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The use of a morphological model for teaching manufacturing processes to students pursuing an industrial engineering degree at Florida International University

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ABSTRACT: In this article the authors present a morphological coherent process model instead of the traditional detailed lecture presentation of individual manufacturing processes. Elements are defined in this approach where a coherent and systematic understanding of materials is developed, in keeping with the course objectives, which is based on a general engineering background that allows the students of the Department of Industrial Systems Engineering (ISE) at Florida International University (FIU), Miami, USA, to evaluate the possibilities and limitations of the different process that reflect invariant relationships, methods and principles.

INTRODUCTION

The College of Engineering and Computing at Florida International University (FIU) in Miami, USA, depicts on its Web page, under the Department of Industrial and Systems Engineering (ISE), that the programmes in the ISE involve the integration of systems of people, Information Technology (IT) and resources, specialising in design improvement, installation and management of enterprise systems for manufacturing of and service industries [1]. In keeping with this statement, the approach to teaching manufacturing processes to ISE students is designed to be more challenging and meaningful than the traditional and more descriptive approach found in various textbooks [2][3].

In this article, the authors present a morphological model of the manufacturing processes. This model has been built up from a few fundamental elements arranged as follows:

- A material flow;
- An energy flow;
- An information flow [4].

In general, it is expected that the formation process of an industrial system engineer should take on an approach to enable the engineer to distinguish among the various processes, and characterise them by means of their possibilities and limitations concerning material geometry, tolerances and surface finish. Hence, for the model to be appropriate, it needs to embrace an all encompassing manufacturing methodologies.

MANUFACTURING PROCESS DEFINED: PHASE ONE

The term *process* is introduced – generally to define a change in the properties of an artefact including geometry, hardness, state and information content [4]. Thus, the process to accomplish manufacturing involves a combination of machining tools, power and manual labour. The general process model is introduced as illustrated in Figure 1.

The approach is presented as a systematic flow system that will allow for the elucidation of an input versus output mass and information consideration. This system approach is further developed to fit into those mass, energy and information flow properties as a function of manufacturing process interactions.

The material mass process flow prospective is introduced as shown in Figure 2. Various manufacturing process – akin to these mass flow prospective – are introduced in a general manner. A more in-depth treatment is covered under Phase two.

PHASE TWO

At this juncture, students are introduced to a project-based learning (PBL) approach [5]. They are required to elaborate on the manufacturing processes that fit the model by way of a guided project. Auxiliary flow material, such as lubricants, cooling fluid and filler materials, should form part of the discussion. A DVD or VHS on the fundamental manufacturing process can be utilised in order to complement the project [6].

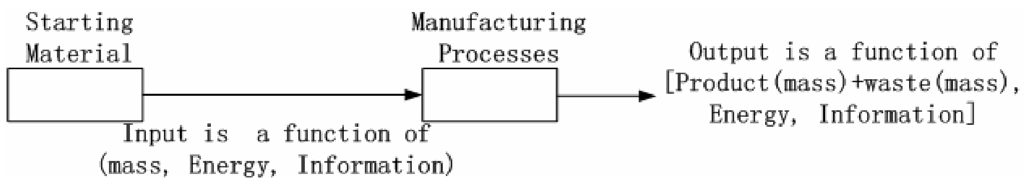

Figure 1: The general process model.

