COLLABORATIVE ENVIRONMENT TO SUPPORT INJECTION MOULD DESIGN

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Abstract: *This work discusses the application of a collaborative environment to support the information exchanging in the initial phases of injection mould development. The exchange of information among injection moulding actors, i.e. customers, mould tool makers and design offices, who are involved in the injection mould development process, has been explored and understood. The relationships between these actors and their core competencies have been also explored defining what kind of information are critical in beginning of the injection mould design process and who is responsible for processing it. IDEF0 (Integration Definition Language for Function Modeling) and IDEF3 (Integration Definition Process Description Capture Method) have been used to model the information, activities and process related with the injection mould conception and design phases. To test the ideas presented in this work and the feasibility of the proposed environment, an experimental system is being developed using Delphi® programming tool.*

Keywords*: collaborative environment; product development; information exchanging; injection mould*

1. Introduction

The plastic transformation industry, in particular injection moulding, has grown significantly in the last years, increasing constantly the technological level of their product, mainly related to the product geometry (plastic components and injection moulds) and their development cycle management process. In this scenario, the time-to-market of these kind of product has become shorter reflecting in very limited design, planning, manufacturing, testing and delivery times. In the case of injection moulding, one of the life-cycle functions responsible for the success of the downstream development phases is its design, where efficient communication and quality information are required if reduction in the whole development time is aimed..

Traditionally, three main actors, which exchange information, can be identified during the injection mould development process. They are: the customer, who orders the mould; the mould maker, who develops and manufactures the mould; and the injection mould design office, who designs the mould. The last one is not always inside of the mould maker plant, being, sometimes, an independent design office, as mould tool makers can find very expensive maintaining such kind of professional.

This paper proposes a collaborative environment to support the communication among these different actors related to the injection mould development process, providing a dynamic exchange of information and at the same time, keeping the history of the development process. Different kinds of collaborative environment can be found in the literature (CADESIGN Magazine, n.88), however none of them has explored the injection mould development process.

Section 2 stresses some issues related to the information exchange in the injection mould context, identifying the main characteristics, information exchanging and competencies of each actors involved in this process. Section 3 presents the proposed environment followed by section 4 which shows some screen dumps of the developed experimental system.

2. Information exchange within injection mould making context

2.1. Identifying critical information and functions for injection mould development process

In order to start the process of developing an injection mould several kind of information, such as geometry of the plastic component, injection mould machine, plastic material, initial injection mould specification, are required. These pieces of information are defined based on the knowledge and competence of each actor involved in this process, who are more discussed in section 2.2.

Thus, when a new injection mould is ordered the information exchange cycle starts. One of the first information to be defined is the technical characteristics of the plastic component. This information is usually defined by the customer, who requests a quotation to the mould maker. The mould maker, in turn, sends the information about the plastic component to the injection mould designer, who can be an internal, or external, actor, in order to have a draft design of the injection mould. Based on a feedback of the injection mould designer, and his knowledge, the mould maker returns to the customer with a defined price, injection mould project and delivery time (deadline). In this scenario, the mould

maker can be considered the main actor of this initial process, exchanging information between the final customer and the injection mould designer (fig. 1).

The exchange of information between the final customer and the designer is crucial for the development process of the injection mould. Although, these two actor do not build a straightforward relationship, which is managed by the mould maker, there will be a stage of this development process where the information exchanging starts to happen independently of the mould maker. This allows the creation of a parallel channel of communication, which can cause misunderstanding to the actors or over expose some other strategic information.

Based on this, there is a need to clearly understand and define which information are created and/or needed by each actor of this process, how the process of exchanging information take places and how each actor can interfere on this information. This is described in the following section.

