

Human Factors Engineering
Prof. V K Tiwari
Prof. P K Ray
Department of Agricultural and Food Engineering
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Ergonomic Design for Manufacturing and Assembly
Lecture - 46

Concepts of Design for Manufacturing [DFM], Design for Assembly [DHA], and Design for Automation [DFA] and their Application; Ergonomic Design Principles

Dear students and participants we are now in week 10. And in the week 10 our topic of discussion is Ergonomic Design for Manufacturing and Assembly. You are already aware that whenever we talk about human factors engineering or ergonomics, we refer to some kind of work system and whenever we refer to some kind of work system, we are referring to the different kinds of jobs.

We are trying to propose or implement ergonomic design based on human factors engineering principles. During this week we are talking about many kinds of the activities we carry out. Many such activities are basically manual in nature. Even if those these activities in certain cases are carried out automatically. Using some automated devices or in extreme cases the robots, but still, we should be aware that these activities are not activities is not just for manufacturing or the production systems but also for other functions or other jobs. Like say we cannot think of a system without having any maintenance system.

Whenever we talk about product design or workstation design, worksystem design. Yes, first part is definitely you design all these system for certain operations, but maintenance has to be there. Now, supposing the person is carrying out maintenance related activities. We have to certify whether those activities or corresponding jobs are also ergonomically designed or not.

We have designed this course where you will find that in each week there are 5 lecture sessions.

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Ergonomic Design for Manufacturing and Assembly

- **Lecture-1:** Concepts of Design for Manufacturing (DFM), Design for Assembly (DHA), and Design for Automation (DFA) and their Application; Ergonomic Design Principles
- **Lecture-2:** Product Design Assessment and Important Measures, Manual Assembly Design Efficiency: Use of Boothroyd Technique
- **Lecture-3:** Assembly Time Determination with PMTS Methods, Human Factors Principles in DHA
- **Lecture-4:** Maintenance in Manufacturing/Production System- Important Ergonomic Design Issues: Part-I
- **Lecture-5:** Maintenance in Manufacturing/Production System-Important Ergonomic Design Issues: Part-II; Job Design and Job Satisfaction

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So, just I will tell you what are the sub topics we will be referring to in each of these 5 lecture sessions.

Lecture-1: Concepts of Design for Manufacturing (DFM), Design for Assembly (DHA), and Design for Automation (DFA) and their Application; Ergonomic Design Principles.

Lecture-2: Product Design Assessment and Important Measures, Manual Assembly Design Efficiency: Use of Boothroyd Technique.

Lecture-3: Assembly Time Determination with PMTS Methods, Human Factors Principles in DHA.

Lecture-4: Maintenance in Manufacturing/Production System- Important Ergonomic Design Issues: Part-I.

Lecture-5: Maintenance in Manufacturing/Production System-Important Ergonomic Design Issues: Part-II; Job Design and Job Satisfaction.

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Ergonomic Design for Manufacturing and Assembly

- ✓ Concepts of Design for Manufacturing (DFM), Design for Assembly (DHA), Design for Automation (DFA) and their Application;
- ✓ Ergonomic Design Principles

Prof. Virendra Kumar Tewari
Department of Agricultural and Food Engineering
Prof. Pradipt Kumar Ray
Department of Industrial and Systems Engineering

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Today we will be discussing the following topic:

Concepts of Design for Manufacturing (DFM), Design for Assembly (DHA), Design for Automation (DFA) and their Application and Ergonomic Design Principles.

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Ergonomic Design and Automation

- Ergonomics/HFE addresses two important issues:
 - ✓ Design of industrial workstations
 - ✓ Design of products

Prof. Virendra Kumar Tewari
Department of Agricultural and Food Engineering
Prof. Pradipt Kumar Ray
Department of Industrial and Systems Engineering

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So, this will be our topic of discussion. Now, as you are aware that whenever we talk about ergonomic design or human factors engineering, we basically we refer to two important issues. First one is the design of the product and the second one is the design of the work station.

