How do we use engineering and scientific methods to study aesthetics concepts in general and design aesthetics in particular? How do we incorporate engineering and scientific methods in the aesthetic design and evaluation process?

What is aesthetics?
The term 'aesthetics' concerns our senses and our responses to an object. If something is aesthetically pleasing to you, it is 'pleasurable' and you like it. If it is aesthetically displeasing to you, it is 'displeasurable' and you don't like it. Aesthetics involves all of your senses - vision, hearing, touch, taste, and smell - and your emotions.

Elements of Aesthetics
There are many different things that contribute to your overall perception of a product, and to your opinion as to whether it is aesthetically pleasing to you.

Vision      Hearing      Touch      Taste      Smell

Your opinion about a product may also be influenced by certain associations that are important to you, such as:
- how fashionable it is
- whether it is a novelty, or an old favorite
- whether it is a symbol of wealth or love
- how much danger or risk is involved
- if it provides a link with your past

You might also take into account whether it is safe and reliable and fit for its purpose. Consistency with a particular aesthetic concept may be a significant factor in creating a product’s appeal too, for example, the current appreciation of 'retro' designs. However, such trends are often cultural and almost certainly always short-lived, so their popularity can’t be guaranteed.
Consideration of aesthetics in design
There are four different 'pleasure types' to consider:

Physio-pleasure - pleasure derived from the senses from touch, smell, sensual pleasure etc. For example the smoothness of a curve in a hand-held product or the smell of a new car.

Socio-pleasure - pleasure gained from interaction with others. This may be a 'talking point' product like a special ornament or painting, or the product may be the focus of a social gathering such as a vending machine or coffee machine. This pleasure can also come from a product that represents a social grouping, for example, a particular style of clothing that gives you a social identity.

Psycho-pleasure - pleasure from the satisfaction felt when a task is successfully completed. Pleasure also comes from the extent to which the product makes the task more pleasurable, such as the interface of an ATM cash machine that is quick and simple to use. It is closely related to product usability.

Ideo-pleasure - pleasure derived from entities such as books, art and music. This is the most abstract pleasure. In terms of products, it is the values that a product embodies, such as a product that is made of eco-friendly materials, and processes that convey a sense of environmental responsibility to the user.

Each of these pleasures should be considered in turn - their importance to the product you are designing, and how each aspect might show itself in that product.

Aesthetics and ergonomics in product design

"More and more people buy objects for intellectual and spiritual nourishment. People do not buy my coffee makers, kettles and lemon squeezer because they need to make coffee, to boil water, or to squeeze lemons, but for other reasons."

Alberto Alessi, Designer

This quote gives an indication of how the world of product design has changed over the past few decades. An appreciation of pleasure in product use is fast becoming of primary importance to both consumer and the design industry alike. Consumers' expectations have been raised; they no longer simply expect the products they buy to be functional and usable. Consumers demand functionality, expect usability and are seeking products that that elicit other feelings such as pleasure or that strike a certain emotional chord. It likely to be the aesthetics
of the product: the way it looks, the feel of the material, the tactile or 'haptic' response of controls or more abstract feelings, such as reflected status, that give pleasure. Traditionally, product design has been considered to comprise three main elements:

- **ergonomics**
- **aesthetics**
- **technology**

Product Designers need knowledge of all these elements. In the case of the design of a small or simple product, the designer’s responsibility may be for all of these elements. In the case of larger products, such as cars, the designer’s responsibility may be for aesthetics only; ergonomists and engineers providing the expertise needed for the other elements. Conventionally, ergonomics has consisted of usability and functionality, and designing pleasure into the product has been the job of the designer. However, increasingly the boundaries between the two disciplines are disappearing, and ergonomists are taking some responsibility for the aesthetics of the design, using scientific methods to increase understanding of the aesthetics (both pleasurable and displeasurable) and applying this to the design of products.

