

Project: Plastics / Metal Hybrids for auto front end module.
Number: 1

Start Date: 2003-02-27
Completion Date: 2003-05-21

Mould Tooling & Die Industry

The following guidelines are intended to provide examples of “experimental development” projects which would qualify for Canadian SR&ED (Scientific Research & Experimental Development) tax credits.

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[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

Project: Plastics / Metal Hybrids for auto front end module.
Number: 1

Start Date: 2003-02-27
Completion Date: 2003-05-21

Project 1 – Plastics / Metal Hybrids for auto front end module.

Scientific or Technological Objectives:

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[NOTE: FOR ADDITIONAL EXAMPLES FOR THE MOULD TOOL & DIE INDUSTRY PLEASE LOG-IN AT WWW.RDBASE.NET, USERNAME: user@mtd password: user]

Development of the design details and process conditions for the manufacture of an automotive front-end module. Since we were only provided with drawings, we needed to develop the required technology and know-how for the correct placement of the metal stampings (as part of the design details) and the process for injecting the plastic. Development of the product and process would increase our company's technology base for the manufacture of plastic / metal hybrids.

Technology or Knowledge Base Level:

This work concerns a proprietary Plastics / metal hybrid technology in which nylon is bonded to a metal stamping, to give better strength and structural integrity that can be achieved with the metal stamping alone. Our company is a 'tier 1' supplier, which has licensed the base technology from the multinational corporation who developed it at a location outside Canada. This project covers subsequent work that was needed to adapt the technology for use it in a front-end module. The technology is not yet well established and at this point in time each application requires its own application development to accommodate the special features of the moulding process. The initial design for the part had been carried out at our customer, a U.S. auto OEM (Original Equipment Manufacturer). The work that follows was required to advance the technology to a sufficient degree that we could design a process to manufacture the parts.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: Positioning for the metal inserts.

The current base technology only gives an approximate position for the metal inserts. The design details including the proper positioning of the metal stamping are crucial for good adhesion. Poor adhesion can lead to problems with variability on part geometry. The original drawings were based on rules of thumb developed by the resin supplier and we had to modify these with the results acquired from our experimentation. The experimentation was needed to provide the required finesse that was not provided by the rough theoretical guidelines available to us.

Description of Work in this Taxation Year:

Activity #1 - 1: Building initial moulds.

Description:

The initial moulds were build using the drawings provided by our customer. Initial runs gave us parts that had adequate strength, but the alignment was poor.

[AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD QUANTIFY HOW MANY RUNS AND SPECIFY STRENGTH RANGES OF PARTS AND THEIR ALIGNMENT. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Technical Documents:

- * Hybrid from module - test
Equipment List.xls (size: 15.9 kb)

Project: Plastics / Metal Hybrids for auto front end module.
Number: 1

Start Date: 2003-02-27
Completion Date: 2003-05-21

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY. CAN WE PROVIDE ANY FURTHER TECHNICAL CONCLUSIONS AS TO WHY THESE "RESULTS" AND RELATED "INTEGRATION ISSUES" WERE NOT "READILY PREDICTABLE" TO YOU FROM A TECHNICAL STANDPOINT?]

Activity #1 - 2: Modification of moulds.

Description:

The moulds were modified empirically in two iterations to give the required alignment.

[AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD BE MORE SPECIFIC AS TO WHAT AND HOW MUCH CHANGED IN EACH ITERATION.]

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

* **ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:**

The base technology had clearly been developed outside Canada. Much of the final development was performed in Canada. The final design and production development (this term includes both product and process development) required further work to advance the technology and remove the technological uncertainty around the shrinkage of the materials in this process. As long as the work carried out in Canada meets the SR&ED criteria, it can form basis for a valid claim, even though the underlying technology was developed outside the country.

Project 2 – Plastic Injection Moulding and Extrusion Dies.

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THIS EXAMPLE HAS BEEN ADAPTED FROM THE CANADA REVENUE AGENCY'S "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

Development of the know-how required to design a PVC housing that would meet our customer's functional requirements. The design of very large extrusion dies for shaping and forming the extruded parts. The development of manufacturing methods for large extrusion dies too large for EDM manufacture. The initial purpose of the project was the design of an injection mould for the manufacture of unusually large PVC parts with a complex profile. The part had a thick exterior wall, four interior chambers and a flange on one end. The project evolved into the development of extrusion dies and the technology required for manufacturing both the dies and the parts. To develop an understanding of the flow characteristics of extruding plastic and to apply this understanding to develop the processing parameters for large extrusion dies with multiple internal chambers, thick wall stock and external flanges.

