The use of software and hardware engineering in the design and development of sheet-metal-forming-die manufacturing expert system

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Abstract
This paper discusses on the application of software and hardware engineering in the design and development of a sheet-metal-forming die manufacturing expert system (DMES) that includes object-oriented information modelling (OOIM), object-oriented database (OODB), object-oriented programming (OOP) and tool-making machines. The design and development of the DMES begins with the identification of areas that can be further improved and search for innovative ideas to solve problems of existing practices. The design elements of the DMES are categorised into three main manufacturing capabilities, namely resource-, process- and strategy-related capabilities (RRCs, PRCs and SRCs). This research uses ObjectStore for its OOIM and OODB and Visual C++ as its OOP base. A case study on one of the tool-making machine selection procedures namely wirecut machine is presented here. Wirecut machining is one of the crucial and critical downstream activities that involves high cost, high quality and precision machining together with the knowledge and application of strategic process and production planning and decision making with collaborative manufacturing principles in mind.

Keywords:
Sheet-metal-forming die, object-orient, expert system, manufacturing capabilities.

Introduction
Object-oriented information modelling (OOIM) is defined as object-oriented (O-O) software development method used to model, analyse and document system requirements [1]. Models can be used to capture different aspects of complex system and present it in a simpler form. Models are useful abstractions of reality employed to clarify, expose and manage highly complex activities [2].

An expert system (ES) is a sophisticated computer programmes that applies human knowledge in a specific area of expertise to create solutions [3]. It emulates human thinking processes in problem-solving situations. ES also has the capability to model experts’ thought process. Hence, application of information models incorporating knowledge-based system (KBS) and ES enables the simplification of complex systems, improve productivity and visualise conceptual, innovative and creative ideas.

Finally the die is ready for production where sheet-metal goes through the die from one end and the latter is pressed and formed to produce the required sheet-metal product by the time the sheet-metal reaches the other end of the die. These stages are shown in Figure 1.

![Figure 1 - Die design and manufacturing stages](image-url)
Table 1 Elements of manufacturing capabilities of the DMES

<table>
<thead>
<tr>
<th>Resource-Related Capabilities (RRCs)</th>
<th>Process-Related Capabilities (PRCs)</th>
<th>Strategy-Related Capabilities (SRCs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forming machines</strong></td>
<td><strong>Machining processes</strong></td>
<td><strong>Cost strategies</strong></td>
</tr>
<tr>
<td><strong>Tool making machines</strong></td>
<td><strong>Machining features</strong></td>
<td><strong>Timing strategies</strong></td>
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<td><strong>Die components</strong></td>
<td></td>
<td><strong>Process restrictions</strong></td>
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<td></td>
<td></td>
<td><strong>Resource restrictions</strong></td>
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</tbody>
</table>

\[ L_r = \sum_{j=1}^{n} t_i (\sum_{j=1}^{m} (r_j + 2\pi r_j)) \]

where \( L_r \) = rough-cut toolpath distance (mm), \( t_i \) = incremental penetration depth per cut (mm), \( r \) = incremental radial distance (mm), \( m \) = number of incremental depth movement, and \( n \) = number of incremental radial movement.

Equation 2 - Die design and manufacturing stages

**Conclusion**

In this paper, OOIM and OODB portions of the DMES have been presented. The DMM of the DMES depicts the manufacturing capabilities of the system that is divided into three namely RRCs, PRCs and SRCs. The application of RRCs, PRCs and SRCs has been briefly explained. A visual format of these capabilities was developed using Visual C++. This enables an O-O, user friendly, easy and fast way to build, expand and amend the database.

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**References**

