Development of a Computer Aided Die Design Software and Die Design Process Modeling

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Abstract

This research contains the studies on creating a three-dimensional (3D) solid modeling software for die design (integration of the geometric modeling core, geometric constraints, design scenarios etc.) and process innovations. Identification of the die design process, improving the process, problems that might occur and possible solutions are collected in this research. Weaknesses and strengths of the Computer Aided Design (CAD) software in the market were inspected from the point of die design. Die design process was modeled, process flow sheet was created and the integrated modules which the software should contain for each and every step in the design process was reported as a result of this research. Pre-release version of the CAD software that was developed during the research process is submitted.

Keywords:

Die Design Process, Computer Aided Design (CAD), Process Optimization

1 INTRODUCTION

Design is an ideological production for a specific purpose. Key elements of a successful design are; understanding requirements, specifications of boundary conditions and providing all the required information.

There are different design types and each of them has different properties. For the best design, these properties should be provided. Project management is also important for the design process. Project management for die design varies from other design types' project management. So, these features can be provided successfully only by specialized software.

Especially for die design sector, customers have distinctive and detailed requirements. Customer specific software must be used.

First CAD software programs were developed in 1960s. They were not designed by computer companies; they were designed by designer companies who are aeronautics and space companies. Such as, CADAM software by Lockheed Company, McAuto (Unigraphics) by Mc Donnell Douglas Company and CATIA by Marcel Dassault Company [1]. For that reason, Mubitek as a die design and software company has decided to develop a CAD software program specialized for die designing.

For this purpose, many different design software solutions have been investigated. As a result of this investigation it is observed that, most of the design solutions are developed for general design processes. Therefore, these solutions are away from simplicity, hard to use and require good hardware. For these reasons, a new software solution is decided to be developed for die design industry.

This software is planned to have the following features:

- Basic drawing and solid modeling functionality.
- Modules for an easy design.
- Wizards for several types of die design in order to save time.
- Die templates for frequently used design types.
- Specialized libraries for die design.
- Dedicated project management flow.

2 DESIGN PROCESS INNOVATIONS

2.1 Analysis

For analyzing the process of die design and CAD drawing; some design scenarios are prepared, many die designs are investigated, some companies' tree structures are studied. Also, some CAD programs are investigated and some assistant solutions for die design, integrated by CAD programs are studied.

In order to prepare design scenarios; some dies are designed to analyze different types of die, such as, drawing die, trimming and trimming with cam die, piercing and piercing with cam die.

Solidworks [2], CATIA [3], Cimatron [4], UG NX [5], NaroCAD [6], Iron CAD [7], Top SOLID [8] design programs are studied.

DynaVista [9], Vamos [10] and Dias [11] assistant solutions are investigated.

In order to develop a CAD program; ACIS [12], Parasolid [13], Granite [14] and Open CASCADE [15] geometric modeling kernels are investigated. Moreover, different CAD programs' data structures are studied. Open CASCADE [15] geometric modeling kernel is chosen since it is open source and easy to extend.

2.2 Pre Design Management

Requirement documents are an important aspect of the design process. Designers must read and study all the requirements at pre-design stage. Moreover, all the documents must be accessible to the designers throughout the design stage. These documents must be written by an individual responsible in order to avoid possible mistakes and data redundancy. Data security can also be achieved by letting only the authorized person to update any information.

There are three kinds of authorized users:

- Administrator: Manages project managers and designers.
- Project Manager: Creates projects and edits details of the projects.
- Designer: Can only see the projects' information.

Die process has three elements; project, product and operation.

A project consists of one or more products. Also, a product consists of one or more operations and generally, every operation has one die. The hierarchical order is given below:

- Project
- Product
- Operation

A screen shot from project browser of the application is shown in Figure1.