Technology or Knowledge Base Level:

Our company is a leader in the design and manufacture of plastic injection moulds, which make up the bulk of our business. We had won a contract to design and build tooling to produce complex moulded PVC housings that were over 57" wide, 12" high and had a wall stock of 3/8-1/2". These very large parts had multiple internal cavities with internal and external flanges.

This example describes a project that began as an injection mould design that was expected to contain only a limited amount of work meeting the SR&ED criteria. At some point the direction of the project changed, when we realized that we had to develop the manufacturing technology needed to produce the extrusion dies.

After the initial design work it became apparent that injection moulding would not give parts that could meet the functional requirements for rigidity and impact resistance. We decided that the parts would have to be extruded. This would be our first attempt at designing and producing extrusion dies of this size.

The size of the available extrusion machines provided a constraint. This impacted on the size of the dies since only a limited amount of space was available for the plastic to expand from the 3" extruder head to the 57" product width. As a result the extruded material had to flow through an angle of 135 degrees, compared to the typical 10 to 20 degrees. There were also concerns that the moulding pressure might blow apart the dies. The dies were therefore designed with a single piece outer construction to obtain maximum strength.

Dies of this nature are normally wire-EDM (Electrical Discharge Machine) manufactured, but because of the complexity of the flow patterns, and the large size of dies this was not possible. Since typical methods of manufacture would not work in this application, a new approach had to be developed. The compound angles of the receiving block and its four interior chambers would have to be separately manufactured. This could only be done using CNC (Computer Numeric Controlled) contoured milling of the outer single-piece receiving block.

Fields of Technology:

106 -- Materials Science and Technology

Scientific or Technological Advancement:

Uncertainty #1: Part Design.

We had to design a part that could be produced with the extrusion process and still meet the functional requirements of the customer. Our base technology did not allow us to be confident that this could be done, since our experience with extrusion was limited and as far as we knew, the dies would be the largest of this type in production on the industry.

Project: Plastic Injection Moulding and Extrusion Dies.
Number: 2

Start Date: 2003-03-01
Completion Date: 2003-07-09

Description of Work in this Taxation Year:

Activity #1 - 1: Multiple model pieces.

Description:

The finished product was made from a number of pieces. We designed these pieces and build models to ensure that the finished pieces would fit together to give a part that met our customer's requirements. We then designed the dies required to manufacture the parts.

[AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD QUANTIFY HOW MANY PIECES WAS THE FINISHED PRODUCT MADE WITH.]

Technical Documents:

- * Trial test materials and comments
- MTD overview of eligible activities.xls (size: 21 kb)

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY. CAN WE PROVIDE ANY FURTHER TECHNICAL CONCLUSIONS AS TO WHY THESE "RESULTS" AND RELATED "INTEGRATED ISSUES" WERE NOT "READILY PREDICTABLE" TO YOU FROM A TECHNICAL STANDPOINT?]

Uncertainty #2: Design and Process for dies construction.

The dies would have to be constructed of a single outer shell to prevent the die from blowing apart under extruding pressures related to flow requirements. Typically extrusion dies are produced with wire-EDM (electric discharge machining). The present dies could not be produced using conventional machining methods for two reasons:

- The large overall size meant that the parts could not fit into any wire-EDM machine.
- The requirement for a 135 degrees angle over an 18" distance.

Description of Work in this Taxation Year:

Activity #2 - 1: Construction of the dies.

Description:

Upon completion of the design of the dies we realized that there were additional technical problems that we had not considered at the beginning of the project. The greatest of these was how to manufacture the dies. To produce the four interior chamber components, fixtures were build for each component. They were then manufactured using CNC contoured milling and sink EDM. These interior chamber components were then mounted using flow dividers to fasten them to the main receiving block. Finally the extrusion die, which was wire EDM and had interior chamber components mounted with flow dividers, was assembled to the receiving block.

Technical Documents:

- * Rough materials
- MTD overview of eligible activities.xls (size: 21 kb)

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

Uncertainty #3: Flow and filling of plastic.

We expect that extrusion of plastic from a 3" extruder head to 57" in a span of less than 18" would lead to poor flow and filling difficulties.