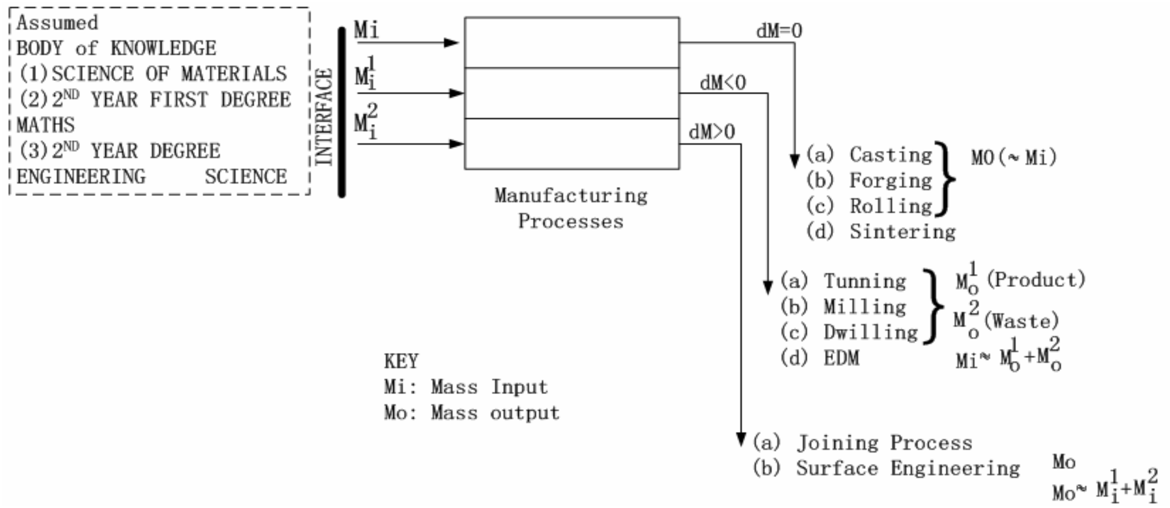

Figure 2: Three main types of mass flow in manufacturing processes.

Figure 3, which shows the classification of the manufacturing processes into groups, is given to students. They are then asked to name and describe the manufacturing processes under the surface creation principle heading of Figure 3. This exercise should include material type – composite and plastic, as depicted by the dotted lines in Figure 3. References [7-9] are suggested to be used for this project.

PHASE THREE

In Phase 3, a total of three full-class periods is required, where two progress presentations and a final presentation by each team are allotted. Thus, the periods are used for interaction on issues related to the projects. These periods are intended to stimulate the interest of students and to motivate them to take an active interest in their learning process, rather than mere *bookish* material for obtaining a certain grade. Key issues, such as energy, health and safety, information flow, characterised by the manufacturing process, are introduced by the instructor, who acts as a *facilitator* during the interaction.

PHASE FOUR

Phase 4 should be used for the recapitulation and to integrate the following:

- Quantitative determinations of forces, stresses, etc, for the manufacturing processes;
- Industrial safety.

It should be shown that the change in geometry of a material can be carried out in one or more steps. Thus,

$$I_0 = I_1 + \Delta I_{p1} + \Delta I_{p2} \ldots\ldots \Delta I_{pn} \ldots$$

Where:
I_0 is the desired geometry;

I_i is the initial shape information of the material;

I_p is the shape change information for a single process.