The best design occurs when all three components are considered together from the start of the design process. Usually, compromises will have to be made, but understanding all the issues involved will help to make the most acceptable compromises. For example, if you are designing a sports car, you will make different compromises from those that you will make if you are designing a family saloon car.

Sports car

The emphasis is on aesthetics and performance. The car may go very fast, look beautiful and make all the right sort of noises. However, it is likely to be difficult to get in and out of, have little storage space, seat only two people and have limited visibility. The physical and functional ergonomics are not the best but the car is exactly what the consumer is expecting of a sports car.
Ergonomics is compromised in order to achieve performance and aesthetics.

Family saloon car

The emphasis is on functionality and usability. The car should first serve the needs of the family, so will have adequate seating and storage space and be suitable for family travelling. It should also have aesthetic appeal but there may be compromises in design in order to provide the required levels of functionality and usability.

Working with aesthetics and ergonomics

Compromises need to be made in different ways depending upon the product.

Where ergonomics and aesthetics meet

Clearly, many aesthetic ideas are easily combined with good ergonomics, for example, chairs that look good and are comfortable too; buttons on your mobile phone that give good feedback. This Alessi corkscrew has obviously been designed to be more than just a corkscrew, but it is extremely functional as well.

Where aesthetics may predominate

There are other products that conflict directly with ergonomics principles. For example, cars that go so fast they thrill you despite (or is it because of?) the risk that you are taking. However, whilst speed limits and traffic calming measures exist to slow fast cars down in dangerous situations, these fast, thrilling objects of desire are still designed and manufactured. Another example of aesthetics having more influence than ergonomics is shoes that are beautiful and very fashionable, but are bad for your feet and your posture, and increase the risk of slipping and hurting yourself. We are all educated as small children about the need to wear well-fitting, flat shoes for healthy feet, but we would complain if all footwear had to be designed by ergonomic principles only.

Where aesthetics must never predominate

Conversely, there are situations where ergonomics principles must override aesthetics, such as products that are used in safety-critical situations. For example, equipment designed for use in operating theatres or by air traffic controllers. There is much legislation concerning the safety of products and designers must work within these constraints of legislation or their products will not be allowed to enter the market place. For more on product safety, see the product evaluation topic.
Where to compromise
Many products are not safety-critical and the designer must take the responsibility for balancing aesthetics and ergonomics appropriately. Miniaturisation of products is an example worth considering. When mobile telephones were first designed, technology dictated that they were the size of a small housebrick! The displays and controls were easily usable by most people, but they considered the phones to be too large and heavy to be very 'mobile'. Technological advances allowed the production of smaller phones and they became truly 'mobile'; fitting easily into handbags and pockets. However, the control and display sizes were compromised and many have become too small for easy use. The optimum compromise was not recognised.
Assignment No. 02
Analysis of product using reverse engineering

Reverse engineering is the process of discovering the technological principles of a device, object, or system through analysis of its structure, function, and operation. It often involves taking something (e.g., a mechanical device, electronic component, software program, or biological, chemical, or organic matter) 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 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. The same techniques are subsequently being researched for application to legacy software systems, not for industrial or defense ends, but rather to replace incorrect, incomplete, or otherwise unavailable documentation.

Motivation
Reasons for reverse engineering:
- 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. Integrated circuits often seem to have been designed on obsolete, proprietary systems, which means that the only way to incorporate the functionality into new technology is to reverse-engineer the existing chip and then re-design it.
- 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 analysing 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.

Reverse engineering of machines

As computer-aided design (CAD) has become more popular, reverse engineering has become a viable method to create a 3D virtual model of an existing physical part for use in 3D CAD, CAM, CAE or other software. The reverse-engineering process involves measuring an object and then reconstructing it as a 3D model. The physical object can be measured using 3D scanning technologies like CMMs, laser scanners, structured light digitizers, or Industrial CT Scanning (computed tomography). The measured data alone, usually represented as a point cloud, lacks topological information and is therefore often processed and modeled into a more usable format such as a triangular-faced mesh, a set of NURBS surfaces, or a CAD model.