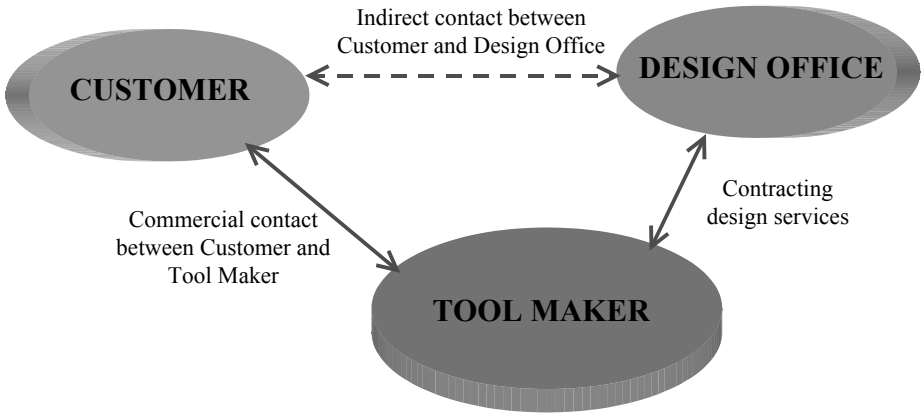


Figure 1. Customer, injection mould designer and mould tool maker relationship

2.2. Core competencies in injection mould development environment

In order to identify and understand the core competencies related to the injection mould development process, a questionnaire was applied to 17 mould makers of Caxias do Sul region. In this questionnaire some issues were covered, such as: support information system, project management, human resources, internal processes, etc.

Based on the initial results of this questionnaire, functional e process models have been built to provide a better understanding and analysis of the process of injection mould development. Such models have been created based on the internal procedures of one medium size mould maker company, and IDEF0 and IDEF3 techniques have been used for it (Cheng-leon, 1999; Cho e Lee, 1999; Huang e Mak, 1999).

Figure 2 depicts a general view of the IDEF0 first level of the function “develop injection mould”, where this function is decomposed initially in “Make Injection Mould Project”, “Send to Customer´s Approval” and “Manufacture Injection Mould”.