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Ergonomic Design and Automation

- **At the design stage of a product and corresponding workstation, we need to look into and assess if all other stages of product development are ergonomically designed**
 - ✓ **These stages are:** manufacturing /production, maintenance, and assembly for a typical product
 - ✓ **At each stage, there are a number of jobs to be carried out:** activities against tasks are done either manually, using machine tools of different kinds, or automated processes

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Related to work system components and all interactions we have discussed. We learnt that, since ages, entire manufacturing activity was highly labor intensive. Later on, as the activities were carried out by machine so the requirement of human labor started decreasing.

Some kinds of the work systems may be health hazard. And particularly certain activities certain jobs are referred to as dangerous operations.

So, for those cases, example- job requires heavy the material handling. So, obviously you prefer these jobs to be made automated.

Automation will be there, but it does not mean that all sorts of human activities are automated. So, there are many such cases where you will find that the certain jobs, many such activities can be done productively, most efficiently, most effectively with minimum time by humans by human labour.

There are many such activities. And for certain activities what you find that for a human being carrying out those activities will not be a problem at all. Within no time a human can carry out those activities. But if those activities are given to a robot to carry out. Then you may find lot of difficulties. So, ultimately bluntly suppose you start using the robots it may happen that the productivity may decrease and in many cases it may not be cost effective.

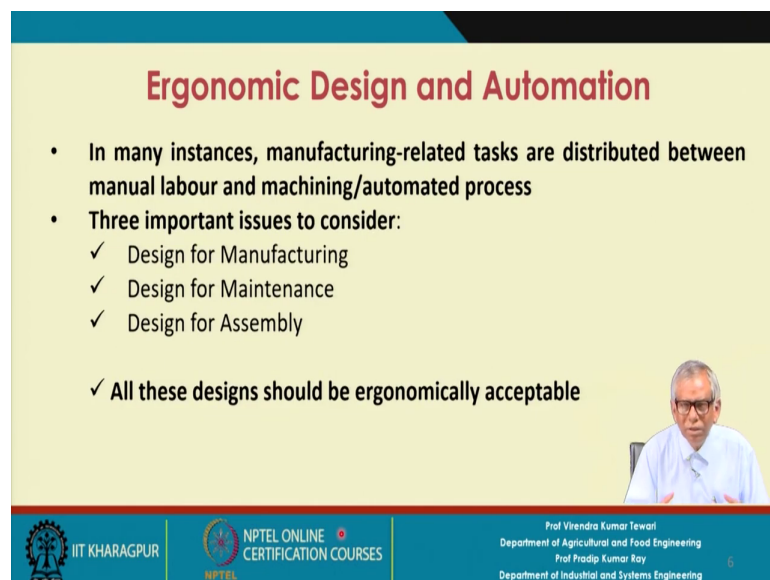
So, ergonomic design and automation, whenever job is not made for automation. In that case you have to certify that design of the job is ergonomically suitable and the interface is well acceptable and that is why the performance is guaranteed.

At the design stage of a product and corresponding workstation, we need to look into and assess if all other stages of product development are ergonomically designed.

These stages are: manufacturing /production, maintenance, and assembly for a typical product.

At each stage, there are a number of jobs to be carried out: activities against tasks are done either manually, using machine tools of different kinds, or automated processes.

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Ergonomic Design and Automation

- In many instances, manufacturing-related tasks are distributed between manual labour and machining/automated process
- Three important issues to consider:
 - ✓ Design for Manufacturing
 - ✓ Design for Maintenance
 - ✓ Design for Assembly
- ✓ All these designs should be ergonomically acceptable

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Department of Agricultural and Food Engineering
Prof. Pradip Kumar Ray
Department of Industrial and Systems Engineering

In many instances, manufacturing-related tasks are distributed between manual labour and machining/automated process

Three important issues to consider:

1. Design for Manufacturing
2. Design for Maintenance
3. Design for Assembly

All these designs should be ergonomically acceptable.