Reverse engineering is also used by businesses to bring existing physical geometry into digital product development environments, to make a digital 3D record of their own products, or to assess competitors’ products. It is used to analyze, for instance, how a product works, what it does, and what components it consists of, estimate costs, and identify potential patent infringement, etc. Value engineering is a related activity also used by businesses. It involves de-constructing and analysing products, but the objective is to find opportunities for cost cutting.

Reverse engineering of protocols

Protocols are sets of rules that describe message formats and how messages are exchanged (i.e., the protocol state-machine). Accordingly, the problem of protocol reverse-engineering can be partitioned into two subproblems: message format and state-machine reverse-engineering.

The message formats have traditionally been reverse-engineered through a tedious manual process, which involved analysis of how protocol implementations process messages, but recent research proposed a number of automatic solutions. Typically, these automatic approaches either group observed messages into clusters using various clustering analyses, or emulate the protocol implementation tracing the message processing.

There has been less work on reverse-engineering of state-machines of protocols. In general, the protocol state-machines can be learned either through a process of offline learning, which passively observes communication and attempts to build the
most general state-machine accepting all observed sequences of messages, and online learning, which allows interactive generation of probing sequences of messages and listening to responses to those probing sequences. In general, offline learning of small state-machines is known to be NP-complete, while online learning can be done in polynomial time.

Other components of typical protocols, like encryption and hash functions, can be reverse-engineered automatically as well. Typically, the automatic approaches trace the execution of protocol implementations and try to detect buffers in memory holding unencrypted packets.

Reverse engineering of integrated circuits/smart cards

Reverse engineering is an invasive and destructive form of analyzing a smart card. The attacker grinds away layer by layer of the smart card and takes pictures with an electron microscope. With this technique, it is possible to reveal the complete hardware and software part of the smart card. The major problem for the attacker is to bring everything into the right order to find out how everything works. Engineers try to hide keys and operations by mixing up memory positions, for example, bus scrambling. In some cases, it is even possible to attach a probe to measure voltages while the smart card is still operational. Engineers employ sensors to detect and prevent this attack. This attack is not very common because it requires a large investment in effort and special equipment that is generally only available to large chip manufacturers. Furthermore, the payoff from this attack is low since other security techniques are often employed such as shadow accounts.

Reverse engineering for military applications

Reverse engineering is often used by militaries in order to copy other nations’ technologies, devices, or information that has been obtained by regular troops in the fields or by intelligence operations. It was often used during the Second World War and the Cold War. Well-known examples from WWII and later include: Jerry can: British and American forces noticed that the Germans had gasoline cans with an excellent design. They reverse-engineered copies of those cans. The cans were popularly known as "Jerry cans".

Tupolev Tu-4: Three American B-29 bombers on missions over Japan were forced to land in the USSR. The Soviets, who did not have a similar strategic bomber, decided to copy the B-29. Within a few years, they had developed the Tu-4, a near-perfect copy.
V2 Rocket: Technical documents for the V2 and related technologies were captured by the Western Allies at the end of the war. Soviet and captured German engineers had to reproduce technical documents and plans, working from captured hardware, in order to make their clone of the rocket, the R-1, which began the postwar Soviet rocket program that led to the R-7 and the beginning of the space race.

K-13/R-3S missile (NATO reporting name AA-2 Atoll), a Soviet reverse-engineered copy of the AIM-9 Sidewinder, was made possible after a Taiwanese AIM-9B hit a Chinese MiG-17 without exploding. The missile became lodged within the airframe, and the pilot returned to base with what Russian scientists would describe as a university course in missile development.

BGM-71 TOW Missile: In May 1975, negotiations between Iran and Hughes Missile Systems on co-production of the TOW and Maverick missiles stalled over disagreements in the pricing structure, the subsequent 1979 revolution ending all plans for such co-production. Iran was later successful in reverse-engineering the missile is currently producing their own copy: the Toophan.