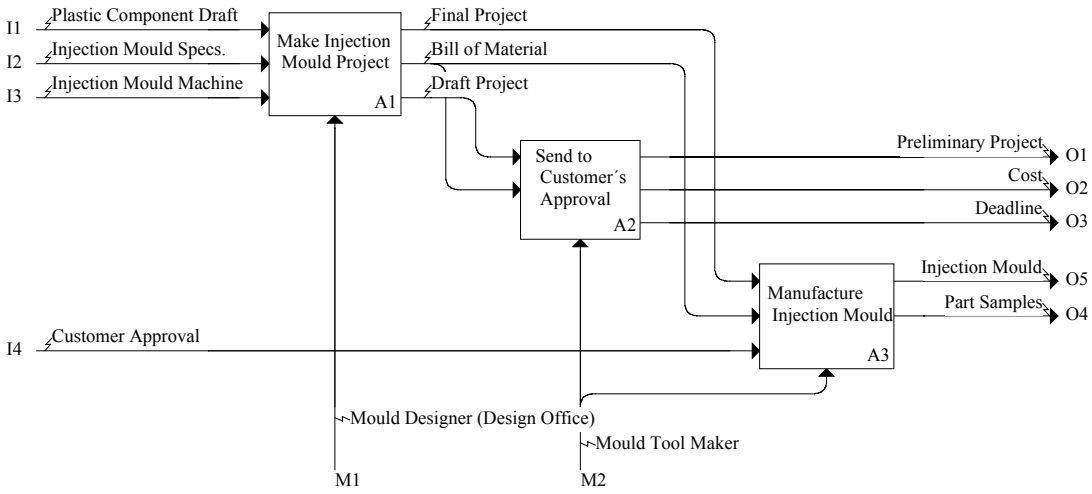


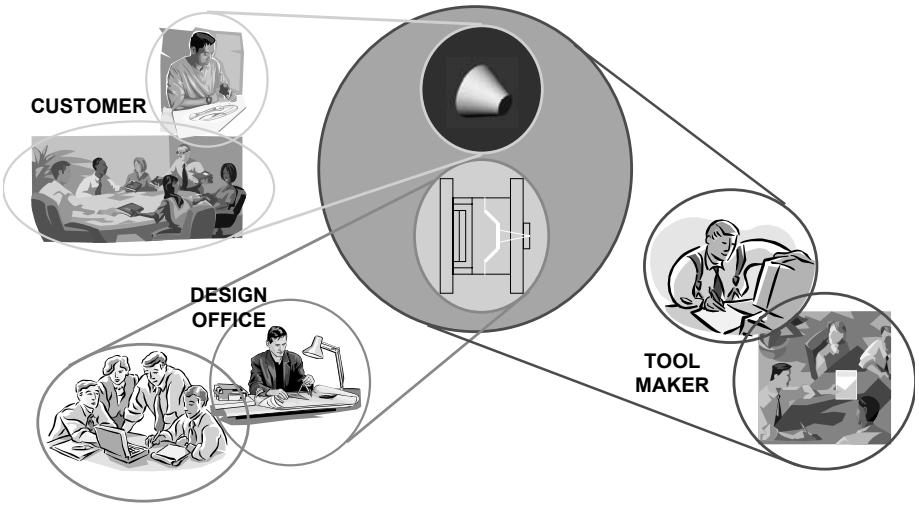
Figure 2. IDEF0 first level model for injection mould development

Although only the Mould Designer and the Mould Tool Maker appear as the main actors in this diagram (M1 and M2), the customer is an important part of this environment providing the product specification and the final approval to start the development process. This model identifies some points where this process could be improved, providing a

better visualisation of the core competencies and the information input and output of each actor. Also, based on this analysis it has been possible to get a better understanding of the injection mould development environment.

Abreu (2000) states that core competencies are sets of basic or needed abilities that must be defined and organised to develop an activity in the best way. In this paper, core competencies mean the abilities and functions developed by each actor involved in the process (customer, mould designer and mould maker). These competencies can help to identify the information relationships during the development process of an injection mould.

The association between each actor's core competencies with the information flow between their activities provides a definition of their tasks within injection mould development process. Based on the functional activities and the information flow models, developed in IDEF0 and IDEF3, it has been possible to establish the relationship (level of interaction and interference) between each actor and the information created in the injection mould development process. Figure 3 depicts the different viewpoints related to the injection mould development process and shows the relationships between the actors and their information exchanging.



Information/Specification	Customer	Mould Maker	Mould Designer
Customer Information	◖	•	•
Plastic Component Geometry	◖	◡	◡
Plastic Component Material	◖	•	•
Plastic Component Quantity	◖	•	•
Injection Mould Machine Information	◖	•	•
Mould material	◖	◡	◡
Cavity/core finishing	◖	•	•
Engraving	◖	•	•
Mould Manufacturing Machines	•	◖	◡
Heat treating	◡	◖	◡
Machining time	•	◖	•
Design costs	•	•	◖
Design time	•	•	◖
Number of impression	◖	◡	◖
Feeding system	◡	◡	◖
Ejection system	•	◡	◖
Design management	◡	◡	◖

Level of interaction: ◖ – strong ◡ – little • – none

Figure 3. General representation of the different viewpoints and interactions within the collaborative environment.

From the customer viewpoint, his core competencies are related to the correct specification of the plastic component, such as plastic material, shrinkage, component geometry, aesthetics, production quantity, injection moulding machine and some injection mould specification, such as mould material, number of impression, cavity and core finishing and engraving. Figure 4 shows a general representation of some of the customer core competencies, and their relation with the IDEF0 models.

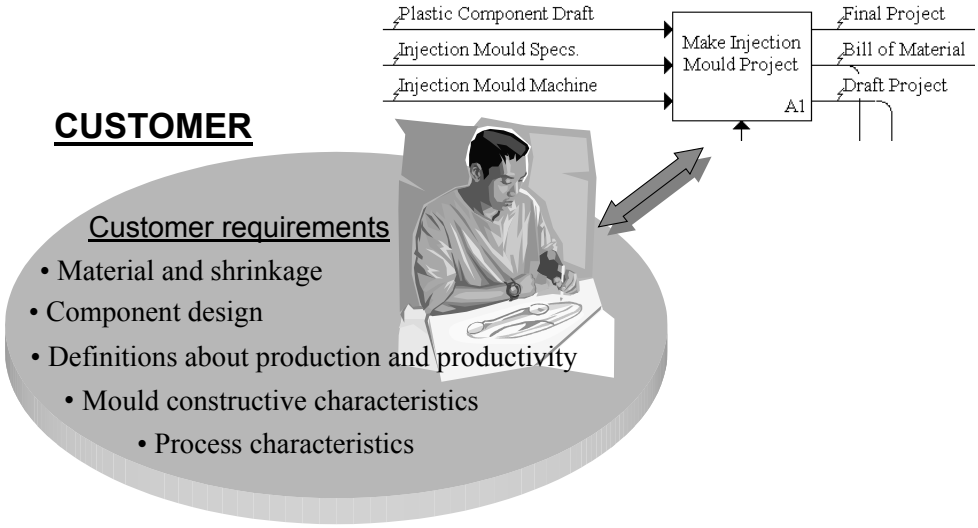


Figure 4. Customer's core competencies.

From the mould maker viewpoint, the analysis of his competencies has shown the complexity and wideness of its activities. This actor is responsible for defining the costs, managing the development of the mould, defining the process planning, manufacturing the components, programming CNC machines, making tests in the mould, etc.. Figure 5 shows some of these competencies and the need for interacting with other mould development teams.

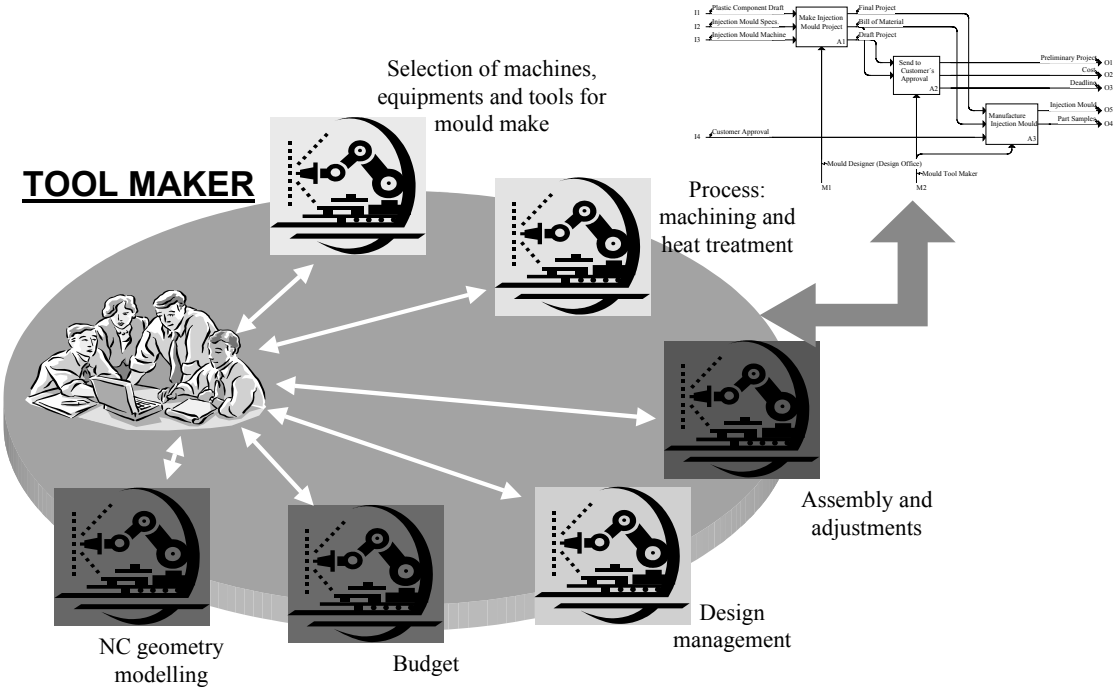


Figure 5. Mould Maker's Core competencies

From the injection mould designer viewpoint, either being part, or not, of the mould making shop, he is resposible for designing the injection mould. Among its activities are geometric modelling of the 3D cavity and core, design of cooling, feeding, ejection and venting systems, mould mechanisms, etc.. For this reason, the exchaging of information between this actor, the mould maker and the customer is quite intense in the initial phases of the injection mould development. Figure 6 depicts some of the core competencies of the injection mould designer.