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Ergonomic Design and Automation

- Opportunities for automation in manufacturing, maintenance, and assembly may exist; however, automation technology may not be 'cost-effective' or productive in many cases
- Many jobs related to manufacturing, maintenance, and assembly, designed ergonomically and done manually, have more flexibility, greater adaptability and job satisfaction.
- Automation is to be used in extreme cases, when considered absolutely essential

Prof. Virendra Kumar Tewari
Department of Agricultural and Food Engineering
Prof. Pradip Kumar Ray
Department of Industrial and Systems Engineering

Opportunities for automation in manufacturing, maintenance, assembly may exist everywhere. So, whether it's a painting booth or pretreatment plant, you have to explore whether the automation is needed or not.

So, under the three or four conditions only automation is recommended. However, automation technology may not be cost effective or productive in many cases.

Many jobs related to manufacturing, maintenance, and assembly, designed ergonomically and done manually, have more flexibility, greater adaptability and job satisfaction.

Automation is to be used in extreme cases, when considered absolutely essential.

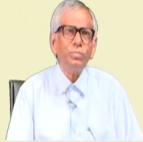
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Ergonomic Design and Automation

- **Main issue:** How to allocate different activities of a task or a job among humans, machines, and computer
- **Comparison between human/operator and machine attribute-wise**

✓ **Fitts' List**

| Attribute | Machine | Operator |
|----------------------|---|--|
| Speed | Much superior | Slow |
| Power | Superior | 1500 W max, 150 Wh for a day |
| Consistency | Ideal for repetitions | Unreliable, subject to fatigue |
| Information capacity | Multi-channel, megabits/sec | Usually single channel, <10 bits/sec |
| Memory | Literal production; access restricted | Better for principles and strategies; innovative and versatile access |
| Reasoning | Deductive, tedious to program, fast, accurate, poor error recognition | Inductive, easy to program, slow, inaccurate, good error correction |
| Sensing | Specialized, narrow range, poor pattern correction | Wide energy ranges, multifunction, great pattern recognition |
| Perceiving | Poor interpretation of written/spoken material; suffers from noise | Good interpretation of variations in written/spoken material; suffers from noise |



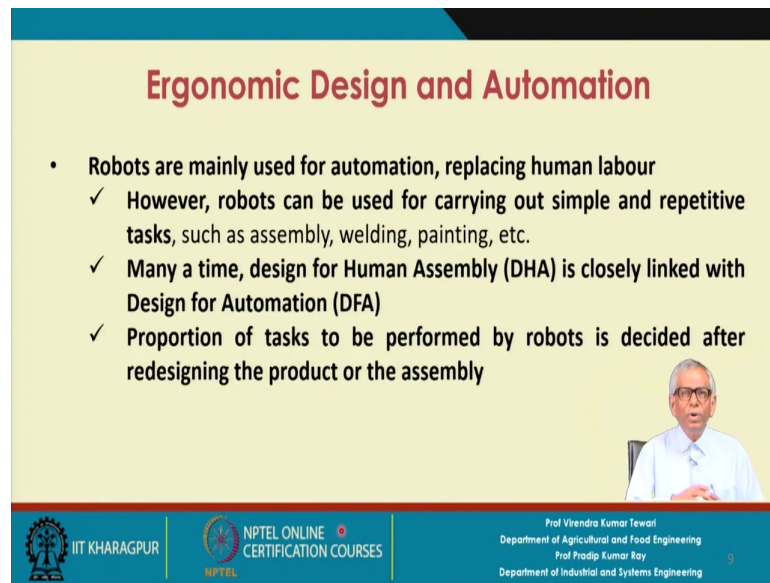
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Now, here you will find that in your textbook there is a list given. And when we refer to this particular table you will find that Fitts many years back says that if he compares between machine and operator with respect to certain criteria you will find the following difference:

| Attribute | Machine | Operator |
|----------------------|---|--|
| Speed | Much superior | Slow |
| Power | Superior | 1500 W max, 150 W/h for a day |
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Ergonomic Design and Automation

- Robots are mainly used for automation, replacing human labour
 - ✓ However, robots can be used for carrying out simple and repetitive tasks, such as assembly, welding, painting, etc.
 - ✓ Many a time, design for Human Assembly (DHA) is closely linked with Design for Automation (DFA)
 - ✓ Proportion of tasks to be performed by robots is decided after redesigning the product or the assembly