China has reversed engineered many examples of Western and Russian hardware, from fighter aircraft to missiles and HMMWV cars. During the Second World War, British military intelligence at the Bletchley Park centre studied captured German "Enigma" message encryption machines. Their operation was then simulated on electro-mechanical devices called "Bombes" that tried all the possible scrambler settings of the "Enigma" machines to help break the coded messages sent by the Germans.

Legality
United States

In the United States even if an artifact or process is protected by trade secrets, reverse-engineering the artifact or process is often lawful as long as it is obtained legitimately. Patents, on the other hand, need a public disclosure of an invention, and therefore, patented items do not necessarily have to be reverse-engineered to be studied. (However, an item produced under one or more patents could also include other technology that is not patented and not disclosed.) One common motivation of reverse engineers is to determine whether a competitor’s product contains patent infringements or copyright infringements.

The reverse engineering of software in the US is generally a breach of contract as most EULAs specifically prohibit it, and courts have found such contractual prohibitions to override the copyright law:[clarification needed] see Bowers v. Baystate Technologies.
Sec. 103(f) of the DMCA (17 U.S.C. § 1201(f)) says that if you legally obtain a program that is protected, you are allowed to reverse-engineer and circumvent the protection to achieve interoperability between computer programs (i.e., the ability to exchange and make use of information). The section states:

(f) Reverse Engineering.—

(1) Notwithstanding the provisions of subsection (a)(1)(A), a person who has lawfully obtained the right to use a copy of a computer program may circumvent a technological measure that effectively controls access to a particular portion of that program for the sole purpose of identifying and analyzing those elements of the program that are necessary to achieve interoperability of an independently created computer program with other programs, and that have not previously been readily available to the person engaging in the circumvention, to the extent any such acts of identification and analysis do not constitute infringement under this title.

(2) Notwithstanding the provisions of subsections (a)(2) and (b), a person may develop and employ technological means to circumvent a technological measure, or to circumvent protection afforded by a technological measure, in order to enable the identification and analysis under paragraph (1), or for the purpose of enabling interoperability of an independently created computer program with other programs, if such means are necessary to achieve such interoperability, to the extent that doing so does not constitute infringement under this title.

(3) The information acquired through the acts permitted under paragraph (1), and the means permitted under paragraph (2), may be made available to others if the person referred to in paragraph (1) or (2), as the case may be, provides such information or means solely for the purpose of enabling interoperability of an independently created computer program with other programs, and to the extent that doing so does not constitute infringement under this title or violate applicable law other than this section.

(4) For purposes of this subsection, the term “interoperability” means the ability of computer programs to exchange information and of such programs mutually to use the information which has been exchanged.

European Union

Article 6 of the 1991 EU Computer Programs Directive allows reverse engineering for the purposes of interoperability, but prohibits it for the purposes of creating a
competing product, and also prohibits the public release of information obtained through reverse engineering of software.

In 2009, the EU Computer Program Directive was superseded and the directive now states:

(15) The unauthorized reproduction, translation, adaptation or transformation of the form of the code in which a copy of a computer program has been made available constitutes an infringement of the exclusive rights of the author. Nevertheless, circumstances may exist when such a reproduction of the code and translation of its form are indispensable to obtain the necessary information to achieve the interoperability of an independently created program with other programs. It has therefore to be considered that, in these limited circumstances only, performance of the acts of reproduction and translation by or on behalf of a person having a right to use a copy of the program is legitimate and compatible with fair practice and must therefore be deemed not to require the authorization of the rightholder. An objective of this exception is to make it possible to connect all components of a computer system, including those of different manufacturers, so that they can work together. Such an exception to the author’s exclusive rights may not be used in a way which prejudices the legitimate interests of the rightholder or which conflicts with a normal exploitation of the program.
Assignment No. 03

Failure mode and effect analysis of one product

Also called: potential failure modes and effects analysis; failure modes, effects and criticality analysis (FMECA).

Description

Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service.

“Failure modes” means the ways, or modes, in which something might fail. Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual.

“Effects analysis” refers to studying the consequences of those failures.

Failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones.

Failure modes and effects analysis also documents current knowledge and actions about the risks of failures, for use in continuous improvement. FMEA is used during design to prevent failures. Later it’s used for control, before and during ongoing operation of the process. Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service.

Begun in the 1940s by the U.S. military, FMEA was further developed by the aerospace and automotive industries. Several industries maintain formal FMEA standards. Before undertaking an FMEA process, learn more about standards and specific methods in your organization and industry through other references and training.

When to Use FMEA

• When a process, product or service is being designed or redesigned, after quality function deployment.
• When an existing process, product or service is being applied in a new way.
• Before developing control plans for a new or modified process.
• When improvement goals are planned for an existing process, product or service.
• When analyzing failures of an existing process, product or service.
• Periodically throughout the life of the process, product or service

FMEA Procedure

(Again, this is a general procedure. Specific details may vary with standards of your organization or industry.)

1. Assemble a cross-functional team of people with diverse knowledge about the process, product or service and customer needs. Functions often included are: design, manufacturing, quality, testing, reliability, maintenance, purchasing (and suppliers), sales, marketing (and customers) and customer service.

2. Identify the scope of the FMEA. Is it for concept, system, design, process or service? What are the boundaries? How detailed should we be? Use flowcharts to identify the scope and to make sure every team member understands it in detail. (From here on, we’ll use the word “scope” to mean the system, design, process or service that is the subject of your FMEA.)

3. Fill in the identifying information at the top of your FMEA form. Figure 1 shows a typical format. The remaining steps ask for information that will go into the columns of the form.

<table>
<thead>
<tr>
<th>Function</th>
<th>Potential Failure Mode</th>
<th>Potential Effects of Failure</th>
<th>S</th>
<th>O</th>
<th>D</th>
<th>P</th>
<th>R</th>
<th>I</th>
<th>T</th>
<th>Recommended Action(s)</th>
<th>Responsibility and Target</th>
<th>Completion Date</th>
<th>Action Taken</th>
<th>Action Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispense too much cash</td>
<td>Insufficient cash on hand</td>
<td>Out of cash</td>
<td>6</td>
<td>5</td>
<td>200</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dispense too little cash</td>
<td>Discrepancy in cash balance</td>
<td>None</td>
<td>2</td>
<td>10</td>
<td>180</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

4. Identify the functions of your scope. Ask, "What is the purpose of this system, design, process or service? What do our customers expect it to do?" Name it with a verb followed by a noun. Usually you will break the scope into separate subsystems, items, parts, assemblies or process steps and identify the function of each.
5. For each function, identify all the ways failure could happen. These are potential failure modes. If necessary, go back and rewrite the function with more detail to be sure the failure modes show a loss of that function.

6. For each failure mode, identify all the consequences on the system, related systems, process, related processes, product, service, customer or regulations. These are potential effects of failure. Ask, “What does the customer experience because of this failure? What happens when this failure occurs?”

7. Determine how serious each effect is. This is the severity rating, or S. Severity is usually rated on a scale from 1 to 10, where 1 is insignificant and 10 is catastrophic. If a failure mode has more than one effect, write on the FMEA table only the highest severity rating for that failure mode.

8. For each failure mode, determine all the potential root causes. Use tools classified as cause analysis tool, as well as the best knowledge and experience of the team. List all possible causes for each failure mode on the FMEA form.

9. For each cause, determine the occurrence rating, or O. This rating estimates the probability of failure occurring for that reason during the lifetime of your scope. Occurrence is usually rated on a scale from 1 to 10, where 1 is extremely unlikely and 10 is inevitable. On the FMEA table, list the occurrence rating for each cause.

10. For each cause, identify current process controls. These are tests, procedures or mechanisms that you now have in place to keep failures from reaching the customer. These controls might prevent the cause from happening, reduce the likelihood that it will happen or detect failure after the cause has already happened but before the customer is affected.