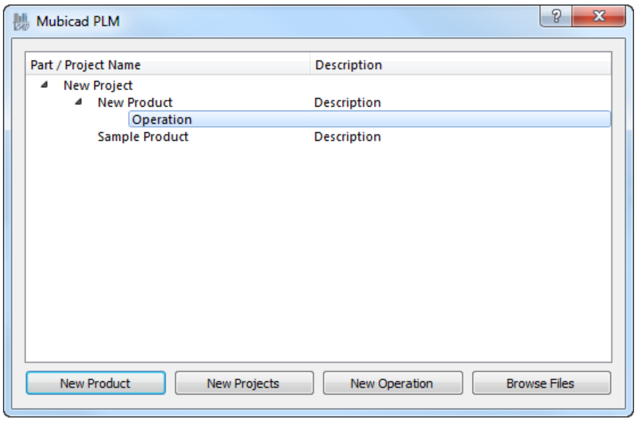

Figure 1: Project browser.

Requirements for die design are listed below;

- Die identification data: Contains main information about die.
- Production data: Contains press data.
- Evaluation data: Contains the evaluation data.

A screen shot from project identification card of the application is shown in Figure 2.

A revision system for die designs is developed. Designers can commit their works to the server. Thus, a list of revisions, commitment dates and author information is available and accessible to the authorized users.

2.3 Design Management

Design process work flow is shown in Figure 3.

During design process, designers meet difficulties or time consuming tasks. In order to avoid these, different modules have been integrated into the application.

- Creating new part,
- Parameters,
- Standard part library,
- Die templates,
- Die wizards according to different types of die design,
- Calculations,
- Coloring,
- Creating bill of materials (BOM),
- Die control.
- Technical dictionary.

Parameters

Parameters are added into part's tree structure during the modeling of a part. In simple terms, these parameters are variable dimensions of the part. When a value of a parameter is changed, application updates the part automatically regarding the new dimension.

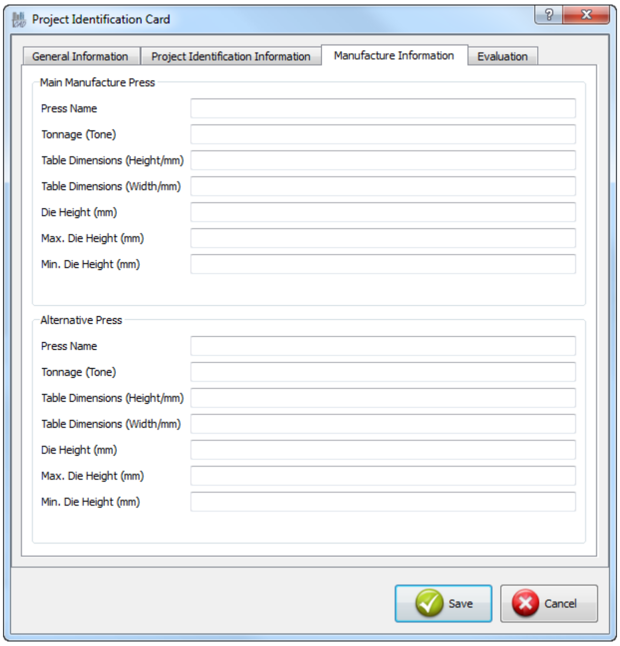

Figure 2: Project identification card.

Creating New Part

During the design process, designer can create parts in a controlled manner. Each part of a die has unique position numbers which are ordered. With this module, parts are created automatically with special parameters.

Standard Part Library

Most frequently used parts are standardized in order to accelerate the manufacturing process. Standard parts differ among manufacturers. Major manufacturers' standard parts are combined as a library within this module. By choosing a manufacturer and a standard part type, related part is loaded automatically.

Die Wizards

Die wizards are based on several die types. For each die type, parametric die templates are integrated in related die wizard. These wizards provide ease of use and help designers.

Die Templates

Die templates consist of base design structure. These templates help users to start design quickly.