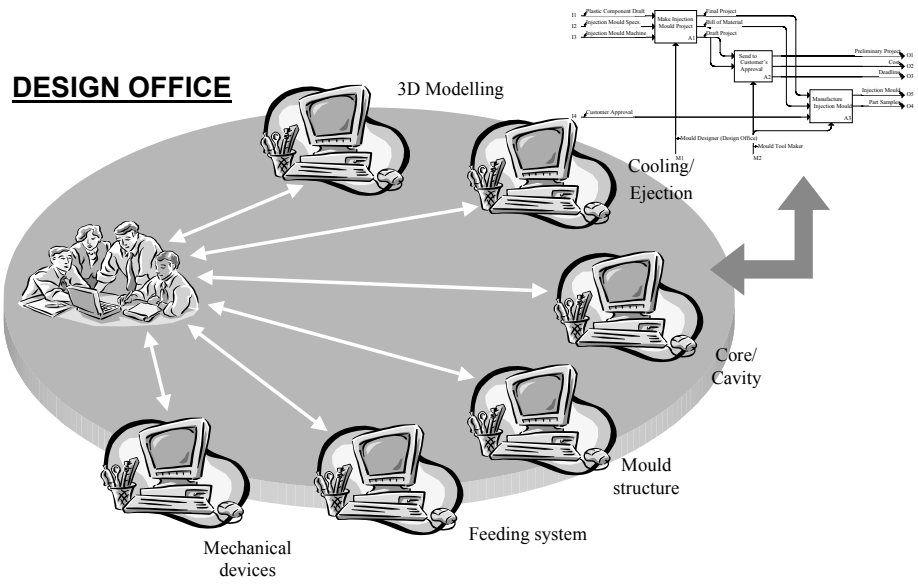


Figure 6. Injection mould Designer's Core competencies

3. The collaborative environment to support injection mould development process

The collaborative environment to support product development is not new and some efforts can be found in the literature, which has been also called "portals", such as Solidworks, Allproject, Autodesk, Construtivo, Gpro, IBM, Neogera E Sistrut (CADESIGN Magazine, n.88). However, these are focused on different fields, such as civil engineering, architecture, and some in mechanical part components. Specifically in the area of injection moulding works have explored and proposed concurrent environment to support injection mould design, but they are focused on the design and manufacturing aspects rather then in the collaborative aspects (Lee et al, 1997; Lee et al, 1997; Ong, 1995; Shakshuki et al, 1995 e Willens et al, 1995). The possibility of more recent network infrastructure, i.e., internet, has brought special attention to additional works in this area (ZHOU et al, 2002).

Based on the analysis of the questionnaire, the core competencies, and the information identified, it has been defined as one of the main goal of the proposed collaborative environment to provide a better integration in terms of information exchange among the actors involved in the injection mould development process. Thus, each actor, based on its core competencies is responsible for generating and managing a set of information, which are accessible to the other actors involved in the development process. Figure 7 depicts a general representation of the collaborative environment proposed.