11. For each control, determine the detection rating, or D. This rating estimates how well the controls can detect either the cause or its failure mode after they have happened but before the customer is affected. Detection is usually rated on a scale from 1 to 10, where 1 means the control is absolutely certain to detect the problem and 10 means the control is certain not to detect the problem (or no control exists). On the FMEA table, list the detection rating for each cause.

12. (Optional for most industries) Is this failure mode associated with a critical characteristic? (Critical characteristics are measurements or indicators that reflect safety or compliance with government regulations and need special controls.) If so, a column labeled “Classification” receives a Y or N to show whether special controls are needed. Usually, critical characteristics have a severity of 9 or 10 and occurrence and detection ratings above 3.

13. Calculate the risk priority number, or RPN, which equals S \times O \times D. Also calculate Criticality by multiplying severity by occurrence, S \times O. These
numbers provide guidance for ranking potential failures in the order they should be addressed.
14. Identify recommended actions. These actions may be design or process changes to lower severity or occurrence. They may be additional controls to improve detection. Also note who is responsible for the actions and target completion dates.
15. As actions are completed, note results and the date on the FMEA form. Also, note new S, O or D ratings and new RPNs.

FMEA Example

A bank performed a process FMEA on their ATM system. Figure 1 shows part of it—the function “dispense cash” and a few of the failure modes for that function. The optional “Classification” column was not used. Only the headings are shown for the rightmost (action) columns.

Notice that RPN and criticality prioritize causes differently. According to the RPN, “machine jams” and “heavy computer network traffic” are the first and second highest risks.

One high value for severity or occurrence times a detection rating of 10 generates a high RPN. Criticality does not include the detection rating, so it rates highest the only cause with medium to high values for both severity and occurrence: “out of cash.” The team should use their experience and judgment to determine appropriate priorities for action.
Assignment No. 04

Concurrent Engineering

Concurrent Engineering - which is sometimes called Simultaneous Engineering or Integrated Product Development (IPD) - was defined by the Institute for Defense Analysis (IDA) in its December 1988 report ‘The Role of Concurrent Engineering in Weapons System Acquisition’ as a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements.

Concurrent Engineering is not a quick fix for a company’s problems and it’s not just a way to improve Engineering performance. It’s a business strategy that addresses important company resources. The major objective this business strategy aims to achieve is improved product development performance. Concurrent Engineering is a long-term strategy, and it should be considered only by organizations willing to make up front investments and then wait several years for long-term benefits. It involves major organizational and cultural change.

The problems with product development performance that Concurrent Engineering aims to overcome are those of the traditional serial product development process in which people from different departments work one after the other on successive phases of development.

In traditional serial development, the product is first completely defined by the design engineering department, after which the manufacturing process is defined by the manufacturing engineering department, etc. Usually this is a slow, costly and low-quality approach, leading to a lot of engineering changes, production problems, product introduction delays, and a product that is less competitive than desired.

Concurrent Engineering brings together multidisciplinary teams, in which product developers from different functions work together and in parallel from the start of a project with the intention of getting things right as quickly as possible, and as early as possible.

A cross-functional team might contain representatives of different functions such as systems engineering, mechanical engineering, electrical engineering, systems producibility, fabrication producibility, quality, reliability and
maintainability, testability, manufacturing, drafting and layout, and program management.

Sometimes, only design engineers and manufacturing engineers are involved in Concurrent Engineering. In other cases, the cross-functional teams include representatives from purchasing, marketing, production, quality assurance, the field and other functional groups. Sometimes customers and suppliers are also included in the team.

In the Concurrent Engineering approach to development, input is obtained from as many functional areas as possible before the specifications are finalized. This results in the product development team clearly understanding what the product requires in terms of mission performance, environmental conditions during operation, budget, and scheduling.

Multidisciplinary groups acting together early in the workflow can take informed and agreed decisions relating to product, process, cost and quality issues. They can make trade-offs between design features, part manufacturability, assembly requirements, material needs, reliability issues, serviceability requirements, and cost and time constraints. Differences are more easily reconciled early in design.

