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DESIGN, MANUFACTURE AND IMPROVEMENT OF DIE FOR THE AUTOMOTIVE INDUSTRY

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Rezumat. *Pentru îmbunătățirea performanței proceselor de presare la rece se introduc permanent noi metode de optimizare a acestui proces, a activităților de proiectare, a procesului de fabricarea sculelor etc. Procedeul de prelucrare mecanică prin presare la rece dobândește, pe zi ce trece, o tot mai largă aplicabilitate, ca urmare a avantajelor pe care le prezintă: productivitate ridicată, precizie mare a pieselor și cost scăzut. Pentru optimizarea procesului de proiectare, la ora actuală se utilizează pe scară largă instrumentele asistate de calculator (CAD/CAE), ce contribuie la scurtarea ciclului de proiectare a produselor. Astfel se pot utiliza programe ca Cadceus sau Catia V5 pentru proiectare, dar și alte programe pentru lucrul cu element finit (Autoform).*

Abstract. *To improve the performance of cold pressing processes, new methods are introduced to optimize this process, design activities, tool manufacturing process, etc. The cold-pressing mechanical machining process gains an ever wider applicability as a result of its benefits: high productivity, high workpiece precision and low cost. To optimize the design process, computer aided tools (CAD / CAE) are currently widely used to help shorten the product design cycle. This is how programs like Cadceus or Catia V5 can be used for design, but also other programs for working with finite element (Autoform).*

Keywords: Quality, Molding process, Die

1. Introduction

This research is highlighting the work done by first author in S.C. Armcomp S.R.L., being employed as Operator on Numerical Control Machines, focusing on improving activities over time.

The purpose of this paper is to analyze the quality of a sheet from the point of view of the geometry of the piece and to develop solutions for the improvement of its quality level.

The following objectives have been set for the purpose of the paper, set out above:

a) Study of the cold deformation principles encountered;

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b) Understanding the role of the compartments directly involved in the development of the tools to produce benchmarks at the site of manufacture;

c) Identification of problems in terms of geometry of the piece and tools;

d) Developing solutions to improve the quality of the manufacturing parts.

Part I - BIBLIOGRAPHIC STUDY

1.1. Particularities of cold stamping and molding

Cold stamping and molding [1] includes machining operations of mechanical parts without pressure. Briefly, cold stamping and molding operations are known as cold pressing operations.

Cold pressing is a constantly developing modern machining process. In most cases, cold pressing operations are performed with special press-operated devices. The shape and dimensions of the pieces obtained correspond exactly enough to the shape and dimensions of the active elements (punch and active plate) of the respective pressing device. After deformation, cold stamping and molding is divided into two main groups: deformation with material detachment and plastic deformation [2].

1.2. Processing by embossing

The stamping operation consists in modifying a blank from the flat to the hollow shape, or increasing the depth of a cavity blank with or without intentionally modifying the thickness of the walls [3].

By stamping, pieces of different shapes and sizes can be obtained starting from the simplest of cylindrical shape of small height and ending with those of asymmetrical complex form.

Stamping is carried out with combined clipping and stamping devices on single-acting presses or molds on double-action presses or multi-position presses. The mold with which the embossing is carried out essentially consists of a punch and an embossing plate. The punch has the shape corresponding to the inner shape of the piece and the embossed plate has a diameter equal to the outer diameter of the piece [4].

Figure 1.1 shows the active elements in the stamping process. To obtain pieces of the desired shape, the blank (sheet) is pushed by a punch through the stamping plate.

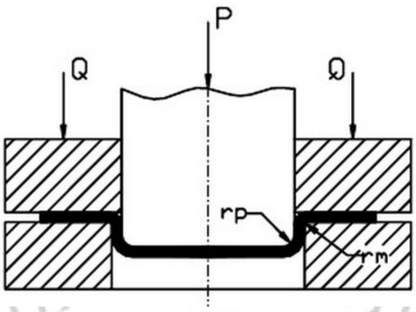


Fig. 1.1 Active elements in the stamping process

1.3. Cutting operations

Cutting is a group of cold plastic processing processes at which the material separation occurs, either totally or partially, after a closed or open contour with two associated edges (Fig. 1.2) [2].