Calculations

In die design there are various calculations, such as, stress, shear stress and sheet thickness calculations. These calculations are calculated with different formulas by designers. This module automates calculation process. So, it prevents waste of time and calculation errors.

Coloring

In a 3D model of a part, color of a face indicates manufacturing precision or type. Each color represents different precision and these values differ among manufacturers. Color palettes are grouped by manufacturers in this module.

Dictionary

Dictionary includes die design specific terms in six different languages. Designers can use it easily in international projects.

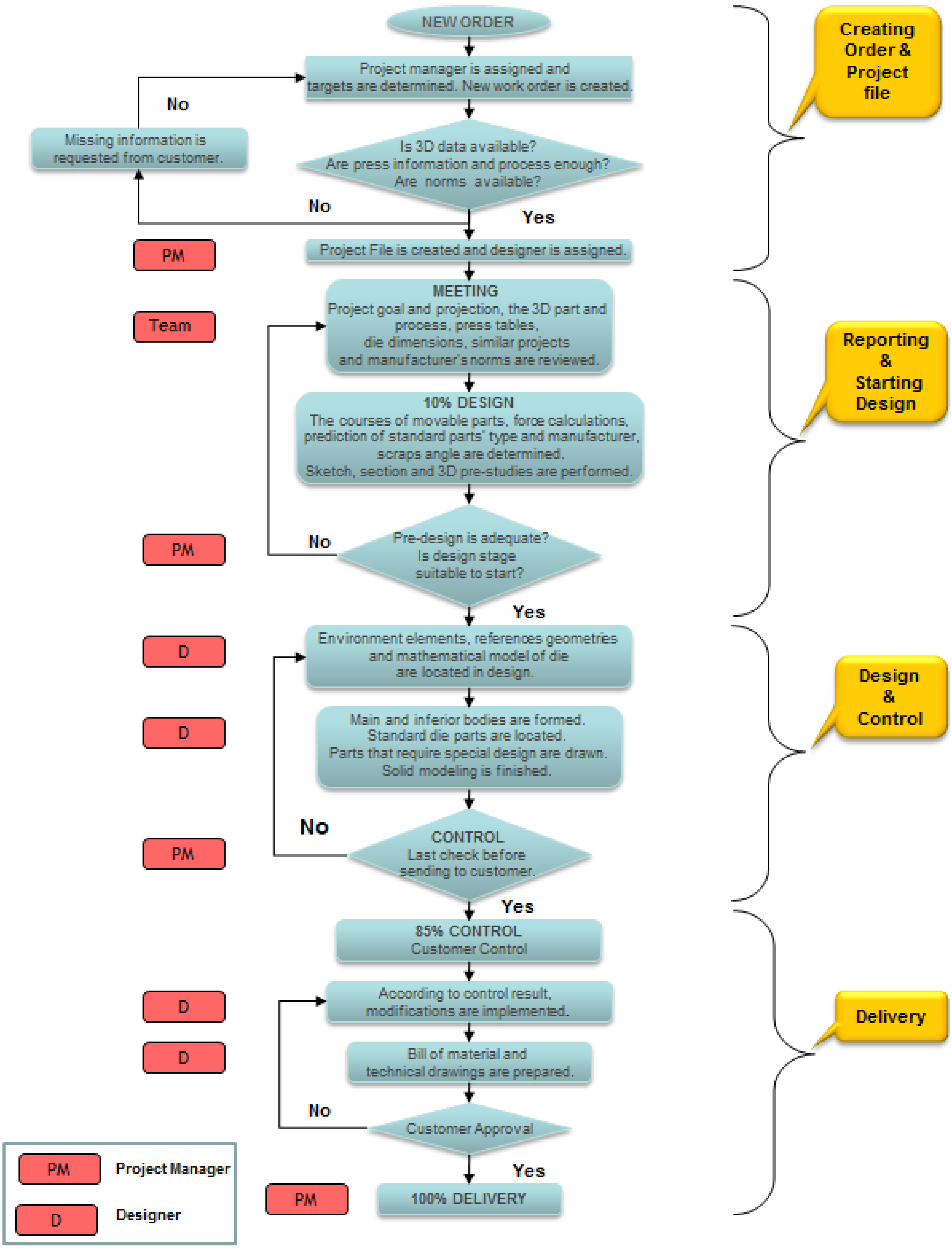

Figure 3: Design process work flow.