Getting the design correct at the start of the development process will reduce downstream difficulties in the workflow. The need for expensive engineering changes later in the cycle will be reduced. Concurrent Engineering aims to reduce the number of redesigns, especially those resulting from post-design input from support groups. By involving these groups in the initial design, less iteration will be needed. The major iterations that do occur will occur before the design becomes final. The overall time taken to design and manufacture a new product can be substantially reduced if the two activities are carried out together rather than in series. The reductions in design cycle time that result from Concurrent Engineering invariably reduce total product cost.

Concurrent Engineering provides benefits such as reduced product development time, reduced design rework, reduced product development cost and improved communications. Examples from companies using Concurrent Engineering techniques show significant increases in overall quality, 30-40% reduction in project times and costs, and 60-80% reductions in design changes after release.

The implementation of Concurrent Engineering addresses three main areas: people, process, and technology. It involves major organizational changes because it requires the integration of people, business methods, and technology
and is dependent on cross-functional working and teamwork rather than the traditional hierarchical organization. One of the primary people issues is the formation of teams. Collaboration rather than individual effort is standard, and shared information is the key to success. Team members must commit to working cross-functionally, be collaborative, and constantly think and learn. The role of the leader is to supply the basic foundation and support for change, rather than to tell the other team members what to do. Training addressed at getting people to work together in teams plays an important role in the successful implementation of Concurrent Engineering.

An example of the use of Concurrent Engineering can be found in General Electric’s Aircraft Engines Division’s approach for the development of the engine for the new F/A-18E/F. It used several collocated, multi-functional design and development teams to merge the design and manufacturing process. The teams achieved 20% to 60% reductions in design and procurement cycle times during the full-scale component tests which preceded full engine testing. Problems surfaced earlier and were dealt with more efficiently than they would have been with the traditional development process. Cycle times in the design and fabrication of some components have dropped from an estimated 22 weeks to 3 weeks.

Another example concerns Boeing’s Ballistic Systems Division where Concurrent Engineering was used in 1988 to develop a mobile launcher for the MX missile and was able to reduce design time by 40% and cost by 10% in building the prototype.

Polaroid Corp.’s Captiva instant camera is also the result of a Concurrent Engineering approach, as a result of which Polaroid was able to make literally hundreds of working prototypes. Throughout the process, development was handled by cross-functional teams.

To be successful with Concurrent Engineering, companies should initially:

- compare themselves to their best competitors (i.e. benchmark)
- develop metrics
- identify potential performance improvements and targets
- develop a clear Vision of the future environment
- get top management support
- get cross-functional endorsement
- develop a clear Strategy to attain the envisioned environment
- get top management support
- get cross-functional endorsement
- develop a detailed implementation plan
• get top management support
• get cross-functional endorsement

Concurrent Engineering is a business strategy, not a quick fix. It will take many years to implement. If management doesn’t have the time or budget to go through the above steps, then it is unlikely that Concurrent Engineering will be implemented.

Many companies have problems introducing Concurrent Engineering. Warning signs include:

• unwillingness to institutionalize Concurrent Engineering
• maintenance of traditional functional reward systems
• maintenance of traditional reporting lines
• no training in teamwork
• unrealistic schedules
• no changes in relationships with vendors
• a focus on computerization rather than process improvement

To make Concurrent Engineering a real success, all the necessary information concerning products, parts and processes, has to be available at the right time. A lot of partially-released information has to be exchanged under tightly controlled conditions. EDM/PDM enables Concurrent Engineering by allowing users, whether in small teams or enterprise-wide groups, to access, distribute, store, and retrieve information from a variety of sources. EDM/PDM systems give engineers and project managers access and release control over projects and drawings, as well the ability to track them.

Making Concurrent Engineering a success is really a management issue. If management doesn’t get it right then it’s not going to matter much whether EDM/PDM is used or not. On the other hand, EDM/PDM can provide valuable support to a successful implementation of Concurrent Engineering.
REFERENCES: