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technical steel research

Properties and service performance

Feasibility study on the production of a seamless three-piece can from tin plate

Report

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Properties and service performance

Feasibility study on the production of a seamless three-piece can from tin plate

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1. SUMMARY REPORT

The packaging steel industry is put under more and more pressure by the application of alternative materials such as plastics and aluminium.
The only way to slow down or push back this threat immediately is to develop materials and processes that might lead to a steel container at lower costs.

This research project has been focused on the possibilities to increase the benefits of the cost-effective wall ironing process. Starting from this principle, a new can making concept was developed, consisting of one production stage to make a special container, from which more can bodies can be made later on by cutting the original into several pieces [1].

In order to achieve a realistic possibility we have striven for a good compatibility with commercial can production.

This meant that :

a) there must be a large market segment, since otherwise adjustments to the wall ironing lines are not profitable.
b) for logistic reasons it is undesirable to produce for different markets; therefore the cans must be identical as much as possible.

The following can concepts have been selected for investigations :

- Ø 73 * 58 mm.
  The dimensions were based upon the 3-piece cans for petfood with the same diameter.

- Ø 66 * 58 mm.
  This can concept was based upon the 3-piece welded milk can, which usually measures Ø 63 * 61 mm. The large export market of this concept is under enormous pressure due to substitution by plastics and paper board.

To start with, the investigations were focused on the technological aspects of the production of the basis container, after which the cutting procedures have been studied.
For the research programme, the standard packaging steel material has been used, namely Al-killed continuous cast steel provided with a tin coating.

The last part of the research programme involved the investigation of mechanical performance of the containers made out of the separate parts of the basis container, as they might be used in the production process of can fillers.

CONCLUSIONS & RECOMMENDATIONS

The aim of this research project has been described as :

> *"The investigations focus on the question whether or not the "Two-in-One" can can be produced in the DWI manufacturing lines and subsequently be processed into two separate cans. The technical feasibility forms the main issue."*

Although the research project only included the study on technical feasibility of the required can concepts, a rough indication of the most important adjustments in an existing DWI production line for the production of this can concept has been provided (see chapter 10).

Deep drawing

Starting with the same blank diameter for both concepts, the deep drawing has been carried out in two steps.

For the Ø 73 mm "Two-in-One" can, the cup diameters are the same after the first and the second draw just like for the standard DWI food can. We did however make use of a larger blank diameter than usual for the DWI-food can, so that a higher cup was obtained.

The cup geometry of the Ø 66 mm "Two-in-One" can is totally different from that of the 33 cl beverage can, which was used as a reference for comparison of the forces during the wall ironing process.

In the deep drawing procedures, neither the first nor the second draw of both concepts gave rise to any problems.

Wall ironing

The measured wall ironing forces for both "Two-in-One" can concepts are considerably higher than those of the reference cans. This is caused by the fact that for the "Two-in-One" can concept material from the first step in the punch must be ironed into the wallthickness, so that at these locations a very high reduction can be observed.
This does not lead however to any negative influence on the wall ironing process.

The stripping of both the "Two-in-One" cans and the reference cans did not cause any problems either.

Mechanical performance

The axial resistance of the Ø 73 mm can reached the required values right away, but the radial resistance remained insufficient. In order to meet these requirements for the radial resistance, the final concept of the can type was provided with beads.

In contrast with the Ø 73 mm "Two-in-One" can, for the Ø 66 mm "Two-in-One" can the axial resistance remained below the required minimum. Since beads would reduce the axial resistance even further, it was decided to increase the wall thickness for this can concept and not apply any beads.

The tests on mechanical performance of the can concepts have proved that the final products have a good mechanical behaviour during sterilisation and sufficient axial strength.

From the research on both Ø 73 mm and Ø 66 mm "Two-in-One" cans can be concluded that there is a technical feasibility to produce a wall ironed can provided with two thickwalls by means of the conventional machinery, and subsequently separate these cans into a full-fledged 2-piece can and a seamless body for a 3-piece can.

Although the technical feasibility formed the main issue of this research project, the economical aspects related to this new can concept are also important.
Direct, visible financial benefits for steelproducers have not been achieved; their clients (canmakers) will profit most from this development, which can lead to a saving in material costs up to 10 % (see appendix C).

The indirect benefits for the steelmaking industry however, resulting from retainment or even improvement of the market position for the steel can, can be considerable.

2. ZUSAMMENFASSUNG

Die Verpackungsstahlindustrie wird unter immer größeren Druck gesetzt durch die Anwendung von alternativen Materialen wie Kunststoffe und Aluminium. Die einzige Weise worauf dieser Trend verzögert oder sogar zurückgestellt werden kann, ist die Entwicklung von Materialen und Herstellungsverfahren die zu geringeren Herstellungskosten leiten für die Stahldose.

Dieses Forschungsprojekt war darauf gerichtet um die Möglichkeiten vom ökonomischen Wandstreckverfahren maximal auszunützen. Auf der Basis von diesem Ausgangspunkt wurde ein neues Dosenherstellungsverfahren entwickelt. Bei diesem Verfahren wird in der ersten Produktionsphase eine spezielle Dose hergestellt, die weiterhin in mehrere Teile erschnitten wird.

Für die Verringerung der Herstellungskosten pro Dose ist das Dosekonzept nicht so wichtig. Um ein realistischer Vergleich zu ermöglichen, haben wir es aber auf einen optimalen Anschluß an die Praxis angelegt.

Dies heißt daß :

a) Ein größes Marktsegment benötigt ist, da die Anpassungen der Wandstreckanlagen sonst nicht rentabel wären;

b) Es auf logistischen Gründen nicht erwünscht ist um für mehreren Märkte zu produzieren, so daß die hergestellte Dosen praktisch ähnlich sein müssten.

Die folgende Dosekonzepte wurden im Rahmen von diesem Forschungsprojekt untersucht :

* Ø 73 * 58 mm.
  Die Ausmaße wurden basiert auf die dreiteilige geschweißte Dose für (Tier)Nahrungswaren mit demselben Diameter.

* Ø 66 * 58 mm.
  Dieses Dosekonzept ist basiert auf die dreiteilige geschweißte Milchdose, die normalerweise Ø 63 * 61 mm mißt. Der größe Exportmarkt für dieses Dosetyp steht unter schweren Druck durch Ersatz von Kunststoffe und Karton.

In erster Stelle wurden die Forschungsarbeiten gerichtet auf die technologische Aspekten für die Herstellung von der Basisdose. Danach wurden die Möglichkeiten zum Scheiden von dergleichen Dosen untersucht.
Für dieses Forschungsprojekt ist die normale Verpackungsstahl-Qualität benutzt, nämlich Weissblech aus Al-beruhigtem strangguß Stahl.

In der letzten Phase wurden auch die mechanische Eigenschaften der separaten Dosen aus dem neuen Herstellungsverfahren untersucht, genau wie sie von Füllern angewendet worden.

FOLGERUNGEN UND EMPFEHLUNGEN

Das Ziel dieses Forschungsprojekten wurde umschrieben als :

> *Die Untersuchungen richten sich auf die Frage ob es möglich wäre die "Two-in-One" Dose mit den üblichen Abstreckanlagen herzustellen und danach weiter zu verarbeiten zu zwei separaten Dosen. Dabei ist die technische Machbarkeit der wichtigste Punkt.*

Obwohl dieses Forschungsziel sich also nur auf die technisch Machbarkeit richtete, haben wir doch eine grobe Skizze gegeben von den Anpassungen die benötigt wären um das "Two-in-One" Dosekonzept mit einer normalen Abstreckanlage zu produzieren (sehe Cpt. 10).

Tiefziehen

Ausgehend von demselben Ausschnittdiameter für beide Dosekonzepten wurde das Tiefziehen wurde ebenfalls für beide Dosekonzepten in zwei Schritten durchgeführt.

Für die Ø 73 mm "Two-in-One" Dose sind die Napfdiameter nach dem ersten und zweiten Zug gleich. Der Ausschnittdiameter für diese Dose war aber ein bißchen größer als der normale Ausschnittdiameter, sodaß der Napf höher wurde.

Die Napfgeometrie der Ø 66 mm "Two-in-One" Dose ist völlig anders als die für eine 33 cl Getränkendose. Diese 33 cl Dosen dienten als Referenzmaterial für die Kräfte während dem Abstreckverfahren.

Beim Tiefziehen gab es keine Probleme für diese Dosekonzepten, weder nach dem ersten noch nach dem zweiten Zug.

Abstrecken

Die Abstreckkräfte die gemessen wurden für die beide "Two-in-One" Konzepten sind erheblich höher als für die Referenzdosen. Die Ursache hierfür liegt in der Tatsache daß für das "Two-in-One" Konzept das Material schon aus der ersten Stufe nach einer dünnere Wandstärke abgestreckt wird, sodaß es an diesen Stellen eine sehr höhe Materialabnahme gibt.
Dies hat aber kein negativer Einfluß auf dem Wandstreckverfahren.

Das Abstreifen von beiden "Two-in-One" Konzepten hat auch keine Probleme mitgebracht.

Technologische Werte

Der Axialwiderstand der Ø 73 mm "Two-in-One" Dose hat sofort die Anforderungen entsprochen, aber der Radialwiderstand blieb unzulänglich. Um dies zu verbessern, wurde das endgültige Konzept dieses Dosetyp ausgerüstet mit Verfestigungssicken.

Im Gegensatz zu der Ø 73 mm "Two-in-One" Dose, war der Axialwiderstand des Ø 66 mm Konzepten nicht ausreichend. Da Verfestigungssicken dieser Widerstand noch weiter zurückbringen würden, wurde entschieden um die Wanddicke für dieses Konzept zu erhöhern.

Die Experimenten haben erwiesen daß die endgültige Dosen ein gutes mechanisches Benehmen beim Sterilisieren und ausreichender Axialwiderstand haben.

Aus den Untersuchungen von sowohl der Ø 73 mm Dose als der Ø 66 mm Dose kann man konkludieren daß es technisch möglich ist um auf den üblichen Produktionsanlagen eine abgestreckte Dose herzustellen mit zwei Verdickungen im Wand, die nachher geschieden wird in eine vollständige zweiteilige Dose und einen nahtlosen Zarge für die dreiteilige Dose.

Obwohl die technische Machbarkeit der wichtigste Punkt unserer Forschungsarbeiten war, sind die ökonomische Aspekte gleichfalls interessant.
Ein direkter, sichtbarer finanzieller Gewinn für die Stahlproduzenten gibt es nicht; ihren Kunden (die Dosenhersteller) werden das meiste profitieren von diesen Entwicklungen, die zu eine Materialeinsparung bis zum 10 % führen können (sehe Appendix C).

Es gibt aber sicherlich ein indirekter Gewinn für die Stahlindustrie, hervorgehend aus der Erhaltung oder sogar Verbesserung der Marktposition für die Stahldose, die ansehnlich sein könnte.

3. SOMMAIRE

De plus en plus, l'industrie du fer blanc est confrontée avec la pression de l'application des matériaux alternatifs comme d'aluminium ou des matières synthétiques. La seule manière de retarder ou bien repousser cette tendance est le développement des matériaux et des méthodes de production qui peuvent résulter à une boîte d'acier plus économique.

Cette recherche se concentrait sur le profit maximal des bénéfices de la technique de fabrication DWI (Drawn and Wall Ironed - des boîtes embouties-étirées). A base de ce point de départ, on a developpé une nouvelle technique de fabrication. Cette nouvelle technique contient une première phase dans laquelle une boîte spéciale est fabriquée, qui est coupée en plusieurs boîtes plus tard [1].

Afin d'obtenir une comparaison réaliste, nous avons aspiré à une correspondance optimale à la pratique.

Ça veut dire que :

a) Il faut que le segment du marché soit assez volumineux pour justifier les frais des altérations dans les lignes de fabrication;
b) Pour des raisons logistiques il n'est pas désirable de produire pour plusieurs marchés; donc, les boîtes produites doivent se ressembler autant que possible.

Les modèles suivants ont été étudiés :

* Ø 73 * 58 mm.
  Cettes dimensions ont été basées sur la boîte trois pièces soudée pour la nourriture (animale) avec le même diamètre.

* Ø 66 * 58 mm.
  Ce modèle a été basé sur la boîte trois pièces soudée à lait, qui normalement est Ø 63 * 61 mm. Le grand marché d'exportation pour ce type de boîte est menacé sérieusement de la substition par des matières synthétiques ou du carton.

En premier lieu, la recherche se concentrait sur les aspects technologiques de la production de la boîte de base. Ci-après les méthodes à la séparer ont été etudiées.
Pour les expériences on a choissi les fer blancs de qualité usuelle, c'est-à-dire de fer blanc produit d'acier calmé d'aluminium, coulé continu et étamé.

Dans la dernière phase des activités aussi les propriétés mécaniques des boîtes séparées ont été étudié, fabriquées par la nouvelle méthode comme elles seront introduites dans le processus de production aux remplisseurs.

CONCLUSIONS ET RECOMMANDATIONS

Le but de cette recherche a été explicité de la façon suivante :

> *La recherche se concentra sur la question s'îl est possible de fabriquer la boîte "Two-in-One" à l'aide d'une machine à étirer normale et ci-après la transformer en deux boîtes séparées. L'essentiel de cette recherche réside dans la faisabilité technique.*

Bien que les activités soyaient orientées vers la faisabilité technique de ce concept, nous néanmoins avons indiqué grossièrement les adaptations nécessaires pour fabriquer ce concept sur une machine à étirer normale (voir cpt. 10).

Emboutissage

Avec un diamètre de flan identique pour les deux modèles, l'emboutissage était exécuté en deux phases.

Pour la Ø 73 mm boîte "Two-in-One", les diamètres de godet sont identiques après le premier et le seconde passe d'emboutissage. Cependant nous avons choissi un flan d'un diamètre plus grand que l'habituel pour des boîtes DWI de nourriture, afin d'obtenir un plus haut godet.

La géométrie de la Ø 66 mm boîte "Two-in-One" est entièrement différent de celle d'une boîte 33 cl pour boissons, qui servissait de référence pour les forces du processus d'étirage.

Ni dans le premier ni dans le seconde passe on a été confronté aux problèmes avec l'emboutissage de ces concepts.

Étirage

Les forces d'étirage mesurées pour les deux concepts "Two-in-One" sont sensiblement plus hautes que celles mesurées pour les boîtes de référence. Cette différence est causée par le fait, qu'en cas de la boîte "Two-in-One" le matériel est étiré dans l'épaisseur du paroi déjà dès premier étage du poinçon, parquel une réduction très prononcée se présente à ces endroits. Cependant, le processus d'étirage n'était pas influencé négativement.

De même, dépouiller les boîtes "Two-in-One" ne produisait pas un seul problème aussi.

Propriétés mécaniques

Pour la boîte Ø 73 mm "Two-in-One", la résistance axiale satisfaisait immédiatement aux exigences, mais la résistance radiale restait insuffisante. Afin de changer cela, le concept final de ce type de boîte a été pourvu des joncs.

Contraire à la boîte Ø 73 mm "Two-in-One", la résistance axiale pour le Ø 66 mm concept restait insuffisante. Parce que les joncs réduiraient cette résistance encore plus, on a décidé d'augmenter l'épaisseur de base pour ce concept-ci.
Les expériences ont prouvé que les boîtes finales se tiennent bonnes à la stérilisation et ont assez de résistance axiale.

Des données présentes sur la Ø 73 mm boîte ainsi que sur la Ø 66 mm boîte "Two-in-One" il faut conclure qu'il est techniquement faisable de fabriquer sur les lignes de production normales une boîte emboutie-étirée avec deux accroissements d'épaisseur de paroi, qui est ensuite coupée dans une boîte 2-pièces complète et un corps sans soudure pour la boîte 3-pièces.

Bien que la faisabilité technique a formé l'objet principal de cette recherche, les aspects économiques sont également intéressants. Pour l'industrie de fer blanc, il n'y a pas une bénéfice directe et visable; leur clients, les producteurs des boîtes, profiteront plus de ces développements-ci, qui pourraient amener une économie du matériel jusqu'au 10 % (voir appendix C).

Cependant, les bénéfices indirectes pour l'industrie du fer blanc, amenée par la préservation ou bien l'amélioration de la compétitivité pour les boîtes en acier, peuvent être considérable.

4. SAMENVATTING

De verpakkingsstaal-industrie komt onder steeds grotere druk te staan door de toepassing van alternatieve materialen zoals kunststoffen en aluminium. De enige manier om deze ontwikkeling te vertragen of zelfs terug te dringen is de ontwikkeling van materialen en produktiemethoden die kunnen leiden tot een stalen bus tegen lagere kosten.

Dit research projekt was erop gericht om de mogelijkheden van het goedkope wandstrek-proces maximaal te benutten. Op basis van dit uitgangspunt is een nieuwe busproduktie-methode ontwikkeld. Bij deze produktietechniek wordt in een eerste produktiefase een speciale bus geproduceerd, die in een later stadium wordt versneden tot meerdere bussen.

Om een realistische vergelijking mogelijk te maken hebben we gestreefd naar een zo goed mogelijke aansluiting op de praktijk.

Dit houdt in dat :

a) Er een groot marktsegment moet zijn, omdat de aanpassingen in de wandstreklijnen anders niet rendabel zijn;
b) Het om logistieke redenen niet wenselijk is om voor verschillende busmaten voor dezelfde markten te produceren; de geproduceerde bussen moeten derhalve praktisch aan elkaar gelijk zijn.

De volgende busconcepten zijn bestudeerd in het onderzoek :

* Ø 73 * 58 mm.
  Deze afmetingen zijn gebaseerd op de driedelige gelaste bus voor (dieren)voedsel met dezelfde diameter.

* Ø 66 * 58 mm.
  Dit bustype is gebaseerd op het driedelige gelaste melkblikje, dat normaliter Ø 63 * 61 mm meet. De grote export-afzet van dit bustype wordt ernstig bedreigd door vervanging door kunststoffen en karton.

In eerste instantie werd het onderzoek gericht op de technologische aspecten voor de produktie van de basiscontainer. Daarna zijn de methoden voor scheiding van de bussen bestudeerd.
Voor dit onderzoek is gebruik gemaakt van de normale verpakkingsstaalkwaliteit, namelijk vertind Al-rustig continugegoten staal.

In de laatste fase van het onderzoek zijn ook de mechanische eigenschappen onderzocht van de afzonderlijke bussen die volgens deze nieuwe produktietechniek zijn gefabriceerd, zoals ze in het produktieproces van de vuller worden gebruikt.

CONCLUSIES EN AANBEVELINGEN

Het doel van dit onderzoek is beschreven als :

> *Het onderzoek richt zich op de vraag of de "Two-in-One" bus kan worden geproduceerd in de gebruikelijke wandstreklijnen en vervolgens worden verwerkt tot twee afzonderlijke bussen. De technische haalbaarheid vormt hierbij het belangrijkste punt van onderzoek.*

Hoewel dit onderzoeksproject zich dus alleen richtte op de technische haalbaarheid van het concept, is toch een ruwe indicatie gegeven van de aanpassingen die benodigd zijn om het concept te kunnen produceren op een normale DWI produktielijn (zie hoofdstuk 10).

Dieptrekken

Het dieptrekken is voor beide busconcepten uitgevoerd in twee stappen.

Voor de Ø 73 mm "Two-in-One" bus zijn de cupdiameters na de eerste en de tweede trek gelijk aan die van de standaardbussen. We hebben hierbij echter gebruik gemaakt van een wat grotere blenkdiameter dan gebruikelijk voor de voedselbus, waardoor een hogere cup werd verkregen.

De cupgeometrie van de Ø 66 mm "Two-in-One" bus is totaal verschillend van die voor een 33 cl drankenblik, dat werd gebruikt als referentieconcept voor de krachtmetingen tijdens het wandstrekproces.

Bij het dieptrekken hebben zich noch bij de eerste, noch bij de tweede problemen voorgedaan voor deze busconcepten.

Wandstrekken

De wandstrekkrachten die gemeten zijn voor de beide "Two-in-One" busconcepten zijn aanmerkelijk hoger dan die voor de referentie-bussen. Dit wordt veroorzaakt door het feit dat voor het "Two-in-One" concept het materiaal reeds vanuit de eerste verjonging moet worden wandverdund, zodat op deze lokaties een zeer hoge reductie ontstaat.
Dit had echter geen negatieve invloed op het verloop van het wandstrekproces.

Het afstropen van de beide "Two-in-One" concepten heeft ook geen problemen opgeleverd.

Mechanische eigenschappen

De axiale weerstand van de Ø 73 mm "Two-in-One" bus voldeed onmiddellijk aan de gestelde eisen, maar de radiale weerstand bleef beneden de gestelde eis. Om hierin verbetering aan te brengen, is het uiteindelijke concept van dit type bus voorzien van verstevigingsrillen.

In tegenstelling tot de Ø 73 mm "Two-in-One" bus, bleef de axiale weerstand voor het Ø 66 mm concept onder de vereiste waarde. Omdat verstevigingsrillen deze weerstand nog verder zouden doen afnemen, is besloten om de wanddikte voor dit concept te verhogen.

De proeven hebben uitgewezen dat de uiteindelijke bussen beschikken over een goed mechanisch gedrag tijdens sterilisatie en voldoende axiale weerstand.

Uit het onderzoek naar zowel de Ø 73 mm bus als de Ø 66 mm bus kan worden geconcludeerd dat het technisch mogelijk is om met behulp van de gebruikelijke produktie-installaties een wandgestrekte bus te produceren met twee wandverdikkingen, die vervolgens wordt gescheiden in een complete tweedelige bus en een naadloze romp voor een driedelige bus.

Hoewel de technische haalbaarheid van deze busconcepten het belangrijkste punt van onderzoek is geweest, is de ekonomische haalbaarheid tevens een belangrijk punt. Een direkte, zichtbare opbrengst is voor de verpakkingsstaal-producenten vooralsnog niet aanwezig; deze is voor de klant (de bussenmaker), die een materiaalbesparing tot 10 % kan bereiken (zie appendix C).

De indirekte voordelen, die het gevolg zijn van het behoud dan wel de uitbreiding van de afzetmarkt voor verpakkingsstaal, kunnen echter zeer groot zijn.

SECTION B

TECHNICAL REPORT

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1. INTRODUCTION

In the western part of Europe, some 15 billion beer and beverage cans are produced. 10 Billion of these cans are made of steel and the remainder of aluminium. In the United States of America, 95 % of the 95 billion beer and beverage cans that are shipped each year are produced out of aluminium.
In order to keep the aluminium industry from gaining a similar monopoly position as in the United States of America, it is essential that the European steel industry develops new materials and/or can manufacturing methods that will lead to the most cost effective situation.

The most important applications for packaging steel are the two- and three-piece cans. The two-piece cans are manufactured by means of the DWI process (Drawn and Wall Ironing), the three-piece cans require a welding process.

Welding process

The welded can is made from a rectangular blank of packaging steel, of which the edges - after rounding - are connected by means of welding (see photo 1 below). Another name for a welded can is a three-piece can.
These cans are characterised by :

1) The basis thickness of the body, which depends on the application. The welded cans is produced in many dimensions out of SR (Single Reduced) as well as out of DR (Double Reduced) tinplate material.

2) Both the bottom and the end are formed from a round blank of the same materials as mentioned for the body. In general, the bottom and end will be a bit thicker than the body.

Photo 1 : Production steps for the welded can

DWI-process

The DWI can is made from a round blank. From this blank a cup is made, which is wall-ironed into a thinwalled can (see photo 2 hereunder). The bottom is an integral part of the can, the end is applied later on. These cans are also referred to as "two-piece cans". This type of can is used both for drinks and for food.
The requirements the cans have to meet depend on the filling medium.

The cans are characterised by :

1) The fact that the wall thickness is thinner than the basis thickness of the material.

2) The wall thickness is between 0.085 - 0.145 mm, depending on the use of the can :
Two-piece cans for drinks : 0.085 - 0.100 mm
Two-piece cans for food : 0.130 - 0.145 mm.

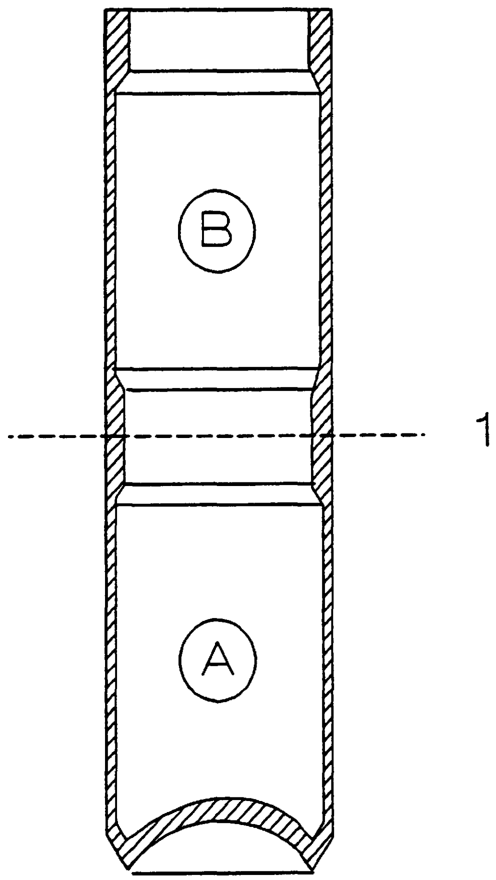
3) A flange at the top side of the can. This flange is thicker (+ 0.050 mm) than the wall and is needed to enable forming of the neck in the can without cracks and/or wrinkles.

In respect of material efficiency, the drawn and wall ironed can (DWI-can) is the most cost-effective container.

Photo 2 : Production steps for the two-piece (DWI) can

The production method that has been investigated in the frame of this research project, combines the above mentioned production methods. By separating the can at line 1 (see figure 1 below) a can (A) and a seamless body (B) are obtained. Both parts of this so-called "Two-in-One" can are processed further on in their own separate production routes.

Figure 1 : Two-in-One can



The objective of this research programme has been to investigate this new can making concept which will result in lower production costs per container.

The aim of this project has been described as :

> *"The investigations focus on the question whether or not the "Two-in-One" can can be produced in the DWI manufacturing lines and subsequently be processed into two separate cans. The technical feasibility forms the main issue."*

A selection of the can types that would be investigated in this project was made after a broad market research. The frequently used can types are shown in the table below.

Table 1 : Frequently used can types

Can diameter [mm]	Trimming height [mm]	Can type	Application
52	133	DWI and 3-piece	250 ml beverage can
63	63	3-piece	170 ml condensed milk can
66	100	DWI	250 ml beverage can
66	115	DWI	330 ml beverage can
66	150	DWI	440 ml beverage can
73	58	DRD	225 ml food can
73	113	DRD/DWI[1] and 3-piece	450 ml food can (petfood)

The material costs of different cans were calculated by means of a Hoogovens computer programme called Cancost (see for details of these calculations appendix C). To find out whether or not a concept would have an economical advantage, standard market prices for tinplate of the used materials had to be fed into this programm. These market prices have been kept at the same level during the project, based upon the consideration that only the relative differences in material costs are important for a can concept.

1 This concept will further be referred to as "Eurocan"

In general the material costs of wall ironed cans are lower than those of welded cans and DRD cans. The application of a seamless 3-piece can has to be found in :

1. Can concepts that are currently produced as a 3-piece welded or a 2-piece DRD can and have a can height that is $\leq$ 75 mm. Considerable cost savings can be achieved.

2. Can concepts that are currently produced as a 2-piece wall ironed can and have a can height that is $\leq$ 75 mm. The cost savings come from the fact that two cans are produced in one stroke, so the production output can be doubled.

Two different can concepts have been taken into account in this research project. These concepts are :

* The Drawn and ReDrawn can used in the food sector (Ø 73 x 58 mm).
* The welded 3-piece can for condensed milk (Ø 63 x 61 mm).

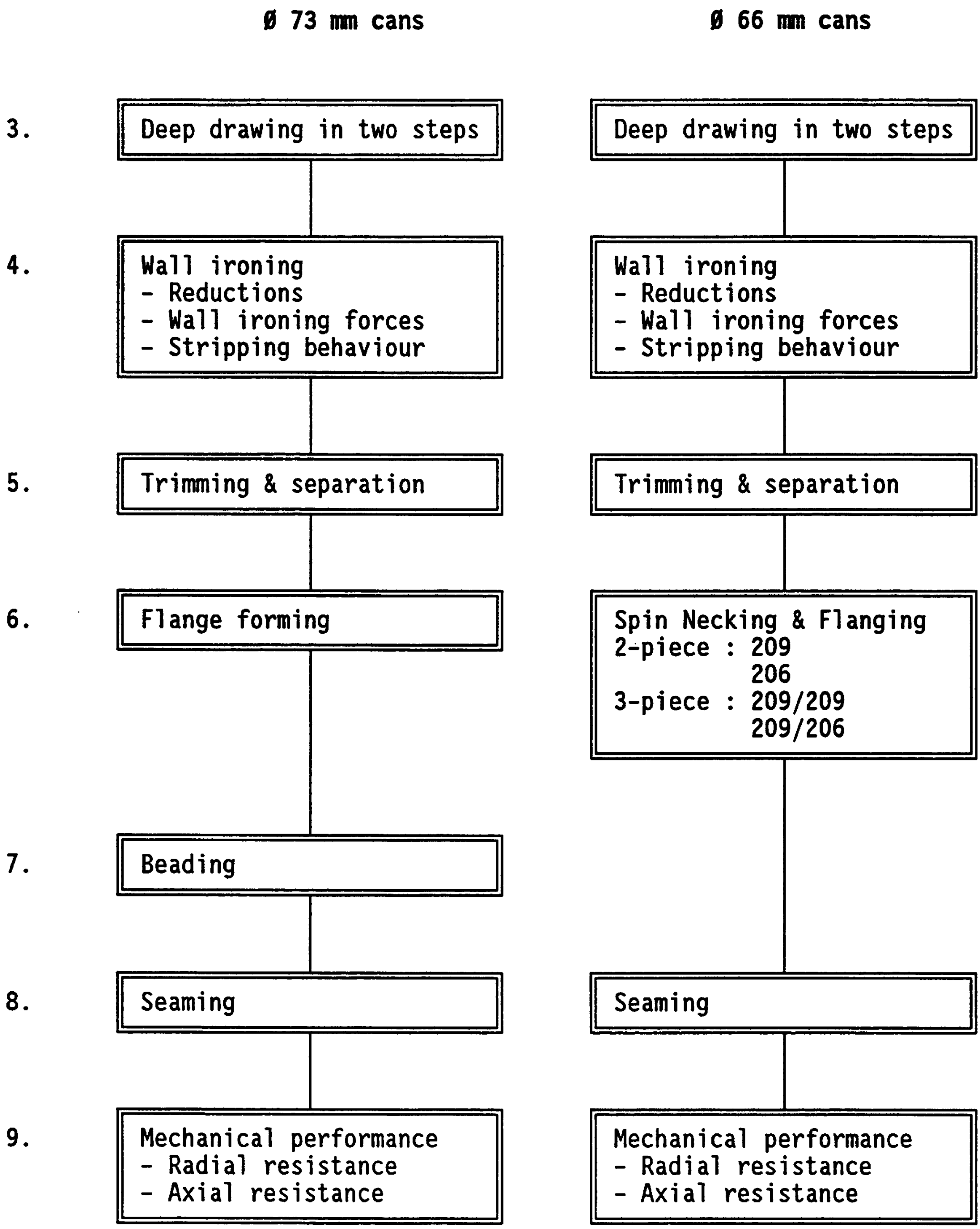
The differences between the concepts are :

- The milk cans are produced without beads whereas the food cans are produced with beads. In this project an investigation to the bead type and bead depth for the Ø 73 mm "Two-in-One" can is included.

- The Ø 73 mm concept is mainly used for pet food at this moment, the Ø 63 mm can is used for condensed milk. Because the application for both can concepts is different the requirements for the mechanical performance are different.

- The "Two-in-One" cans that are compared to the food cans are produced with the same diameter of Ø 73 mm. The cans for the comparison with the milk cans are, for practical reasons, produced with a diameter of Ø 66 mm. This small difference will not have any effect on the conclusions.

In the flow chart below, a view of the different operations for the investigation are shown. The numbers mentioned in front of each subject refer to the numbers of the chapters in this report.



For the investigation of the Ø 73 mm integral "Two-in-One" can a standard Ø 73 mm Eurocan was used as a reference, for both wall ironing and mechanical performance. For the Ø 66 mm integral "Two-in-One" cans the 33 cl beverage can was used as a reference for the wall ironing process. For the separated "Two-in-One" cans, welded cans (Ø 63 x 61 mm) were used as a reference for the mechanical performance tests.

The investigations for the Ø 66 mm "Two-in-One" cans had to be done twice, because the cans produced during the first test runs were not able to meet the requirements for the axial resistance.

2. TEST MATERIALS

2.1 Test material for the Ø 73 mm can

The can used as a reference for the Ø 73 mm integral "Two-in-One" can is the Eurocan. This can is used as a reference for the whole process, from deep drawing up to the mechanical performance tests. Normally this can is made out of tinplate that is not reflown. Therefore both the batch and the continuous annealed materials that were used to produce the Ø 73 mm "Two-in-One" cans and the Eurocans, were used in a not-reflown tin condition.

The test material for the Ø 73 mm cans consists of two variants :
1. Batch annealed DWI material, temper class T52
2. Continuous annealed DWI material, temper class T61.

