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An example of simulation tools use for large injection moulds design: the CONTENUR™ 2400 L solid waste container

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Large containers volumes more than 1100 l, are usually produced in slow procedures as rotomoulding process without part weigth restrictions. T.I.I.P., injection moulding plastic group of the Department of Mechanichal Engineering of the Zaragoza University depeloped with CONTENUR™ a new product under european normes for solid waste containers up to 2000 l volume, the result was a new main body up sixty kilograms weigth in one part. The design process combined several CAE tools (aesthetical design, mechanichal design and reologhical simulation), and last June shown final result and tested. Nowadays more than five thousand samples are on the street without basic modifications in the mould (more than one hundred tons weigth). The paper focus on the methodology used to integrate tool and process design with product definition (i.e. injection pressure and clamp force vs thickness and part shape). Some parameters about process control in this particular mould (injection rate, temperature, viscosity, gate location, …) are detailed.

1. INTRODUCTION

CAE tools have constituted an authentic revolution in the last years within injection of thermoplastic. The sequential process until the final solution (development, test of prototypes, modification of figures, new test…) has been replaced by faster and consisting procedure with the designer, transformer and final client working together on the same computer files (concurrent engineering). Therefore the timing for mould manufacture and completion have been reduced enormously, but some interesting advices about CAE use are described in [1].

The Workshop of Injection of the Plastics Industry of the University of Zaragoza (T.I.I.P.), C.S.I.C. associated unit, has been working with CAE tools in injection of thermoplastic more than fifteen years, with enormous advantage for the hundreds of projects made in different sectors (automotive, household-electric, packaging, toys, etc.).

Nevertheless, always this group have been conscious of the necessity to arrange simulation with procedure of manufacture next to the machine, of such form that has been collaborated and directed the constitution of the Research Association of the Workshop of Injection of the Plastic Industry (a.i.T.I.I.P.) organization without profit spirit that provides services to the transforming companies. This centre has been supported by national organizations as the Aragon's government and Spanish Ministry of Industry through different programs and research lines (new processes, new designs, process measuring techniques…).

2. THE CONTENUR PROJECT

When in 1999 the first Spanish company in manufacture of containers for the collection of urban solid remainders (CONTENUR SPAIN, S.L.) went to the T.I.I.P. to work jointly in the design of pieces of great size in injection arrived the moment for testing the real possibilities of these programs in this field.

Main objective was the fast manufacture of containers of great capacity (2400 litres in ahead) to compete against market products with welded metallic plate solutions or plastics ones made by rotational moulding with the inclusion of expensive reinforcement structures Obviously, between all pieces that constitute the set, the main challenge consisted of the manufacture of a single part bucket.

For the design of this element, the following aspects had to be considered:

- Agreed basic dimensions with the European norm EN – 12.574 [2].
- Unloading resistance (discharge sides) (Figure 1)
- High impact resistance
- Easily cleaning surfaces, friendly aspect, aesthetical design
- Minimum cost (processing and assembly, even for on street maintenance)
- Restriction of the clamping force imposed by the installed press machine (8.000 tons)
- Prepared for labelling, that is to say, with visible free and flat spaces
- Material restrictions: same materials used for other CONTENUR designs.

Special mention requires two limitations: minimum cost and maximum clamping force under 8.000 ton. For a minimum cost, thickness is fundamental (by the cost of raw material), inasmuch as the time of manufacture and therefore the cost of machine derived approximately depends on the square from the thickness [3]. On the other hand, to reduce the closing force the projected area of the piece and the distribution of pressures are strongly related with part thick (narrow sections forced a pressure of high injection, that could as well suppose a high force of closing).

Figure 1. boundary conditions, non linear material model, finite element model

The methodology applied [4], is related below:

a) Determination of the feasibility of the product: clamping force evaluation and thickness part on an agreed basic geometry to adjust dimensions with the norm. Main results are shown in Table 1.
b) Material selection, combining MFI and mechanical behaviour, and injection points locations were simulated, uneven knowing the final geometry of the component. Best results were found for several injection points arranged around bottom area in the main container body.