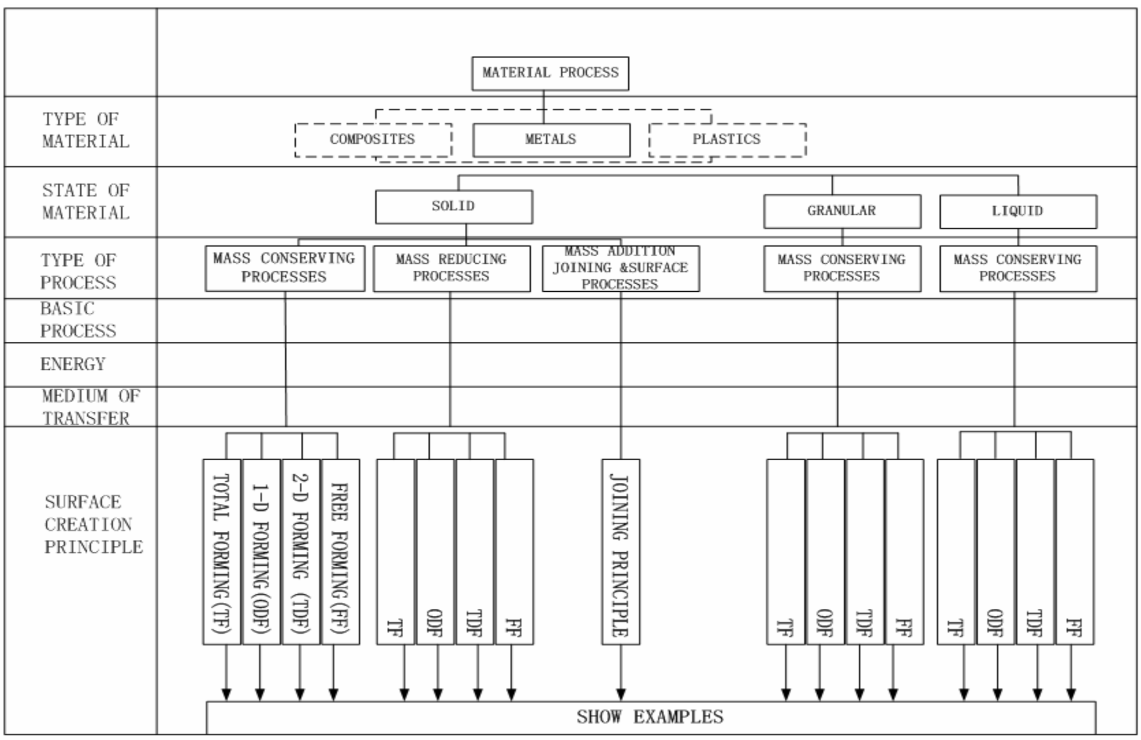

Figure 3: Classification of the manufacturing processes.

From the foregoing, a general morphological model, as shown in Figure 4, built up from fundamental elements related to the three flow systems is obtained from which all manufacturing processes can be deduced [4].

CONCLUSION

The fundamental elements in this morphological model give a systematic and coherent picture of manufacturing process field. It enables a logical and less *boring delivery* when compared to the traditional method of teaching manufacturing processes to persons who are not likely to pursue hands-on experience of any of the manufacturing processes during their working life. Furthermore, this model can also be utilised to generate new process ideas, which is an inherent part of the formation process in the pedagogy slant of the training of an industrial systems engineer.

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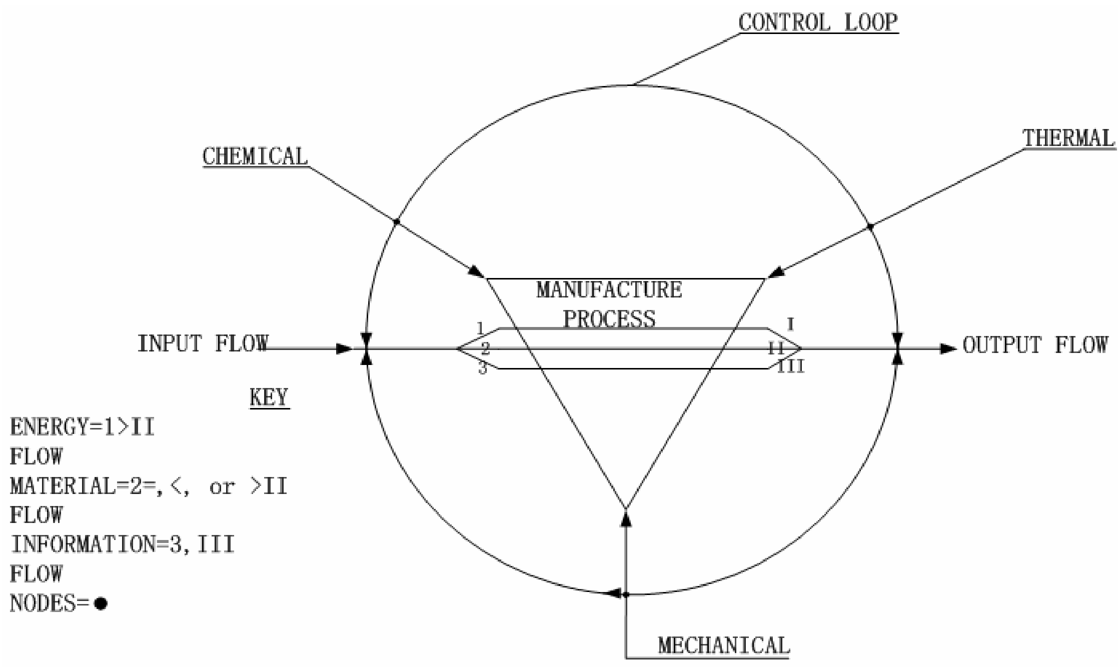

Figure 4: Model for the manufacturing flow processes.