Creating Bill of Materials

After the completion of design process, bill of material is needed by the purchasing department in order to take necessary actions. Creating bill of materials is a time consuming job which is done manually. With this module, application automatizes this process, and creates the bill of materials easily.

Die Control

Die design must be controlled after its design is completed. Generally every manufacturer has different methods. Usually, a list of questions is answered then a control score is calculated. In order to provide standardization, lists from different manufacturers were studied and a proper list is prepared. The list is integrated in this module. Control list is associated with the die by the application.

3 GEOMETRIC MODELING

Basic CAD software should have the following functionalities to satisfy the modern Computer Aided Design software requirements. Ability to;

- Sketch geometries in two dimensional (2D) space.
- Define geometric relations (constraints) between 2D geometries.
- Convert 2D geometries into 3D solids.
- Ability to perform various operations on solids, such as combine and intersect.
- Import and export modeling data into other file formats.
- Define constraints between mechanical parts (solids) in order to compose an assembly.

The application is planned as a basic CAD program. Considering CAD software requirements, geometric operations are determined based on surveys which are taken by experienced CAD program users.

The required operations are separated into two parts. The first part contains 2D operations and the second part contains 3D operations.

2D operations are listed below:

- Ability to draw primitive geometries, such as line and circle, and derived geometries such as rectangle.
- Corner and chamfer operations for fast drawing.
- Ability to create symmetric and mirrored geometries.
- Ability to define relations between geometries such as parallelism, tangency, angle and concentric constraints.
- Ability to project geometries to planes and keep synchronization between the source and projected geometries.

A Sample 2D sketch which is drawn with the application is given in Figure 4.

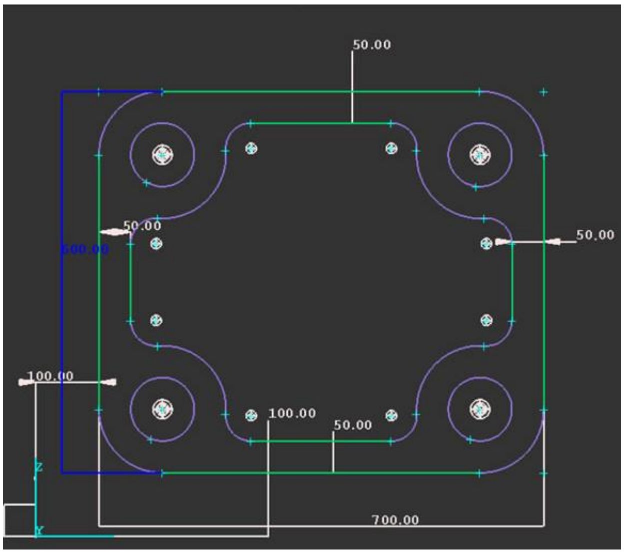

Figure 4: Sample of 2D sketch.

A CAD application must solve relations between geometries and return the optimized solution to the end user. Although this process seems easy for pairwise geometries, it becomes a complex problem when chain relations are added to the system. In order to overcome this problem, an external solver library (Siemens 2D Constraint Manager) [16] which has also been used in several market-leader software is integrated to the application. Operations to generate 3D solids are separated into two classes, namely sketch based and non-sketch based operations.

Sketch based operations are listed below:

- Extrusion of a contour.
- Pocketing of a contour.
- Revolving a contour by an axis.
- Sweeping a contour along a line or an axis.