Description of Work in this Taxation Year:

Activity #3 - 1: Testing of die.

Description:

Upon "first test" the dies functioned as designed, however there were problems with the receiving plate and in particular the flow of the plastic being extruded. The dies did withstand the high processing pressure, however the angles called for in the design were not sufficiently contoured to provide the required flow of plastic. It was necessary to rework the contoured shape of the receiving block many times over the next few months before finally obtaining a successful result. The problem was developing a shape that would force the material in a lateral direction.

Project: Plastic Injection Moulding and Extrusion Dies.
Number: 2

Start Date: 2003-03-01
Completion Date: 2003-07-09

[AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD SPECIFY THE PROCESSING PRESSURE AND QUANTIFY HOW MANY TIMES IT WAS NECESSARY TO REWORK THE CONTOURED SHAPE. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION FOR THE CURRENT ACTIVITY WOULD CONTAIN A CONCLUSION AS TO THE OPTIMAL SHAPE OF THE DIE.]

* ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:

In the course of carrying out SR&ED, new information is often acquired that can have a significant impact on the scope, direction or duration of a project. In this case resolving the technological uncertainties required to design the die, resulted in die that could not be manufactured with routine techniques. It was necessary to take a new approach to die manufacture and assembly. Normally it is relatively easy to accommodate changes in scope or direction into an SR&ED claim, since the claim is written after the work has been done. The additional technological advancement required and / or the associated technological uncertainties can be included, even if they were not obvious at the beginning of the project. In this case "a method to cut metal in complex shapes that are not possible with EDM" would be added to the list of technological advancements. If the project is split in two and submitted in two or more tax years, then the changes will be made to the advancements and uncertainties in the second or subsequent years work, with an explanation as to what had generated the need for change. This project provided an opportunity for the mould maker to design and manufacture unique extrusion dies, expanding their technology base from that required for the design and manufacture of injection moulds that formed the bulk of their business. They took a new approach to die manufacture and assembly, drawing on the experience of their designers to develop the die design, and to learn about the flow characteristics of extruded plastic.

Project: Automotive Exterior Trim (A Tale of Three Stakeholders).
Number: 3

Start Date: 2001-01-14

Completion Date: 2001-09-16

Project 3 – Automotive Exterior Trim (A Tale of Three Stakeholders).

Scientific or Technological Objectives:

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This example describes the shared effort of three groups to bring a new product to market for automotive exterior trim. This system is being developed to replace painted plastic parts used for exterior trim panels and moldings, with non-coated raw plastic parts that provide the same appearance and durability as paint. The resulting cost savings to the OEM will be significant if the project succeeds. The three companies involved are Resin-Us Inc., the resin supplier, Mould-R Inc., the mould maker and Process-R, the company that will manufacture the parts.

Resin-Us Inc.

The creation of a new plastic that can be used in applications such as the exterior panels of automobiles. Techniques to resolve the following issues:

- Obtain the required gloss level and surface consistency to provide an acceptable appearance.
- Achieve this at the same time as surface strength or impact resistance requirements are met.
- Ensure that the manufactured parts have the required long-term resistance to the elements.

Process-R Inc.

The creation of process technology that will enable our company to make exterior panels and other automotive parts from a new plastic. Technological advancements will be required so that:

- The new plastic can be processed in injection moulding applications.
- The properties of the plastic will facilitate the production of a part with the required geometry.
- New techniques can be developed for post mould handling of parts made from the new plastic.

Mould-R Inc.

The creation of a mould that is capable of acquiring and maintaining the high level lens quality surface finish required to mould a "wet look" paint-like part.

Can an SPI A-1 lens quality finish be applied to an automotive mould consistently over a large surface area?

Is there a tool steel available to support this type of mould finish?

If both tool steel and polish criteria can be met, will the surface last through the moulding process?

How will the surface tension effects created by the smooth surface associated with the high finish effect the flow of plastic?

Can a runner system be developed to compensate for any flow problems, and if so how?

Technology or Knowledge Base Level:

Resin-Us was asked by their customer, the processor for a resin that could be molded to give a part that has the same: High gloss appearance, Abrasion resistance, Surface Durability and Chemical Environmental Resistance as paint. The resin supplier has never supplied a material that meets these criteria before and therefore must create a new plastic that it hopes may be used in applications such as the exterior panels of automobiles. It was expected that the resin supplier would provide samples to the supplier.

Process-R Inc's goal is to develop a process that will use the new resin to manufacture automotive body sidemoldings. They plan to work with the resin supplier to develop specifications for the plastic and a process that can use this material to obtain a product that meets the technical specifications for the part.

Mould-R needs to take the part geometry and plastic material specifications and create a mould that will produce a part that will meet the conditions specified for use in automotive exterior trim.

[AN IDEAL DESCRIPTION WOULD SPECIFY VALUES FOR PROPERTIES OF THE MATERIAL AND TECHNICAL SPECIFICATIONS FOR THE PART.]

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Project: Automotive Exterior Trim (A Tale of Three Stakeholders).
Number: 3

Start Date: 2001-01-14

Completion Date: 2001-09-16

Scientific or Technological Advancement:

Uncertainty #1: Production of Compound Material.

Plastic parts are used routinely for exterior panels of cars and other vehicles. They are usually painted to achieve the required gloss levels, surface strength and impact resistance. The challenge is to produce a compounded material that will give parts with the required mechanical properties, which has a uniform surface that will be durable enough to withstand the environment to which it is exposed.

Description of Work in this Taxation Year:

Activity #1 - 1: Formulation and Testing of plastic.

Description:

The plastic was formulated based on what was known about the materials using the principles of chemical science and engineering combined with past experience. The supplier molded it into sheet form for use in testing.

A series of tests were then performed to satisfy the conditions spelled out by the OEM for vehicle exteriors. The results of these tests were analyzed and adjustments were made to the formula for re-testing.

The resin was released to the plastics processor. Although it met only part of the required conditions for durability, it met most of the requirements for mouldability.

The plastics supplier continued work on the resin to complete all of its chemical requirements for things like weather resistance. Communication is maintained with the mould maker and the processor, and modifications are made to the formulation both to resolve weatherability issues and to contribute to resolving part appearance issues.

[AUTHOR'S NOTE: QUANTIFY HOW MANY TESTS AND SPECIFY THE REQUIRED CONDITIONS OF PARTS AND THEIR MOULDABILITY. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Technical Documents:

- * Literature from search.

- * Customer visit reports including pictures

- * Meeting minutes and memos

- * Time sheets-T4s

- * Contracts

- * Invoices

- * Expense reports.

Conclusions:

- * [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY SPECIFYING WHAT IS THE OPTIMAL MATERIAL AND WHY? CAN WE PROVIDE ANY FURTHER TECHNICAL CONCLUSIONS AS TO WHY THESE "RESULTS" AND RELATED "INTEGRATED ISSUES" WERE NOT "READILY PREDICTABLE" TO YOU FROM A TECHNICAL STANDPOINT?]

Uncertainty #2: Part Production.

Having resolved the material selection issue the next challenge is to produce a part that does not need to be painted to obtain the desired surface and durability.

Project: Automotive Exterior Trim (A Tale of Three Stakeholders).

Start Date: 2001-01-14

Number: 3

Completion Date: 2001-09-16

Description of Work in this Taxation Year:

Activity #2 - 1: Sample Parts Testing.

Description:

Sample parts of the new plastic were made utilizing existing moulds with geometry similar to the intended body side molding required for the specific application. The processing requirements were extrapolated from the indications of part appearance obtained in these initial tests. Part handling systems were developed and the initial parts were used to evaluate the process. The moulds utilized for these initial tests are set aside. Tests are carried out on them, with changes being made to the processing system to obtain the best results. These results were recorded and copies were sent both to the plastics processor's engineering department and the mould maker's engineering department. The plastics processor analyses the data and prepares for the next test. The moulds are then sent back to the mould maker. After some time the moulds returned. The plastic processor analysed the first sample part, and made further changes to the processing parameters attempting to correct problems with part appearance. The moulds were returned to the mould maker a number of times before it was determined that the requirements can or cannot be met.

[AUTHOR'S NOTE: QUANTIFY HOW MANY TESTS, SPECIFY THE CHANGES MADE TO THE SYSTEM, THEIR RESULTS AND HOW MANY TIMES WERE THE MOULDS RETURNED TO THE MOULD MAKER.]

Technical Documents:

- * Initial project description.

- * Test results and Lab books.

- * Process specifications (versions).

- * Time records (employees / machinery)

- * Invoices and work orders.

Conclusions:

- * [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY. CAN WE PROVIDE ANY FURTHER TECHNICAL CONCLUSIONS AS TO WHY THESE "RESULTS" AND RELATED "INTEGRATED ISSUES" WERE NOT "READILY PREDICTABLE" TO YOU FROM A TECHNICAL STANDPOINT?]

Uncertainty #3: Mold Production.

The third major challenge is to produce a mould that can be used with the new resin system to obtain parts with the required mechanical properties.

Description of Work in this Taxation Year:

Activity #3 - 1: Mold Testing.

Description:

Candidate samples of tool steel were acquired for tests on surface polishing. The results of these tests were used to select a steel for the mould. Moulds were designed and built utilizing the chosen steel.

The moulds were then tested under simulated production conditions. The mould maker then released the moulds to the plastic processor for initial production mould process testing. They were returned to the mould maker along with sample parts and the data from the processor's tests.

[AUTHOR'S NOTE: SPECIFY THE GRADE AND REASON FOR THE STEEL USED. QUANTIFY HOW MANY TESTS AND SPECIFY KEY DATA.]

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

- * [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

Project: Automotive Exterior Trim (A Tale of Three Stakeholders).

Start Date: 2001-01-14

Number: 3

Completion Date: 2001-09-16

Activity #3 - 2: Analyzing of Test Parts.

Description:

Analyze the test sample parts to determine what changes can be made to the mould or the handling system to correct problems in part appearance.

[AUTHOR'S NOTE: SPECIFY THOSE CHANGES. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

Activity #3 - 3: Inspection of the Mold.

Description:

Inspect the mould for a number of performance characteristics including surface finish, durability and determine coating requirements for surface protection.

[AUTHOR'S NOTE: SPECIFY THE SURFACE FINISH, DURABILITY AND THE COATING REQUIREMENT. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Technical Documents:

- * Project plan.

- * Test results, analysis and conclusions.

- * Timesheets.

- * Supplier invoices.

- * Prototypes, moulds and parts.

- * Photographes.

- * Engineering reports.

- * Customer feedback report.

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY. CAN WE PROVIDE ANY FURTHER TECHNICAL CONCLUSIONS AS TO WHY THESE "RESULTS" AND RELATED "INTEGRATED ISSUES" WERE NOT "READILY PREDICTABLE" TO YOU FROM A TECHNICAL STANDPOINT?]

Project 4 – In-line Compounding.

Scientific or Technological Objectives:

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To develop a capability for the direct compounding of a glass-filled polypropylene resin in an injection moulding machine and improve the physical properties of glass-filled moulded parts by increasing the length of the glass fibers.

Technology or Knowledge Base Level:

Normally, filled resins are precompounded prior to the injection moulding process. There are limits to the length of the fibers that can be introduced and in many case better product performance would be achieved if longer fibers could be used. A company wanted to develop a capability for the direct compounding of a glass-filled polypropylene resin in an injection moulding machine.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering
- 402 -- Life Sciences - Animal Health and Disease

Scientific or Technological Advancement:

Uncertainty #1: Equipment.

- The twin screw extruder, which was designed for continuous extrusion operation, was required to run discontinuously (start / stop). It was not known what effect this would have on the uniformity of the resin properties and the distribution of the glass fibers.
- The twin screw extruder normally experienced little or no resistance to the outflow of resin. It was not known how much backpressure would be created by transferring the compounded resin to a shooting pot and how this might affect the operation of the extruder. It was also not known if the extruder could exert sufficient pressure to fill the shooting pot.
- Shooting pots in two stage injection units are usually filled quickly at the end of the plasticizing cycle of the injection screw. It was not known how the continuous filling of the shooting pot during plasticizing by the twin screw extruder would affect the uniformity of the melt.

Description of Work in this Taxation Year:

Activity #1 - 1: Changes to the Equipment.

Description:

- Design changes to the injection unit to allow the standard, single, injection moulding screw to be replaced by a standard intermeshing twin screw extruder intended for extrusion processing.
- Redesign of the injection unit barrel head to interface with the extruder and feed in the continuous glass woven roving.
- Design of a mechanism and structure to feed the glass woven roving from containers to the barrel head.
- Modifications to the machine controls to control the operation of the twin screw extruder.