Table 1
Results for simple plastic model, first analysis using simulation tools

Main body thickness (mm) / weight (kg)	Maximum injection pressure (MPa)	Required clamping force (kN)
6 / 52	96	166000
7 / 60	71	122000
8 / 68	55	94000
9 / 76	44	74000
10 / 84	35	59000

c) Analysis of the body form and thickness of the part comparing constructive alternatives: it sidewalls shapes, metallic elements of reinforcement if necessary, inclusion of tubes injected with gas assisted techniques to increase inertia of the sections were considered, etc. Obviously mould dimensions and the presence of undercuts supposed a problem added for the design of piece and mould.
d) Part volume were adapted and different aesthetic forms appeared - feasible conjunction of the possible thickness by manufacture with the thickness and forms by mechanical resistance. In this step, finite analysis, solid 3D design and filling simulation were made simultaneously (Figures 2 and 3).

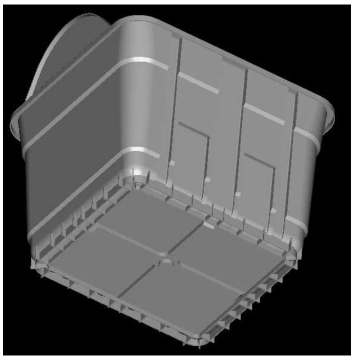

Figure 2. basic line, Pro-Engineer software, before final moulding arrangements

With these basic magnitudes a departure point for the final drawing of geometry and the inclusion of the elements of detail like output angles settles down, radios, position of accessories of the set (cork, skid, etc.). In parallel component flow analysis was set in definitive way, fixing optimum positions for manifolds working together with the mould maker, Kyowa Japan Company.

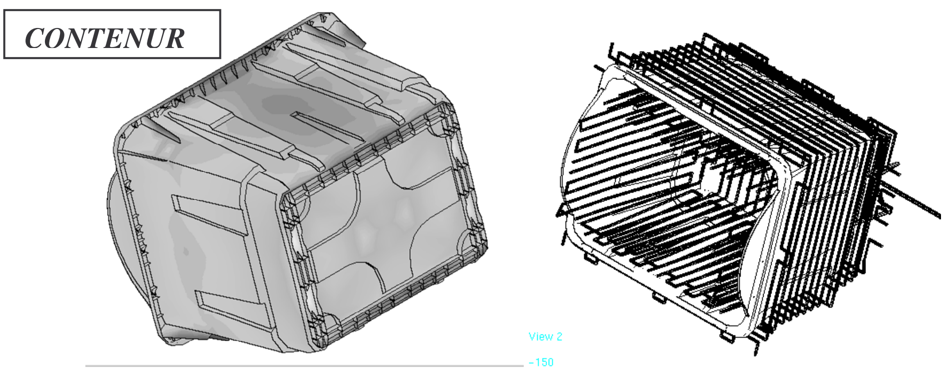

Figure 3. Software C-Mold: plastic temperature at ejection and cooling lines layout

The main aspects of the process and their simulation are:

- modelled of the figure for the work with geometries type 2.5 D.
- Location of the entry points to cavity. The use of race tracks for a better control of the filling was considered.
- optimal conditions of process: the selection of temperature and its relation with thickness and cycle strongly conditioned the permissible values for the design.
- the adjustment of the filling form by means of the correct programming of speeds became essential. At constant speed profile, the increase of pressure supposed values of inadmissible force of closing by the limitation imposed to the dimensions of the machine. This procedure was experimentally validated with tests in machine industrially to follow with a container of smaller dimensions already existing.
- Fixed the filling possibilities, this it was verified in with a new numerical model by the mould maker from the initial ideas sent by the design equipment and with the final data of necessary the hot camera for the feeding of the mould. The sequential technology was considered like a possibility with the purpose of reducing filling pressure, but the practical implantation, the maintenance and possible shutdowns took to misestimate their use.
- Finally, the analyses of cooling of the mould, packing and warpage induced by the process were developed. Of this form different constructive materials were used in addition according to their thermal conductivity.

Figure 4. real sample in Contenur assembly plant

Actually more than 7000 pieces were made without detecting problem some in the injection, expulsion or life in good condition of the component (Figure 4). CAE tools were basic in design process, but joined with knowledge and real test using similar (but smaller) moulds.

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