Prof. Virendra Kumar Tewari
Department of Agricultural and Food Engineering
Prof. Pradip Kumar Ray
Department of Industrial and Systems Engineering

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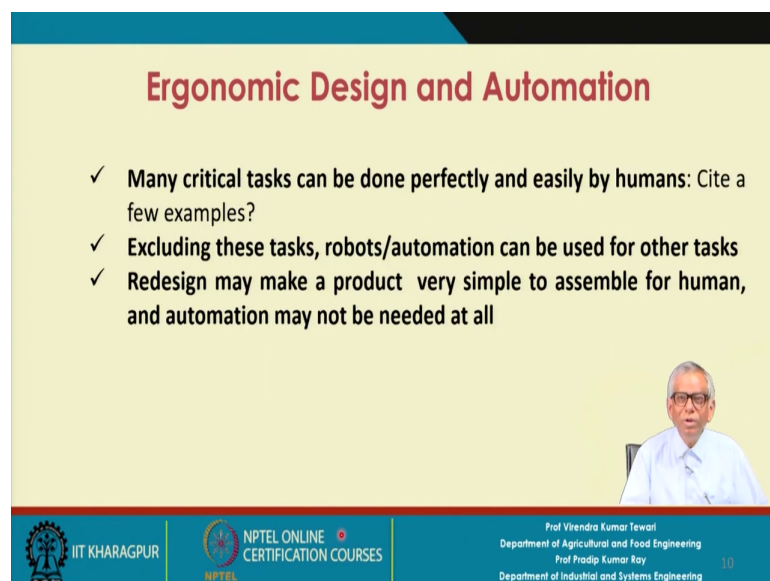
9

So, you use robots for automation. So, the robots are mainly used for automation replacing human labours. However, robots can be used for carrying out simple and repetitive task. such as assembly, welding, painting, etc.

Many a time, design for Human Assembly (DHA) is closely linked with Design for Automation (DFA)

Proportion of tasks to be performed by robots is decided after redesigning the product or the assembly.

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Ergonomic Design and Automation

- ✓ Many critical tasks can be done perfectly and easily by humans: Cite a few examples?
- ✓ Excluding these tasks, robots/automation can be used for other tasks
- ✓ Redesign may make a product very simple to assemble for human, and automation may not be needed at all

Prof. Virendra Kumar Tewari
Department of Agricultural and Food Engineering
Prof. Pradip Kumar Ray
Department of Industrial and Systems Engineering

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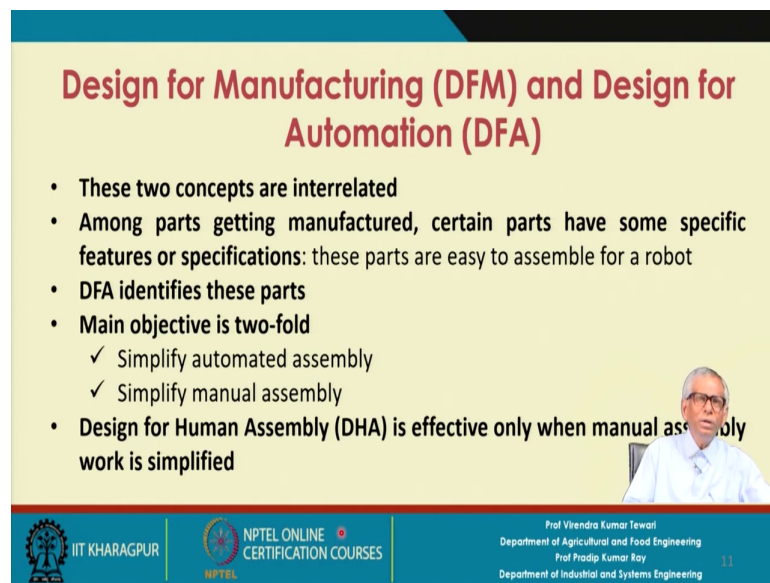
So, you have to first look into whether the design is perfect and is matching with the robotics conditions. That is very important, because robots have lot of limitations. So, whether the design is matching with the robot's capability or robots potential. Many critical tasks can be done perfectly and easily by humans provided that the design is ergonomically acceptable.