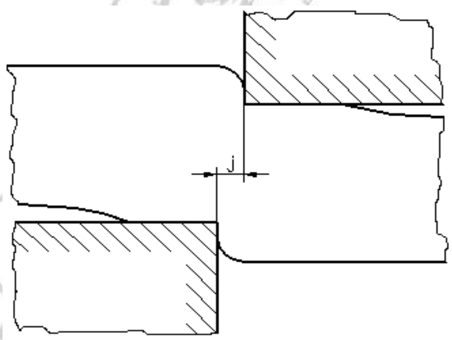


Fig. 1.2 Cutting shear

After the machine used, these methods are divided into two subgroups, namely: scissors cutting and punching (stamping).

Table 1 gives formulas for calculating cutting forces at parallel die edges and for determining press force.

Table 1. Calculation of cutting forces and determination of press force

Piece shape	Force calculated for cropping	Required force in the press
Either one	$P=L\cdot S\cdot \tau$	$P_p=L\cdot S\cdot \sigma_r+Q_b$
Round	$P=\pi\cdot d\cdot S\tau$	$P_p= \pi\cdot d\cdot S\cdot \sigma_r+Q_b$

Where: L - the length of the cutting perimeter in mm;

Qb - the force required to compress the extraction, depression, damping mechanism in KgF;

d - diameter of the piece, in mm.

1.4. Working through shaping

Depending on the deformation, the edges of the pieces can be deflected both in the inner contour and in the outline of the contours.

Embossing the edges of the inner contour

The deflection of the edges of the holes consists in the formation of the edges around the pre-machined holes (sometimes without them) or on the edges of the cavity pieces. The edges are obtained by stretching the piece material [4].

Figure 1.3 shows the diagram of the bore deflection diagram. Through this operation, due to the material's extensibility, there is a strong thinning phenomenon at the edge of the material.

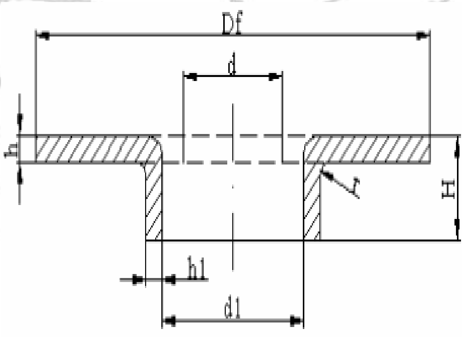


Fig. 1.3 Holes edge deflection operation

The thickness h1 can be determined with the relation: h1 = h.

The maximum bore diameter d1 is limited by the maximum deformation values of the material for which the fissure of the blank at the boss edge should not occur.

In the case of defrosted material, the material is pulled, and the increase in diameter from d to d1 is achieved only on account of material thinning.

Embossing the edges of the outer contour

The contouring of the outlines of the outline is a widespread operation in the automotive and aircraft industry and differs from the outset of the edges of the holes (the inner contour), the stress state, the deformation character, and the purpose of the machining.

The contour of the outer contour is embossed with crank presses, hydraulic presses and friction presses using rubber, hammers, casting molds, and sometimes with rubber or special bending machines and the edges of the parts.

Part II - CASE STUDY - PRESENTATION FLOW T0 AND FLOW TB

The T0 execution stream presents the steps needed to design and build a tool starting from the input data as follows:

- input data;
- manufacturing datasheet;
- designing;
- project launch;
- control.

2.1. Input data

Entry data is provided by the client and includes:

- 3D piece surface (Fig. 2.1)

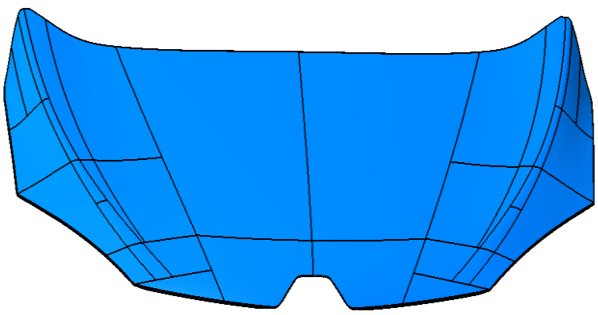


Fig. 2.1 3D piece surface

- Drawing of part 2D indicating the area of the part (Fig. 2.2)

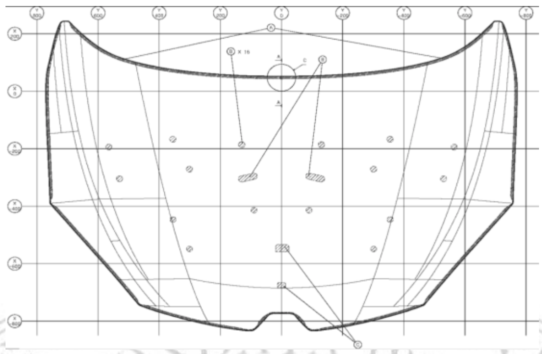
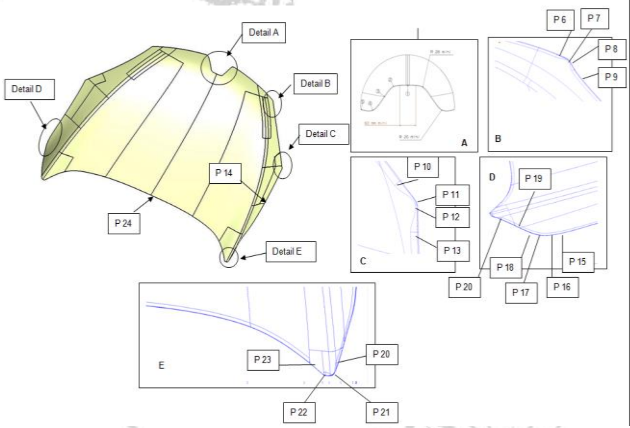


Fig. 2.2 2D drawing

- Shuttle Sheet, contains information about the height of the dashboard (Fig. 2.3)



Points (P)	Hauteur bord (H)
P1	4
P1à P2	4
P2à P3	4
P3 à P4	4
P4 à P5	4 à 8
P5 à P6	8
P6 à P7	8 / 4
P7 à P8	4
P8 à P9	4 / 7
P9 à P10	7
P10 à P11	7 / 4
P11 à P12	4
P12 à P13	4 / 9
P13 à P14	9
P14 à P15	9

Fig. 2.3 Renault Megane front hatchback door leaf

- Geometry folder, this document contains track geometry data (measurement points, tolerances, etc.) (Fig. 2.4).

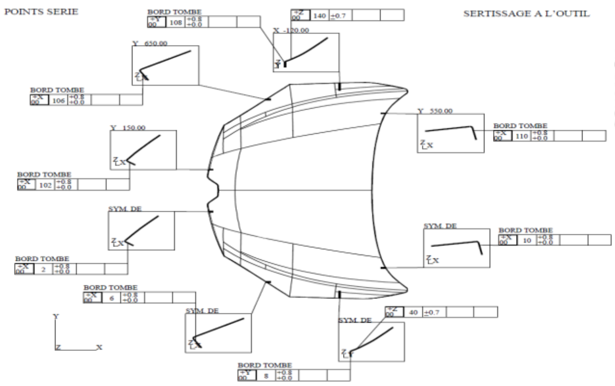


Fig. 2.4 Renault Megane front panel geometry file

2.2. Manufacturing data sheet

The technology for making the sheet piece is developed through a series of cold plastic deformation or cutting operations [5].

The Factsheet (Fig. 2.5) contains information about:

- The manufacturing line where the tool will work;
- Press type (TGP, GP, DE);
- Number of operations of the range;
- Gross mass of the piece on the vehicle;
- The sense of transfer;
- Table format (dimensions, thickness, hue, efforts);

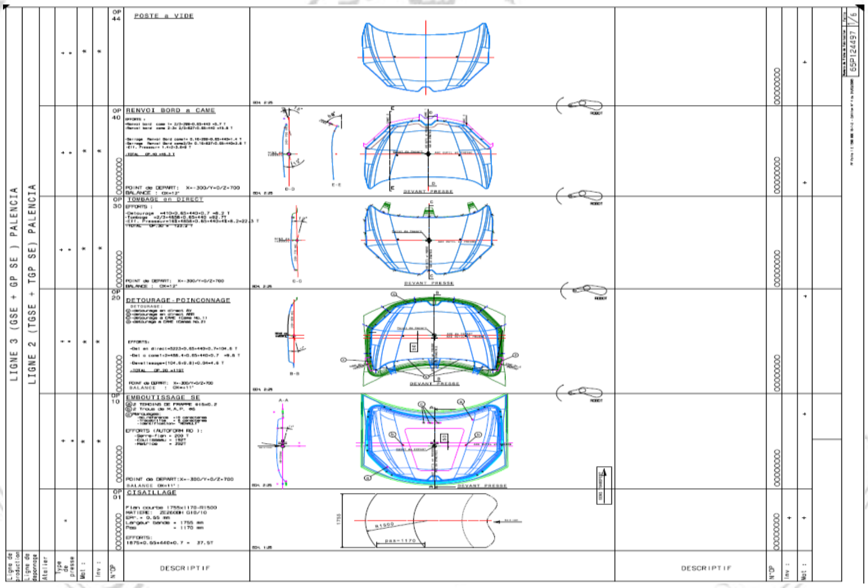
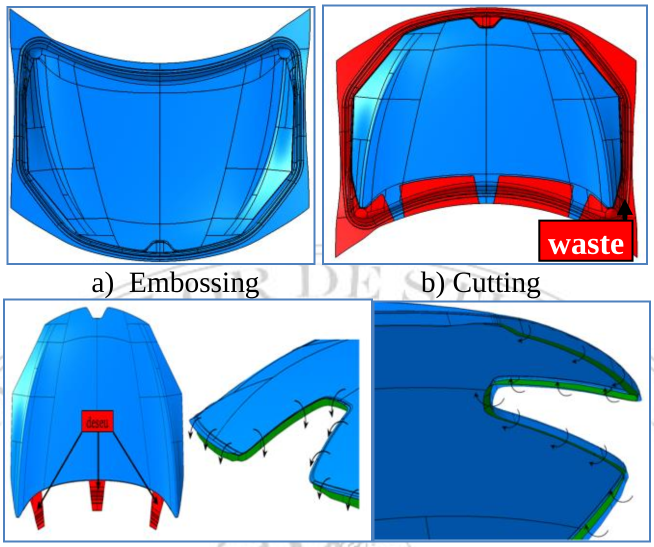


Fig. 2.5 Renault Megane RS's 2D Manufacturing Fabrication Data Sheet

According to the manufacturing data sheet, the studied hood panel is made from 4 operations. The 4 operations applied to the blank to the output of the product line are (Fig. 2.6):

- Operation 10 - Stamping;
- Operation 20 - Trimming;
- Operation 30 - Trimming + Edging;
- Operation 40 - Boring the LOGO area.



a) Embossing b) Cutting

c) Cutting + boring d) Boring the logo area

Fig. 2.6 The execution of the piece

2.3. Tool Design (Software Catia V5)

Computer aided design (CAD) is now increasingly used in very diverse areas, and some specialists believe that this technology has reached its maturity. However, the recent transformations of the main assisted design systems show that the CAD field is still on the rise [6].

The CATIA V5R18 (Computer Aided Three Dimensional Interactive Applications) product of Dassault Systemes is currently one of the world's most widely used CAD / CAM / CAE systems with applications in a variety of industries, from the car manufacturing industry, to aerospace and automotive (Fig. 2.7).

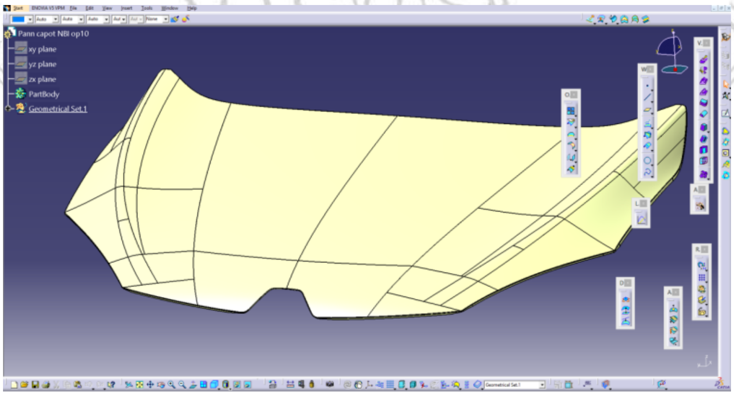


Fig. 2.7 The Catia V5 software interface

2.4. Parts control

The control of the parts is made visually to identify the defects of appearance, but also with specialized machinery and tools for geometrical checks.