Technical Documents:

- * Testing data - rough work
nature of the work.doc (size: 28.2 kb)

Conclusions:

- * [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

Uncertainty #2: Process.

- Relationship between throughput (operating speed) and fiber length.
- Relationship between throughput and uniformity (homogeneity) of fiber distribution.
- Relationship between the amount of glass and the uniformity of fiber distribution.
- Compounded resin property changes resulting from increased length of glass fibers.
- Sensitivity of properties to glass fiber length distribution.
- Sensitivities of material properties to screw speed, injection speed, melt temperature, mould temperature and hold pressure.

Project: In-line Compounding.
Number: 4

Start Date: 2001-03-05
Completion Date: 2001-06-08

Description of Work in this Taxation Year:

Activity #2 - 1: Influence of moulding process parameters.

Description:

The influence of moulding process parameters such as the amount of glass fiber, resin melt temperature, screw speed, injection speed and hold pressure. Measure the impact strength and heat deflection temperature of moulded parts. Measure the glass fiber length distribution.

[AUTHOR'S NOTE: QUANTIFY OR SPECIFY THESE PARAMETERS. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY. CAN WE PROVIDE ANY FURTHER TECHNICAL CONCLUSIONS AS TO WHY THESE "RESULTS" AND RELATED "INTEGRATED ISSUES" WERE NOT "READILY PREDICTABLE" TO YOU FROM A TECHNICAL STANDPOINT?]

* ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:

In this example the work carried out in the project meets the requirements of experimental development. The technological advancement sought is the "knowhow" required to compound glass-filled polypropylene resin directly in an injection moulding machine. The technology involves both the development of machinery and process control.

This example also illustrates the relationship between technological advancement and technological uncertainty, i.e. the attempt at technological advancement, in this case the technological "know-how", becomes obvious when the work is directed to resolve the technological uncertainties involved in the equipment, the process and the material.

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* [NOTE: FOR ADDITIONAL EXAMPLES FOR THE MOULD TOOL & DIE INDUSTRY PLEASE LOG-IN AT WWW.RDBASE.NET, USERNAME: user@mtd password: user]

Project 5 – Bottle Filling - Product Range Extension.

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

Development of a small single serve container that would be hotfillable and provide the required shelf life for juice, isotonic and sauce applications.

Determination of the relative impact of condensation and thermal contraction on vacuum formation in a single-serve hotfilled PET bottle.

Technology or Knowledge Base Level:

With the wider consumer acceptance of plastics containers in the food and beverage market, there is an on-going trend to replace glass containers with plastic. A plastics container company embarked on a program to develop a small single serve container that would be hotfillable and provide the required shelf life for juice, isotonic and sauce applications.

Hot filling is employed to sterilize the internal surface of the container and closure and not to reduce microbial counts in the product. Bottles from any reputable manufacturer will have very low microbial loads since the melt and reheat-blow processing sterilizes them. In most modern processes, the product with which the bottle is filled has already been pasteurized by a thermal treatment before filling. Subsequent handling should maintain this cleanliness.

In the filling process the hot liquid, typically at 185°F (85°C), is introduced into the bottle by a fill tube, which is withdrawn leaving a headspace, and the bottles are conveyed to a capper where more headspace is created by sloshing. Our industry specification is that bottles must be able to withstand a headspace of 15 mm depth.

After capping, the bottle cools and the water vapour in the headspace condenses contributing to a vacuum. The liquid also thermally contracts. The bottles must be designed to withstand the hot filling and the subsequent vacuum that forms when the liquid cools. The vacuum level also determines the amount of residual oxygen in the bottle, which impacts on the shelf life of oxygen sensitive products.

The bottle generally has an industry standard finish (the threaded part of the bottle) of 43 mm³, a size that imposes severe challenges on bottle design. To withstand this partial vacuum, PET bottles are made with panels and domes. The panels are designed to flex on cooling and take up the vacuum, while the rest of the bottle remains rigid so as to meet toplevel, shrinkage and ovalization specifications.

Since the company had been manufacturing larger size (1L and 2L) hotfill containers for the beverage market for a number of years, the engineer who prepared the technical descriptions included in the company's SR&ED claims was concerned because the project appeared to be a routine design and engineering procedure at first glance. Since he felt that there was a significant amount of technical uncertainty that would have to be resolved in order to successfully complete the project, he contacted his local CRA office for advice on how to prepare his claim.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: Parameters that control the vacuum.