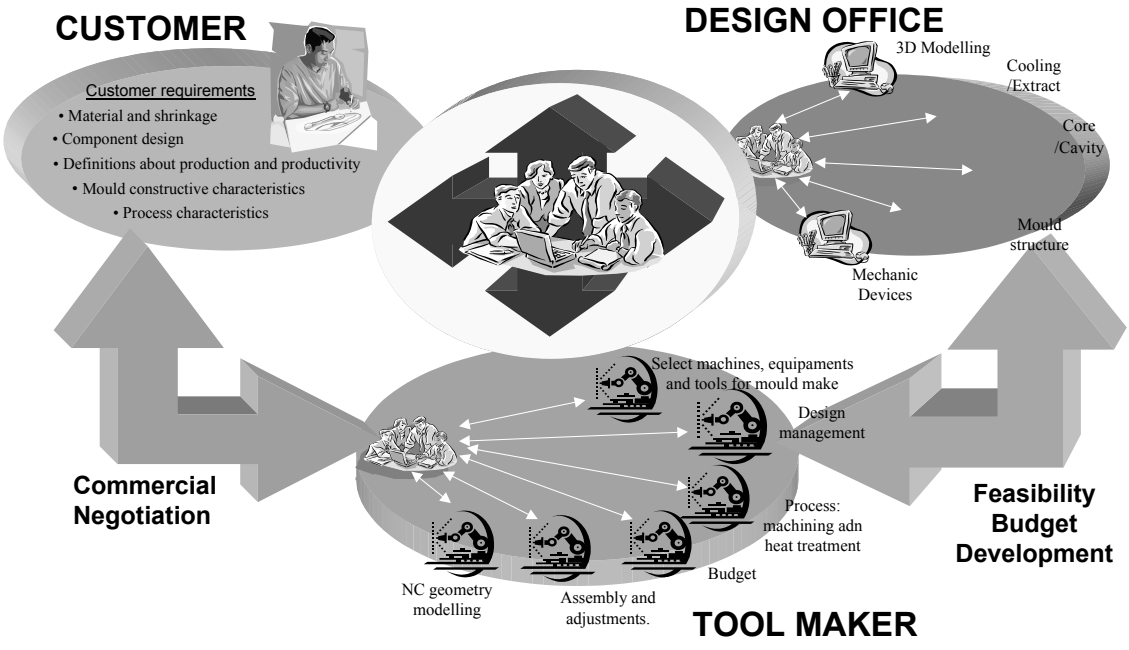


Figure 7. General representation of the collaborative environment.

In this environment, changes made in each actors' related information require that the reasons for these changes to be documented, capturing the history of the development process. The environment has been structured to allow each actor to work based on his core competencies, having knowledge and control on his information. On the other hand, the environment makes also possible that other actors can have access to some of this information allowing the exchange of information and ideas within a specific product development process.

4. An injection mould experimental system to support the collaborative environment

In order to test the ideas explored in this work, an experimental system has been developed. The system has been developed in Delphi®, where three main environment have been defined based on the core competencies of each actor. Each actor has access to a set of information, which is previously defined by the mould tool maker, who is responsible for managing this collaborative environment. The information are stored and shared through a common database. For the implementation purpose the access to this database was defined locally.

Each actor can access the environment, inputting or changing information related to its core competencies, and thus, interacting with other actors involved in this process. During this process of exchanging information each actor is responsible for the information he/she is providing.

Figure 8 depicts a screen dump identifying the three main working areas for information adding and visualisation within the collaborative environment:

- Product Information area, where each actor can add or edit information about the product in development;
- Comments area, where each actor inputs its comments related to any changes make in the original information;
- History area, where all changes made during the development process are documented.