Geometric checks are carried out on the control means (Fig. 2.8) using the 3D Dea Delta coordinate measuring machine (Fig. 2.9). This machine measures by comparing the theoretical surface with the real one.

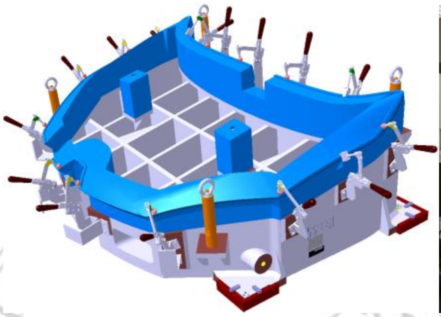


Fig. 2.8 Control layout

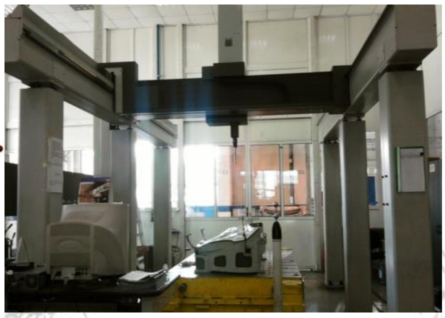


Fig. 2.9 3D coordinate measuring machine

Below are the steps that are being taken to raise the quality of parts.

Figure 2.10 shows how to remove the appearance flaws in the logo area:

a) The first step was to identify the problem area. For this, an abrasive stone was used, with which the surface of the piece was polished to highlight the defect.

b) All operations were analyzed to identify the cause. It is noted in Figure 2.10.b that the defect occurs in the stamping operation.

c) The solution was to modify the stamping operation by introducing some auxiliary profiles in order to stretch the material.

d) The result is a positive one, the defect being eliminated.

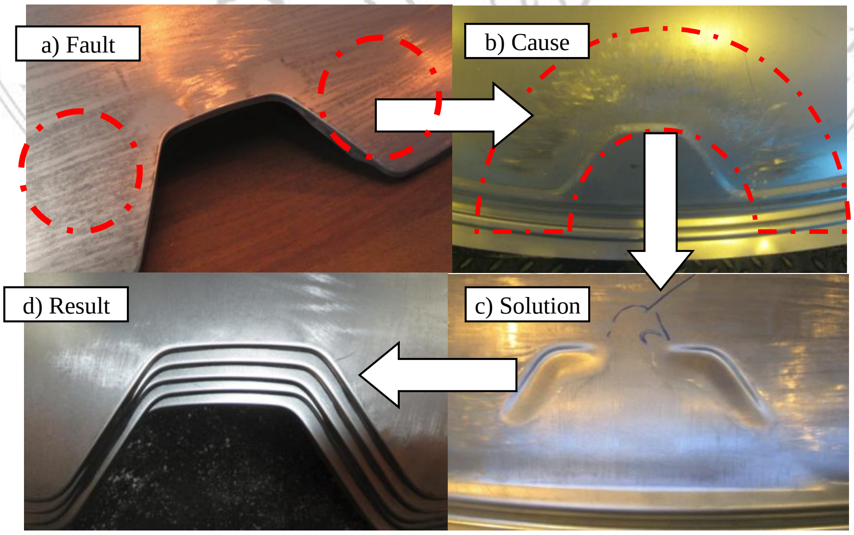


Fig. 2.10. Removal of appearance defect in the LOGO area.

Figure 2.11 shows the case where the piece remains stuck in the mold due to the vacuum created in the drawing process. This makes the tool's functionality in the manufacturing site impossible because the robotic arm of the line can not catch the piece to lead it to the next operation.

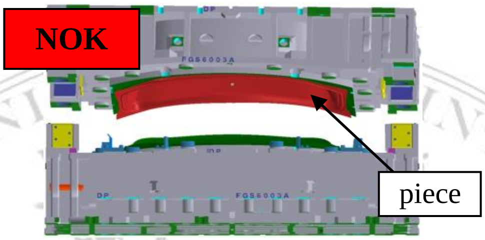


Fig. 2.11 The piece stuck in the mold

The proposed solution was to introduce 4 holes in the die detailing (Fig. 2.12) to eliminate the vacuum, the result being positive (Fig. 2.13).