Non-sketch based operations are listed below:

- Fillet and chamfer operations.
- Combine, subtract and intersect operations.
- Pattern, mirror and offset operations.
- Creating reference planes.
- Measuring in 3D space.

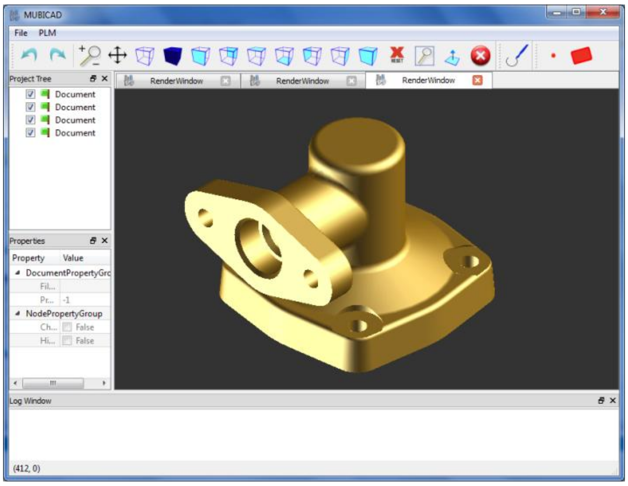

Figure 5: Mechanical part.

A mechanical part is shown in Figure 5.
This application uses an open source modeling kernel which handles several of the geometric operations and presentation of geometries on the screen.
The application stores all data (geometries, constraints, etc.) in a specific tree structure. The tree structure provides great flexibility to application's data requirements. Any kind of data can be added easily and can be edited by the end user via property browser if the data is editable. In Figure 6, an example tree structure with illustration is given.

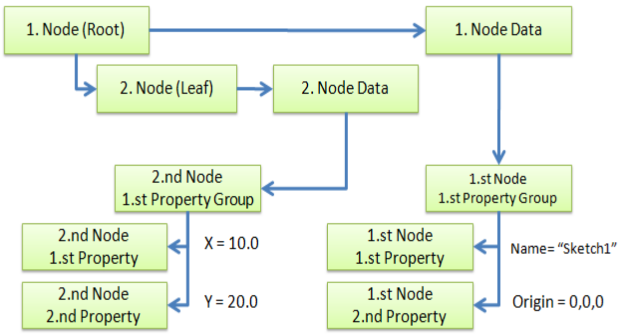

Figure 6: Example of tree structure.

This kind of data structure keeps data in a history based manner, in which each new operation is placed on top of the preceding operations. History based structure helps users to change their drawings and keep track of the changes more easily.

The application stores drawings within its native file format. Using native file format ensures that no data will be lost. Native file format stores tree structure. When a file is loaded, geometry is rebuilt from the tree nodes regarding their historical order. In Figure 7, a sample project tree is shown.

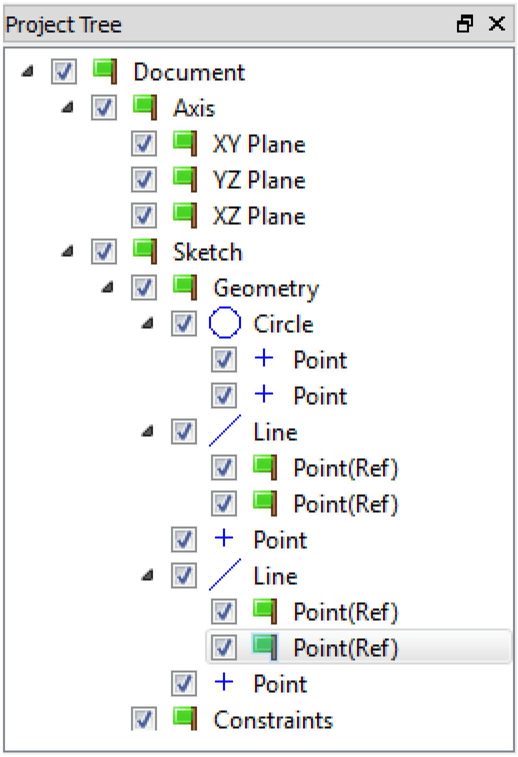

Figure 7: Sample of project tree.