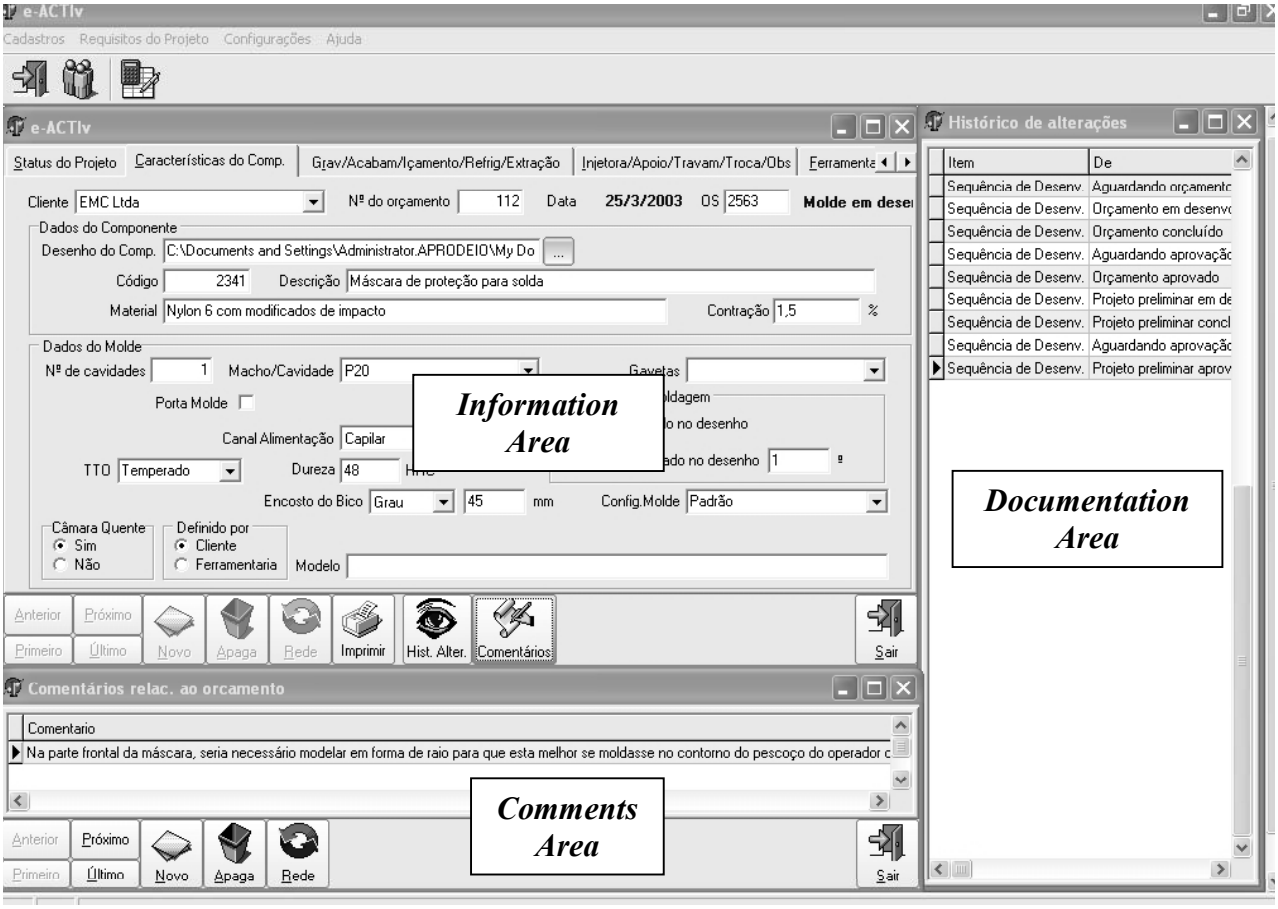


Figure 8. Screen Dump of the experimental system

The proposed system provides also the possibility of checking the status of a product (injection mould) throughout its development time. Thus, it is possible to check and analyse the results of each phase, as well as the reasons for such results, for example the final cost of the mould, conceptual phase, design phase, manufacturing phase, assembly, tests, plastic component samples, etc.. This supervision process can be done by any of the actors, involved in a specific development process, and becomes more helpful as the number of project grows.

5. Conclusion

This work has discussed issues related to the definition, characteristics and implementation of a collaborative environment to support injection mould development process. A study of this process has been realised throughout a questionnaire and IDEF0 and IDEF3 models based on injection mould tool maker of Caxias do Sul.

Three actors, i.e., customer, mould designer and mould tool maker, and their core competencies have been identified, as well as the existing interactions between these actors and the information exchange. The tool maker has been defined as the main element on this environment.

An experimental system has been implemented, however, further work is necessary to test the ideas in a web-based environment, involving a larger number of users. There is also a need to evaluate the application of a formal process to this environment, forcing each actor to respond when required.

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