Cite a few examples. Excluding these tasks robots' automation can be used for other tasks.

Excluding these tasks, robots/automation can be used for other tasks

Redesign may make a product very simple to assemble for human, and automation may not be needed at all.

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Design for Manufacturing (DFM) and Design for Automation (DFA)

- These two concepts are interrelated
- Among parts getting manufactured, certain parts have some specific features or specifications: these parts are easy to assemble for a robot
- DFA identifies these parts
- Main objective is two-fold
 - ✓ Simplify automated assembly
 - ✓ Simplify manual assembly
- Design for Human Assembly (DHA) is effective only when manual assembly work is simplified

Prof. Virendra Kumar Tewari
Department of Agricultural and Food Engineering
Prof. Pradip Kumar Ray
Department of Industrial and Systems Engineering

These two concepts are interrelated among parts getting manufactured. Certain parts have some specific features or specifications. These parts are easy to assemble for a robot.

DFA identifies these parts, main objective is two-fold that is- Simplify automated assembly and simplify manual assembly

Design for Human Assembly (DHA) is effective only when manual assembly work is simplified.

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Ergonomic/HF Design Principles for Manufacturing, Assembly, and Automation

- These principles are for product design
- Prior to application of the principles/norms, assessment of an existing design of a product/assembly is to be done from a number of perspectives
- There are three main perspectives:
 - ✓ **Product Design Assessment and Improvement Measures** for simplifying assembly operations
 - ✓ **Design efficiency** based on time taken for manual assembly
 - ✓ **Use of Predetermined Motion Time standards** for assembly work

Prof. Virendra Kumar Tewari
Department of Agricultural and Food Engineering
Prof. Pradip Kumar Ray
Department of Industrial and Systems Engineering

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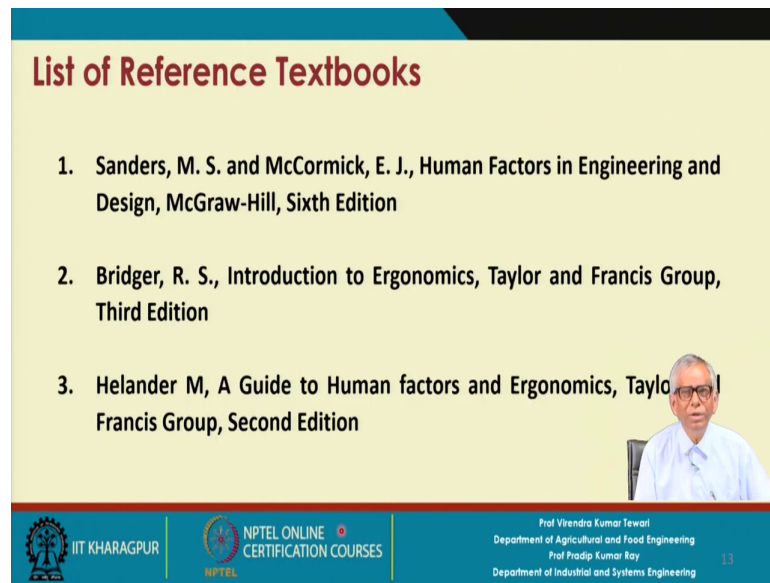
There are three main perspectives:

Product Design Assessment and Improvement Measures for simplifying assembly operations

Design efficiency based on time taken for manual assembly

Use of Predetermined Motion Time standards for assembly work.

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List of Reference Textbooks

1. Sanders, M. S. and McCormick, E. J., Human Factors in Engineering and Design, McGraw-Hill, Sixth Edition
2. Bridger, R. S., Introduction to Ergonomics, Taylor and Francis Group, Third Edition
3. Helander M, A Guide to Human factors and Ergonomics, Taylor and Francis Group, Second Edition

Prof Virendra Kumar Tewari
Department of Agricultural and Food Engineering
Prof Pradip Kumar Ray
Department of Industrial and Systems Engineering

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You have to use human factor principles everywhere when you design a job, when you design assembly related activities.