In an assembly project, native file format support is not sufficient. In order to import standard part drawings like bolts and to use drawings produced in other applications, an import/export module is implemented. This module supports some of the widely used open file formats (IGES 5.3, STEP AP 203 and 214). Robust support for other formats is planned to be implemented in the future because data exchange capability has a great importance in CAD software market.

Figure 8: Standard screw, STEP format.

A standard screw is in STEP format is shown in Figure 8.

An assembly editor is planned to be implemented for the application. Assembly editor will help users to position previously drawn parts. Pre-assembled mechanical parts are shown in Figure 9.

The application is designed to be cross platform. Although, the application is being developed under Windows operating system; no platform specific routines are used. In order to ensure cross-platform support, Qt cross platform application and UI framework [17] has been chosen as the GUI solution. This framework also handles layout management that provides layout flexibility to the application. A screen shot from an early version of the application is shown in Figure10.

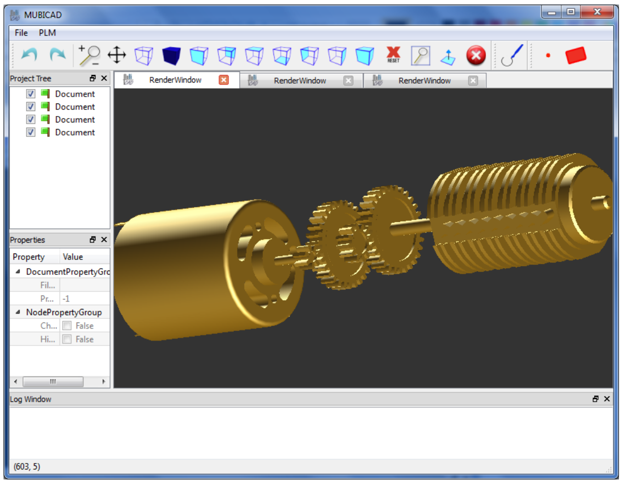

Figure 9: Pre-assembled mechanical parts.

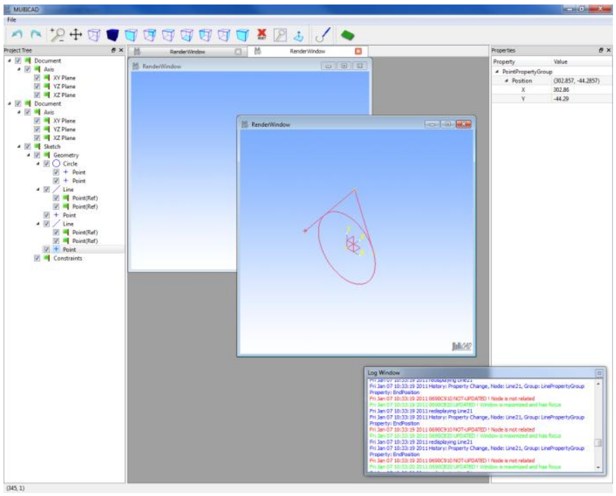

Figure 10: Screen shot from an early version of the application.

4 CONCLUSIONS

Die design is a very comprehensive process. There are too many details and many people can work in a project. These cause the process to become complicated. Documents and details must be managed besides drawing. For a good design, everything related with die design must always be available and reliable. There exist several assistant programs that run with CAD programs. In order to make design process easier, quicker and more reliable, all the details and model data should be together in a solution. In other words, project management, revision system, drawing and modeling editors should be working together flawlessly.

With specific modules and wizards, improvement rates can be up to 60% – 70%, based on conventional methods in die design process.

5 ACKNOWLEDGEMENT

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