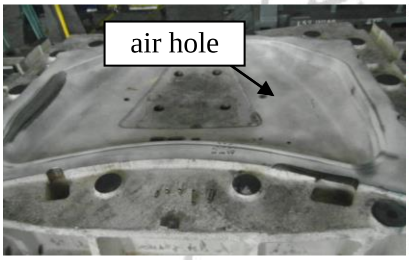


Fig. 2.12 Milling of holes in die

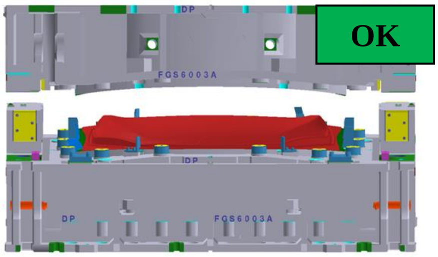
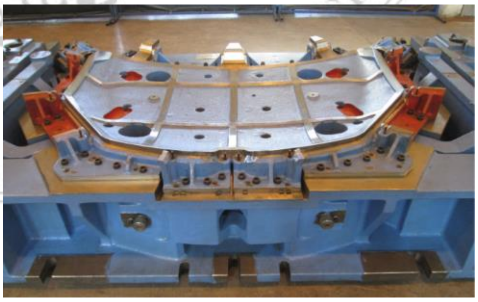


Fig. 2.13 Result OK

Delivering tools to the customer and the manufacturing process

Delivering tools to the customer is done when the quality of parts and tools is accepted by the customer.

a) Lower support



b) Superior support

Fig. 2.14 The ready-made shipment

Preparing the delivery cards involves: washing them; painting; waxing of active surfaces to protect them against corrosion. Figure 2.14 shows the last operation before part delivery.

After the delivery of the tools, the last step is putting them into operation at the customer and starting the manufacturing process. This implies:

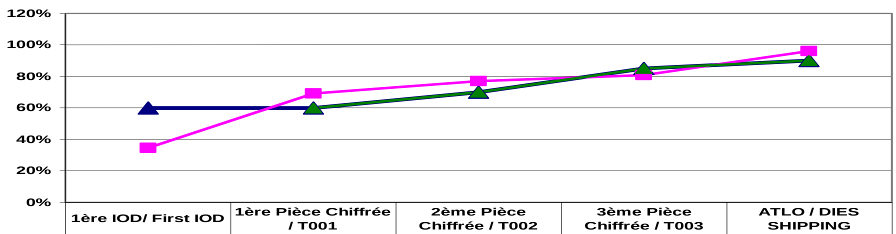
- First assembly of the press machine and grip system: extractors, robot trajectories.
- First check of the compatibility of all tools on the manufacturing line.
- Testing specific low speed mechanization.
- Reinstall and the first pressing occurs.
- The tool is retouched to achieve the optimal geometry and appearance at the expected rhythm.

Part III - CONCLUSIONS AND CONTRIBUTIONS

In making a car part by cold plastic deformation, particular attention must be paid to the overall quality of the tool making processes. So all the tools needed to make the piece have to be taken into consideration.

In developing a tool, attention must be paid to the quality of the simulation processes, the quality of the Design, the quality of the surfaces generated by the Modeling, and the quality of the production. Further on the adjustment and the tests the tools are subjected to must work intelligently, economically, and solve most problems as soon as they are observed, in order to reduce the time required for the project.

For quality analysis, experience is needed to quickly identify defects, possible risks, and to find immediately feasible solutions.



	1ère IOD/ First IOD	1ère Pièce Chiffrée / T001	2ème Pièce Chiffrée / T002	3ème Pièce Chiffrée / T003	ATLO / DIES SHIPPING
Obiectiv Aptitude	60%	60%	70%	85%	90%
Realizat Aptitude	35%	69%	77%	81%	96%
Vizibilitate		60%	70%	85%	90%

Fig. 3.1 Evolution of Green Record

From the point of view of the quality obtained on the hood panel, the paper contribution was the development and verification of their implementation on practice. Practically getting a Green Record over the parts obtained, it can be concluded that the objectives have been met (Fig. 3.1).

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