Table 2 : Processing conditions

Material		T52 BA	T61 CA
CR Thickness	[mm]	0.302	0.305
Annealing		Batch	Continuous
Tin coating weight	[g/m²]	2.8/2.8	2.8/2.8
Reflown		No	No
Roughness Ra	[μm]	0.14/0.21	0.19/0.19

Table 3 : Chemical analysis in weight %

Material		T52 BA	T61 CA
C	[%]	0.038	0.043
Mn	[%]	0.225	0.223
P	[%]	0.013	0.013
S	[%]	0.016	0.016
$Al_{a.s.}$	[%][2]	0.038	0.040
N_{tot}	[%][3]	0.0062	0.0041

[2] $Al_{a.s.}$ = acid soluble aluminium

[3] N_{tot} = total nitrogen

Table 4 : Mechanical properties, measured at 90° to rolling direction

Properties			T52 BA 0.30 mm	T61 CA 0.30 mm
R_e	: yield point	[N/mm²]	225	338
A_{YP}	: yield point elongation	[%]	0	1.9
R_m	: tensile strength	[N/mm²]	328	430
A_u	: uniform elongation	[%]	24	20
A_{80}	: total elongation (80 mm)		36	28
n	: strain hardening coefficient		0.19	0.16
R	: Lankford coefficient		2.2	1.2
R30T	: Rockwell hardness		51	59

Microstructure

The microstructure of both materials are characterised by the following :

Ferrite grain
The batch annealed variant is characterised by an elongated grain, the so-called "pancake" structure, with an average grain size in accordance with ASTM 9.
The continuous annealed variant is characterised by a more equi-axial grain with an average grain size in accordance with ASTM 12. That means that this variant has a much finer and more regular shaped grain.

Cementite distribution
Both materials have a large quantity of fine and sharply directed globular cementite particles and a very small quantity of grain boundary cementite. The microstructure corresponds to the chemical composition, processing conditions and mechanical properties as shown in the tables above.

2.2 Test material for the Ø 66 mm can

2.2.1 Test material for the first series of test runs

For the Ø 66 mm "Two-in-One" can welded milk cans were used as a reference for the mechanical performance tests. The materials that were used to produce the cans for the first series of test runs of the Ø 66 mm "Two-in-One" cans are mentioned below. These concepts were produced from reflown material with a cold rolled thickness of 0.24 mm. DWI material is usually not reflown, the reasons that reflown material was used for these cans are:

- The normal welded milk can is made out of reflown material to obtain a higher product corrosion resistance.

- The material thickness, of 0.24 mm, selected for the first series of tests for the "Two-in-One" milk can forms part of the Hoogovens product range for reflown material.

The materials that were used to produce the Ø 66 mm "Two-in-One" cans for the second series of test runs, with a cold rolled thickness of 0.26 mm, were also in reflown condition, to be able to make a comparison with the first series of tests.

The test materials for the first test run were taken from two current materials, namely :
1. Batch annealed material temper class T52
2. Continuous annealed material temper class T61

Table 5 : Processing conditions

Material		T52 BA	T61 CA
CR Thickness	[mm]	0.24	0.24
Annealing		Batch	Continuous
Tin coating weight	[g/m²]	2.6/2.5	2.5/2.4
Reflown		yes	yes
Total free tin	[g/m²]	1.9/1.8	1.9/1.8

Table 6 : Chemical analysis in weight %

Material		T52 BA	T61 CA
C	[%]	0.060	0.059
Mn	[%]	0.226	0.234
P	[%]	0.010	0.010
S	[%]	0.014	0.013
$Al_{a.s.}$	[%][4]	0.034	0.053
N_{tot}	[%][5]	0.0098	0.0045

Table 7 : Mechanical properties, measured at 90° to rolling direction

Material code				T52 BA 0.24 mm	T61 CA 0.24 mm
Properties				2-in-1	
R_e	:	yield point	[N/mm²]	242	431
A_{yp}	:	yield point elongation	[%]	0	9.4
R_m	:	tensile strength	[N/mm²]	335	445
A_u	:	uniform elongation	[%]	19	17
A_{80}	:	total elongation (80 mm)		35	23
n	:	strain hardening coefficient		0.17	0.14
R	:	Lankford coefficient		1.7	0.7
R30T	:	Rockwell hardness		56	62

[4] $Al_{a.s.}$ = acid soluble aluminium

[5] N_{tot} = total nitrogen

Microstructure

The microstructure of the applied materials T52 BA and T61 CA has the following characteristics :

Ferrite grain

- The batch annealed variant T52 BA is characterised by an equi-axed grain. The grain size is in accordance with ASTM 11.
- The continuous annealed variant T61 CA is characterised by an equi-axed grain with an average grain size in accordance with ASTM 13.

Cementite distribution

- The batch annealed variant T52 BA has a moderate quantity of fine and directed globular cementite particles in the grain and a moderate quantity of grain boundary cementite.
- The continuous annealed variant T61 CA has a large quantity of fine and strongly directed globular cementite particles in the grain and a small quantity of grain boundary cementite.

These structures correspond to the chemical composition, the steel processing and the mechanical properties as presented in the tables above.

Table 8 : Mechanical properties, measured at 90° to rolling direction (reference material for the 33 cl beverage can)

Material code		T52 BA 0.28 mm	T61 CA 0.28 mm
Properties		2-in-1	
R_e : yield point	[N/mm²]	256	320
A_{yp} : yield point elongation	[%]	0	0[6]
R_m : tensile strength	[N/mm²]	349	421
A_u : uniform elongation	[%]	15	16
A_{80} : total elongation (80 mm)		20	27
n : strain hardening coefficient		0.16	0.15
R : Lankford coefficient		1.6	0.9
R30T : Rockwell hardness		53	58

6 Not measured

2.2.2 Test materials for the second series of test runs

For the second series of test runs, the same temper classes have been used.

Table 9 : Processing conditions

Material		T52 BA	T61 CA
CR Thickness	[mm]	0.26	0.26
Annealing		Batch	Continuous
Tin coating weight	[g/m²]	2.90/2.85	2.95/2.52
Reflown		yes	yes
Total free tin	[g/m²]	2.25/2.20	2.44/1.96

Table 10 : Chemical analysis in weight %

Material		T52 BA	T61 CA
C	[%]	0.059	0.051
Mn	[%]	0.236	0.265
P	[%]	0.019	0.016
S	[%]	0.018	0.012
$Al_{a.s.}$	[%][7]	0.05	0.03
N_{tot}	[%][8]	0.006	0.0033

[7] $Al_{a.s.}$ = acid soluble aluminium

[8] N_{tot} = total nitrogen

Table 11 : Mechanical properties, measured at 90° to rolling direction

Properties			T52 BA 0.26 mm	T61 CA 0.26 mm
R_e	: yield point	[N/mm²]	267	410
A_{yp}	: yield point elongation	[%]	0	7.1
R_m	: tensile strength	[N/mm²]	391	438
A_u	: uniform elongation	[%]	27	18
A_{80}	: total elongation (80 mm)		35	25
n	: strain hardening coefficient		1.8	0.15
R	: Lankford coefficient		1.6	1.4
R30T	: Rockwell hardness		55	63

2.3 Test schedules for the "Two-in-One" cans

2.3.1 Test schedule for the Ø 73 mm cans.

Table 12 : Test schedule for the Ø 73 mm cans.

Material	T 52 BA ; T 61 CA			
Can concept	2-in-1		Euro	
Can geometry - wall thickness [mm] - flange thickness [mm]	 0.13 0.16	 0.14 0.17	 0.13 0.16	 0.14 0.17

2.3.2 Test schedule for both test runs of the Ø 66 mm cans.

Table 13 : Test schedule for the Ø 66 mm cans.

Material	T52 BA; T61 CA (0.24 mm)		T52 BA; T61 CA (0.26 mm)	
Can concept	2-in-1		2-in-1	
Can geometry - wall thickness [mm] - flange thickness [mm]	 0.12 0.14	 0.13 0.15	 0.14 0.16	 0.15 0.17

3. DEEP DRAWING

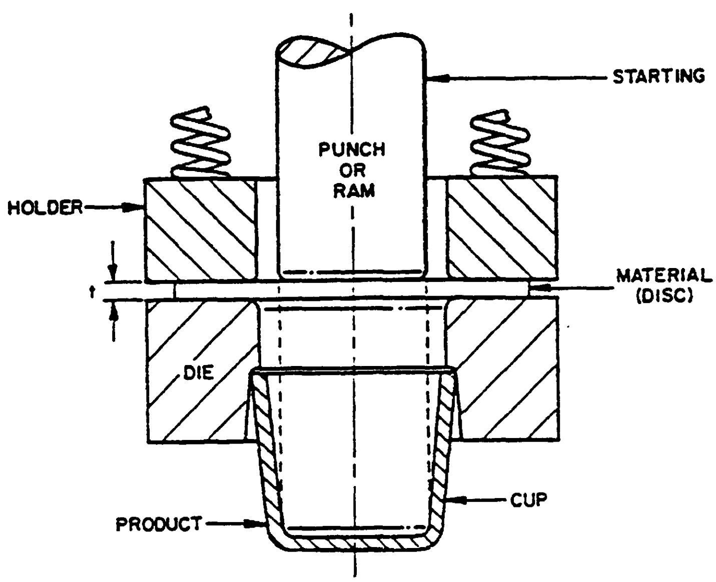
With deep drawing a blank is pressed through a die opening by means of a punch (Figure 2). Because the diameter of the blank is larger than that of the die opening, a cup is formed. The diameter of the blank edge is reduced to the punch diameter. To prevent the edge from wrinkling, a blank holder is used. A correct interaction between blank holder force, lubricant and mechanical properties of the material will lead to a smooth cup, without wrinkles.

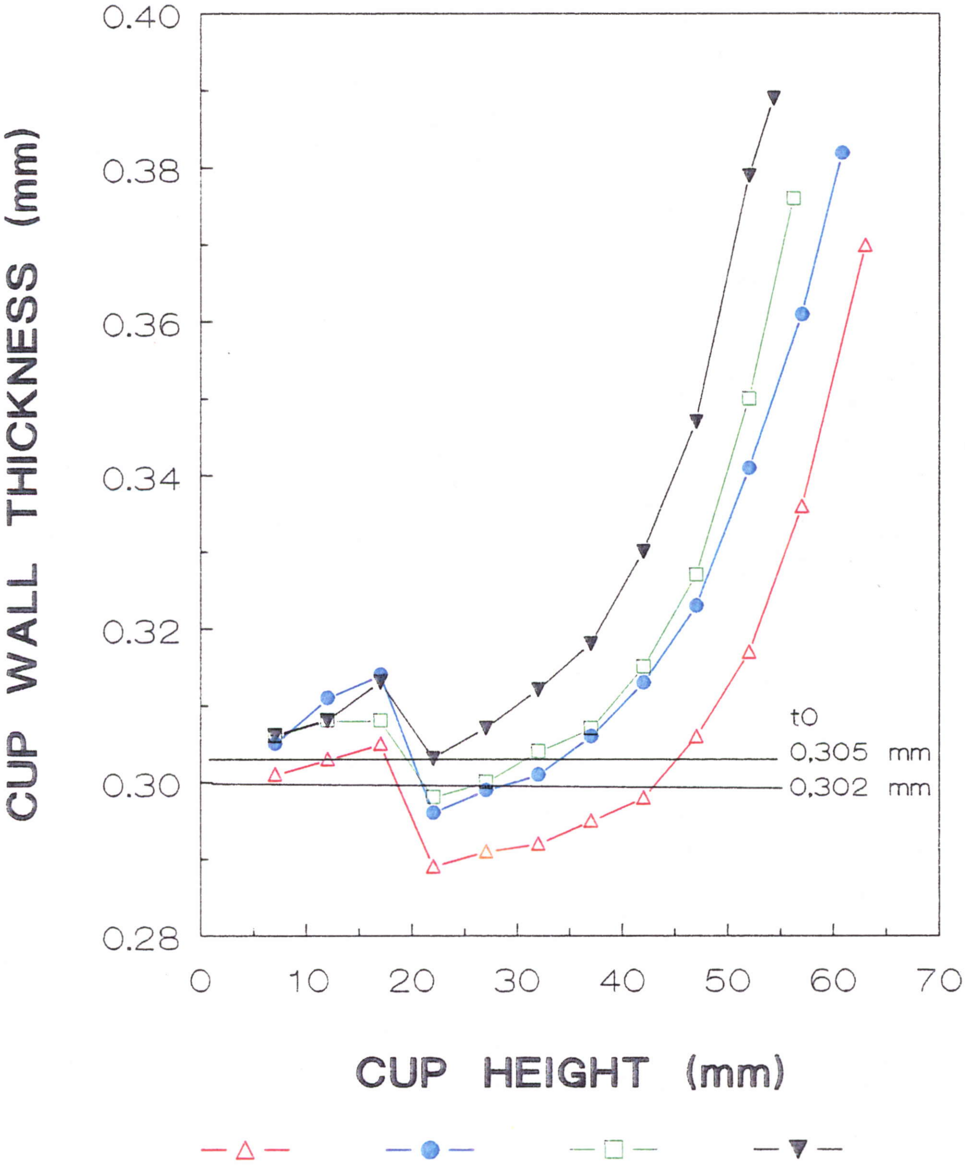
Two typical characteristics can be found in the wall of the drawn part :

1. At the beginning of the draw, just over the radius that forms the transition between wall and bottom the weakest spot is found, where fracture will occur in case of overload. Depending on the processing conditions like blank diameter, blank holder force, material properties and friction conditions, the sheet thickness at this weak spot will be more or less reduced.

2. As the wall of the part is formed the wall thickness will increase. This is related to the fact that the material volume that comes available from the periphery of the blank is not completely transferred into length. Due to the compression ability of the material, it will partially be transformed in thickness.

Figure 2 : Schematic view of deep drawing





Material	T52 BA	T61 CA	T52 BA	T61 CA
Concept	"Two-in-One"		Eurocan	

Cup height after second draw :

Concept	**"Two-in-One"**		**Euro-can**	
Material	T52 BA	T61 CA	T52 BA	T61 CA
Cup height	65 mm	62.8 mm	58.2 mm	56.3 mm

Figure 3 : Cup height and wall thickness of the variants after the second draw

3.1 Deep drawing for the Ø 73 mm can

In general, only one deep drawing stroke outside the bodymaker takes place for the production of DWI food cans. The cupper supplies cups with a diameter of Ø 100 mm, which are fed into the wall ironers where a redraw operation reduces the cup diameter to the diameter of the required can, before the actual wall ironing takes place.

In the pilot line at Hoogovens, the deep drawing is executed in two separate strokes, because no redraw operation is available in the wall ironing machine. This has no influence on the wall ironing operation itself.

During deep drawing for the Ø 73 mm can, the following processing conditions were maintained :

Table 14 : Processing conditions for cups of "Two-in-One" and Eurocan.

First draw			
Press		Excenter press Bliss	
Punch diameter	[mm]	100	
Blank diameter	[mm]	Two-in-one	Eurocan
		156	150
Deep drawing ratio		1.56	1.50
Punch radius	[mm]	3	
Lubrication		Emulsion : 10 % Esso ERG 3872B	
Blank holder force	[kN]	Material T52 BA : 6 Material T61 CA : 9	
Second draw			
Press		Hydraulic press Atrema	
Punch diameter	[mm]	73.1, deep drawing ratio 1.37	
Punch radius	[mm]	2.5	
Lubrication		Emulsion : 10 % Esso ERG 3872B	
Blank holder force	[kN]	Material T52 BA : 4.5 Material T61 CA : 6.8	

During deep drawing no differences in processability have been noticed between the cups for the "Two-in-One" can and those for the Eurocan. Differences were found however in cup geometry as a function of the differences in material properties and blank diameter. These differences show in the cup height and the cup wall thickness distribution. It has had little influence on further processing of the cups in wall ironing.
Since the cup edge of T61 CA material variant B is thicker, the reduction in the first ironing die will be somewhat higher.

Figure 3 (see opposite page) shows the cup heights and wall thickness distribution for the variants of the Ø 73 mm can after the second draw.

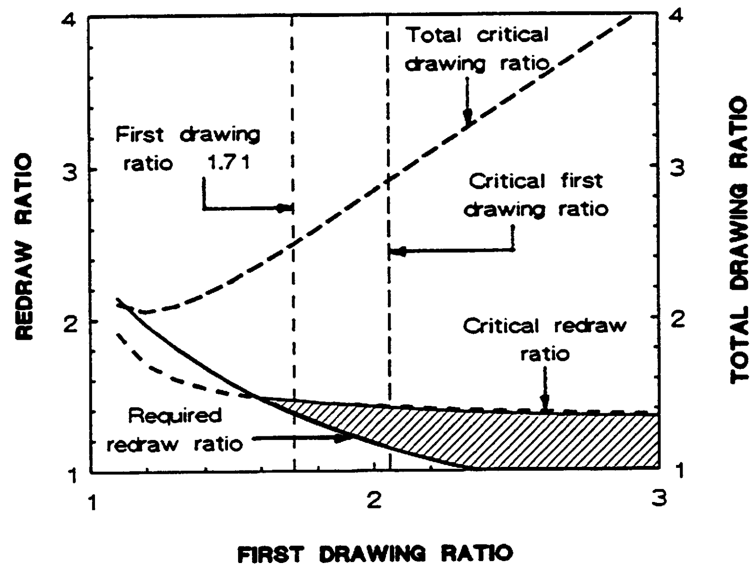
3.2 Deep drawing of the Ø 66 mm can

For the deep drawing of the cups for the first test series for the Ø 66 mm "Two-in-One" milk can were carried out with a material thickness of 0.24 mm, both T52 BA and T61 CA.
Some modifications in the design of the deep drawing tools have been necessary (see figures below).

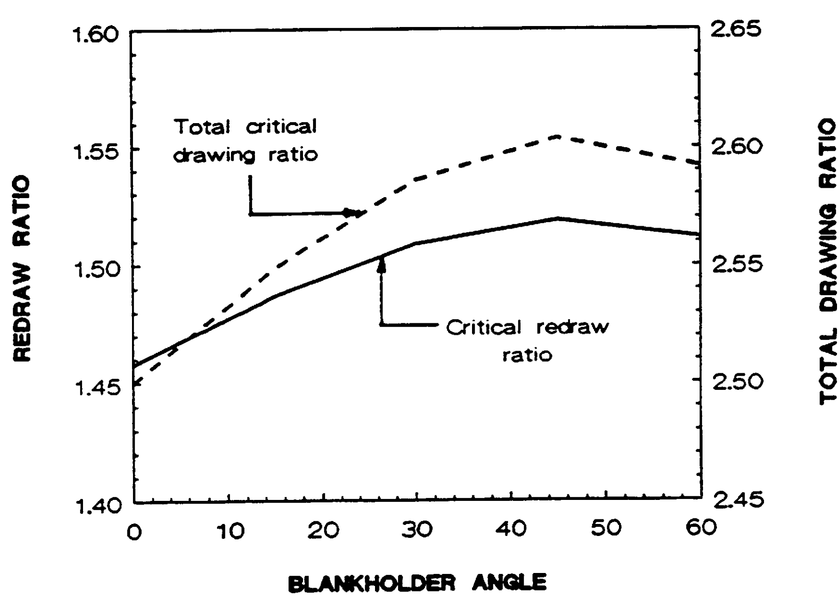
Figure 4 : Critical drawing ratios calculated with a PC model for deep drawing

Product :
- Blank diameter 156 mm
- Final cup diameter 66 mm

4A



First drawing ratio 1.71 **4B**



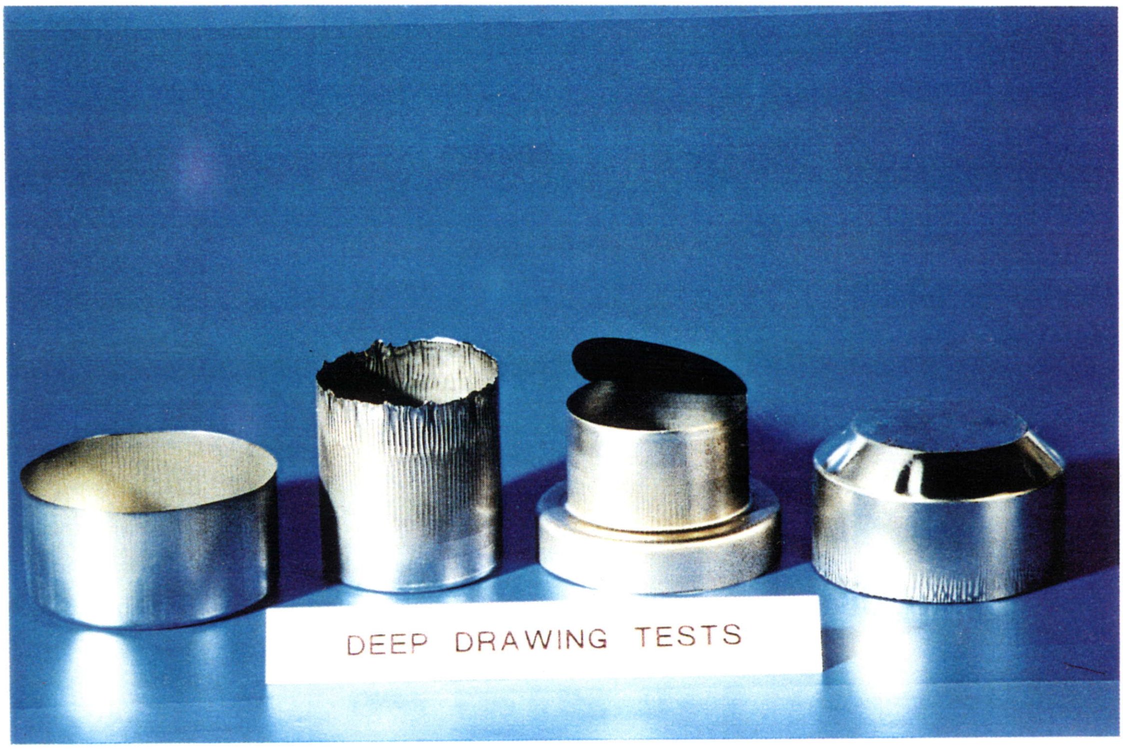


Photo 3 : Deep drawing test (Ø 66 mm)

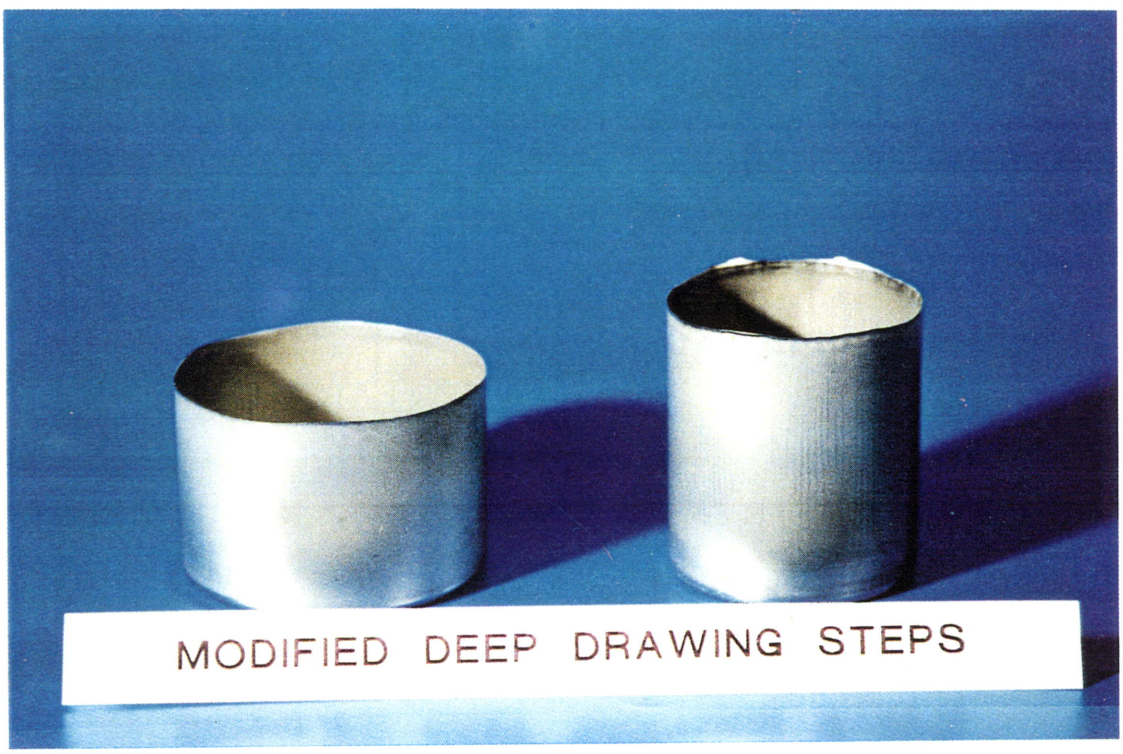
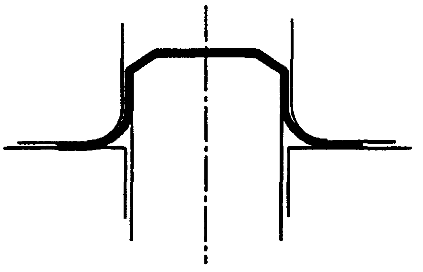


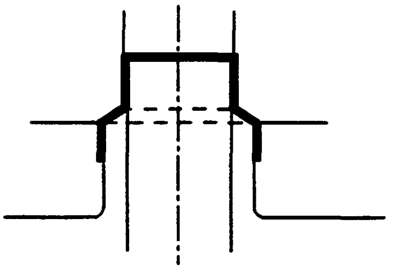
Photo 4 : Deep drawing steps for the "Two-in-One" milk can

Figure 5 : Schematic view of Auble drawing process

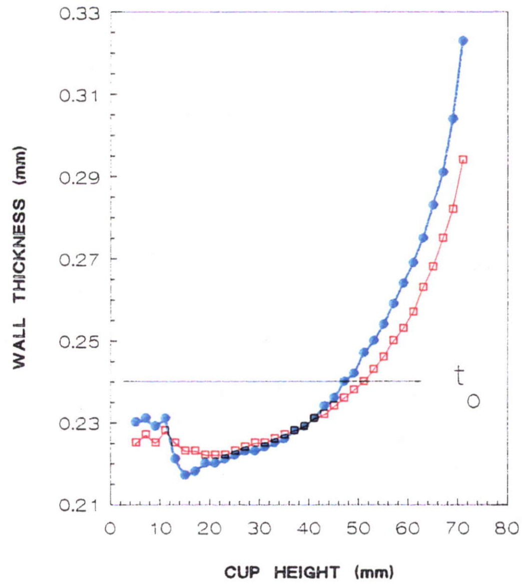
First draw



Redraw

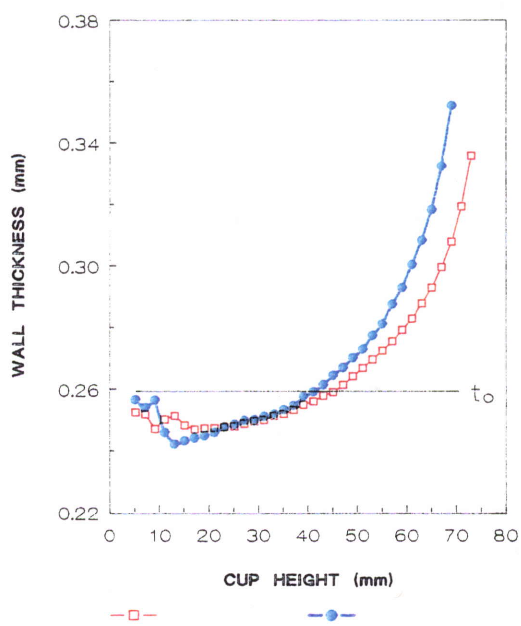


The last modification with deep drawing ratios of 1.90 and 1.24 respectively has given acceptable deep drawing processability for both materials (see photos 3 and 4 at the opposite page).



Material	T52 BA	T61 CA
Cup height	75 mm	74 mm
Sheet thickness	0.24 mm	0.24 mm

Figure 6 : Cup height and wall thickness of material variants after the second draw (0.24 mm)



Material	T52 BA	T61 CA
Cup height	75 mm	74 mm
Sheet thickness	0.26 mm	0.26 mm

Figure 7 : Cup height and wall thickness of material variants after the second draw (0.26 mm)

The second series of tests were carried out with a material thickness of 0.26 mm; the drawing tool for the first draw had to be adapted for this material thickness. The drawing tools for the second draw did not have to be modified.

During deep drawing for the Ø 66 mm can, the following processing conditions were maintained :

Table 15 : Processing conditions for deep drawing of the cups for "Two-in-One" milk can.

First draw	
Press Punch diameter [mm] Blank diameter [mm] Deep drawing ratio Punch radius [mm] Lubrication Blank holder force [kN]	Excenter press Bliss 82 156 1.90 3 Emulsion : 10 % Esso ERG 3872B Material T52 BA (0.24 mm) : 8 Material T61 CA (0.24 mm) : 10 Material T52 BA (0.26 mm) : 9 Material T61 CA (0.26 mm) : 12
Second draw	
Press Punch diameter [mm] Punch radius [mm] Lubrication Blank holder force [kN]	Hydraulic press Atrema 66.1, deep drawing ratio 1.24 2.5 Oil : Grace Darex Material T52 BA (0.24 mm) : 3.5 Material T61 CA (0.24 mm) : 4.2 Material T52 BA (0.26 mm) : 4.4 Material T61 CA (0.26 mm) : 5.8

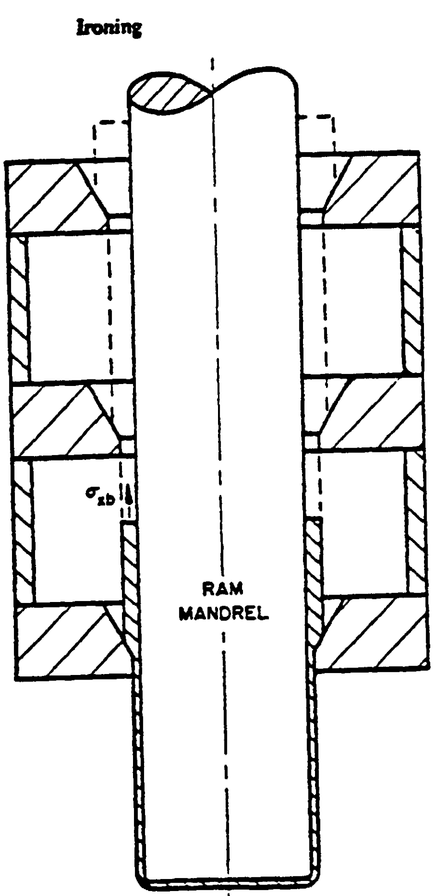
As a function of the cup height the cup wall thickness distributions of the variants after the second draw are shown as figures 6 and 7 (opposite page). The differences in cup geometry between the material variants as presented can be completely explained by the differences in mechanical values, especially the yield point and R-value.

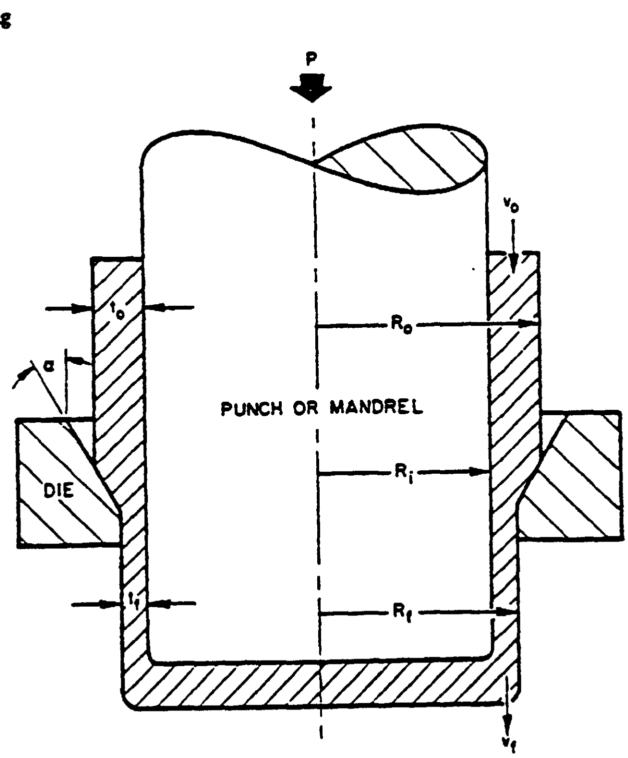
For the Ø 66 mm "Two-in-One" can concept two experiments have been carried out, in view of difficulties in meeting the required axial resistance, as will be explained further on in this report (see par. 9.2).

4. WALL IRONING

In the wall ironing process, the wall thickness is considerably reduced, whereas the bottom thickness remains unchanged.
A cup, made in the deep drawing process is placed around a punch and pressed through a number of dies. The dimensions of the inner diameter of each of these dies are chosen in such way, that the cup wall gets thinner and thinner, and therefore also higher. Usually, three dies with a spacer in between them are positioned one after another, in such a way that the can is never stuck in more than one die. Fracture of the cup wall due to overreduction in the ironing dies has to be avoided at all time. Figure 8 gives a schematic view of this process.

Figure 8 : Schematic view of wall ironing process





In general, an original sheet thickness of 0.30 mm will be reduced to 0.10 mm. In view of the necessary formability during necking and flanging procedures however, additional wall thickness is required. This seaming operation requires sufficient deformation capacity of the material, so that the upper part must have an extra thickness. Most commonly, the thickness at this location is 0.15 mm. This additional thickness is achieved by providing the punch at the upper part of the cup wall with a step to a smaller punch diameter.
At the end of the punch stroke, the bottom profile is formed by pressing the flat bottom of the can, still around the punch, against a die provided with the desired bottom profile. In the backward stroke, the can is stripped from the punch by means of spring-mounted components holding the upper edge of the can. This procedure is referred to as stripping.

At Hoogovens a wall ironer is available for which the maximum can height is 200 mm, being the maximum distance between stripper and bottom forming die. For this practical reason, the investigations are limited to a maximum effective can height of 180 mm after trimming.

4.1 Wall ironing for the "Two-in-One" can

The principle of the "Two-in-One" can is shown in figure 9. Other combinations, like a "three-in-one" can for instance are also possible. By deep drawing and wall ironing an extra high can is produced, that is cut at some place in the middle, which forms the following products.

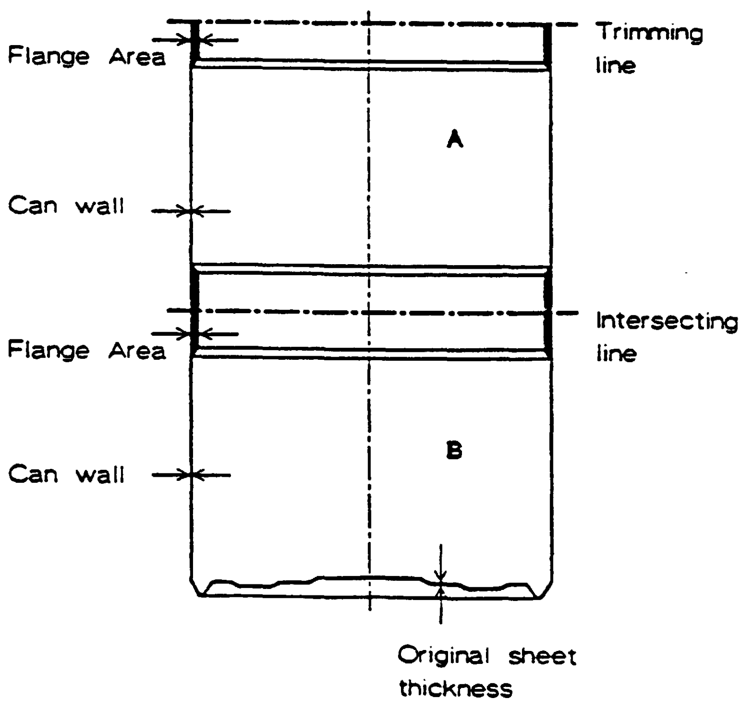
- The lower part forms a "normal" 2-piece DWI can (A).
- The upper part will form a seamless can wall, possibly suitable for a 3-piece can (B).

In figure 9 can also be seen that at the intersecting line some extra material thickness is foreseen. This material is necessary in view of the fact that after separating, both cans will be provided with either an end at one side or at both sides. For formability reasons the necking and flanging procedures involved require additional wall thickness.

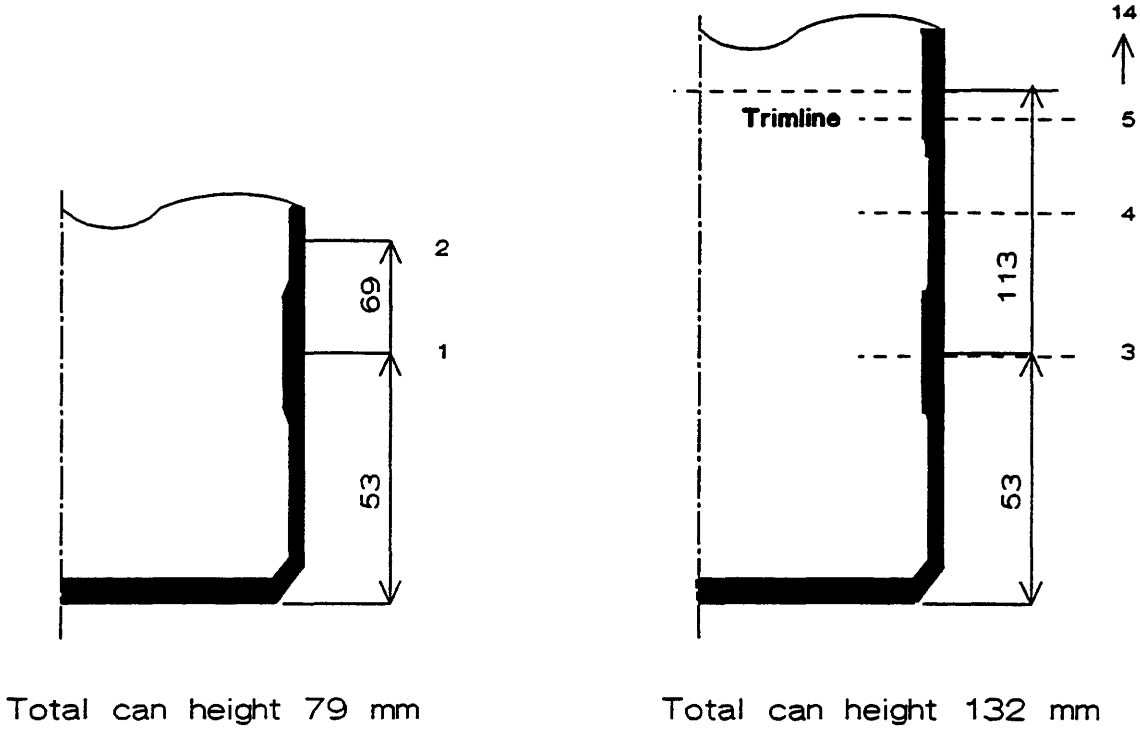
The extra height and the additional wall thickness at half height are the most important differences when compared to a normal DWI can. Therefore, our investigations will focus on these aspects. Next to that, the method of separating the cans will be studied.

During production of a combined 2-piece and 3-piece can, the reductions in can wall thickness are higher than those of the normal 2-piece can production.

Figure 9 : Schematic view of a wall-ironed "Two-in-One" can



Schematic view of "TWO-IN-ONE" cans with different remaining heights



The influence of the can height on the thickwall variation

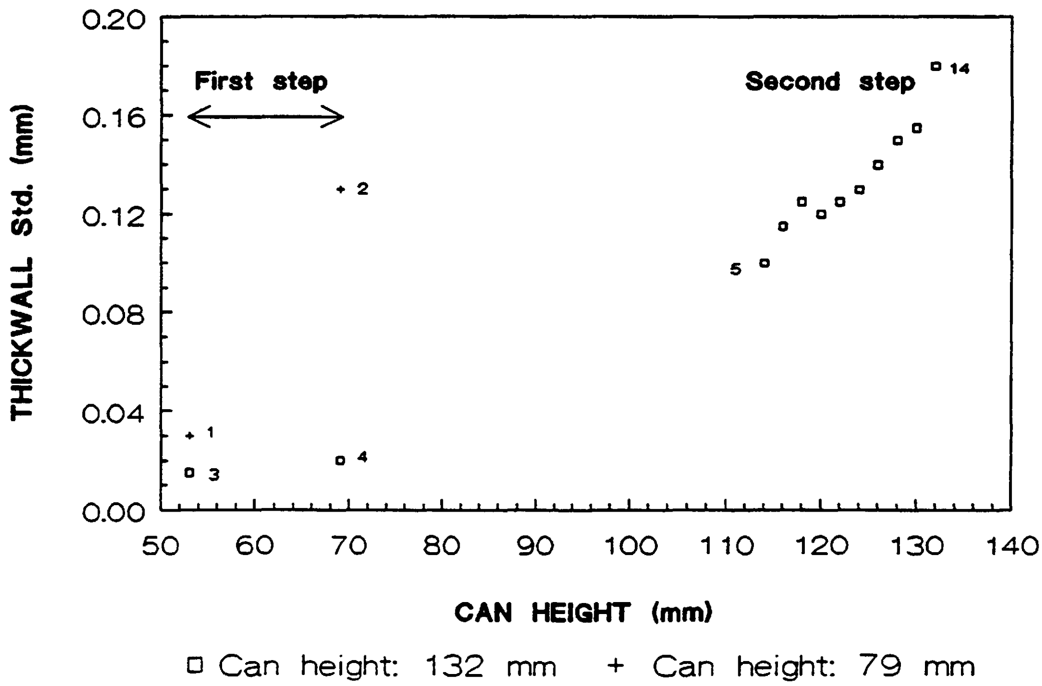


Figure 10 : Influence of the remaining height on thickwall standard deviation for the "Two-in-One" can

4.1.1 Thickwall variation

During wall ironing of cans, a certain variation in thickness always appears over the circumference of the can. This variation is caused by :

- Inevitable misalignment of the punch towards the dies. (The punch can never be exactly positioned towards the dies. The machine bearing and the guiding of the punch play an important role in this phenomenon).
- The anisotropy of the material.
- The variations in thickness inherent to a rolled wide strip, like crown, feather edge and run down.

In practice a minimum variation in edge thickness over the circumference of the can is strived for in order to keep the can height lopsidedness as small as possible and enable good processing of the can during necking and flanging. This last issue is very important for the production of 33 cl beverage cans, since these cans are strongly necked in. The necking process is very sensitive to thickness variations. Moreover, if the lopsidedness gets too large, the stripping behaviour is effected with the risk of jamming the trimmer.

In general a small thickness variation in the flange is an advantage for further processing. The wall thickness variation at half height of the can is smaller than the thickness variation at the top of the can.
At half height, in the first step of the can, the remaining height is very large. This will give a high resistance against thickness variations. At the top of the can, in the second step, the remaining height reaches its minimum and consequently the resistance against thickness variations will be very low.

Figure 10 (opposite page) shows two cans indicating their remaining height. In the lower part of this figure the standard deviation of thickness measurements over the can wall is shown for the first step and the second step of a can with a height equal to that of the final product and a height of 79 mm (just over the first step).

From the figure it becomes clear that :
- the low can gives a thickness variation in thickwall up to the level of the high can;
- the variation of thickness in the first step of the high can is much smaller than the variation in the second step;
- the thickness variation in the second step of the "Two-in-One" can increases in proportion of the reduction of the remaining height to the can edge.

In general, the thickwall thickness variation reduces to a very low level if the remaining height to the untrimmed can edge grows. This means in practice that for a specific trimming height, the thickwall thickness variation will reduce if the untrimmed can height is set higher.

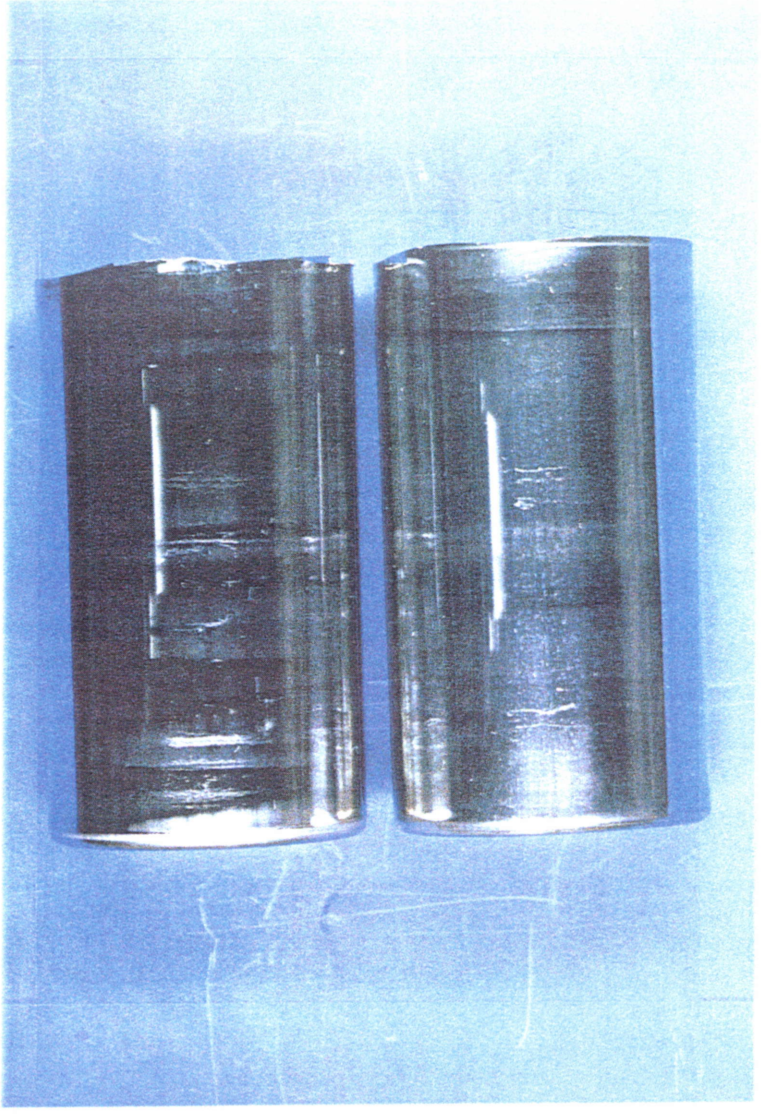


Photo 5 : Can wall performance of a can wall ironed with a sizing ring and a can wall ironed with 3 rings

4.2 Wall ironing for the Ø 73 mm can

4.2.1 Reductions

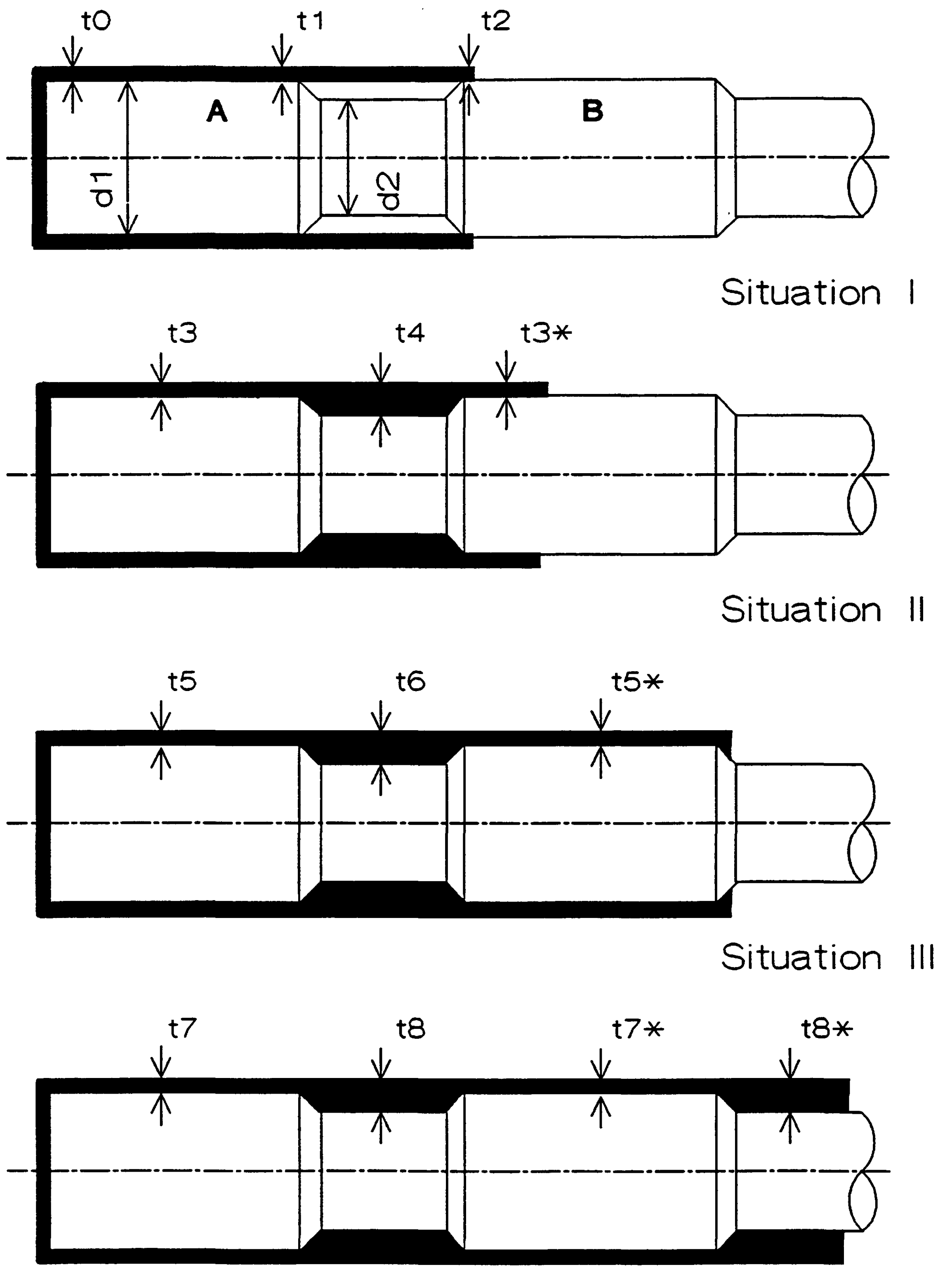
The toolbox in the Hoogovens wall ironer is provided with 4 dies. The first one of these dies is not used as a real redrawing die, but functions only as a pre-sizing die. This method is used because the wall ironer is not provided with a blank holder mechanism enabling execution of the redraw operation in the wall ironer. In figure 37 (appendix A) a schematic view of the toolpack is shown. Photo 5 (see opposite page) shows the can wall performance of a can produced with and without a sizing die.

Table 16 : Processing conditions for wall ironing of the test runs for the Ø 73 mm "Two-in-One" can and Eurocan.

Wall ironer Production speed Coolant Coolant flow	Schuler PAZ1 100 cans/min. Water 50 l/min.			
	Tooling			
	"Two-in-One" concept		Eurocan concept	
	0.14/0.17	0.13/0.16	0.14/0.17	0.13/0.16
Wall ironing dies	diam. [mm]	diam. [mm]	diam. [mm]	diam. [mm]
Pre-sizing die First die Second die Third die	73.637 73.450 73.388 73.322	73.637 73.450 73.363 73.307	73.637 73.440 73.363 73.284	73.637 73.440 73.352 73.274
Punch diameter Punch step	73.060 mm 0.03 mm		73.045 mm 0.03 mm	

The important differences between the "Two-in-One" can and the Eurocan are:

* The cup of the "Two-in-One" can appears to have such a height, that the edge already enters the first punch step.
* After the first ironing die the highest part of the can has already entered the second step.



Situation I	:	Start wall ironing
Situation II	:	After first die
Situation III	:	After second die
Situation IV	:	After third die

Situation IV

Figure 11 : Schematic view of wall ironing steps for the "Two-in-One" cans

The situation is explained with the help of the schematic view of the wall ironing steps as shown in figure 11 (see opposite page). The formula's that have been used to calculate the reductions in the different dies are mentioned in appendix D.
The reductions in the different situations in the wall ironing of a "Two-in-One" are stated in tables 13 and 14 hereunder.

Table 17 : Can wall thickness in the wall ironing situations I to V (see opposite page, figure 11)

Material	T52 BA (0.30 mm)				T61 CA (0.31 mm)			
Concept	0.14/ 0.17 mm TIO[9]	0.13/ 0.16 mm TIO	0.14/ 0.17 mm EURO[10]	0.13/ 0.16 mm EURO	0.14/ 0.17 mm TIO	0.13/ 0.16 mm TIO	0.14/ 0.17 mm EURO	0.13/ 0.16 mm EURO
Thickness [mm] according to appendix D								
t0	0.300	0.300			0.310	0.310		
t1	0.307	0.307	0.319	0.319	0.316	0.316	0.323	0.323
t2	0.370	0.370	0.376	0.376	0.382	0.382	0.389	0.389
t3 = t3*	0.218	0.215	0.217	0.218	0.218	0.220	0.222	0.221
t4	0.248	0.252			0.254	0.256		
t5 = t5*	0.168	0.157	0.167	0.167	0.173	0.162	0.172	0.166
t6	0.200	0.186			0.202	0.189		
t7 = t7*	0.135	0.126	0.125	0.120	0.136	0.127	0.127	0.124
t8 = t8*	0.163	0.155	0.155	0.151	0.165	0.156	0.158	0.152

From this table becomes evident that most variants are a little bit too thin in wall thickness and flange thickness. Nevertheless, a good comparison can be made between the material variants and the can concepts.

[9] TIO = "Two-In-One" can

[10] Euro = "Eurocan"

Wall thickness distribution of one of the "Two-in-One" concepts.
The wall thickness follows the punch geometry very well.

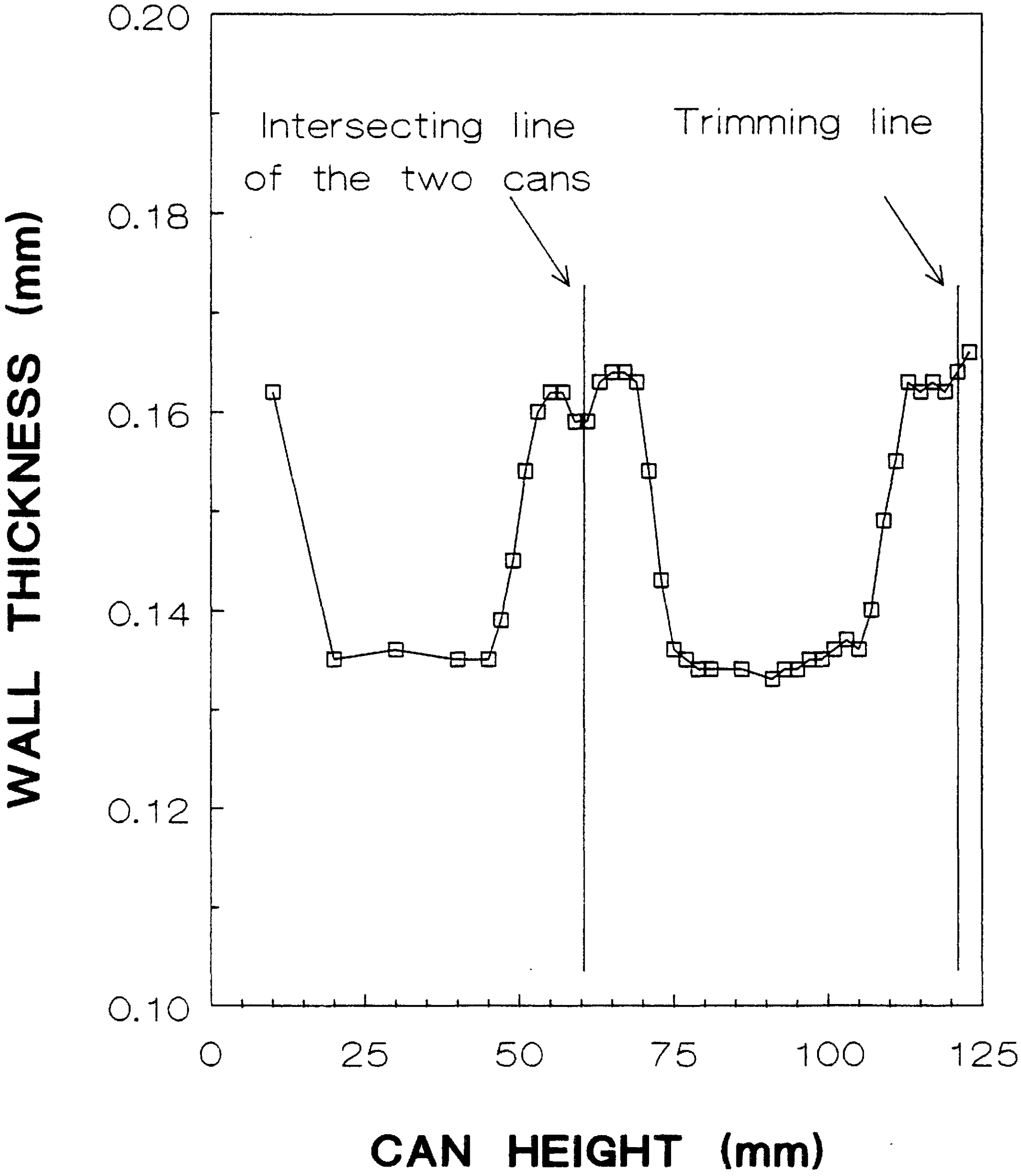


Figure 12 : Wall thickness distribution in relation to the can height

Table 18 : Maximum reductions in % occurring for the "Two-in-One" and Eurocan

Material	T52 BA (0.30 mm)				T61 CA (0.31 mm)			
Concept	0.14/ 0.17 mm TIO	0.13/ 0.16 mm TIO	0.14/ 0.17 mm EURO	0.13/ 0.16 mm EURO	0.14/ 0.17 mm TIO	0.13/ 0.16 mm TIO	0.14/ 0.17 mm EURO	0.13/ 0.16 mm EURO
Location								
Pre-sizing die								
t1	1.0	1.0			1.3	1.3		
t2	7.8	7.8	15.2	15.2	8.6	8.6	17.0	17.0
First die								
t3	29.0	30.0	32.0	31.7	31.0	30.3	31.3	31.6
t4	19.2	17.9			19.6	19.0		
t3*	*36.1*	*37.0*			*37.5*	*37.0*		
Second die								
t5	22.9	28.4	23.0	23.4	21.0	26.4	22.5	24.9
t6	8.2	13.5			7.3	14.1		
t5*	*31.5*	*36.1*			*31.9*	*36.7*		
Third die								
t7	19.6	18.8	25.7	28.7	21.3	21.6	26.2	25.3
t8	2.9	1.2			4.6	3.7		
t7*	*33.5*	*31.7*			*32.7*	*32.8*		
t8*	2.9	1.2	7.2	9.6	4.6	3.7	8.1	8.4

The italic printed reductions are extra high, due to material flow from the first punch step.

A few of the wall ironed cans were taken out to measure the wall thickness from the bottom of the can, up to the edge of the can. The measurements are shown in figure 12 (see opposite page) where the presented line is an average value. From the figure becomes evident that the material follows the punch geometry very good.

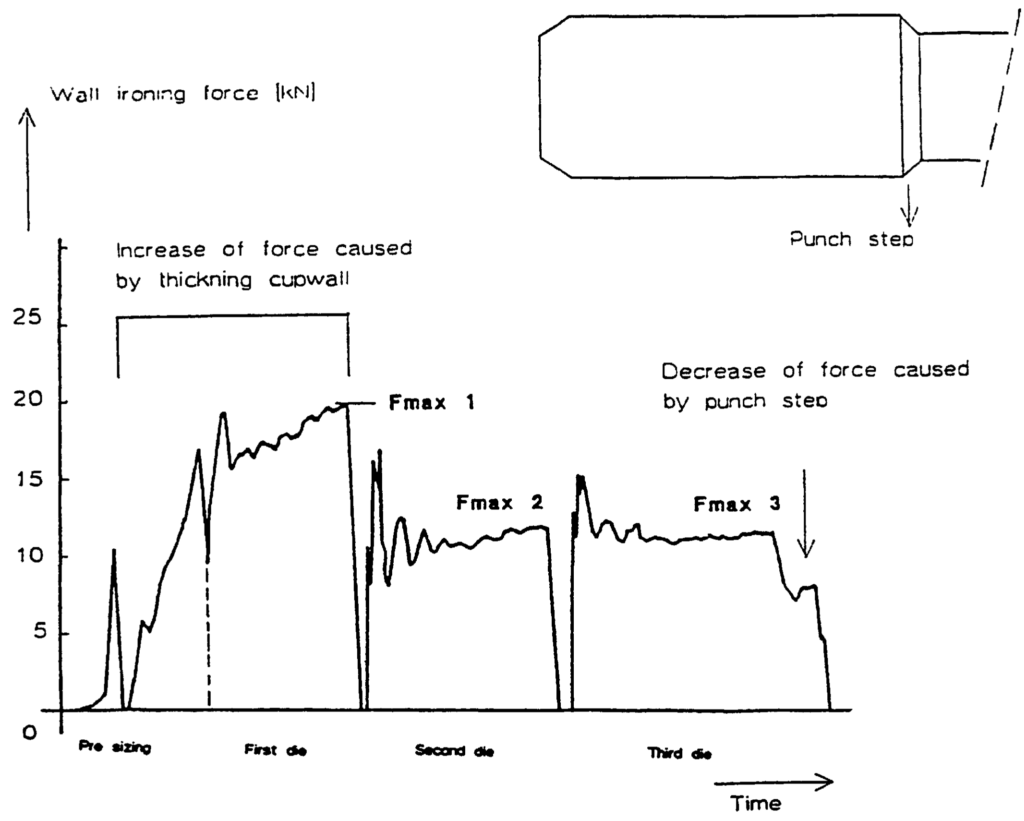


Figure 13 : Wall ironing forces for the Eurocan

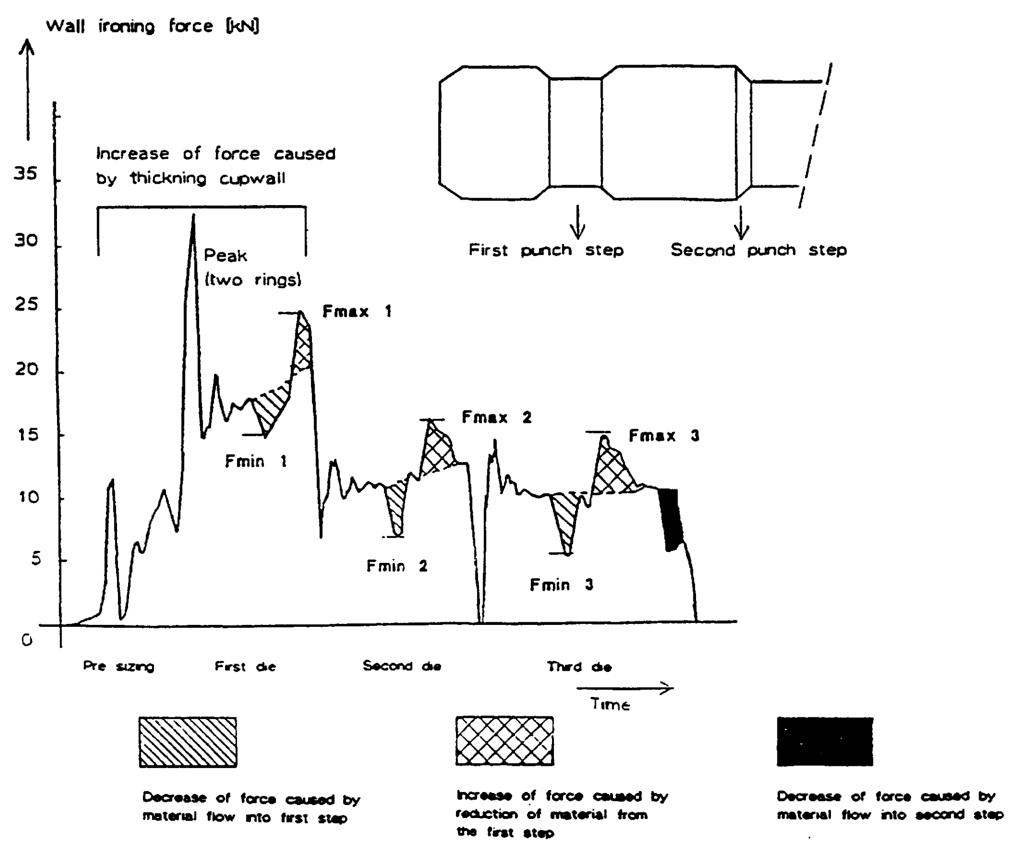


Figure 14 : Wall ironing forces for the "Two-in-One" can

4.2.2 Wall ironing forces

The wall ironer at Hoogovens is provided with force measurement devices to measure both the total wall ironing force as well as the stripping force. From the geometry of the punch for the "Two-in-One" can concept a higher fluctuation in wall ironing force can be expected, than for the Eurocan is observed.
In the figures 13 and 14 (see opposite page) the wall ironing forces for both the Eurocan and the Ø 73 mm the "Two-in-One" can are presented. The figures are characteristic for the differences between both concepts, regardless of the material variant or the can wall thickness.

The force curve as shown in figure 13 gives a characteristic picture of a DWI can as it is traditionally produced. The peak, at the start of the reduction in each die, originates from the punch-die impact. The damping effects originate from the measuring device. In figure 13 the different production steps pre-sizing die, first, second and third ironing die can easily be recognised.

Figure 14 shows the wall ironing forces for the Ø 73 mm "Two-in-One" can. The peak force at the beginning of the first ironing die can be explained by the fact that the can at that moment has not left the pre-sizing die completely yet, so that the sum of the force in the pre-sizing die and in the first die is being measured. For this research project this problem is not really relevant. The measured wall ironing forces are mentioned in appendix E.

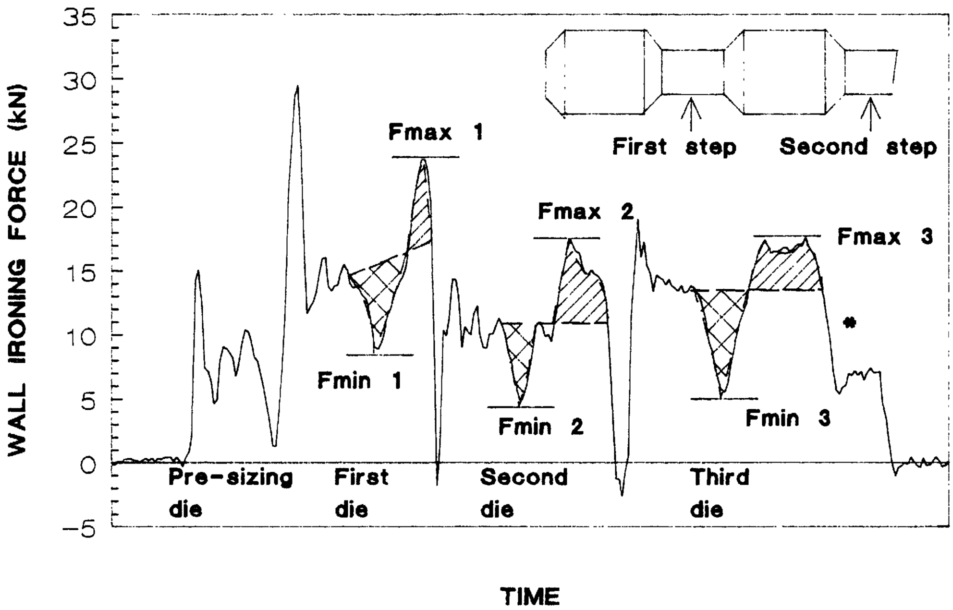
The following conclusions can be made :

- The wall ironing forces for the T61 material average out 14% higher than for cans from T52 material. This can be explained from the higher deformation resistance of the T61 material.

- The wall ironing forces at the production of the "Two-in-One" cans are considerably higher than compared to the production of the Eurocans. On average, this increase is over short periods about 20% higher than the maximum occurring wall ironing force in a die for the production of the Eurocan. This increase in wall ironing force is induced by the extra material flow from the first punch step.

- At the production of the "Two-in-One" can, the wall ironing forces show stronger fluctuations than at the production of the Eurocan, which can be explained from the differences in punch geometry.

In the first die the increase in force is caused by the thickning of the cup wall.



Decrease in force caused by material flow in first step

Increase in force caused by material flow from first step

*Decrease in force caused by material flow in second step

Figure 15 : Wall ironing forces for the "Two-in-One" can with a step of 0.05 mm

4.2.3 Maximum allowable step size

The minimum reduction in the last die is determined by the step size of the punch that has been selected. The rate of reduction in the last die forms an important factor for the stripping behaviour. For the maximum step size in relation to the maximum reduction occurring in the third die the following can be deducted :

$$\frac{(t_6 + P_s) - (t_6 - P_s)}{(t_6 + P_s)} \times 100\ \% = R_{\text{max. in \% (max. reduction third die)}}$$

t_6 = equivalent to the final flange thickness t_9.

Further deduction leads to :

$$P_s = \frac{\frac{R_{max}}{100} * t_9}{2 - \frac{R_{max}}{100}}$$

For a flange thickness of 0.16 mm and a maximum reduction of 47 % this results in a maximum step size of 0.05 mm. This means a wall thickness of 0.11 mm Figure 15 (see opposite page) shows the measured wall ironing forces for cans produced with the step size of 0.05 mm.

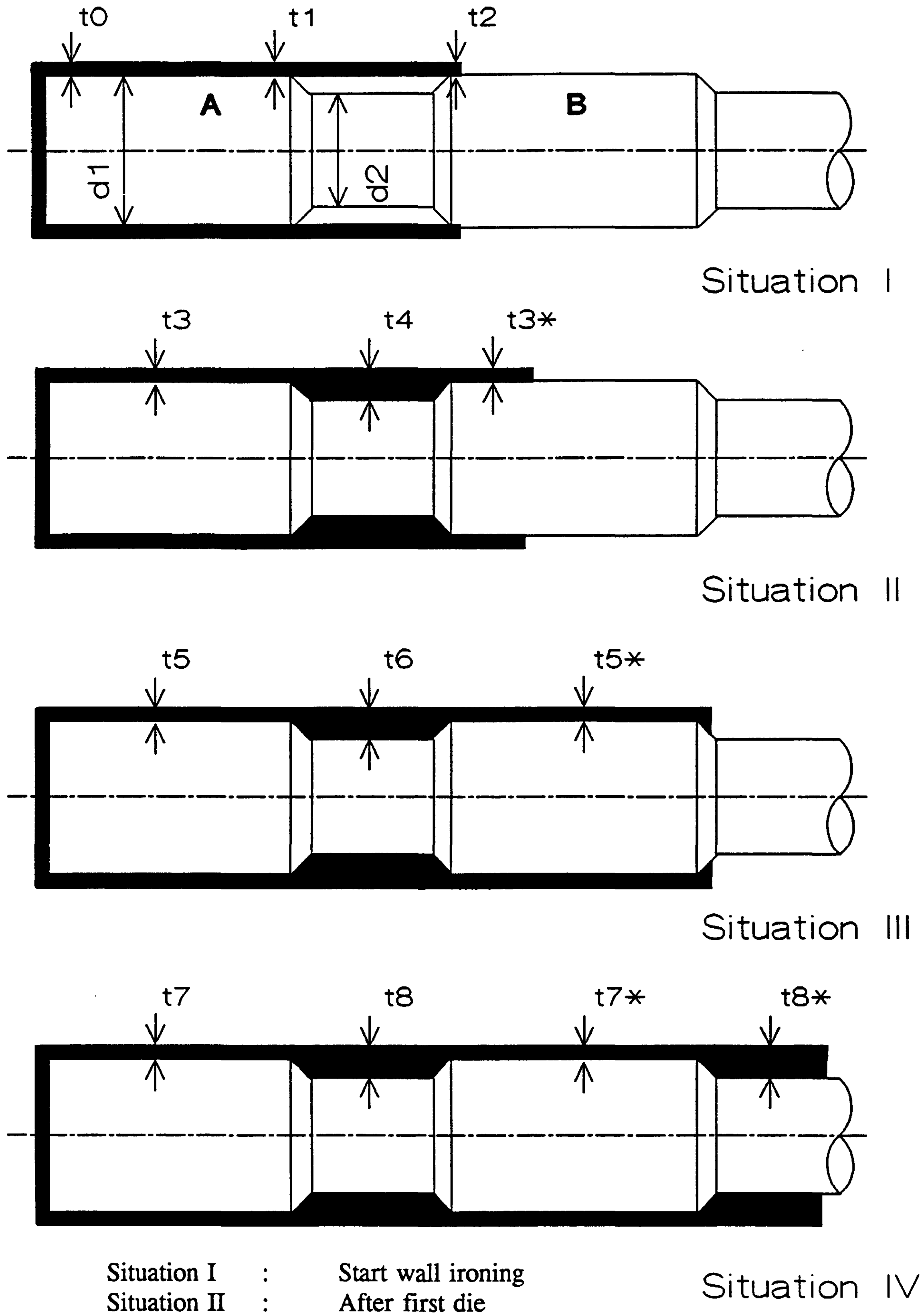


Figure 16 : Wall ironing steps

4.3 Wall ironing for the Ø 66 mm can

4.3.1 Reductions

The toolbox in the Hoogovens wall ironer is, for the production of the Ø 66 mm "Two-in-One" cans, provided with 3 dies; no pre-sizing die was installed. This means that in practice the cup is directly fed into the first wall ironing die. A schematic view of the wall ironing situations is presented in figure 16 (see opposite page).

From experience we have learned that this method has no influence on the test results.

Table 19 : Processing conditions for wall ironing of the first series of test runs for the Ø 66 mm "Two-in-One" can.

Wall ironer Production speed Coolant Coolant flow	Schuler PAZ1 100 cans/min. Water 50 l/min.		
	Tooling		
	"Two-in-One" concept		Reference 33 cl
	0.13/0.15	0.12/0.14	0.09/0.14
Wall ironing dies	diam. [mm]	diam. [mm]	diam. [mm]
First die Second die Third die	66.290 66.183 66.144	66.290 66.165 66.116	66.399 66.278 66.157
Punch diameter Punch step	65.900 mm 0.02 mm		65.990 mm 0.05 mm

The formula's according to which the reductions were calculated are shown in appendix D.
The measured reductions and wall ironing forces during the wall ironing of the first series of test runs are shown in tables 20 and 21 on the next page :

Table 20 : Can wall thickness of Ø 66 mm cans in wall ironing situations I to IV (see figure 16 at previous page) - first series

Material	T52 BA - 0.24 mm		T61 CA - 0.24 mm	
Concept	0.13/0.15 mm	0.12/0.14 mm	0.13/0.15 mm	0.12/0.14 mm
Thickness [mm] according to appendix D				
t0	0.240	0.240	0.240	0.240
t1	0.234	0.234	0.234	0.234
t2	0.294	0.294	0.324	0.324
t3 = t3*	0.208	0.207	0.208	0.210
t4	0.229	0.227	0.230	0.232
t5 = t5*	0.157	0.149	0.156	0.152
t6	0.177	0.168	0.177	0.171
t7 = t7*	0.130	0.119	0.130	0.120
t8 = t8*	0.149	0.138	0.148	0.141

Table 21 : Can wall thickness of Ø 66 mm cans in wall ironing situations I to IV (see figure 16 at previous page) - second series

Material	T52 BA - 0.26 mm		T61 CA - 0.26 mm	
Concept	0.14/0.16 mm	0.15/0.17 mm	0.14/0.16 mm	0.15./0.17 mm
Thickness [mm] according to appendix D				
t0	0.260	0.260	0.260	0.260
t1	0.260	0.260	0.265	0.265
t2	0.336	0.336	0.352	0.352
t3 = t3*	0.240	0.253	0.240	0.257
t4	0.260	0.279	0.263	0.294
t5 = t5*	0.186	0.178	0.172	0.175
t6	0.192	0.199	0.194	0.196
t7 = t7*	0.134	0.147	0.135	0.147
t8 = t8*	0.155	0.167	0.157	0.168

Table 22 : Reductions for Ø 66 mm cans [%]

Location	T52 BA "2-in-1"		T61 CA "2-in-1"		T52 BA 33 cl	T61 CA 33 cl
Concept	0.13/ 0.15 mm	0.12/ 0.14 mm	0.13/ 0.15 mm	0.12/ 0.14 mm	0.09/ 0.145 mm	0.09/ 0.145 mm
Pre-sizing die						
t2					21.3	20.2
First die						
t3	9.6	9.6	9.6	8.7	16.8/34.5[11]	19.1/35.5[11]
t4	2.1	3.0	1.7	0.9		
t3*	29.3	29.6	35.8	35.2		
Second die						
t5	24.5	28.0	25.0	27.6	32.1	30.8
t6	14.9	18.8	14.9	18.6		
t5*	*31.4*	*34.4*	*32.2*	*34.5*		
Third die						
t7	17.2	20.1	16.7	21.1	39.2	40.0
t8	5.1	7.4	5.1	7.2	3.4	7.1
t7*	*26.6*	*29.2*	*26.6*	*29.8*		
t8*	5.1	7.4	5.1	7.2		

The italic printed reduction are extra high reductions resulting from the material flow in the first punch step.

11 Reduction resulting from processing without a pre-sizing die, when the cup is fed directly into the first die.

Table 23 : Reductions for Ø 66 mm "Two-in-One" cans during the second test run [%]

Location	T52 BA (0.26 mm)		T61 CA (0.26 mm)	
Concept	0.14/0.16 mm	0.15/0.17 mm	0.14/0.16 mm	0.15/0.17 mm
First die				
t2	4.8	0	6.6	0
t3	22.6	17	25.3	16.5
Second die				
t4	30	29.4	28.3	32.7
t5	20	21	19.2	24.6
t4*	33.5	34.8	33.1	39.8
Third die				
t6	20.2	17.4	21.5	16
t7	8.9	6.2	9.9	4.6
t6*	28.6	25.1	29.4	24
t7*	10.4	8.2	10.8	5.1

From the reduction schedule of the involved variants, the following can be concluded in respect of the comparison with the 33 cl can :

- Even though a comparison with the 33 cl can is not quite correct, it does give an insight into the reduction level of the "Two-in-One" milk can. The "Two-in-One" can concepts 0.12/0.14 mm leads to reduction levels compatible with those of the 33 cl can (0.090/0.145 mm) in the first and second die.

- From the reduction schedule it also appears that similar to the Ø 73 mm "Two-in-One" can, a large fluctuation in reduction can be expected during production of the "Two-in-One" can.

The wall thickness follows the punch geometry very well.

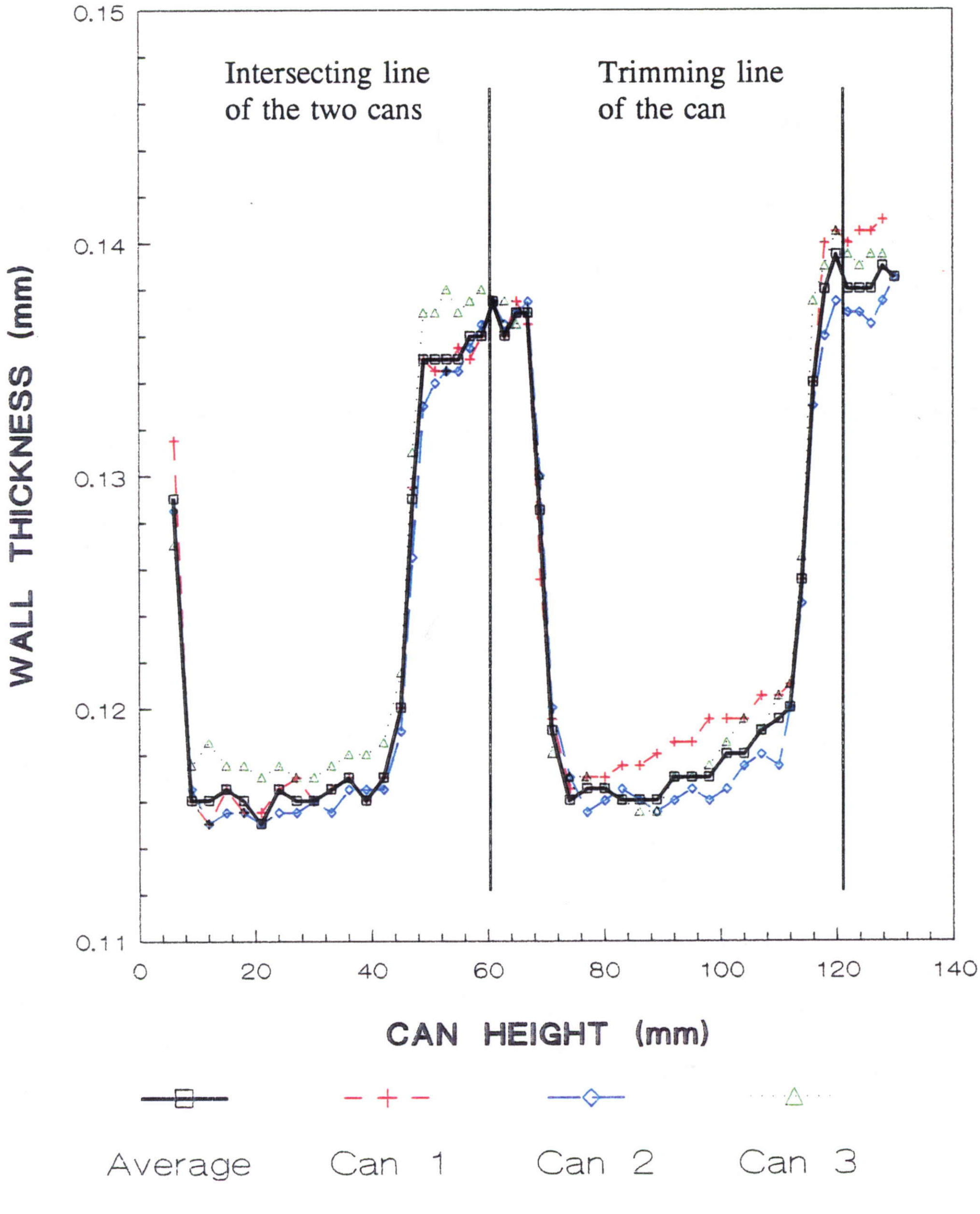


Figure 17 : Wall thickness distribution in relation to the can height

The punch used for these test runs had unfortunately been grinded incorrectly, resulting in the absence of the thickwall at the top (in view of the total time available for this project, we have not been able to correct this). Figure 17 (at the opposite page) shows the wall thickness distribution of the Ø 66 mm "Two-in-One" cans after wall ironing. What can be seen from the picture is that the cans produced during the first test runs are trimmed at the bottom of the thickwall, a point where no extra material, needed for the next step, is available yet.

For the wall ironing tests of the Ø 66 mm the 33 cl beverage can has been used as a reference.
In the table below the processing conditions for the second test runs are presented. This second test run was necessary to be able to meet the required value for the axial resistance.

Table 24 : Processing conditions for wall ironing of the second series of test runs for the Ø 66 mm "Two-in-One" can.

Wall ironer Production speed Coolant Coolant flow	Schuler PAZ1 100 cans/minute Water 50 liter/minute	
	Tooling	
	"Two-in-One" concept	
	0.14/0.16	0.15/0.17[12]
Wall ironing dies	diameter [mm]	diameter [mm]
First die Second die Third die	66.463 66.290 66.252	66.528 66.319 66.276
Punch diameter Punch step	65.991 mm 0.02 mm	

12 Changed in view of mechanical performance, see par. 9.2

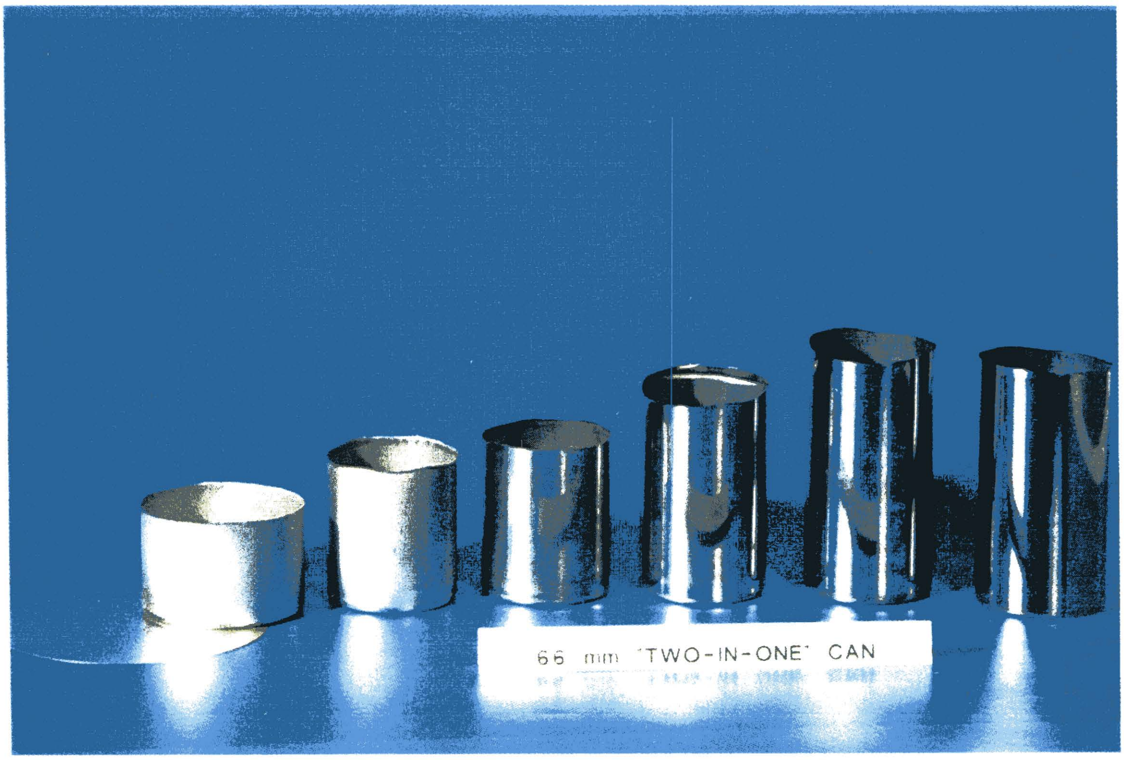
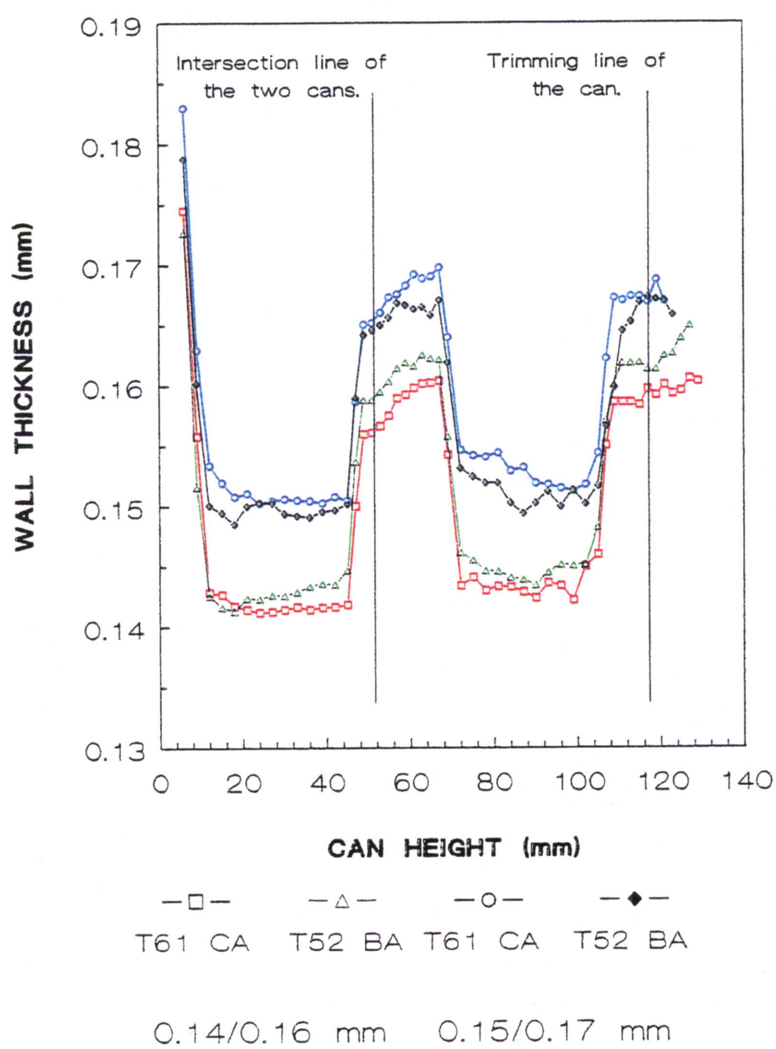


Photo 6 : Deep drawing and wall ironing steps for the "Two-in-One" milk can

For the second test runs of the Ø 66 mm "Two-in-One" cans a new punch was used, with a thickwall at the top. Figure 18 (hereunder) shows the wall thickness distribution of the Ø 66 mm "Two-in-One" cans after wall ironing. What can be seen from the picture is that the cans produced during the second test runs are trimmed in the step where extra material, needed for the next step, is available.

Photo 6 (see opposite page) shows the deep drawing and wall ironing for the Ø 66 mm "Two-in-One" can.

Figure 18 : Wall thickness distribution in relation to the can height



In the first die the increase in force is caused by the thickning of the cup wall.

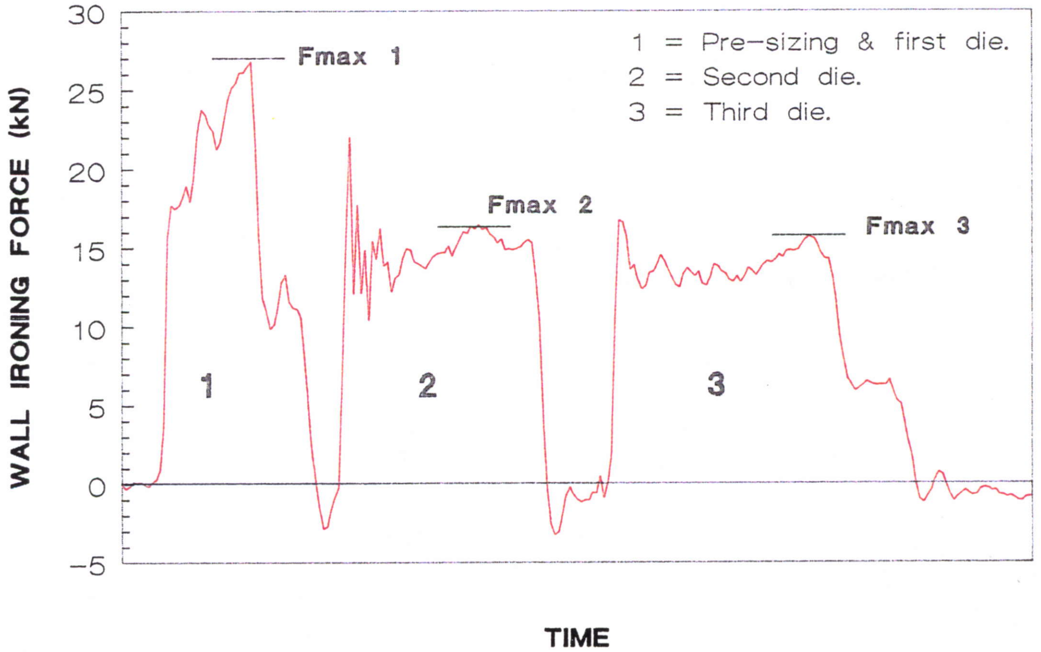


Figure 19 : Wall ironing forces for the 33 cl can

In the first die the increase in force is caused by the thickning of the cup wall.

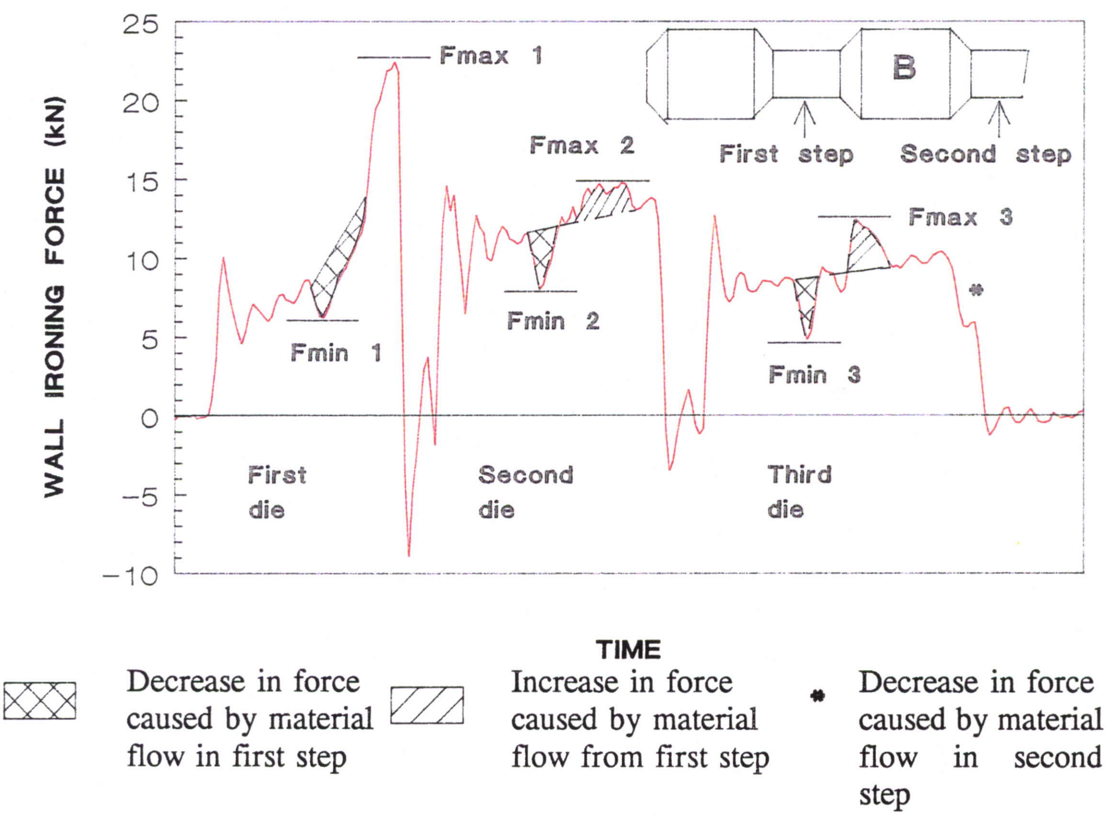


Figure 20 : Wall ironing forces for the "Two-in-One" milk can

4.3.2 Wall ironing forces

The wall ironing forces for both the Ø 66 mm "Two-in-One" can and the 33 cl beverage can from the first test runs are presented in figures 19 and 20 (see opposite page). The figures are characteristic for the differences between both concepts, regardless of material variant or can wall thickness. The reductions at the production of the Ø 66 mm "Two-in-One" cans are expected to have a higher fluctuation than those at the production of the standard 33 cl beverage cans, due to the extra step in the body wall.

In figure 19 the pre-sizing die, as well as the first, second and third ironing die can easily be recognised. This figure presents a characteristic force curve for a DWI beverage can. The peak, at the beginning of the wall ironing in a die, results from the impact of the die; the damping effects are caused by the measuring device.
The difference between the wall ironing curves of figure 19 and figure 20 is quite obvious. The fluctuations in reduction are clearly recognizable in the curve.

The measured wall ironing forces are mentioned in appendix E. The measurement for one of the variants was not correct, due to a malfunction in the measuring device.

From these measurements the following can be concluded :

- The wall ironing force for the T61 material is on average 22% higher than for the T52 material. This can, again, be explained by the higher deformation resistance of the T61 material.
- The maximum wall ironing force measured during the production of the "Two-in-One" milk cans are compatible to those of the 33 cl beverage can.
- The wall ironing forces of the "Two-in-One" can fluctuate stronger than the wall ironing forces of the beverage can. The large fluctuation in the first die is induced by the fact that the cup is very high, so that the cup edge exceeds the first step (see figure 16).

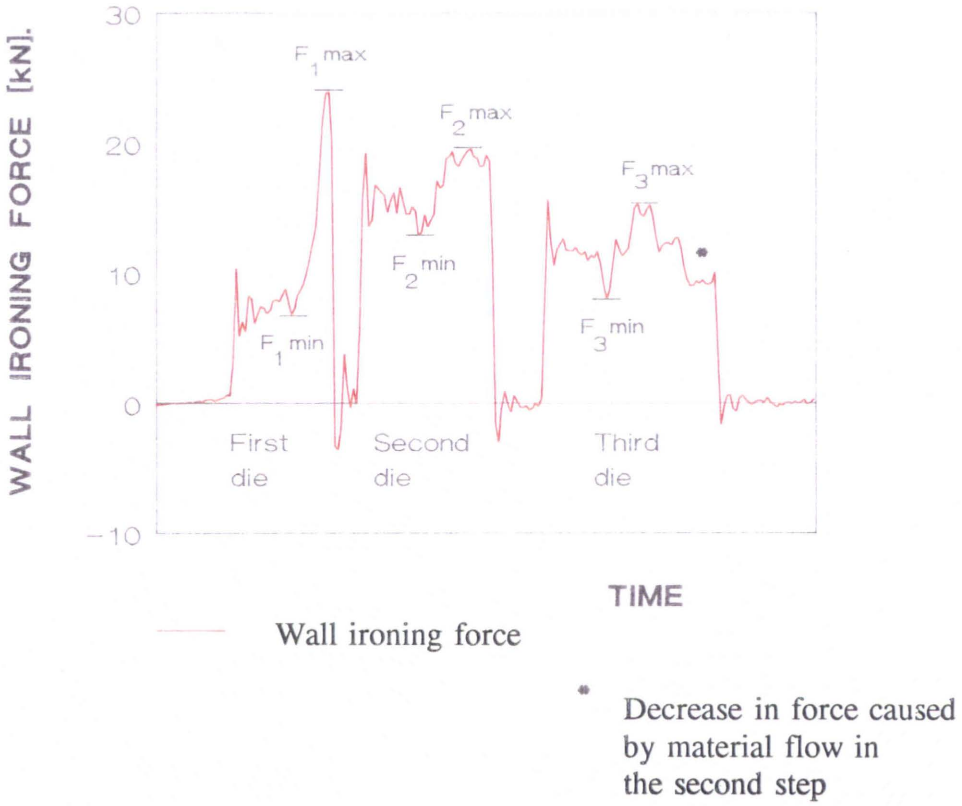


Figure 21 : Wall ironing forces for the "Two-in-One" milk can (second test run)

These test runs were repeated for cans with a higher wall thickness. The measured values for wall ironing forces and the reductions of the standard 33 cl beverage cans from the first test runs, were used as a reference.

Figure 21 (see opposite page) presents the measured wall ironing forces for the second test runs of the Ø 66 mm "Two-in-One" cans. The values of the reductions and wall ironing forces that were measured during these test runs are shown in appendix E.

Conclusions from the second test runs are :

- In appendix E can be seen that with a higher reduction, the measured wall ironing force is also higher.

- The wall ironing forces in the first and third die are comparable to those of the first test runs. The force in the second die is higher than that of the previous tests.

- Due to the fact that these cans have been produced with a larger bottom thickness, the blow off air used for stripping can be higher, so that stripping will be easier.

No problems have been observed during wall ironing of both test runs.

4.4 Stripping behaviour

At the production of DWI-cans in general, it is important that the cans can easily be stripped from the wall ironing punch. Therefore a stripper is mounted to the backside of the toolbox. It consists of a circle of 32 segments which move outwards when the punch with the can around it moves through the last ironing die. As soon as the punch with the can has passed the segments, they will collapse against the punch. The can is hooked behind the segments during the back stroke of the punch and will be stripped off.
At the same time air is pressed into the can in order to prevent underpressure in the can and to support the stripping process. This way the can must come off the punch, visually undamaged.
A stripper is schematically shown in figure 22 hereunder.

Figure 22 : Schematic view of stripper

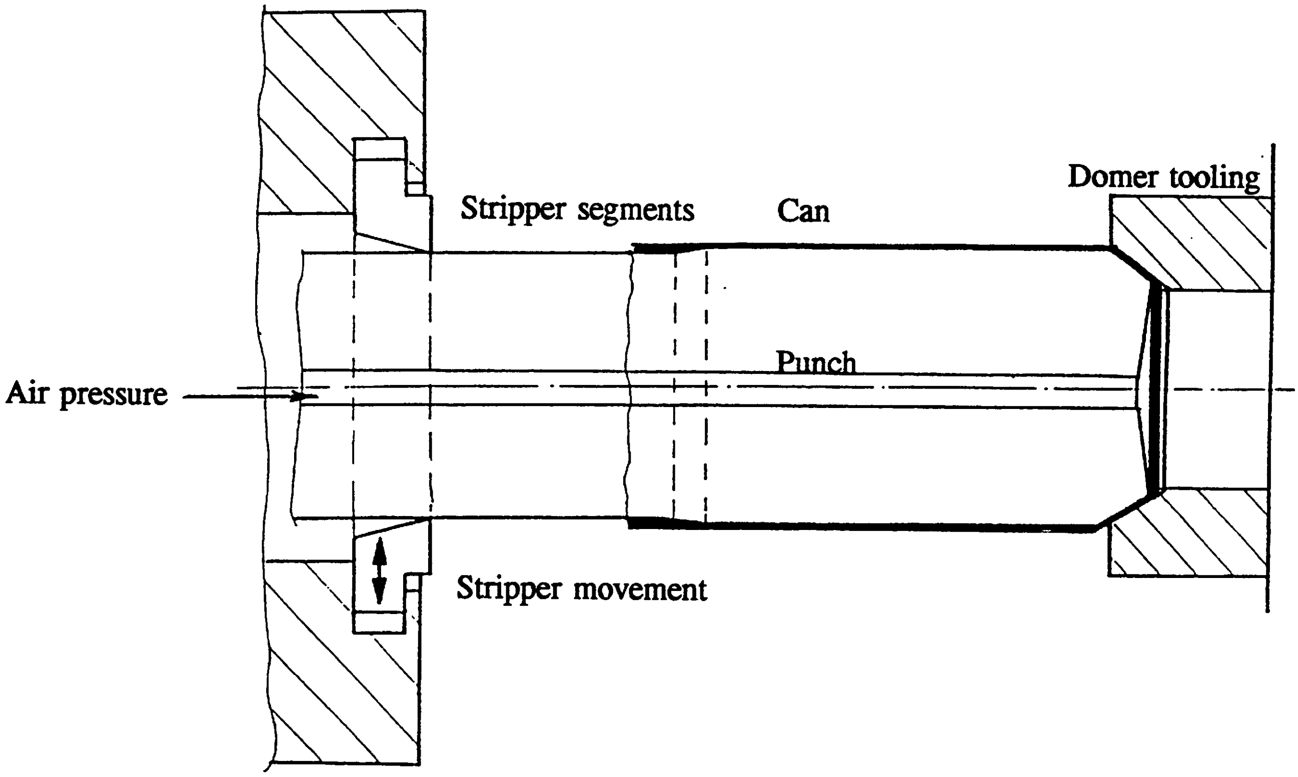


Photo 7 :   Some examples of strippability of cans

4.4.1 Stripping behaviour of the Ø 73 mm can

From tests carried out on the stripping behaviour we have learned that:

* No differences are found between stripping behaviour of the Euro-can or the "Two-in-One" can.
* The stripping behaviour for the cans from T61 material is less favourable than for the T52 material, which can be explained by the higher deformation resistance of T61 material compared to T52 material. Therefore, cans from T61 material will shrink tighter around the punch.

Both the Eurocan and the Ø 73 mm "Two-in-One" can showed a poor stripping behaviour, see photo 5 at the opposite page.

After some experiments to try to improve the stripping behaviour, it was concluded that the stripping behaviour has improved by:

* Using a deep drawing oil during cupping instead of an emulsion.
* Changing the drum switches on the wall ironer that provide for the air release. The wall ironer at Hoogovens is provided with mechanical switches. Changing the mechanical drum switch into an electrical drum switch, will allow an easy setting of the blow off air.

This way the stripping behaviour was improved, but had not reached an optimum.

4.4.2 Stripping behaviour of the Ø 66 mm can

The controlled air support, mentioned with the Ø 73 mm can, was installed and used for these tests. No significant problems occurred during stripping. The stripping behaviour for the Ø 66 mm "Two-in-One" beverage can is generally better than for the Ø 73 mm "Two-in-One" food can.
The depth of the step for the Ø 66 mm "Two-in-One" can is both smaller than that of the Ø 73 mm "Two-in-One" can as well as smaller than that of the 33 cl beverage can. In addition to the use of controlled air support, this has a favourable effect on the stripping behaviour of this can concept.

Photo 8 : Products after trimming and separation of the "Two-in-One" can

5. TRIMMING AND SEPARATION

The steel sheet from which the 2-piece can is made has a material texture related to the hot and cold rolling processes. The deformation of the material in some directions will be higher than in others. This results in an unequal upper edge of the cup after the deep drawing process.
This anisotropy of material properties causes a pattern of peaks and valleys in the upper edge of the cup, called earing.

After wall ironing, the can does not only show earing, but also shows the results of the fact that the misalignment of the punch towards the ironing dies may have caused a certain lopsidedness of the can wall. For this reason, a small part of the upper edge of the can (5 to 8 mm) must always be removed; this procedure is referred to as trimming.

5.1 Trimming and separation of the Ø 73 mm can

The "Two-in-One" can is trimmed to a height of 121 mm and subsequently separated on a height of 60 mm from the bottom.
The only difference between the Eurocan (113 mm) and the "Two-in-One" can is the trimming height. Since the trimming equipment allows simple adjustment of this height, it does not form a problem.
The machinery used to separate the 3-piece can bodies, the so-called "Wobble Cutter", has been used to separate the 2-piece "Two-in-One" cans. The "Wobble Cutter" can only be used for separation of cans without reinforcement beads. In appendix G the technical specification of the "Wobble Cutter" has been included.
Separation of the bodies by means of existing equipment turned out to be very well possible.

The trimmed "Two-in-One" can and the bodies resulting after separation are shown on photo 6 (at the opposite page).

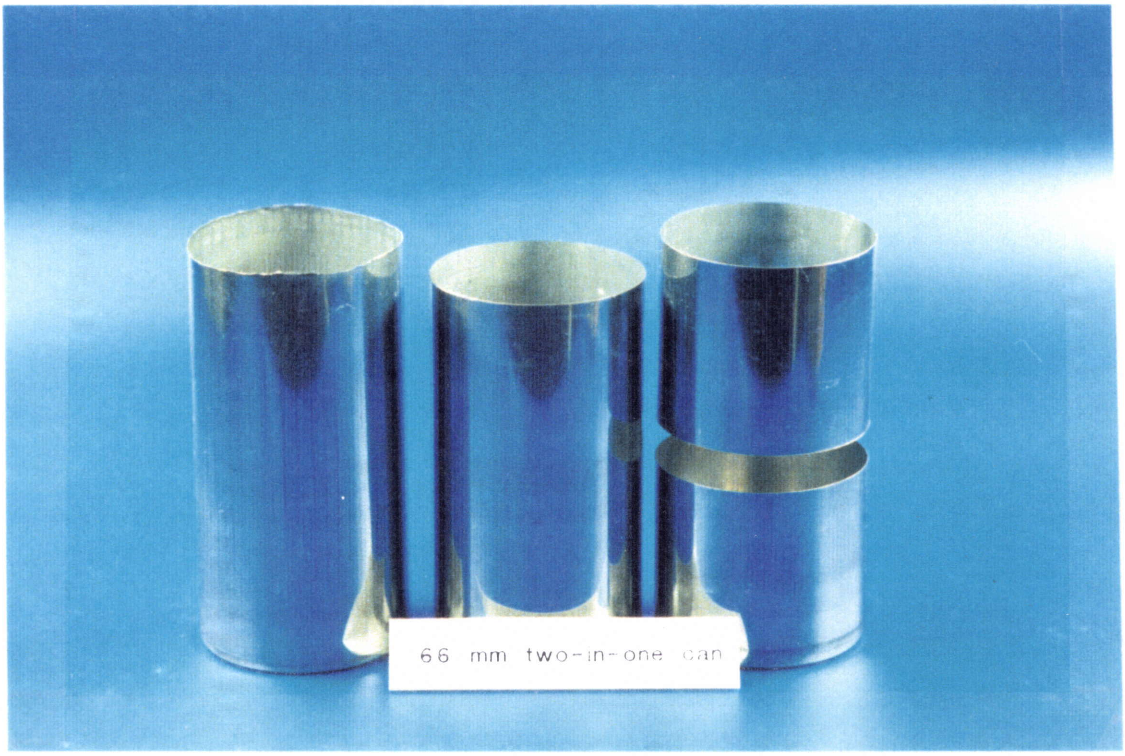


Photo 9 : A wall ironed, a trimmed and a separated can (Ø 66 mm)

5.2 Trimming and separation of the Ø 66 mm can

The first series of test runs have been trimmed by means of the trimmer in the Hoogovens laboratories. Since this trimmer is unsuitable for the separation of the cans, a special trimmer has been used for this purpose. With this trimmer, good separation lines were achieved and trim burrs were avoided.

For the second series of test runs that have been done for the Ø 66 mm can the special trimmer was modified, so both trimming and separating operations could be done on this device. The variation in can height is rather small. Photo 9 (at the opposite page) shows a wall ironed can, a trimmed can and a separated can.

With this adjusted trimmer, both good separation lines as well as trimming lines have been obtained. Trim burrs could be avoided on both the 2-piece and the 3-piece cans.

Photo 10 : Products after necking and flanging of 3-piece can and flanging of the 2-piece can

6. FLANGE FORMING

6.1 Flange forming for the Ø 73 mm can

The procedure for flange forming that is commonly used in the production of Ø 73 mm food cans, for both 2-piece and 3-piece cans, is the spin flanging method (see figure 23, next page). In addition to the spin flanging method, die flanging is used as an alternative. With die flanging the can is pushed to a die which has the contours of the final flange. A disadvantage hereby is the higher axial load to the body of the can and the risk of wall crushing. Therefore spin flanging is preferred for the flanging of wall ironed cans, in view of the lower axial load of the body wall.

The lower part of the "Two-in-One" can, that forms the 2-piece can, is provided with a flange by means of spin flanging at the upper edge. The upper part of the "Two-in-One" can forms the seamless body of a 3-piece can. This body is at the upper part provided with a flange by means of spin flanging, like the 2-piece can. The bottom of the seamless body is provided with a necked-in flange edge by means of spin necking and flanging. This way the cans become stackable.

Table 25 : Flange edge dimensions for the Ø 73 mm can

Concept	2-piece	3-piece	
	Upper edge	Upper edge	Bottom edge
Flange diameter [mm] Plug diameter [mm]	2.5 73	2.5 73	2.5 70
Type of end [mm]	73	73	70

Photo 10 (at opposite page) shows the cans after flange forming.

No problems have been observed during spin flanging or spin necking and flanging processes of the 2-piece and 3-piece cans.

Spin flanging is a flange forming process by which the flange material is formed to a larger diameter than the can diameter.

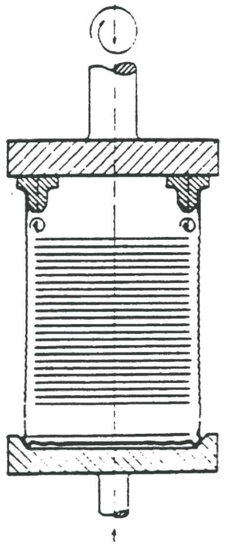


Figure 23 : Schematic view of spin flanging

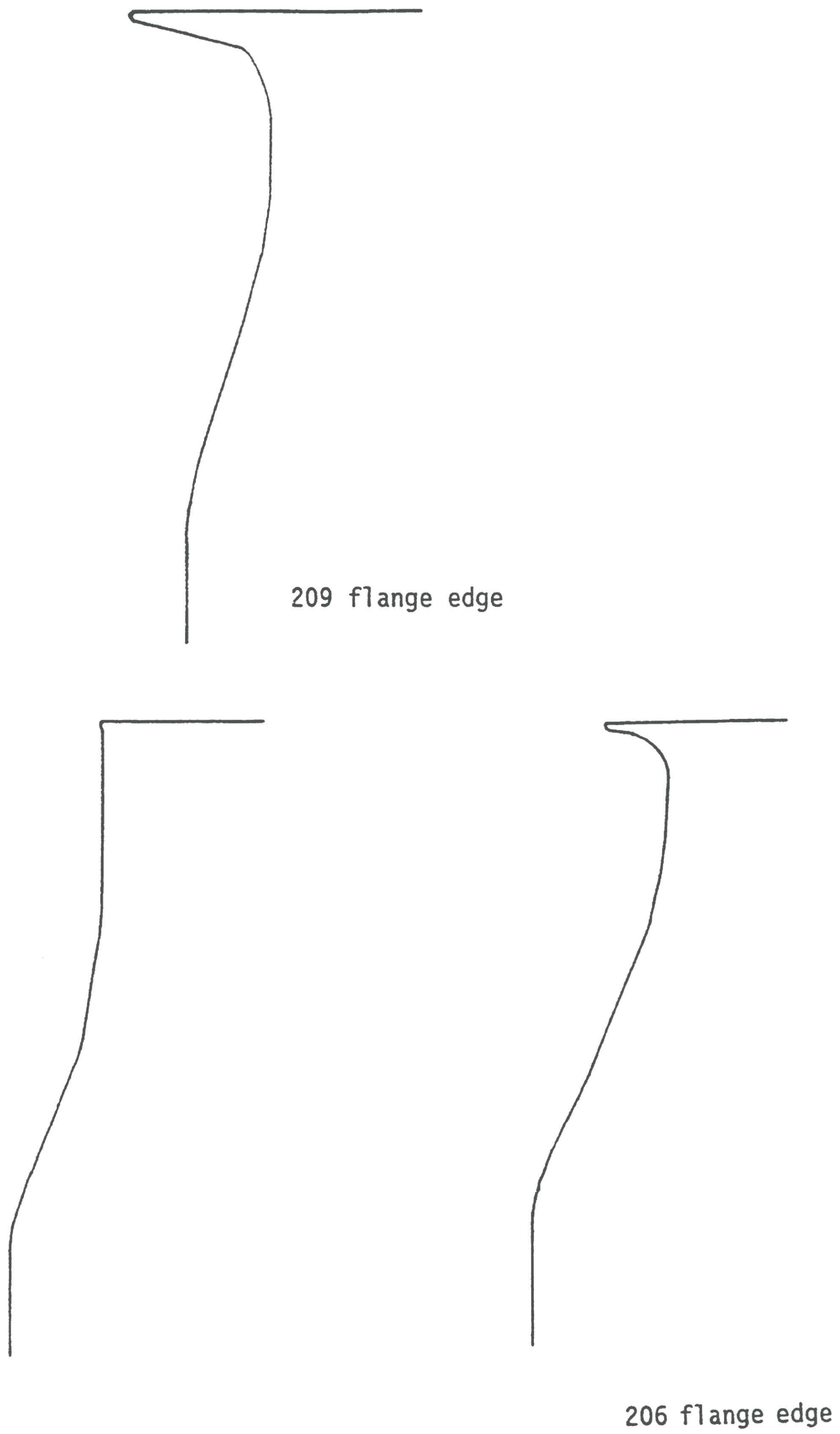


Figure 24 : Profile of the 206 and 209 seaming edge

6.2 Spin necking and flanging for the Ø 66 mm can.

The flange forming operation for the Ø 66 mm cans is different to that of the Ø 73 mm cans. Both 2-piece and 3-piece cans are provided with either a 209 or a 206 flange edge by means of spin necking and flanging so that the appropriate end can be seamed to it.

The 209 flange edge

The 209 flange edge is used for the ends of milk cans (see figure 24 at the opposite page). This edge can be formed in one step, without overpressure inside the can during the necking process.

The 206 flange edge

The 206 flange edge is usually applied for the 33 cl beverage can, it is formed in two steps. In the first step the cans are prenecked (see figure 24). This is a very critical process in which internal overpressure is needed, to obtain a good preneck form. In the second step, where the actual neck and flange is formed, no internal pressure is applied.
For the necking of the 206 neck both prenecking and necking curves, normally applied for the 33 cl beverage can, were used. This process is very sensitive to variations in inside diameter of the cans, and to the presence of trim burrs.

Figure 25 : Schematic view of spin necking & flanging process

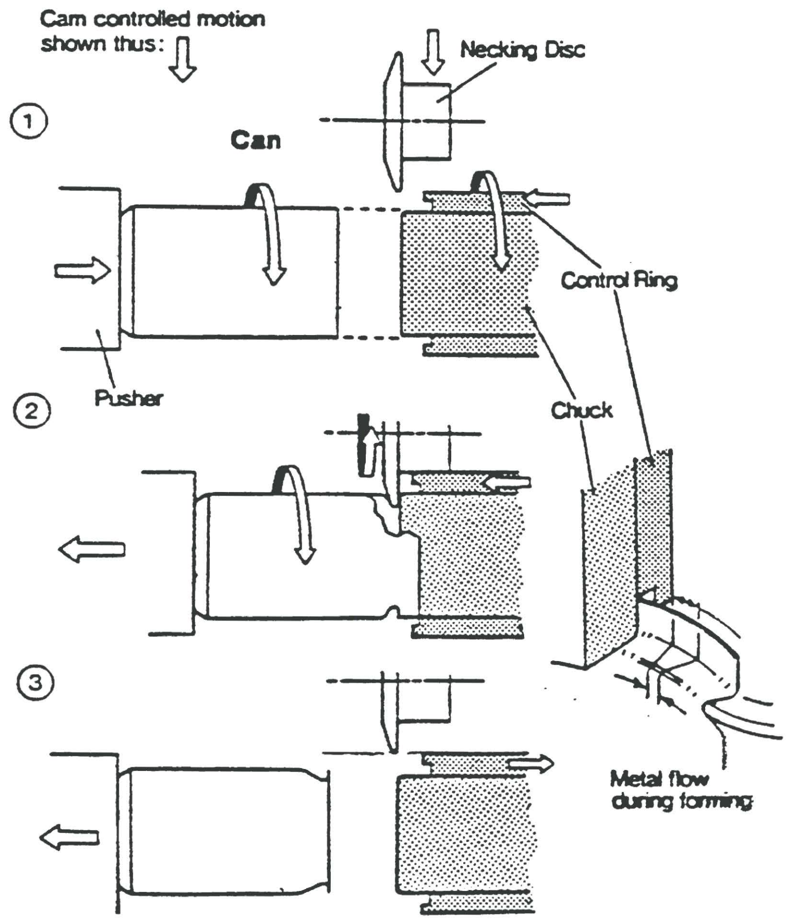


Photo 11 : Stacked 2-piece cans

Photo 12 : Stacked 3-piece cans

6.2.1 Spin necking for the 2-piece "Two-in-One" can

The 2-piece can is formed from the lower part of the wall ironed can. Therefore this can is already provided with a bottom, and is only necked and flanged at the upper part. The cans were provided with either a 206 or a 209 flange edge.

During the necking of the 2-piece cans of both test runs no problems were observed.

6.2.2 Spin Necking for the 3-piece "Two-in-One" can.

The 3-piece can, or seamless body, has to be necked and flanged at both sides of the can. The seamless bodies from the first test runs could unfortunately not be provided with a flange edge, since due to incorrect grinding of the punch, the additional thickness at the upper edge of the can started at the point where the cans were trimmed, instead of 9.5 mm under that point. Therefore, no extra thickness was available at the top of the seamless body. As a result the seamless bodies, produced during the first test runs were not included in further test procedures.

The second test run was carried out with a new punch. The bottom of these cans was provided with a 209 flange edge, the top with either a 209 or a 206 flange edge. No problems occurred during the necking of both sides of these cans.

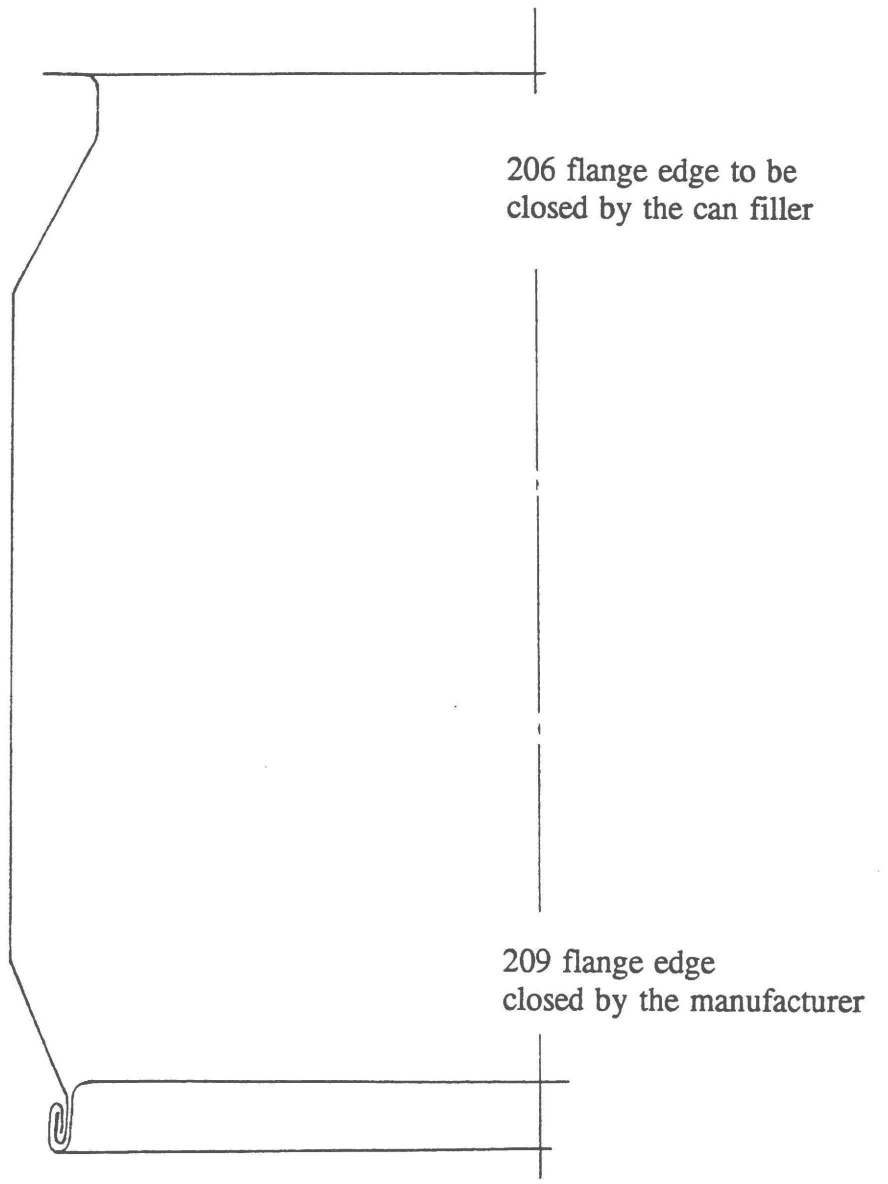
For the 3-piece cans a 206 flange edge at the top is preferred over a 209 flange edge; the cans become stackable. The cans with a 209 flange edge at both sides stack very unstable, just like the welded milk cans. This can be seen on the photos 9 and 10 (at the opposite page).

From the necking and flanging tests the following conclusions can be made :

* Both the 2-piece and 3-piece cans of the Ø 73 mm "Two-in-One" concept can easily be necked and flanged.
* By necking and flanging the upper part of the cans, the Ø 73 mm "Two-in-One" cans become stackable.
* The Ø 66 mm "Two-in-One" can concepts can be provided with either a 209 or a 206 flange without problems.
* By spin necking and flanging the upper part of the cans with a 206 flange, the Ø 66 mm "Two-in-One" cans also become stackable.

The can manufacturer will have to seam the side of the can with the 209 flange edge, so the can filler only needs to seam the 206 ends (see figure 26 below).

Figure 26 : Schematic view of a seamless can with seamed bottom



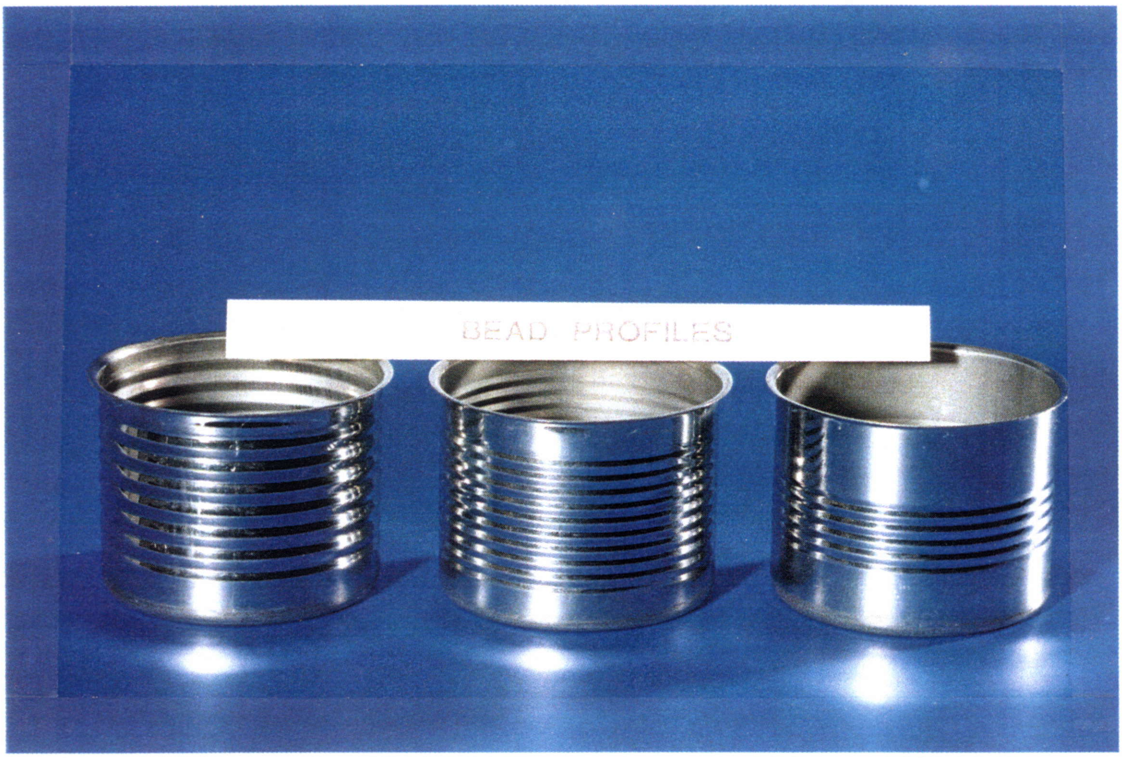


Photo 13 : Selected bead profiles

Photo 14 : Finale 2-piece and 3-piece seamless handy cans

7. BEADING

For an investigation to the bead depth, several bead concepts were selected for the Ø 73 mm can (see photo 11 at the opposite page). The bead concept on the left, with the wide beads, was not included in further tests, in view of the can appearance. Only the cans produced with the thinnest wall thickness were taken into account for this investigation (wall thickness 0.127 mm). No significant difference based on material properties was observed.

The figure shows that:

- the radial resistance increases when the beads get deeper.
- the axial resistance is reduced if the bead depth increases.

The bead concept selected as the most suitable is type C on photo 11, with a bead depth of 0.3 mm. The reasons for these selections are:

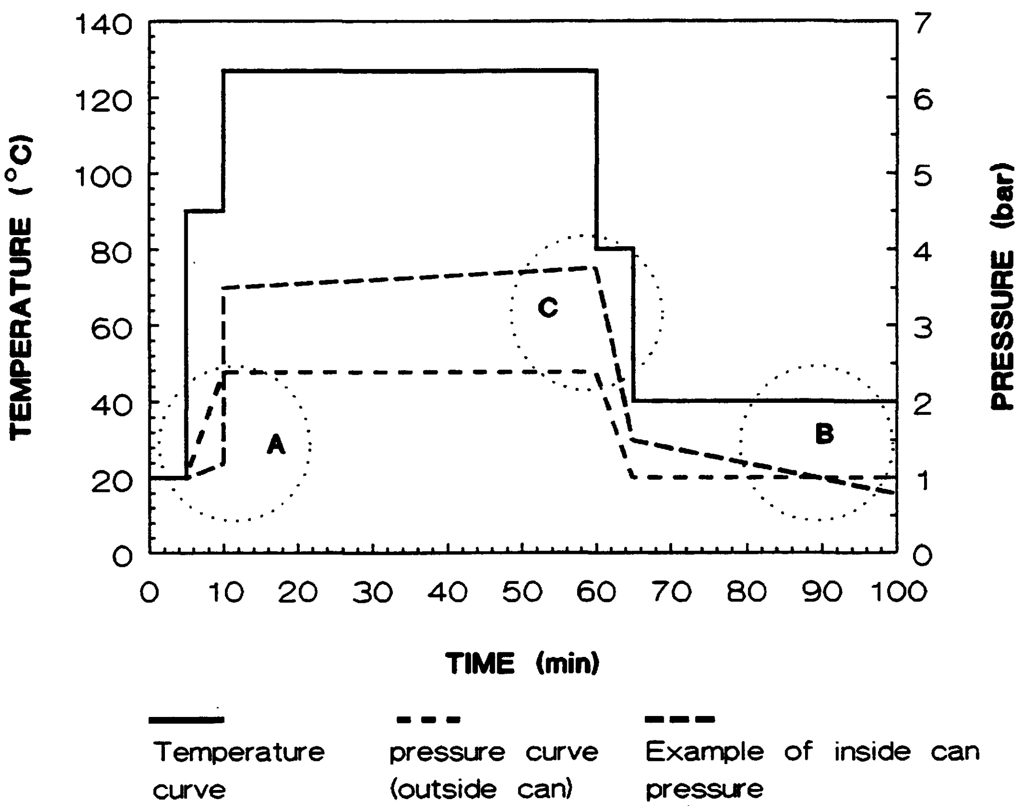
- A can with a bead depth of 0.3 mm still has a sufficient axial resistance as well as a sufficient radial resistance.

- Type C is the most suitable bead profile in view of the fact that the can gets a paper wrap around it after filling. If bead type B would be used, there might a possibility of insufficient adherence of the paper wrap. With bead type C this risk is considerably reduced.

- Since the paper wrap is slightly pulled into the valleys in between the beads, the printed images would be more disturbed on cans with beads over the entire cans.

Examples of the final products for the Ø 73 mm "Two-in-One" cans with beads are shown on photo 12 (also at the opposite page).

Schematic view of temperature and pressure curves used during sterilization. The inside can pressure curve is only used as an example.



Zone A & B

Critical zones for the can body because the outside pressure is higher than the inside pressure. This can cause collapsing of the can.

Zone C

Critical zone for the can ends/bottom because the inside can pressure is higher than the outside pressure.

Figure 27 : Simulation of the sterilization process

8. SEAMING

8.1 Seaming of the Ø 73 mm can

Both the Ø 73 mm "Two-in-One" cans and the Eurocans were provided with a standard (300) end for food cans.

8.2 Seaming of the Ø 66 mm can

For the first series of tests runs only the 2-piece "Two-in-One" cans were closed. The cans that were provided with a 209 flange edge were closed with a standard 209 end for milk cans. The 2-piece cans that were provided with a 206 flange edge, were closed with a 206 end normally used for 33 cl beverage cans, since no 206 ends for milk cans are commercially available yet.

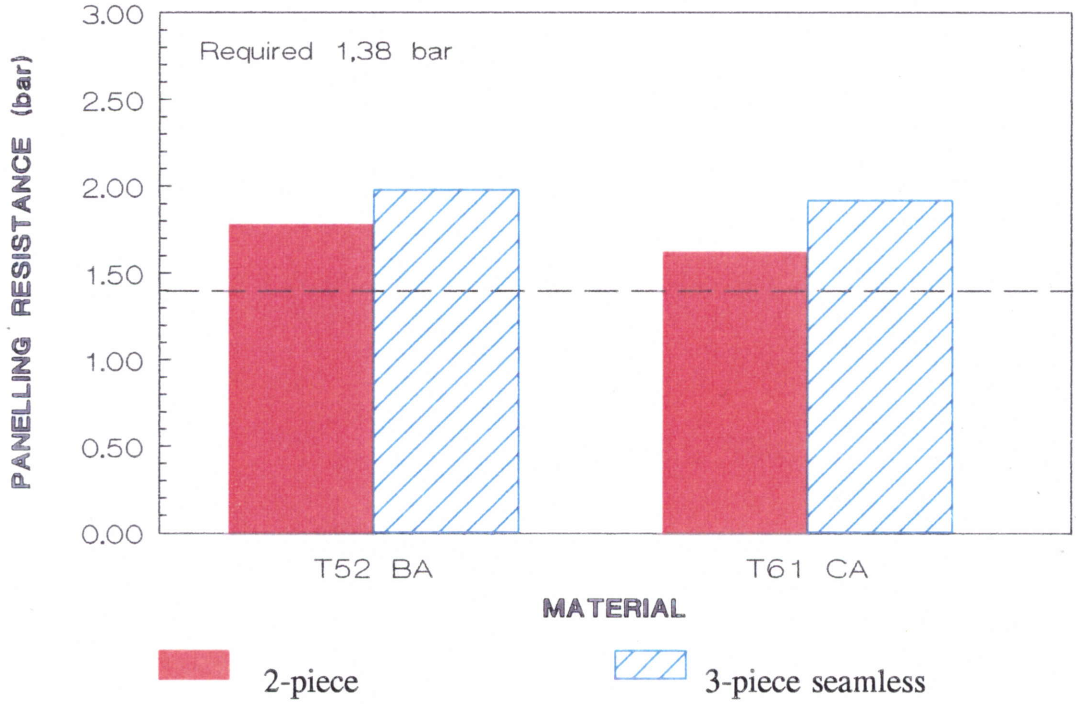
For the second series of test runs both 2-piece and 3-piece cans were closed. The 2-piece "Two-in-One" cans were closed in the same way as in the first test runs. The 3-piece "Two-in-One" cans were at the bottom all provided with a 209 end for milk cans. The top of these cans was either closed with a 209 end or with a 206 end.

The dimensions of the "Two-in-One" can after seaming are Ø 66 x 58 mm.

As a reference 3-piece welded milk cans (Ø 63 x 61 mm) were closed with a 209 end at the upper side. The cans had already been flanged as well as provided with a 209 end at the bottom.

No problems have been noticed during the different seaming operations.

Average panelling resistance of 73 x 58 mm cans with 4 beads.
Wall thickness of tested cans is 0.127 mm.



Average axial load of 73 x 58 mm cans with 4 beads.
Wall thickness of tested cans is 0.127 mm

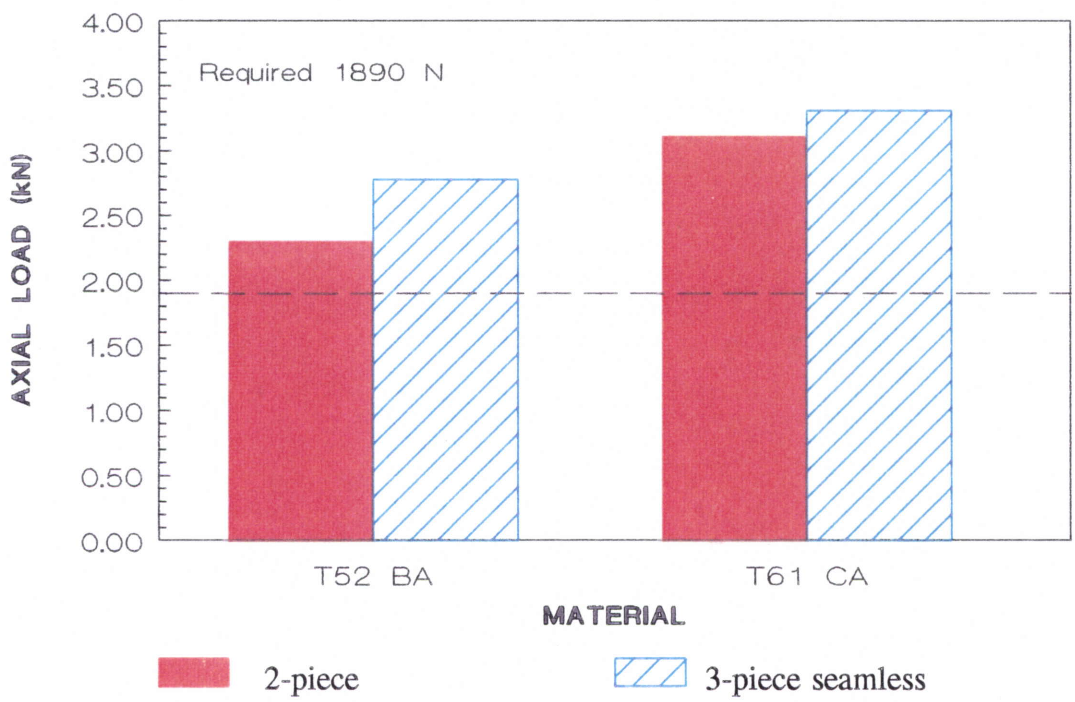


Figure 28 : Panelling resistance and axial load of final can concepts

9. MECHANICAL PERFORMANCE

The two aspects that are important for both the food and the beverage cans in respect of the mechanical performance, are:

* The radial or panelling resistance. The radial strength must be sufficient to allow sterilisation of the products.

* The axial or stacking resistance. The axial strength must be high enough to be able to allow stacking of filled cans.

The requirements for both axial and radial resistance vary per can filler. The load largely depends on the sterilisation process and the desired stacking height.

9.1 Mechanical performance for the Ø 73 mm can

9.1.1 Radial resistance of the Ø 73 mm can

The sterilisation process that is used in a canfillers plant for petfood is shown in figure 27 (see previous page). The pressure curves and process temperatures presented are the actual settings of a can filler, these settings have been simulated in a laboratory sterilisator.
The critical points for the can and can ends that can be found in the sterilisation process are :

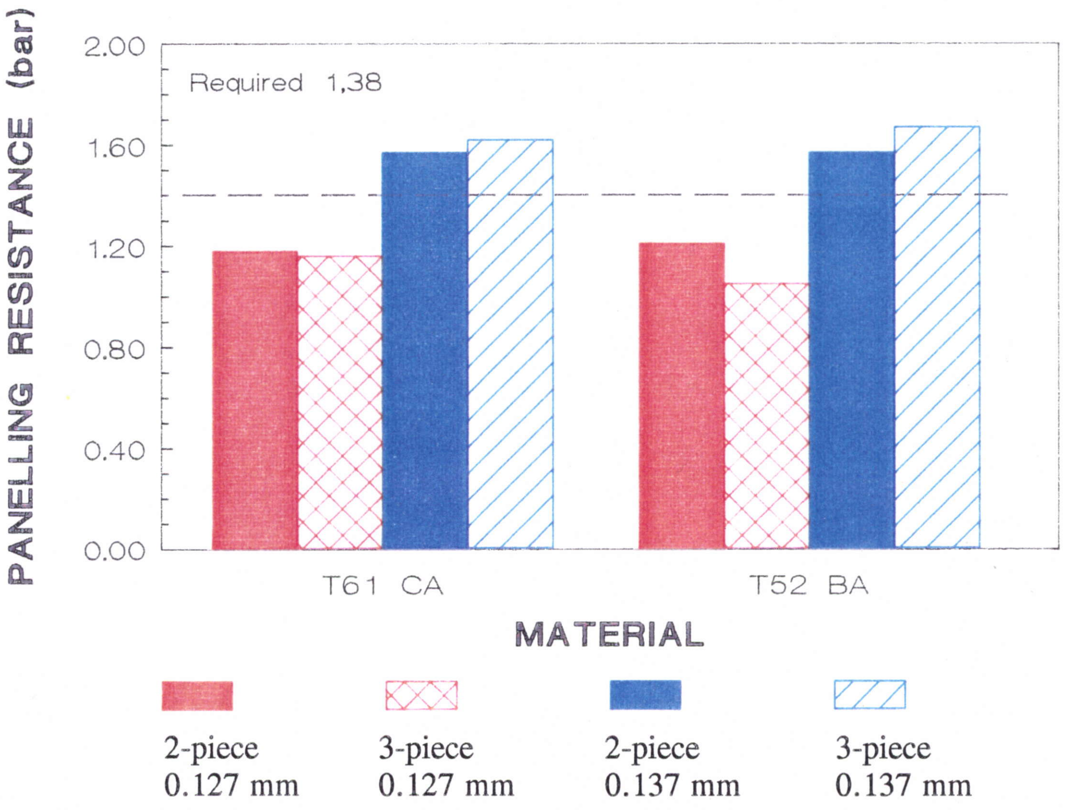
- During heating and pressure building in the sterilisator the maximum load on the can is an overpressure equal to the retort pressure that is set (zone A in the figure). The measure of overpressure depends on the heat conductivity between filling medium and retort. This situation can be critical to the can body, and therefore the radial resistance must at least be equal to the retort pressure.

- Most critical for the ends is the higher internal pressure that is found in zone C in the figure as a consequence of expansion of the filling medium and gas pressure in the head zone.

- After cooling (zone B) an underpressure in the can is observed, due to a small plastic deformation of the ends. This is a critical situation for the can body (radial load).

The minimum radial resistance that had to be met with Ø 73 x 58 mm and Ø 73 x 115 mm cans is 1.38 bar. First cans without reinforcement beads were tested, without filling medium in closed condition (see figure 28 at the opposite page and 31 at the next page).

Panelling resistance



Axial load

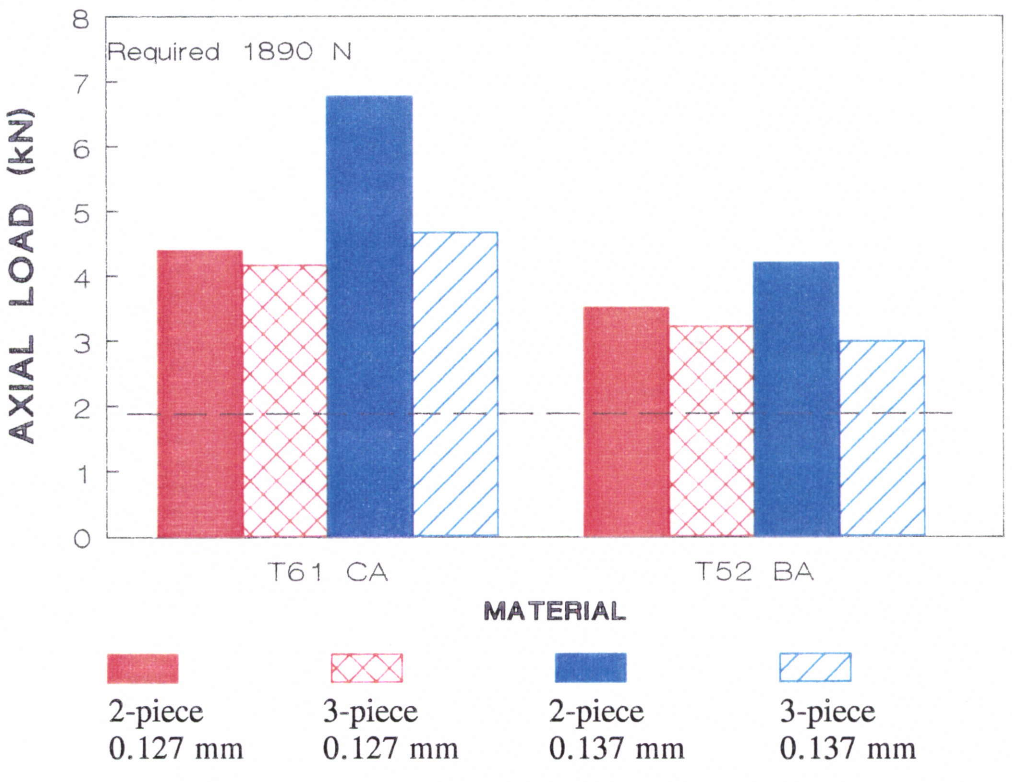


Figure 29 : Panelling resistance and axial load of Ø 73 * 58 mm cans without beads

Conclusions for the radial resistance for cans without beads are :

1. The cans with a wall thickness of 0.137 mm have a radial resistance that, in average, is 0.4 bar higher than those with a wall thickness of 0.127 mm. The cans with the thinner walls are not able to meet the required value.

2. The material strength seems to have no influence. Since an elastic collapse is involved, only the can geometry and the modulus of elasticity play a role [9].

3. The radial resistance of 3-piece cans is in most cases higher than that of a 2-piece can. This can be explained on the basis of a favourable effect from the seam for connecting body and bottom end in case of the 3-piece can.

9.1.2 Axial resistance of the Ø 73 mm can

The required axial resistance for the cans is 1.89 kN, to allow stacking of the filled cans. The results for the axial resistance for cans without beads is shown in figure 29 (see previous page).

Conclusions for the axial resistance for cans without beads are :

1. All can concepts are able to meet the requirement 1.89 kN.
2. The wall thickness of the can has little influence on the axial resistance. The expected difference of 17 % [9] in favour of the cans with a thickness of 0.137 mm does not become evident.
3. The axial resistance for the cans from th T61 CA material is higher than for the cans from the T52 BA material.

The investigation showed that the cans with a wall thickness of 0.127 mm were not able to meet the required value for the radial resistance. The radial resistance of these cans can be increased by the application of beads.

9.1.3 The influence of beads on the radial and axial resistance

The axial load gives rise to plastic deformation [9]. Therefore the material strength and the can geometry will largely define the maximum allowable axial load.
Since the radial resistance shows in an elastic collapse, only differences in can geometry can lead to differences in the radial resistance.

In chapter 7 is already discussed which bead type and bead depth is chosen. Figure 28 (see par. 9.1.1) shows the radial and axial resistance of the can with the beads. In the figure only the results for the cans with a wall thickness of 0.127 mm are presented, because the thicker can concept will surely meet the required value.

Conclusions according to the final product are :

- Processing the 2-piece and 3-piece "Two-in-One" cans into full-fledged cans has not raised any technical problems.
- Beads may be needed to increase the radial resistance of the cans, depending on the wall thickness selected.
- All cans that were produced were able to meet the required value for the axial resistance.

Photo 12 (see chapter 7) shows some examples of the final products.

9.2 Mechanical performance for the Ø 66 mm can

Similar to the Ø 73 mm cans the two important aspects for the mechanical performance of the cans are :

- The radial resistance or panelling resistance.
- The axial resistance or stacking resistance.

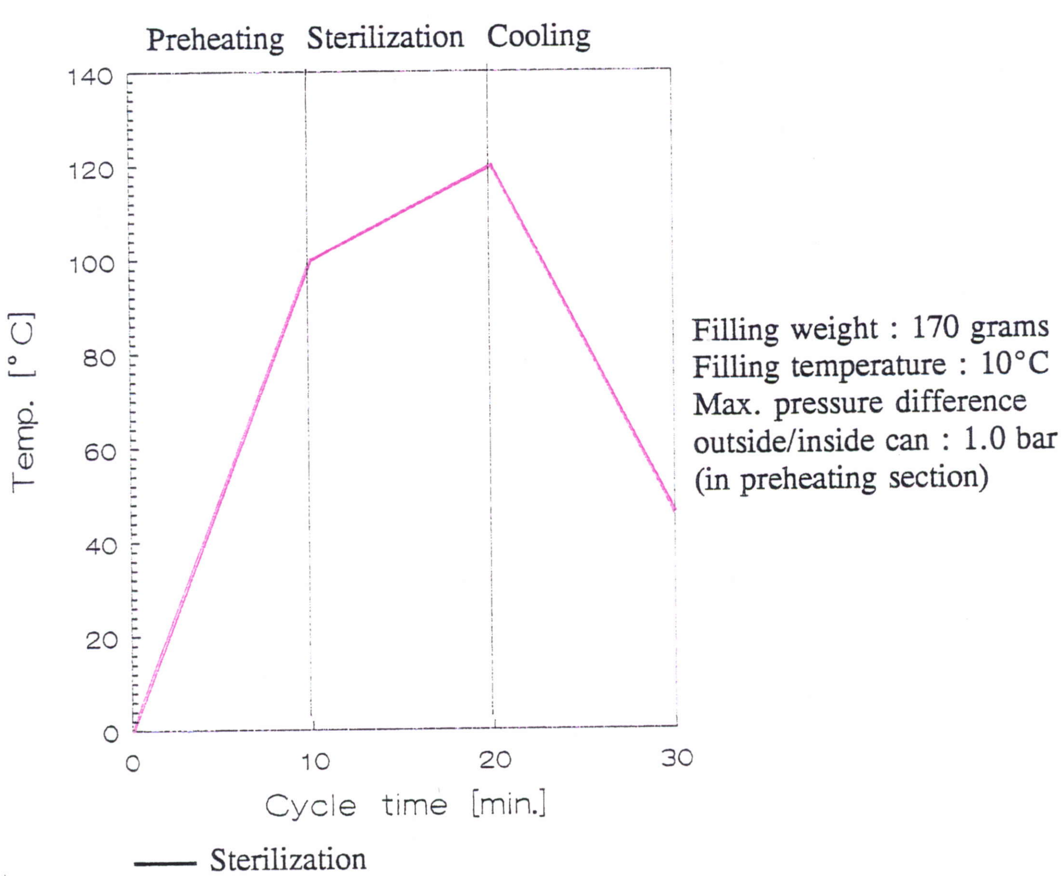
The requirements for both values vary among different manufacturers.
The "Two-in-One" cans that were tested were :

1. Cans from the first test runs, with wall thicknesses of 0.12 and 0.13 mm. These were only 2-piece cans, since the 3-piece cans have not been closed. As a reference welded milk cans of Ø 63 x 61 mm were used with a wall thickness of 0.19 mm.
2. Cans from the second test runs, with wall thicknesses of 0.14 and 0.15 mm. Both 2-piece and 3-piece cans were included in these tests. The welded reference cans that were used as a reference to these cans had a wall thickness of 0.16 mm.

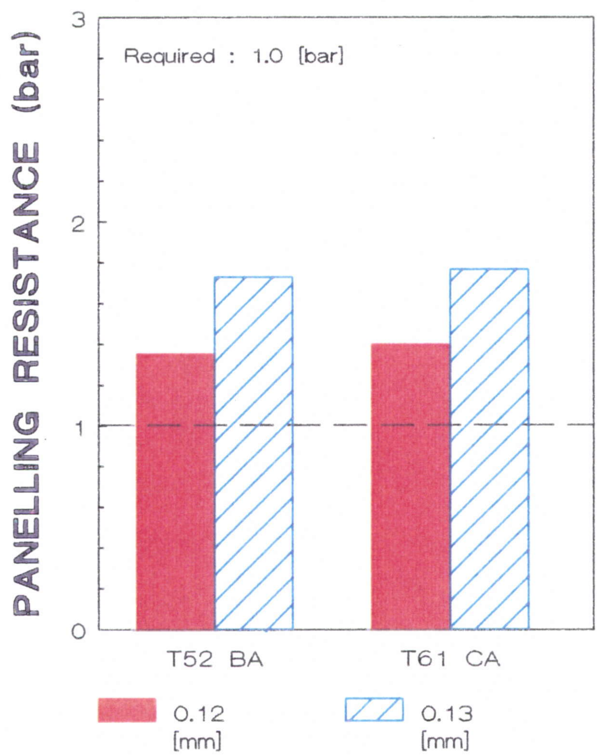
9.2.1 Radial resistance of the Ø 66 mm can

The can is during the sterilisation process submitted to an outside pressure. Figure 30 (below) shows a schematic view of this sterilisation process.

Figure 30 : Schematic view of sterilisation process



Panelling resistance of cans with a 206 seaming edge



Panelling resistance of cans with a 209 seaming edge

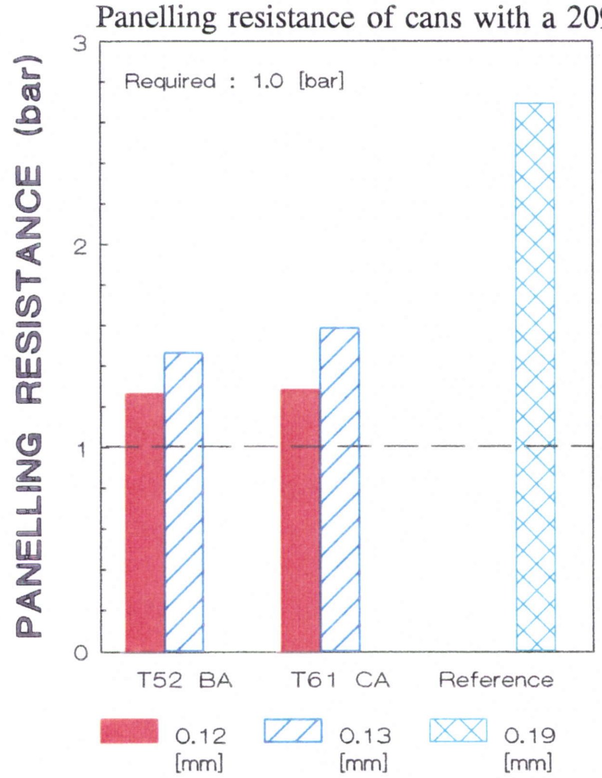


Figure 31 : Panelling resistance of Ø 66 * 58 mm cans without beads

The minimum required radial resistance for milk cans is 1.0 bar. All cans tested were empty closed cans without reinforcement beads. The measured values for the radial resistance are shown in the table below.

Table 26 : Measured values for the radial resistance for Ø 66 mm "Two-in-One" cans and reference milk cans.

Can type	206 edge	Std. dev.	209 edge	Std. dev.
"Two-in-One" 2-piece cans				
T52 BA 0.12 mm	1.4	0.1	1.3	0.1
T52 BA 0.13 mm	1.7	0.1	1.5	0.1
T52 BA 0.14 mm	2.0	0.2	1.8	0.1
T52 BA 0.15 mm	2.3	0.1	2.1	0.1
"Two-in-One" 2-piece cans				
T61 CA 0.12 mm	1.4	0.1	1.3	0.1
T61 CA 0.13 mm	1.8	0.1	1.6	0.1
T61 CA 0.14 mm	1.9	0.1	1.8	0.1
T61 CA 0.15 mm	2.3	0.1	2.1	0.1
"Two-in-One" 3-piece cans				
T52 BA 0.14 mm	2.1	0.1	1.9	0.1
T52 BA 0.15 mm	2.4	0.2	2.1	0.2
"Two-in-One" 3-piece cans				
T61 CA 0.14 mm	2.3	0.1	2.0	0.1
T61 CA 0.15 mm	2.7	0.1	2.4	0.2
Welded cans T61 63 x 61 mm				
0.16 mm			1.9	0.1
0.19 mm			2.7	0.1

The cans produced in the first test runs were already able to meet the required value for the radial resistance.
The cans produced during the second test runs (wall thickness 0.14 mm and 0.15 mm) were included in the radial resistance test, because another wall thickness for the reference can was used (0.16 mm instead of 0.19 mm).

The values mentioned in the table have been visualised in figure 31 (see opposite page) and figures 32 and 33 (turnover). The required value is shown as a horizontal line. From the values can be seen that the cans with a 209 flange edge have a lower radial resistance than those with a 206 flange edge. The 3-piece cans have a better radial resistance than the 2-piece cans, which can be explained from the shorter straight wall of these cans due to the two seams for the end and the bottom.

All cans meet the required value for the radial resistance.

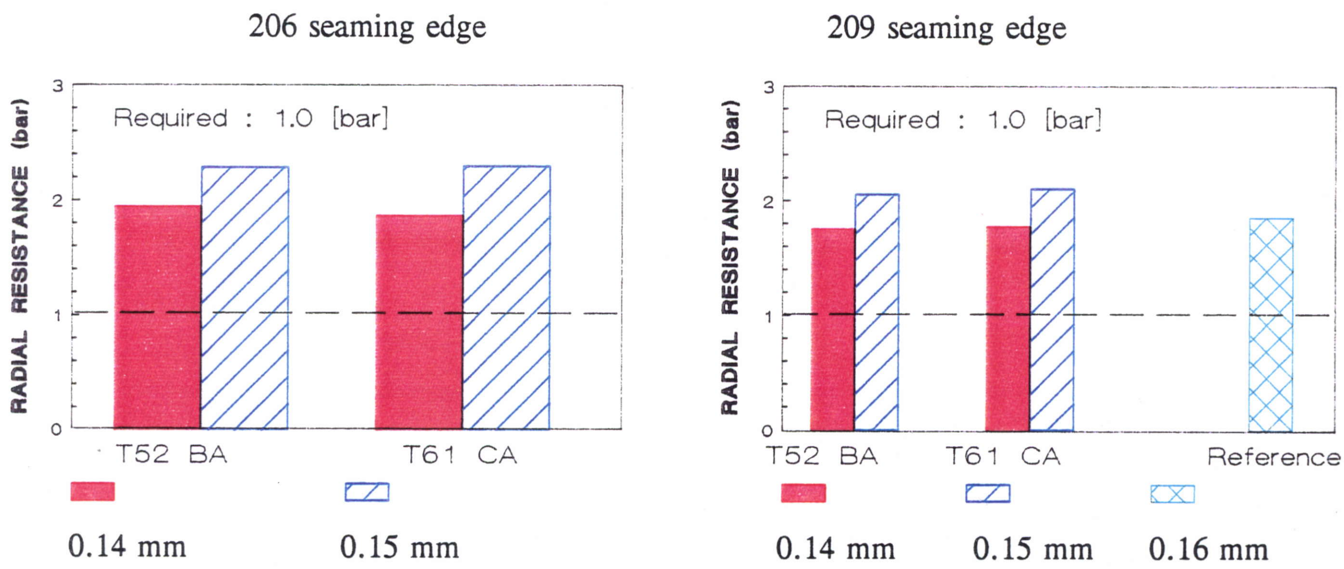


Figure 32 : Radial resistance of two-piece cans

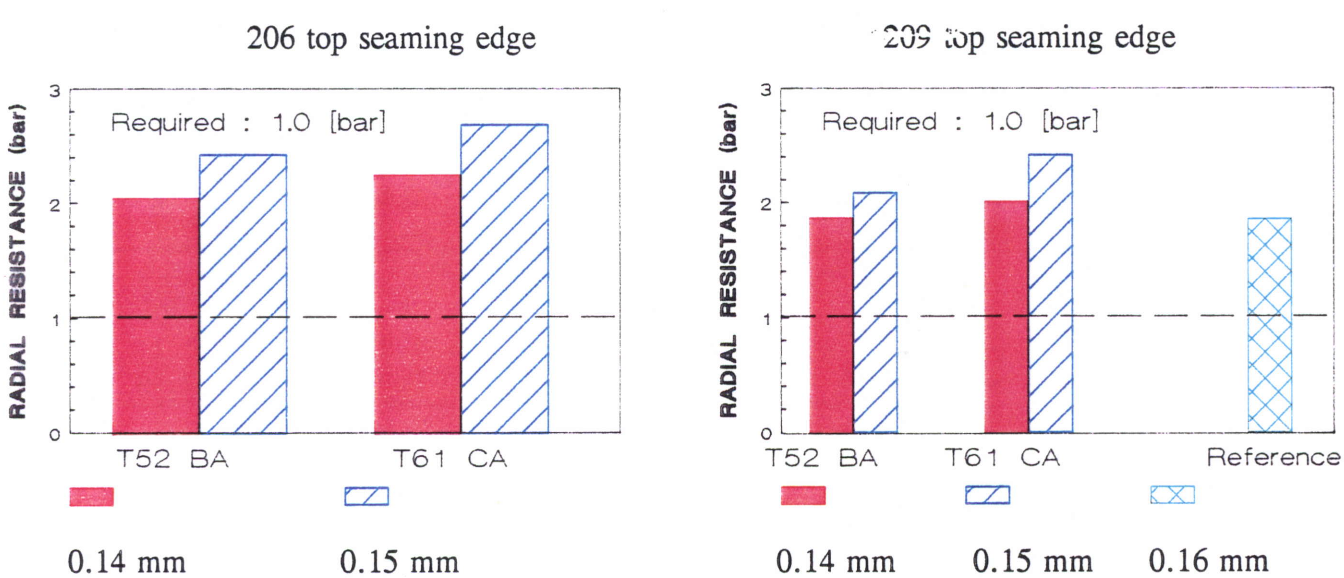


Figure 33 : Radial resistance of three-piece cans
with a 209 end at the bottom

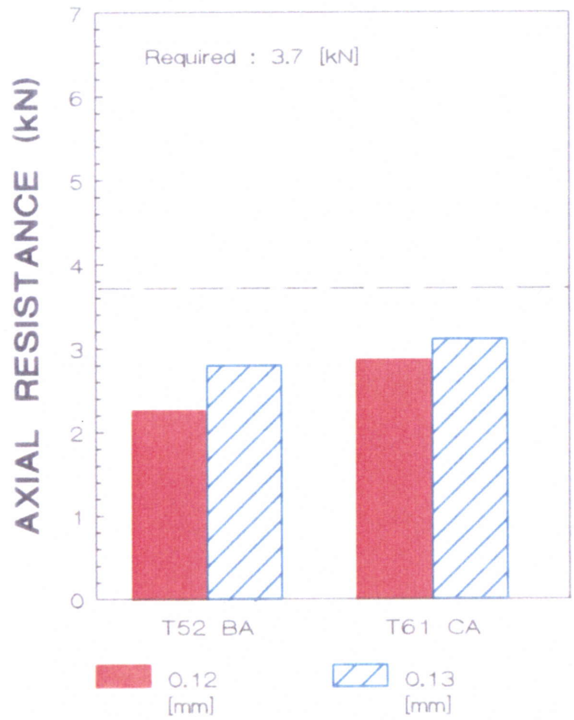
9.2.2 Axial resistance of the Ø 66 mm can

An axial load imposed upon a straight wall of a can body without beads will cause a slight elastic deformation. When the critical resistance is reached, the can will break in a sudden collapse. Both the "Two-in-One" and reference cans have been tested without beads.
The minimum required value for the axial resistance for these cans is 3.7 kN. The measured values for the different cans are shown in the table below.

Table 27 : Measured values for the axial resistance for Ø 66 mm "Two-in-One" cans and reference milk cans.

Can type	206 edge	Std. dev.	209 edge	Std. dev.
"Two-in-One" 2-piece cans				
T52 BA 0.12 mm	2.3	0.1	2.5	0.1
T52 BA 0.13 mm	2.9	0.1	3.1	0.1
T52 BA 0.14 mm	2.9	0.2	3.6	0.1
T52 BA 0.15 mm	3.5	0.1	4.1	0.1
"Two-in-One" 2-piece cans				
T61 CA 0.12 mm	2.9	0.1	2.9	0.2
T61 CA 0.13 mm	3.1	0.3	3.2	0.5
T61 CA 0.14 mm	3.6	0.1	4.3	0.1
T61 CA 0.15 mm	4.1	0.1	4.8	0.1
"Two-in-One" 3-piece cans				
T52 BA 0.14 mm	3.2	0.1	3.9	0.3
T52 BA 0.15 mm	3.5	0.1	4.2	0.1
"Two-in-One" 3-piece cans				
T61 CA 0.14 mm	3.6	0.1	4.4	0.2
T61 CA 0.15 mm	4.1	0.1	4.9	0.1
Welded cans				
T61 63 x 61 mm				
0.16 mm			7.5	0.1
0.19 mm			5.9	0.1

Axial resistance of cans with a 206 seaming edge



Axial resistance of cans with a 209 seaming edge

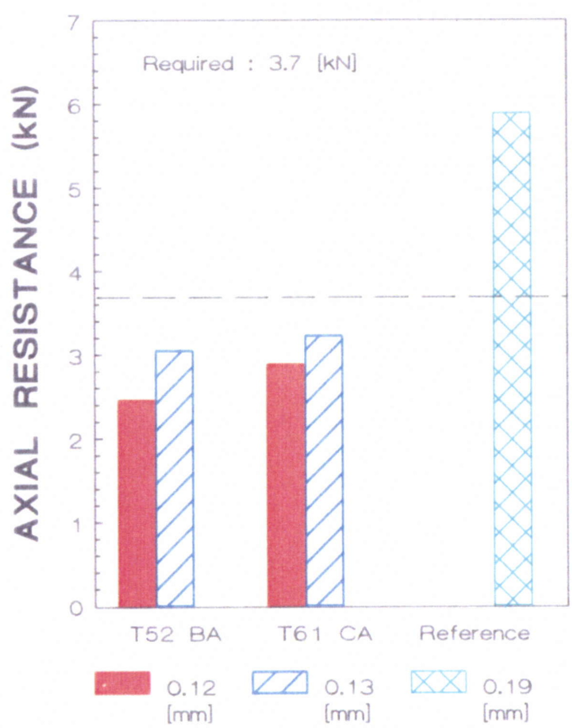


Figure 34 : Panelling resistance of Ø 66 * 58 mm cans without beads

The values mentioned in the table have been visualised in figure 34 (see opposite page) and figures 35 and 36 (turnover). The required value is shown as a horizontal line.

During testing of the axial resistance it was observed that the bottom of the 2-piece "Two-in-One" can suffered from a slight deformation before the sudden collapse appeared. This kind of deformation was not observed for the 3-piece "Two-in-One" cans. To eliminate that kind of deformation there would have to be a change in bottom profile, the bottom profile that was used to produce the cans was however of no influence for the production of the chosen concept.

By producing a wall ironed "Two-in-One" can with the same diameter of the reference can Ø 63 mm, the axial resistance might be increased with approximately 2.4% according to the formula hereunder [9] :

$$F = K_r * 2 * \pi * E * t^2$$

in which

$$K_r = \frac{0.605 + 0.000135 * 2r/t}{1 + 0.00311 * 2r/t}$$

r = radius of the can
t = wall thickness
E = Young's modulus

The stackability of these cans can be improved by spin necking and flanging the top to a 206 flange edge.

From the mechanical performance tests the following can be concluded :

* Processing the 2-piece and 3-piece "Two-in-One" cans into full-fledged cans did not give rise to any technical problems.
* The wall thikness of the cans is of influence on the mechanical performance. A bigger wall thickness leads to a higher radial and axial resistance.
* For the Ø 73 mm "Two-in-One" can beads had to be applied on the cans with a wall thickness of 0.127 mm, to be able to meet the required value for the radial resistance.
* Beads can not be applied for the Ø 66 mm "Two-in-One" can, since the axial resistance would be reduced even further. It was decided to increase the wall thickness for this can concept.
* All final can concepts have been able to meet the required values for the radial and axial resistance.

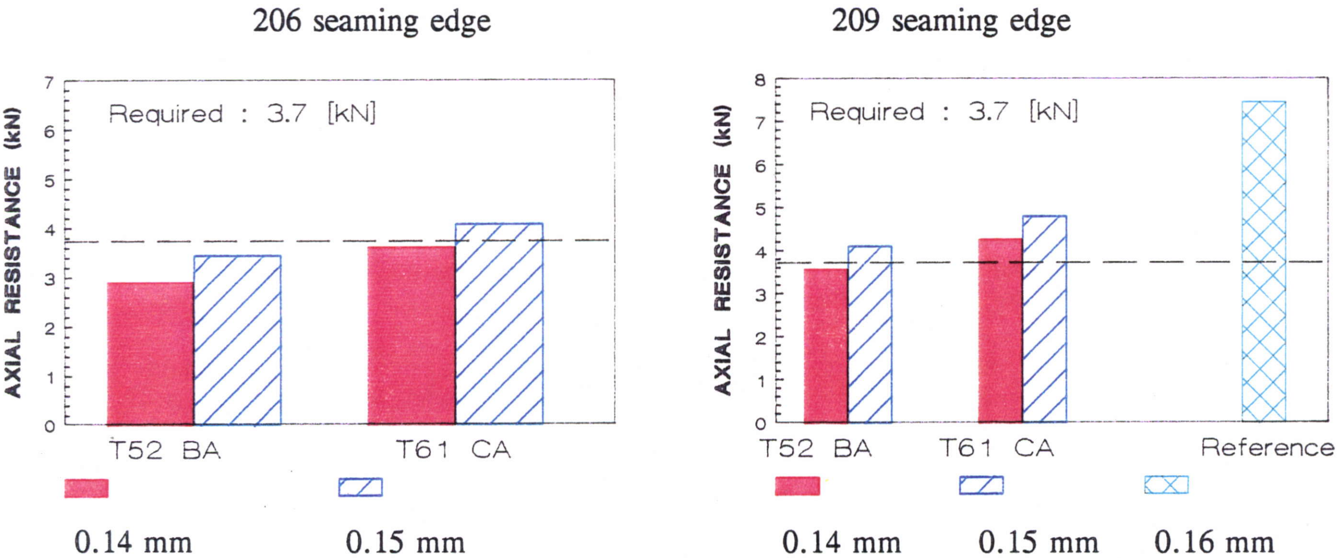


Figure 35 : Axial resistance of two-piece cans

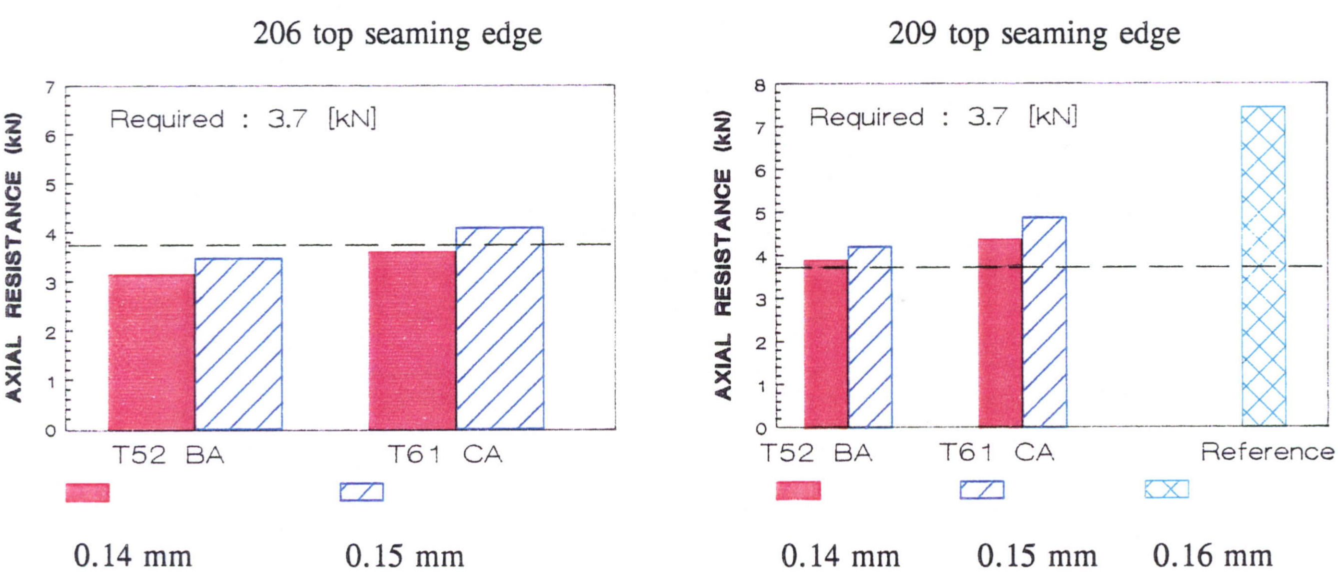


Figure 36 : Axial resistance of three-piece cans with a 209 end at the bottom

10. PROPOSED LINE CONCEPT FOR THE "TWO-IN-ONE" FOOD CAN

It has been proven that the extra step in the can wall of the "Two-in-One" can does not lead to insurmountable problems with wall ironing and stripping of the cans afterwards.

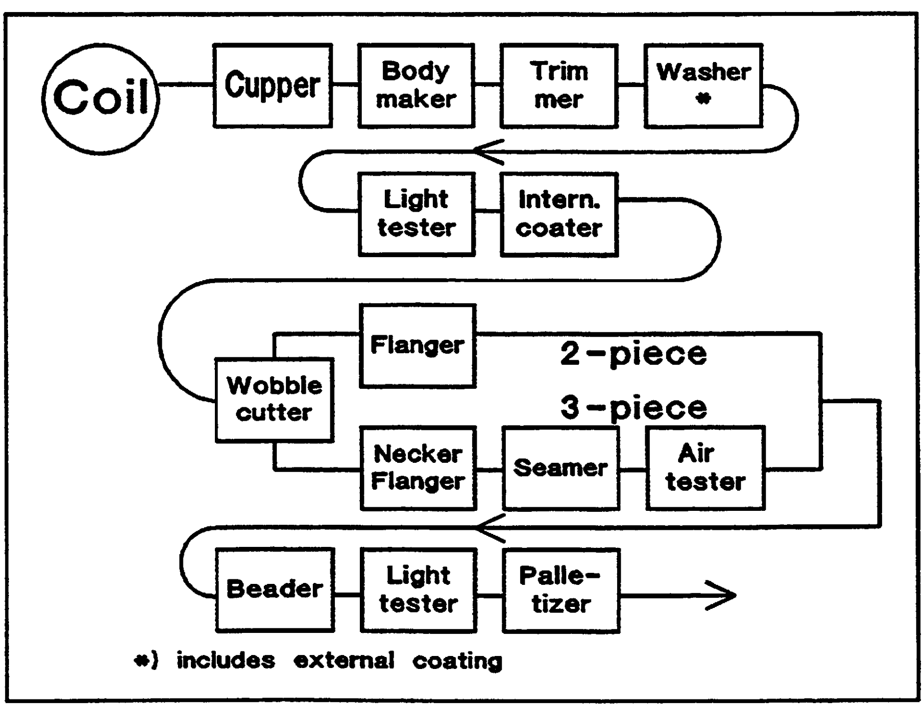
Depending on the line concept at a production plant for DWI food cans (overcapacity in the cupper and/or the bodymaker in particular), a bodymaker would have to be added or separated.

The necessary adjustments for this bodymaker are formed by the punch configuration and the wall ironing die diameters, which are set to a thinner can wall and thickwall in comparison with the can concept that is normally produced.
By this reduction in thickness, the extra material for the higher "Two-in-One" can and the extra step can be obtained, though it may be necessary to adjust the bead profile to obtain the required radial and axial stability.

After the washer (see figure 37 hereunder) the wall-ironed "Two-in-One" can will have to be processed separately from the standard food can and brought into its own circuit.
The separation of the "Two-in-One" can into two cans is carried out by means of the Wobble cutter.

Obviously, the production logistics need to be worked out in more detail.

Figure 37 : Line concept for the "Two-in-One" food can



11. CONCLUSIONS & RECOMMENDATIONS

The aim of this research project has been described as :

> *"The investigations focus on the question whether or not the "Two-in-One" can can be produced in the DWI manufacturing lines and consequently be processed into two separate cans. The technical feasibility forms the main issue."*

Although the research project only included the study on technical feasibility of the required can concepts, a rough indication of the most important adjustments in an existing DWI production line for the production of this can concept has been provided.

Deep drawing

The deep drawing has been carried out in two steps for both concepts.

For the Ø 73 mm "Two-in-One" can, the cup diameters are the same after the first and the second draw. We did however make use of a larger blank diameter than usual for the food can, so that a higher cup was obtained.

The cup geometry of the Ø 66 mm "Two-in-One" can is totally different than that of the 33 cl beverage can, which was used as a reference for the forces during the wall ironing process.

In the deep drawing procedures, neither the first nor the second draw of both concepts gave rise to any problems.

Wall ironing

The measured wall ironing forces for both "Two-in-One" can concepts are considerably higher than those of the reference cans. This is caused by the fact that for the "Two-in-One" can concept material from the first step must be ironed over the wall, so that at these locations a very high reduction can be observed.
This does not lead however to any negative influence on the wall ironing process.

The stripping of both the "Two-in-One" cans and the reference cans did not cause any problems either.

Mechanical performance

The axial resistance of the Ø 73 mm reached the required values right away, but the radial resistance remained insufficient. In order the meet the requirements for the radial resistance, the final concept of the can type was provided with beads.

In contrast with the Ø 73 mm "Two-in-One" can, for the Ø 66 mm "Two-in-One" can, the axial resistance remained below the required minimum. Since beads would reduce the axial resistance even further, it was decided to increase the wall thickness for this can concept and not apply any beads.

The test on can strength of the can concepts have proved that the final products have a good sterilisation behaviour and sufficient axial strength.

From the research on both Ø 73 mm and Ø 66 mm "Two-in-One" cans can be concluded that there is a technical feasibility to produced a wall ironed can provided with two thickwalls, by means of the conventional machinery and subsequently separate these cans into a full-fledged 2-piece can and a seamless body for a 3-piece can.

Although the technical feasbility of these can concepts formed the main issue of this research project, the economical feasibility is equally important. The packaging steel industry will not profit from any direct financial benefits (which are for their clients, namely a saving in material costs up to 10 %) but the indirect profitability for the steel industry, resulting from the preservation or even improvement of the market position for packaging steel may be considerable.

FINAL CONCLUSION :

THE "TWO-IN-ONE" CONCEPT HAS BEEN PROVED TO BE TECHNICALLY FEASIBLE

Acknowledgements

The project leader gratefully acknowledges the contributions made by Mr. F. Jonker, Mr. C. Weijers and Mrs. M. Boon for the realisation of this research project.

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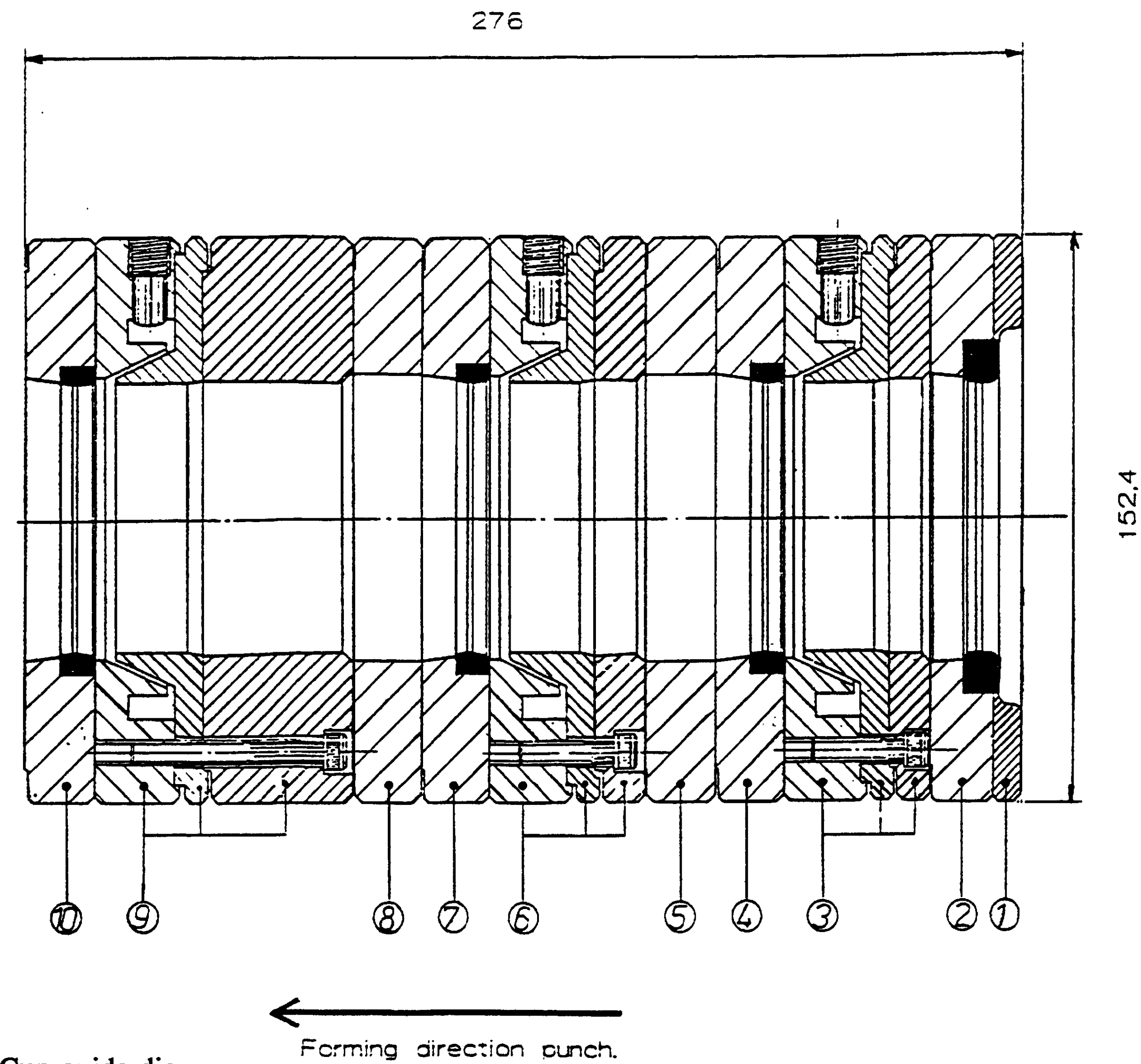
Dimensions in mm

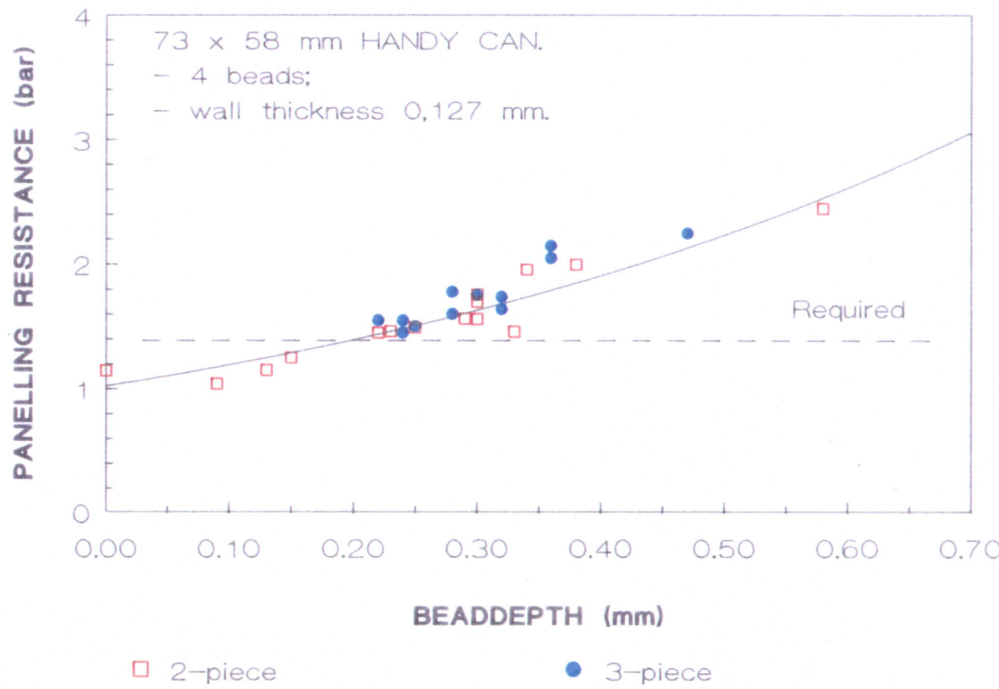


Tools

1. Cup guide die
2. Pre sizing die
3. First coolant ring
4. First wall ironing die
5. Spacer ring
6. Second coolant ring
7. Second wall ironing die
8. Spacer ring
9. Third coolant ring
10. Third (final) wall ironing die

Figure 38 : Schematic view of used toolpack for Ø 73 mm concept

Panelling resistance with 4 beads



Panelling resistance with 9 beads

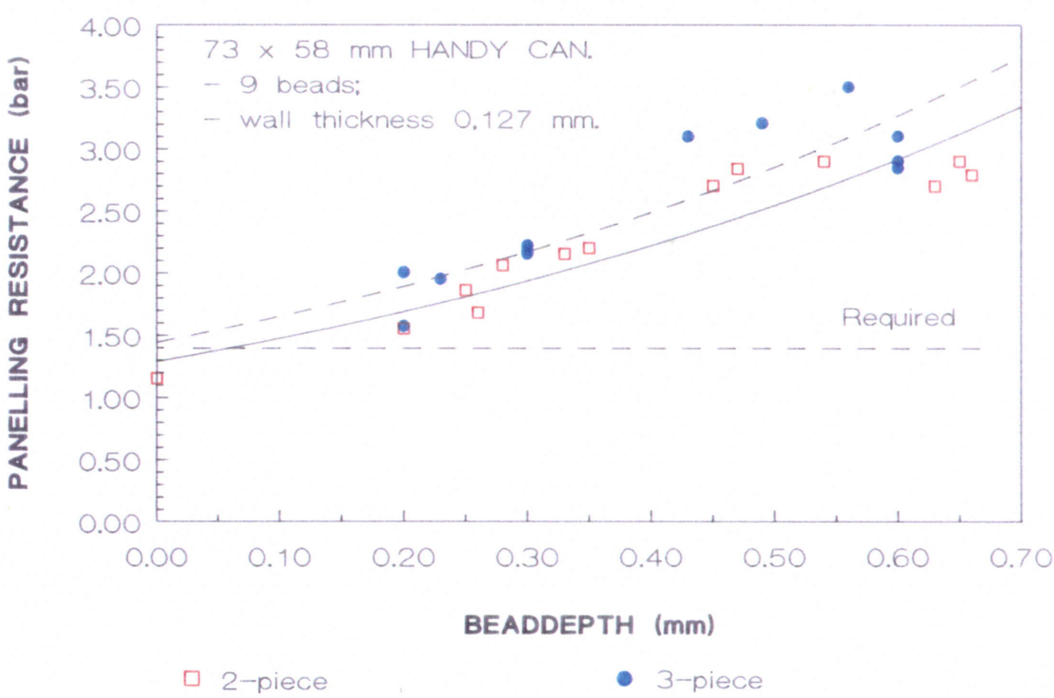


Figure 39 : Influence of bead depth and number of beads on panelling resistance

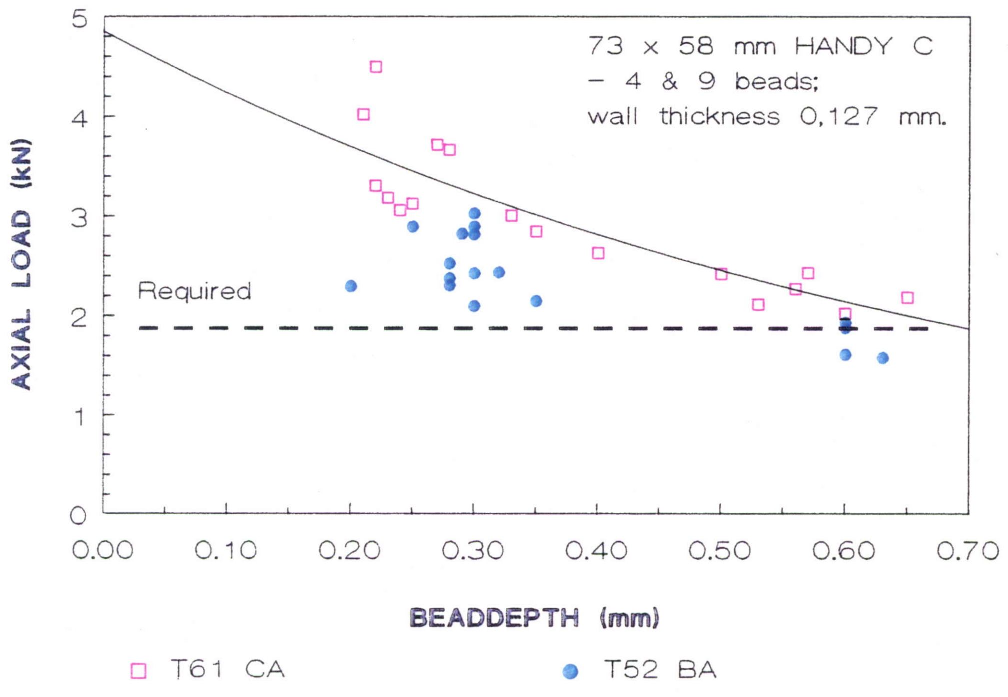


Figure 40 : Influence of bead depth on axial load

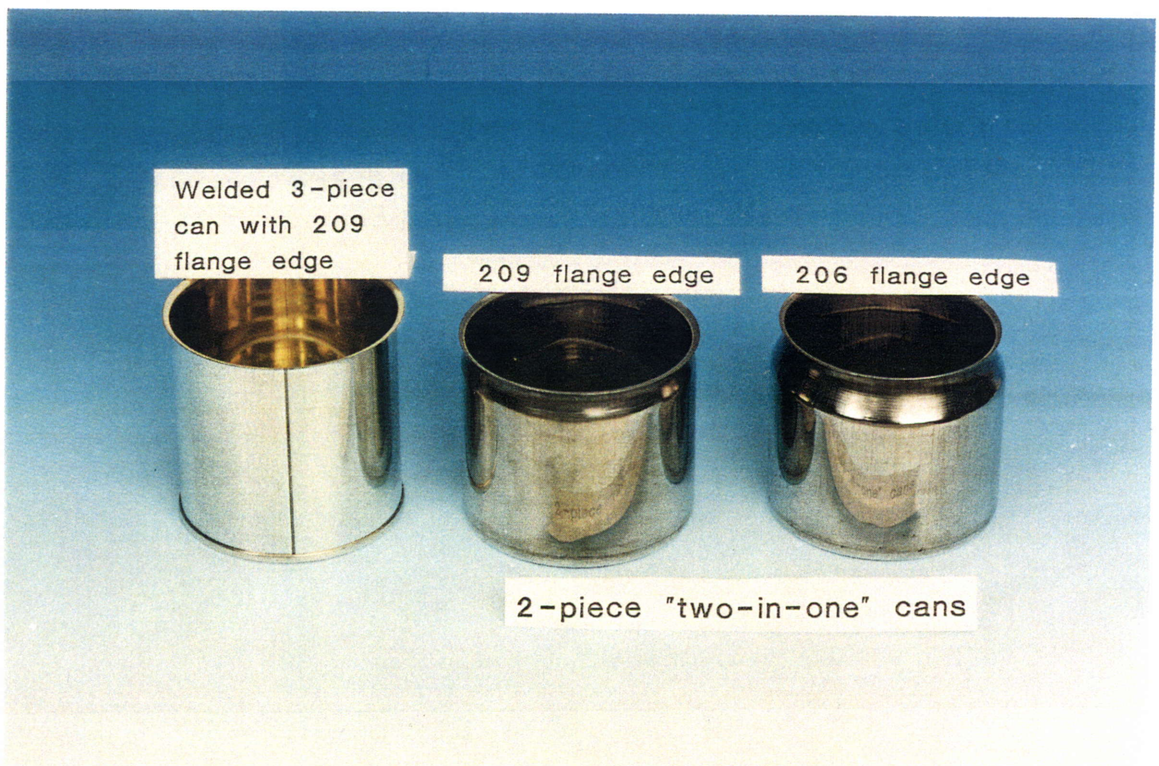


Photo 15 : Different tested can types

Photo 16 : Different spin necking and flanging steps of 3-piece cans with a 209 flange at the top

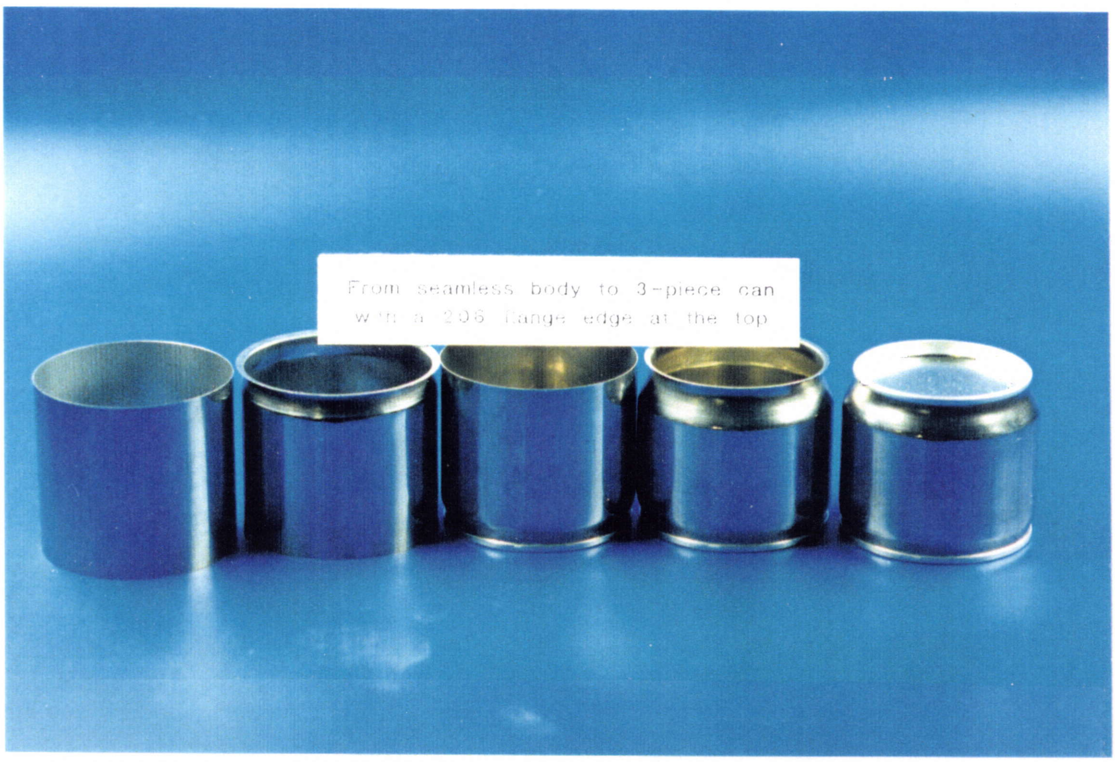


Photo 17 : Different spin necking and flanging steps of 3-piece cans with a 206 flange at the top

Photo 18 : The stackable "Two-in-One" Ø 73 * 58 mm food can

Photo 19 : Stackability of 2-piece and 3-piece seamless cans

Photo 20 : Some examples of the 45 cl Eurocan

Photo 21 : Some examples of the Ø 73 * 58 mm (pet)food cans

Photo 22 : Some examples of the Ø 63 * 61 mm milk cans

CANCOST CALCULATIONS

Cancost calculations for the following can concepts :

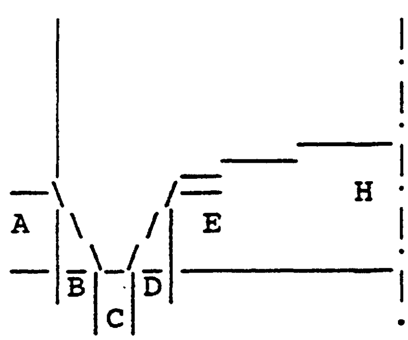
CANCOST

list of codes in input parameters

----

can model	1=DRD 2=DWI 5=3-pc/soldered 6=3-pc/welded
material	0=steel 1=aluminium
double reduced	0=no 1=yes
coating	0=none 1=tin 2=ECCS 3=lacquer 9=special
shape ordered	0=sheet 1=coil
rolling dir. on can wall	0=along axis 1=circumferential
lacquer	1=epoxy fenol 2=vinyl

bottom sizes



model	2				
can contents	44.2	cl	can diameter	73.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.300	mm	wall thickness	0.130	mm
edge thickness	0.160	mm	edge height	36.0	mm
trim scrap	6.0	mm			
material	0		double reduced	0	
coating	1		weight of coating	4.0	gr/m2
n-out blanks	7		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	114.1	mm			
trim height	121.1	mm			
blank diameter	152.1	mm			
strip width	953	mm	at	7 out	
weight of trimmed can	41.1	gr			
total can costs	8.566	ct	=	85.66	fl/1000 cans
material efficiency	83.7	%			
coating costs	0.262	ct	=	3.1	% of total costs

---

weight of trim scrap	1.7	gr	=	3.5	% of total material
weight of skeleton scrap	6.3	gr	=	12.8	% of total material
weight of trimmed can	41.1	gr	=	83.7	% of total material
weight of untrimmed can	42.8	gr	=	87.2	% of total material
total material needed	49.1	gr			
costs of trim scrap	0.302	ct	=	3.02	fl/1000 cans
costs of skeleton scrap	1.096	ct	=	10.96	fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	2				
can contents	44.2	cl	can diameter	73.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.300	mm	wall thickness	0.140	mm
edge thickness	0.170	mm	edge height	36.0	mm
trim scrap	6.0	mm			
material	0		double reduced	0	
coating	1		weight of coating	4.0	gr/m2
n-out blanks	7		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	114.1	mm			
trim height	121.1	mm			
blank diameter	156.0	mm			
strip width	977	mm		at 7 out	
weight of trimmed can	43.2	gr			
total can costs	9.009	ct	=	90.09	fl/1000 cans
material efficiency	83.7	%			
coating costs	0.275	ct	=	3.1	% of total costs

---

weight of trim scrap	1.8	gr	=	3.6	% of total material
weight of skeleton scrap	6.6	gr	=	12.8	% of total material
weight of trimmed can	43.2	gr	=	83.7	% of total material
weight of untrimmed can	45.0	gr	=	87.2	% of total material
total material needed	51.6	gr			
costs of trim scrap	0.321	ct	=	3.21	fl/1000 cans
costs of skeleton scrap	1.149	ct	=	11.49	fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	6				
can contents	22.0	cl	can diameter	73.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.210	mm	wall thickness	0.180	mm

for bottom blanks:

material	0	double reduced	0	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	11	distance bl.-bl.	1.0	mm
shape ordered	1			

for wall blanks:

material	0	double reduced	0	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	4	shape ordered	0	
	rolling direction on can wall		1	

---

results (for 1 can unless otherwise stated)

internal can height	53.1	mm		
blank diameter	90.0	mm	(bottomblanks)	
strip width	883	mm	at 11 out (bottom blanks)	
	919	mm	at 4 out (wall blanks)	
weight of trimmed can	31.3	gr		
total can costs	6.786	ct	=	67.86 fl/1000 cans
material efficiency	95.3	%		
coating costs	0.277	ct	=	4.1 % of total costs

---

weight of bottom	10.5	gr	=	31.9 % of total material
weight of wall	20.8	gr	=	63.3 % of total material
weight of can	31.3	gr	=	95.3 % of total material
weight of scrap	1.6	gr	=	4.7 % of total material
total material needed	32.8	gr		
costs of bottom	1.987	ct	=	19.87 fl/1000 cans
costs of scrap	0.295	ct	=	2.95 fl/1000 cans
total costs of bottom	2.282	ct	=	22.82 fl/1000 cans
costs of wall	4.504	ct	=	45.04 fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	6				
can contents	19.4	cl	can diameter	73.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.210	mm	wall thickness	0.140	mm

for bottom blanks:

material	0	double reduced	0	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	11	distance bl.-bl.	1.0	mm
shape ordered	1			

for wall blanks:

material	0	double reduced	1	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	4	shape ordered	0	
	rolling direction on can wall		1	

---

results (for 1 can unless otherwise stated)

internal can height	50.1	mm	
blank diameter	90.0	mm	(bottomblanks)
strip width	883	mm	at 11 out (bottom blanks)
	919	mm	at 4 out (wall blanks)
weight of trimmed can	25.9	gr	
total can costs	6.070	ct	= 60.70 fl/1000 cans
material efficiency	94.3	%	
coating costs	0.268	ct	= 4.4 % of total costs

---

weight of bottom	10.5	gr	= 38.2 % of total material
weight of wall	15.4	gr	= 56.1 % of total material
weight of can	25.9	gr	= 94.3 % of total material
weight of scrap	1.6	gr	= 5.7 % of total material
total material needed	27.5	gr	
costs of bottom	1.987	ct	= 19.87 fl/1000 cans
costs of scrap	0.295	ct	= 2.95 fl/1000 cans
total costs of bottom	2.282	ct	= 22.82 fl/1000 cans
costs of wall	3.789	ct	= 37.89 fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	6				
can contents	19.4	cl	can diameter	73.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.210	mm	wall thickness	0.190	mm

for bottom blanks:

material	0	double reduced	0	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	11	distance bl.-bl.	1.0	mm
shape ordered	1			

for wall blanks:

material	0	double reduced	0	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	4	shape ordered	0	
	rolling direction on can wall		1	

---

results (for 1 can unless otherwise stated)

internal can height	50.1	mm		
blank diameter	90.0	mm (bottomblanks)		
strip width	883	mm		at 11 out (bottom blanks)
	919	mm		at 4 out (wall blanks)
weight of trimmed can	31.4	gr		
total can costs	6.691	ct	=	66.91 fl/1000 cans
material efficiency	95.3	%		
coating costs	0.268	ct	=	4.0 % of total costs

---

weight of bottom	10.5	gr	=	31.8 % of total material
weight of wall	20.9	gr	=	63.5 % of total material
weight of can	31.4	gr	=	95.3 % of total material
weight of scrap	1.6	gr	=	4.7 % of total material
total material needed	33.0	gr		
costs of bottom	1.987	ct	=	19.87 fl/1000 cans
costs of scrap	0.295	ct	=	2.95 fl/1000 cans
total costs of bottom	2.282	ct	=	22.82 fl/1000 cans
costs of wall	4.409	ct	=	44.09 fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	1				
can contents	22.0	cl	can diameter	73.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.180	mm	trim scrap	6.0	mm
material	0		double reduced	0	
coating	1		weight of coating	4.0	gr/m2
n-out blanks	7		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	53.1	mm			
blank diameter	153.1	mm			
strip width	959	mm		at 7 out	
weight of trimmed can	23.8	gr			
total can costs	6.061	ct	=	60.61	fl/1000 cans
material efficiency	79.8	%			
coating costs	0.265	ct	=	4.4	% of total costs

---

weight of trim scrap	2.2	gr	=	7.4	% of total material
weight of skeleton scrap	3.8	gr	=	12.8	% of total material
weight of trimmed can	23.8	gr	=	79.8	% of total material
weight of untrimmed can	26.0	gr	=	87.2	% of total material
total material needed	29.8	gr			
costs of trim scrap	0.449	ct	=	4.49	fl/1000 cans
costs of skeleton scrap	0.775	ct	=	7.75	fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	2				
can contents	33.0	cl	can diameter	66.0	mm
bottom size A	5.0	mm	bottom size B	3.5	mm
bottom size C	1.0	mm	bottom size D	2.0	mm
bottom size E	4.0	mm	bottom size H	11.0	mm
bottom thicknes	0.300	mm	wall thickness	0.100	mm
edge thickness	0.150	mm	edge height	15.0	mm
trim scrap	8.0	mm			
material	0		double reduced	0	
coating	1		weight of coating	3.5	gr/m2
n-out blanks	8		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	111.2	mm			
trim height	118.2	mm			
blank diameter	132.6	mm			
strip width	948	mm	at 8 out		
weight of trimmed can	30.6	gr			
total can costs	6.472	ct	=	64.72	fl/1000 cans
material efficiency	82.0	%			
coating costs	0.164	ct	=	2.5	% of total costs

---

weight of trim scrap	2.0	gr	=	5.2	% of total material
weight of skeleton scrap	4.7	gr	=	12.7	% of total material
weight of trimmed can	30.6	gr	=	82.0	% of total material
weight of untrimmed can	32.5	gr	=	87.3	% of total material
total material needed	37.3	gr			
costs of trim scrap	0.339	ct	=	3.39	fl/1000 cans
costs of skeleton scrap	0.824	ct	=	8.24	fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	2				
can contents	70.4	cl	can diameter	66.0	mm
bottom size A	5.0	mm	bottom size B	3.5	mm
bottom size C	1.0	mm	bottom size D	2.0	mm
bottom size E	4.0	mm	bottom size H	11.0	mm
bottom thicknes	0.300	mm	wall thickness	0.100	mm
edge thickness	0.150	mm	edge height	50.0	mm
trim scrap	12.0	mm			
material	0		double reduced	0	
coating	1		weight of coating	3.5	gr/m2
n-out blanks	6		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	229.3	mm			
trim height	236.3	mm			
blank diameter	173.3	mm			
strip width	933	mm		at 6 out	
weight of trimmed can	52.6	gr			
total can costs	11.089	ct	=	110.89	fl/1000 cans
material efficiency	82.4	%			
coating costs	0.281	ct	=	2.5	% of total costs

---

weight of trim scrap	2.9	gr	=	4.6	% of total material
weight of skeleton scrap	8.3	gr	=	13.0	% of total material
weight of trimmed can	52.6	gr	=	82.4	% of total material
weight of untrimmed can	55.6	gr	=	87.0	% of total material
total material needed	63.8	gr			
costs of trim scrap	0.509	ct	=	5.09	fl/1000 cans
costs of skeleton scrap	1.439	ct	=	14.39	fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	2				
can contents	35.3	cl	can diameter	66.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.240	mm	wall thickness	0.120	mm
edge thickness	0.140	mm	edge height	41.0	mm
trim scrap	6.0	mm			
material	0		double reduced	0	
coating	1		weight of coating	4.0	gr/m2
n-out blanks	7		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	111.4	mm			
trim height	118.4	mm			
blank diameter	149.0	mm			
strip width	934	mm	at	7	out
weight of trimmed can	31.5	gr			
total can costs	6.892	ct	=	68.92	fl/1000 cans
material efficiency	83.5	%			
coating costs	0.251	ct	=	3.6	% of total costs

---

weight of trim scrap	1.4	gr	=	3.6	% of total material
weight of skeleton scrap	4.8	gr	=	12.8	% of total material
weight of trimmed can	31.5	gr	=	83.5	% of total material
weight of untrimmed can	32.9	gr	=	87.2	% of total material
total material needed	37.7	gr			
costs of trim scrap	0.250	ct	=	2.50	fl/1000 cans
costs of skeleton scrap	0.884	ct	=	8.84	fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	2				
can contents	35.3	cl	can diameter	66.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.240	mm	wall thickness	0.130	mm
edge thickness	0.150	mm	edge height	41.0	mm
trim scrap	6.0	mm			
material	0		double reduced	0	
coating	1		weight of coating	4.0	gr/m2
n-out blanks	7		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	111.4	mm			
trim height	118.4	mm			
blank diameter	153.5	mm			
strip width	961	mm	at	7 out	
weight of trimmed can	33.4	gr			
total can costs	7.303	ct	=	73.03	fl/1000 cans
material efficiency	83.6	%			
coating costs	0.266	ct	=	3.6	% of total costs

---

weight of trim scrap	1.5	gr	=	3.7	% of total material
weight of skeleton scrap	5.1	gr	=	12.8	% of total material
weight of trimmed can	33.4	gr	=	83.6	% of total material
weight of untrimmed can	34.8	gr	=	87.2	% of total material
total material needed	39.9	gr			
costs of trim scrap	0.268	ct	=	2.68	fl/1000 cans
costs of skeleton scrap	0.933	ct	=	9.33	fl/1000 cans

*** results are only to be used comparativily ***
***   no guarantee is given for exact value   ***

model	2				
can contents	35.3	cl	can diameter	66.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.240	mm	wall thickness	0.140	mm
edge thickness	0.160	mm	edge height	41.0	mm
trim scrap	6.0	mm			
material	0		double reduced	0	
coating	1		weight of coating	4.0	gr/m2
n-out blanks	7		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	111.4	mm			
trim height	118.4	mm			
blank diameter	157.7	mm			
strip width	988	mm	at	7 out	
weight of trimmed can	35.3	gr			
total can costs	7.714	ct	=	77.14	fl/1000 cans
material efficiency	83.6	%			
coating costs	0.281	ct	=	3.6	% of total costs
lacquer costs	0.000	ct	=	0.0	% of total costs

---

weight of trim scrap	1.6	gr	=	3.7	% of total material
weight of skeleton scrap	5.4	gr	=	12.7	% of total material
weight of trimmed can	35.3	gr	=	83.6	% of total material
weight of untrimmed can	36.8	gr	=	87.3	% of total material
total material needed	42.2	gr			
costs of trim scrap	0.286	ct	=	2.86	fl/1000 cans
costs of skeleton scrap	0.983	ct	=	9.83	fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	2				
can contents	35.3	cl	can diameter	66.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.240	mm	wall thickness	0.150	mm
edge thickness	0.170	mm	edge height	41.0	mm
trim scrap	6.0	mm			
material	0		double reduced	0	
coating	1		weight of coating	4.0	gr/m2
n-out blanks	7		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	111.4	mm			
trim height	118.4	mm			
blank diameter	161.9	mm			
strip width	1013	mm		at 7 out	
weight of trimmed can	37.1	gr			
total can costs	8.124	ct	=	81.24	fl/1000 cans
material efficiency	83.6	%			
coating costs	0.296	ct	=	3.6	% of total costs

---

weight of trim scrap	1.7	gr	=	3.7	% of total material
weight of skeleton scrap	5.6	gr	=	12.7	% of total material
weight of trimmed can	37.1	gr	=	83.6	% of total material
weight of untrimmed can	38.8	gr	=	87.3	% of total material
total material needed	44.4	gr			
costs of trim scrap	0.304	ct	=	3.04	fl/1000 cans
costs of skeleton scrap	1.032	ct	=	10.32	fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	2				
can contents	35.3	cl	can diameter	66.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.260	mm	wall thickness	0.140	mm
edge thickness	0.160	mm	edge height	41.0	mm
trim scrap	6.0	mm			
material	0		double reduced	0	
coating	1		weight of coating	4.0	gr/m2
n-out blanks	7		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	111.4	mm		
trim height	118.4	mm		
blank diameter	152.9	mm		
strip width	957	mm		at 7 out
weight of trimmed can	35.9	gr		
total can costs	7.715	ct	=	77.15 fl/1000 cans
material efficiency	83.6	%		
coating costs	0.264	ct	=	3.4 % of total costs

---

weight of trim scrap	1.6	gr	=	3.6 % of total material
weight of skeleton scrap	5.5	gr	=	12.8 % of total material
weight of trimmed can	35.9	gr	=	83.6 % of total material
weight of untrimmed can	37.5	gr	=	87.2 % of total material
total material needed	42.9	gr		
costs of trim scrap	0.281	ct	=	2.81 fl/1000 cans
costs of skeleton scrap	0.986	ct	=	9.86 fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	2					
can contents	35.3	cl		can diameter	66.0	mm
bottom size A	0.0	mm		bottom size B	0.0	mm
bottom size C	0.0	mm		bottom size D	0.0	mm
bottom size E	0.0	mm		bottom size H	0.0	mm
bottom thicknes	0.260	mm		wall thickness	0.150	mm
edge thickness	0.170	mm		edge height	41.0	mm
trim scrap	6.0	mm				
material	0			double reduced	0	
coating	1			weight of coating	4.0	gr/m2
n-out blanks	7			distance bl.-bl.	1.0	mm
shape ordered	1					

---

results (for 1 can unless otherwise stated)

internal can height	111.4	mm			
trim height	118.4	mm			
blank diameter	156.8	mm			
strip width	982	mm		at 7 out	
weight of trimmed can	37.8	gr			
total can costs	8.119	ct	=	81.19	fl/1000 cans
material efficiency	83.6	%			
coating costs	0.278	ct	=	3.4	% of total costs

---

weight of trim scrap	1.7	gr	=	3.7	% of total material
weight of skeleton scrap	5.8	gr	=	12.7	% of total material
weight of trimmed can	37.8	gr	=	83.6	% of total material
weight of untrimmed can	39.4	gr	=	87.3	% of total material
total material needed	45.2	gr			
costs of trim scrap	0.298	ct	=	2.98	fl/1000 cans
costs of skeleton scrap	1.035	ct	=	10.35	fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

model	2				
can contents	35.3	cl	can diameter	66.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.260	mm	wall thickness	0.150	mm
edge thickness	0.170	mm	edge height	41.0	mm
trim scrap	4.5	mm			
material	0		double reduced	0	
coating	1		weight of coating	4.0	gr/m2
n-out blanks	7		distance bl.-bl.	1.0	mm
shape ordered	1				

---

results (for 1 can unless otherwise stated)

internal can height	111.4	mm			
trim height	118.4	mm			
blank diameter	156.0	mm			
strip width	977	mm		at 7	out
weight of trimmed can	37.8	gr			
total can costs	8.034	ct	=	80.34	fl/1000 cans
material efficiency	84.5	%			
coating costs	0.275	ct	=	3.4	% of total costs

---

weight of trim scrap	1.2	gr	=	2.8	% of total material
weight of skeleton scrap	5.7	gr	=	12.8	% of total material
weight of trimmed can	37.8	gr	=	84.5	% of total material
weight of untrimmed can	39.0	gr	=	87.2	% of total material
total material needed	44.7	gr			
costs of trim scrap	0.224	ct	=	2.24	fl/1000 cans
costs of skeleton scrap	1.025	ct	=	10.25	fl/1000 cans

*** results are only to be used comparativily ***
***   no guarantee is given for exact value   ***

model	6				
can contents	33.0	cl	can diameter	66.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.230	mm	wall thickness	0.155	mm

for bottom blanks:

material	0	double reduced	0	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	12	distance bl.-bl.	1.0	mm
shape ordered	1			

for wall blanks:

material	0	double reduced	1	
coating	1	weight of coating	3.5	gr/m2
n-out blanks	8	shape ordered	0	
	rolling direction on can wall		0	

---

results (for 1 can unless otherwise stated)

internal can height	104.2	mm	
blank diameter	83.0	mm	(bottomblanks)
strip width	888	mm	at 12 out (bottom blanks)
	945	mm	at 8 out (wall blanks)
weight of trimmed can	39.6	gr	
total can costs	8.953	ct	= 89.53 fl/1000 cans
material efficiency	96.5	%	
coating costs	0.332	ct	= 3.7 % of total costs

---

weight of bottom	9.8	gr	= 23.8 % of total material
weight of wall	29.9	gr	= 72.7 % of total material
weight of can	39.6	gr	= 96.5 % of total material
weight of scrap	1.5	gr	= 3.5 % of total material
total material needed	41.1	gr	
costs of bottom	1.780	ct	= 17.80 fl/1000 cans
costs of scrap	0.266	ct	= 2.66 fl/1000 cans
total costs of bottom	2.046	ct	= 20.46 fl/1000 cans
costs of wall	6.907	ct	= 69.07 fl/1000 cans

*** results are only to be used comparativily ***
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model	6				
can contents	17.0	cl	can diameter	63.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.200	mm	wall thickness	0.190	mm

for bottom blanks:

material	0	double reduced	0	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	12	distance bl.-bl.	1.0	mm
shape ordered	1			

for wall blanks:

material	0	double reduced	0	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	14	shape ordered	0	
	rolling direction on can wall		0	

---

results (for 1 can unless otherwise stated)

internal can height	55.1	mm		
blank diameter	80.0	mm	(bottomblanks)	
strip width	857	mm	at 12 out (bottom blanks)	
	925	mm	at 14 out (wall blanks)	
weight of trimmed can	27.4	gr		
total can costs	5.876	ct	=	58.76 fl/1000 cans
material efficiency	95.9	%		
coating costs	0.237	ct	=	4.0 % of total costs

---

weight of bottom	7.9	gr	=	27.6 % of total material
weight of wall	19.5	gr	=	68.3 % of total material
weight of can	27.4	gr	=	95.9 % of total material
weight of scrap	1.2	gr	=	4.1 % of total material
total material needed	28.6	gr		
costs of bottom	1.528	ct	=	15.28 fl/1000 cans
costs of scrap	0.230	ct	=	2.30 fl/1000 cans
total costs of bottom	1.757	ct	=	17.57 fl/1000 cans
costs of wall	4.119	ct	=	41.19 fl/1000 cans

*** results are only to be used comparativily ***
*** no guarantee is given for exact value ***

```
model                6
can contents        17.0  cl        can diameter        63.0  mm
bottom size A        0.0  mm        bottom size B        0.0  mm
bottom size C        0.0  mm        bottom size D        0.0  mm
bottom size E        0.0  mm        bottom size H        0.0  mm
bottom thicknes     0.200 mm        wall thickness      0.160 mm


for bottom blanks:

material             0              double reduced       0
coating              1              weight of coating    4.0  gr/m2
n-out blanks        12              distance bl.-bl.     1.0  mm
shape ordered        1


for wall blanks:

material             0              double reduced       1
coating              1              weight of coating    4.0  gr/m2
n-out blanks        14              shape ordered        0
                    rolling direction on can wall        0

-------------------------------------------------------------------

results (for 1 can unless otherwise stated)

internal can height          55.1   mm
blank diameter               80.0   mm ( bottomblanks )
strip width                 857     mm     at 12 out ( bottom blanks )
                            925     mm     at 14 out ( wall blanks )
weight of trimmed can        24.3   gr
total can costs               5.534 ct  =   55.34 fl/1000 cans
material efficiency          95.4   %
coating costs                 0.237 ct  =    4.3  % of total costs

-------------------------------------------------------------------

weight of bottom              7.9   gr  =   30.9  % of total material
weight of wall               16.5   gr  =   64.4  % of total material
weight of can                24.3   gr  =   95.4  % of total material
weight of scrap               1.2   gr  =    4.6  % of total material
total material needed        25.5   gr
costs of bottom               1.528 ct  =   15.28 fl/1000 cans
costs of scrap                0.230 ct  =    2.30 fl/1000 cans
total costs of bottom         1.757 ct  =   17.57 fl/1000 cans
costs of wall                 3.777 ct  =   37.77 fl/1000 cans


    *** results are only to be used comparativily ***
    ***   no guarantee is given for exact value   ***
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```

model	6				
can contents	17.0	cl	can diameter	63.0	mm
bottom size A	0.0	mm	bottom size B	0.0	mm
bottom size C	0.0	mm	bottom size D	0.0	mm
bottom size E	0.0	mm	bottom size H	0.0	mm
bottom thicknes	0.200	mm	wall thickness	0.140	mm

for bottom blanks:

material	0	double reduced	0	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	12	distance bl.-bl.	1.0	mm
shape ordered	1			

for wall blanks:

material	0	double reduced	1	
coating	1	weight of coating	4.0	gr/m2
n-out blanks	14	shape ordered	0	
	rolling direction on can wall		0	

---

results (for 1 can unless otherwise stated)

internal can height	55.1	mm		
blank diameter	80.0	mm	(bottomblanks)	
strip width	857	mm	at 12 out (bottom blanks)	
	925	mm	at 14 out (wall blanks)	
weight of trimmed can	22.3	gr		
total can costs	5.297	ct	=	52.97 fl/1000 cans
material efficiency	94.9	%		
coating costs	0.237	ct	=	4.5 % of total costs

---

weight of bottom	7.9	gr	=	33.6 % of total material
weight of wall	14.4	gr	=	61.3 % of total material
weight of can	22.3	gr	=	94.9 % of total material
weight of scrap	1.2	gr	=	5.1 % of total material
total material needed	23.5	gr		
costs of bottom	1.528	ct	=	15.28 fl/1000 cans
costs of scrap	0.230	ct	=	2.30 fl/1000 cans
total costs of bottom	1.757	ct	=	17.57 fl/1000 cans
costs of wall	3.539	ct	=	35.39 fl/1000 cans

*** results are only to be used comparativily ***
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CALCULATION OF REDUCTIONS IN CAN WALL THICKNESS DURING WALL IRONING OF THE Ø 73 MM "TWO-IN-ONE" CAN

Presizing ironing die :

At t_2 : $\frac{t_0 - t_2}{t_0} \times 100\ \%$

t_3 : $\frac{t_1 - t_3}{t_1} \times 100\ \%$

First ironing die :

At t_4 : $\frac{t_2 - t_4}{t_2} \times 100\ \%$

t_5 : $\frac{t_2 - t_5}{t_2} \times 100\ \%$

t_{4*} : $\frac{t_3 - t_4}{t_3} \times 100\ \%$

The reduction at t_{4*} is higher than at t_4, which forms a deviation from the standard 2-piece situation.

Second ironing die :

At t_6 : $\frac{t_4 - t_6}{t_4} \times 100\ \%$

t_7 : $\frac{t_4 - t_7}{t_4} \times 100\ \%$

t_{6*} : $\frac{t_5 - t_{6*}}{t_5} \times 100\ \%$

The reduction of can wall thickness in the second ironing die at t_{6*} will be higher than at t_6 ($t_6 = t_{6*}$), which forms a deviation from the standard 2-piece situation.

Third ironing die :

At t_8 : $\frac{t_6 - t_8}{t_6} \times 100\ \%$

t_9 : $\frac{t_6 - t_9}{t_6} \times 100\ \%$

t_{8*} : $\frac{t_7 - t_{8*}}{t_7} \times 100\ \%$

t_{9*} : $\frac{t_{6*} - t_{9*}}{t_{6*}} \times 100\ \%$

The reduction of can wall thickness in zone t_{8*} will also be higher than in the standard 2-piece situation ($t_8 = t_{8*}$).

CALCULATION OF REDUCTIONS IN CAN WALL THICKNESS DURING WALL IRONING OF THE Ø 66 MM "TWO-IN-ONE" CAN

First ironing die :

At t_2 : $\frac{t_0 - t_2}{t_0} \times 100\ \%$

t_3 : $\frac{t_1 - t_3}{t_1} \times 100\ \%$

Second ironing die :

At t_4 : $\frac{t_2 - t_4}{t_2} \times 100\ \%$

t_5 : $\frac{t_2 - t_5}{t_2} \times 100\ \%$

t_{4*} : $\frac{t_3 - t_4}{t_3} \times 100\ \%$

Third ironing die :

At t_6 : $\frac{t_4 - t_6}{t_4} \times 100\ \%$

t_7 : $\frac{t_4 - t_7}{t_4} \times 100\ \%$

t_{6*} : $\frac{t_5 - t_{6*}}{t_5} \times 100\ \%$

t_{7*} : $\frac{t_{4*} - t_{7*}}{t_{4*}} \times 100\ \%$

MEASURED WALL IRONING FORCES FOR THE Ø 73 MM CANS

Table 27 : Measured wall ironing forces [kN]

Location	T52 BA Material				T61 CA Material			
	"Two-in-One"		Eurocan		"Two-in-One"		Eurocan	
Code	1	2	3	4	5	6	7	8
First die :								
Fmin 1	14.0	13.5			16.8	16.2		
Fmax 1	24.8	24.2	19.5	20.4	*31.9*	25.8	22.3	23.9
Second die :								
Fmin 2	6.4	7.9			8.0	9.0		
Fmax 2	15.9	16.9	11.8	13.9	18.4	18.7	14.0	16.3
Third die :								
Fmin 3	4.8	4.0			5.9	4.9		
Fmax 3	14.5	13.6	11.3	11.6	17.3	16.7	13.2	13.9
Stripping :								
F1				2.6			4.1	3.8
F2	2.2	2.3	2.2	1.6	2.2	2.4	2.8	3.4

Note : The italic printed force is too high, due to incorrect setting of the ironing die, so that wall ironing took place in two dies at the same time.

Table 28 : Wall ironing forces for the "Two-in-One" can with a step of 0.05 mm [kN]

Location	T52 BA material			T61 CA material		
	"Two-in-One"		Euro-can	"Two-in-One"		Eurocan
Step (mm)	0.03	0.05	0.03	0.03	0.05	0.03
Code	2	9	4	6	10	8
First die :						
Fmin 1	13.5	8.5		16.2	9.4	
Fmax 1	24.2	23.5	20.4	25.8	25.2	23.9
Red. minimum	17.9	14.0		19.0	15.2	
Red. maximum	37.0	36.7	31.7	37.0	37.5	31.6
Second die :						
Fmin 2	7.9	4.8		9.0	6.6	
Fmax 2	16.9	17.3	13.9	18.7	19.2	16.3
Red. minimum	13.5	0		14.1	0	
Red. maximum	36.1	32.2	23.4	36.7	31.7	24.9
Third die :						
Fmin 3	4.0	5.6		4.9	6.8	
Fmax 3	13.6	17.7	11.6	16.7	20.2	13.9
Red. minimum	1.2	9.8	9.6	3.7	10.2	8.4
Red. maximum	31.7	48.2	28.7	32.8	47.1	25.3
Stripping :						
F1		4.2	2.6		4.4	3.8
F2	2.3	3.4	1.6	2.4	3.9	3.4

From the table, the effect of the large step at these reductions becomes evident. Especially the reduction in the second and the third die show a large fluctuation. The reduction in the second die even decreases to 0.
This is a result of the fact that the diameter for the first die was selected actually too small. In this way, the wall thickness after the first die is already equal to the thickness of the first step after the second die.

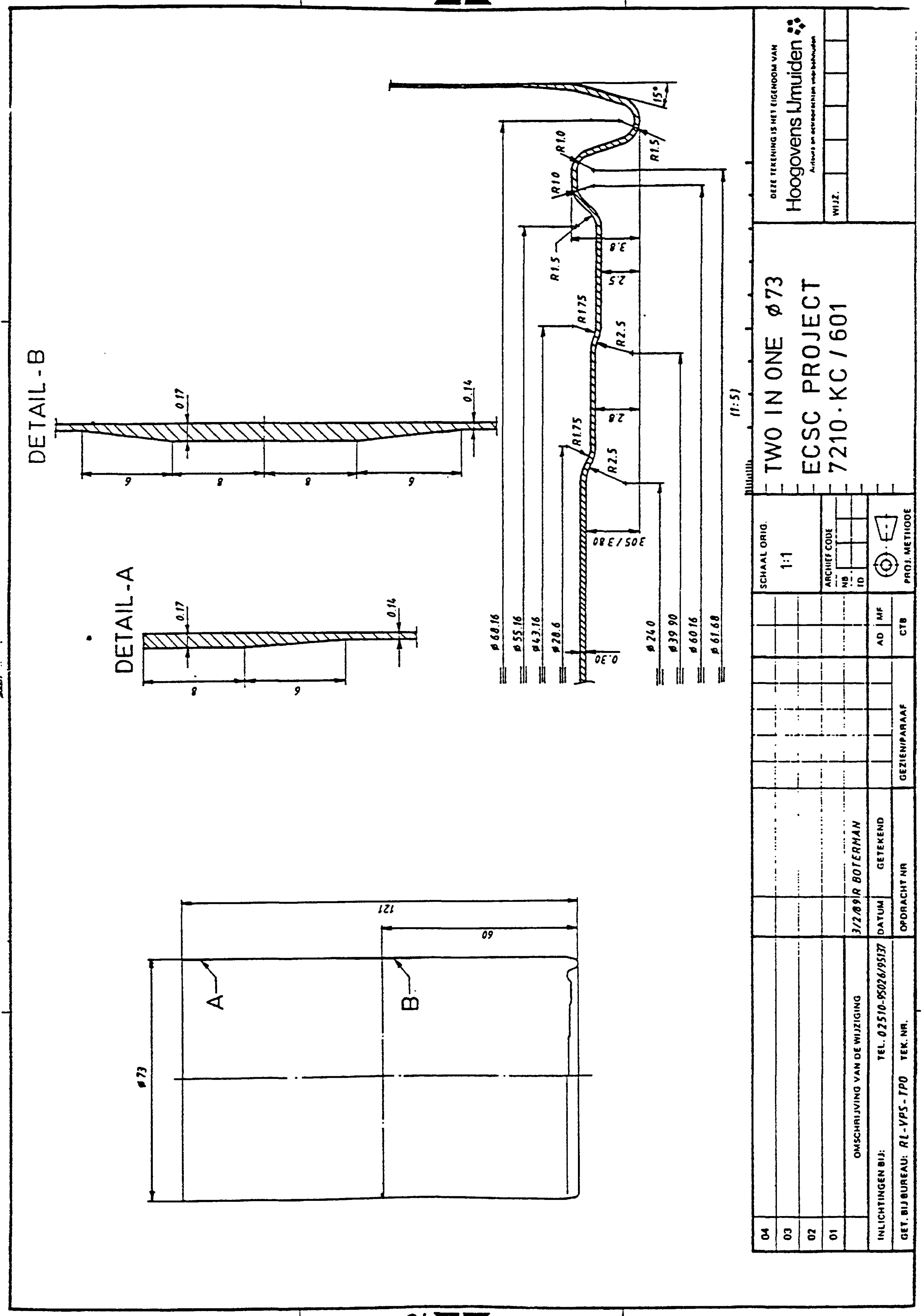
MEASURED WALL IRONING FORCES FOR THE Ø 66 MM CANS

Table 29 : Wall ironing forces measured during the first test run [kN]

Location	"Two-in-One" can			33 cl can	
Material	T52 BA 0.24 mm		T61 CA 0.24 mm	T52 BA 0.28 mm	T61 CA 0.28 mm
Code	1	2	4	3	6
First die :					
Fmin 1	5.0	5.5	6.2		
Fmax 1	18.0	18.6	22.4	20.8	22.4
Second die :					
Fmin 2	7.0	7.9	8.0		
Fmax 2	12.8	13.2	14.8	13.9	15.2
Third die :					
Fmin 3	3.4	6.1	4.8		
Fmax 3	9.6	11.7	12.2	12.1	14.0
Stripping :					
F1	2.8	2.4	3.2	3.2	3.3
F2	1.5	1.5	2.1	2.2	2.1

Table 30 : Wall ironing forces measured during the second test run [kN]

Location	T52 BA material (0.26 mm)		T61 CA material (0.26 mm)	
Code	A	B	A	B
First die :				
Fmin 1	5.6	9.1	6.9	8.2
Fmax 1	20.3	14.7	24.1	18.5
Second die :				
Fmin 2	13.0	13.7	12.5	13.4
Fmax 2	19.4	25.6	29.5	25.3
Third die :				
Fmin 3	8.2	4.6	8.3	5.3
Fmax 3	14.3	11.7	15.2	12.9
Stripping :				
F1	2.2	1.5	2.6	1.9
F2	0.3	0.4	1.0	0.7


DETAIL-A
DETAIL-B
A
B
ø73
121
60
TWO IN ONE ø73
ECSC PROJECT
7210·KC/601
DEZE TEKENING IS HET EIGENDOM VAN
Hoogovens IJmuiden
WIJZ.
SCHAAL ORIG.
1:1
ARCHIEF CODE
PROJ. METHODE
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3/2/89 R BOTERMAN
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OPDRACHT NR
OMSCHRIJVING VAN DE WIJZIGING
INLICHTINGEN BIJ:
TEL. 02510-95026/95137
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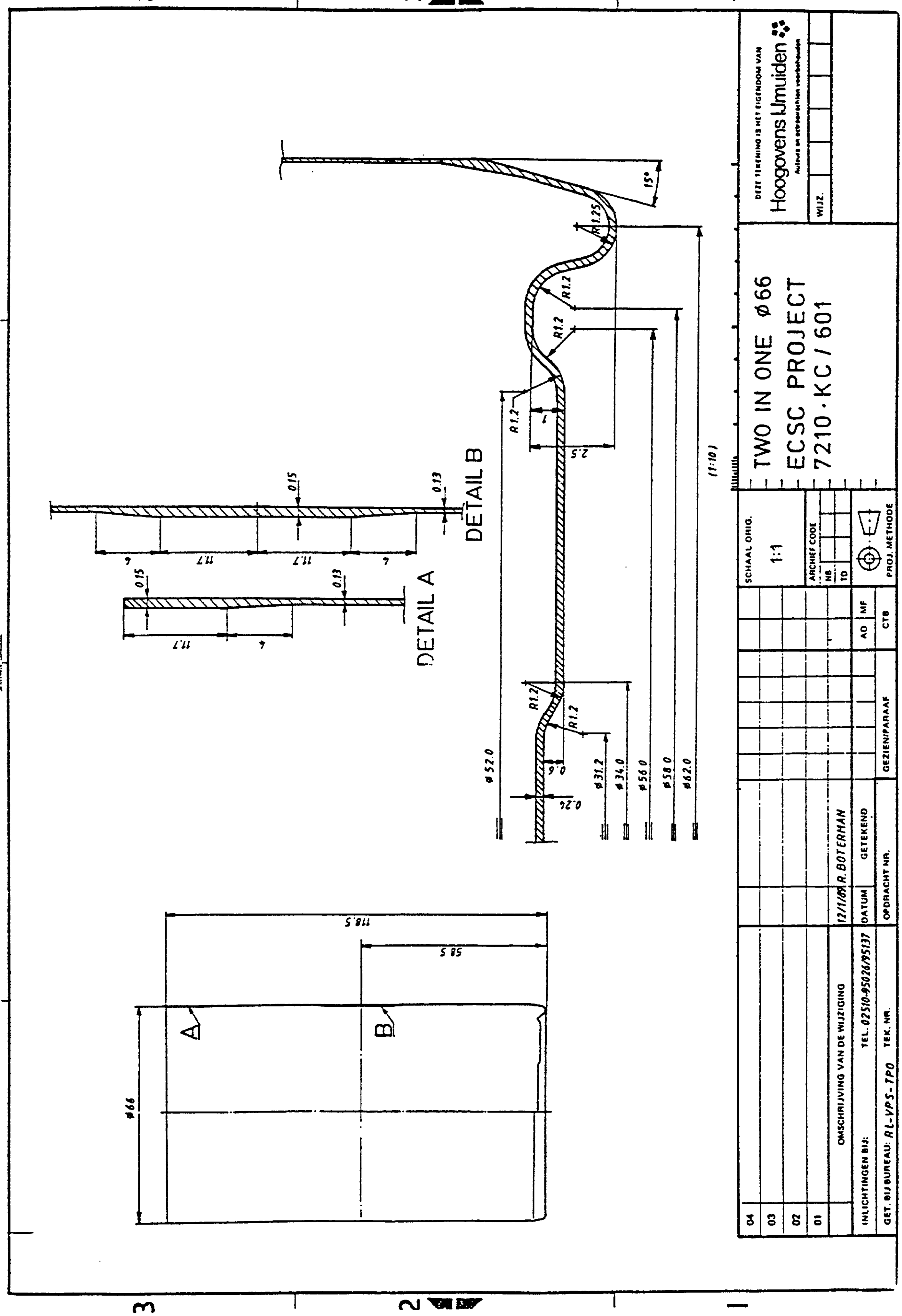
TWO IN ONE Ø66
ECSC PROJECT
7210·KC/601
DEZE TEKENING IS HET EIGENDOM VAN
Hoogovens IJmuiden
WIJZ.
SCHAAL ORIG.
1:1
ARCHIEF CODE
NB
TD
PROJ. METHODE
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GEZIEN/PARAAF
12/1/89 R. BOTERMAN
DATUM
GETEKEND
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TEK. NR.
04
03
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01
DETAIL A
DETAIL B
(1:10)
A
B
Ø66
118.5
58.5
0.15
0.13
11.7
4
15°
R1.25
R1.2
2.5
Ø52.0
Ø31.2
Ø34.0
Ø56.0
Ø58.0
Ø62.0
0.6
0.24

European Commission

EUR 15157 — Properties and service performance
Feasibility study on the production of a seamless three-piece can from tin plate

L. Hartman

Luxembourg: Office for Official Publications of the European Communities

1994 — XXV, 183 pp. — 21.0 x 29.7 cm

Technical steel research series

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This research project examined the wall-ironing process used in packaging. A novel can concept was developed involving a single production stage to make a special container from which more can bodies may then be made.

Dimensions of ø73 x 58 mm for three-piece cans aimed at the pet-food market, and ø66 x 58 mm three-piece welded milk cans were produced, the latter having considerable export-market potential.

Standard packaging steel material was used, namely A1-killed continuous cast steel with a tin coating. Experiments were carried out into the production, cutting and also the mechanical performance of the containers under conditions that might be found on production lines.

Deep drawing was carried out in two steps without any problems being encountered. The measured wall-ironing forces are considerably higher than those of the reference can (33 cl beer can) due to the very high reduction necessitated by the novel two-in-one design. Stripping did not pose any problems.

Axial strength of the ø73 mm can was achieved from the start, although radial strength was insufficient. This was cured by adopting beads in the final design. The smaller ø66 mm can did not achieve the required strength values and wall thickness had to be increased.

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