Without knowing the parameters that control the vacuum formed in the headspace of a hotfilled bottle, it is not possible to calculate the stresses on the bottle or to determine the shelf life of the product.

Project: Bottle Filling - Product Range Extension.
Number: 5

Start Date: 2002-05-04
Completion Date: 2002-10-11

Description of Work in this Taxation Year:

Activity #1 - 1: Analyzing and Evaluating test results.

Description:

Several bottle and vacuum panel designs were evaluated using finite element analysis to determine the optimize design for building a prototyping mould.

Bottles made with the optimized design were filled at 85°C and tested using the standard hotfilled container procedures and specifications. Modifications were done on the panel design and material distribution to optimize the structural performance of the bottle.

Overall volume change of the bottles was measured using the displacement method in a graduated cylinder. The change was compared to the calculated value of liquid contraction and vapour condensation. A series of experimental runs were carried out on the filling line to determine the major factors that impacted on the pressure and amount of the headspace gasses. These were two level factorial designs that looked at the impact of bottle shape (two potential designs with differences in geometry, finish size, filling liquid temperature, filling speed and two different types of nozzles. These runs were repeated during two separate shifts (one a day shift the other a night shift, to provide different cooling speeds due to different ambient temperatures).

The pressure in the headspace was measured. The rate of oxygen transmission through the bottle wall was also measured using a proprietary method. The results were analyzed to determine the effect of each of the variables on pressure and product shelf life.

[AUTHOR'S NOTE: QUANTIFY HOW MANY BOTTLE/VACUUM PANEL DESIGNS, EXPERIMENTS AND RUNS WERE EVALUATED AND SPECIFY THESE RESULTS. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Conclusions:

* The project was concluded successfully. The company had always believed that the major factor in creating vacuum pressure was the condensation in the headspace, but closer examination reveals some surprises. The work showed that the major cause of vacuuming was simply from cooling the liquid from 85 to 23°C. The work showed that there is a significantly higher oxygen/liquid ratio in the headspace for the single serve containers when compared to the larger size containers; this has very serious implications for oxygen sensitive liquids.

Based on this study, it was concluded that smaller finish sizes are necessary if we are to design successful smaller-volume containers for hotfill applications. This will lead to lighter-weight (lower cost) containers and lower cost closures.

*** ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:**

Work to extend a product line is not automatically SR&ED. In this case the work meets the criteria for SR&ED since a technological advancement is required and the work is carried out systematically. The CRA R&T advisor recommended that the project description should be modified to clarify the number of experimental runs required to advance the technology, their length and the amount of material that was scrapped in these experiments. The review process was facilitated by this additional information.

Uncertainty #2: Container satisfying required properties.

In the following example, our company had production problems with the manufacture of a bottle that had been developed in our plant.

In order to reduce material cost and improve cycle time during the preform injection process, the company had decided to reduce the weight of an existing plastics bottle by 5% for a juice application. Since it was uncertain whether the lighter weight container could still satisfy all physical properties and specifications, it was necessary to proceed with a prototyping injection mould to manufacture the new preforms. The lighter weight preforms were subsequently blown into the same juice container for testing. During the development of this lighter weight container, it was found that the bottle satisfied all the specified requirements, except the top load condition, i.e. the bottle was collapsing when the specified force was applied to the top of the container.

Using Design of Experiment techniques, the poor top load condition was eventually rectified with a new preform design to allow material to be distributed in the desirable area during the blow moulding process. The technology to produce the lighter weight preform and container was then transferred to a production plant.

Project: Bottle Filling - Product Range Extension.
Number: 5

Start Date: 2002-05-04
Completion Date: 2002-10-11

Description of Work in this Taxation Year:

Activity #2 - 1: Performing Tests.

Description:

A few months after the bottle had been in production, the process operator found that the bottle had failed the specified top load requirement during his routine quality check. With the help of the Quality Assurance technician, the process operator was able to run several experiments and determined that the preform heating profile had drifted and had to be adjusted to achieve the original material distribution. The operator already knew that the bottle could achieve the top load condition when processed properly, so there was no technological uncertainty when the experiments were run.

[AUTHOR'S NOTE: THERE IS A LACK OF UNCERTAINTY. IT SEEMS LIKE ROUTINE SOLUTION: NOT ELIGIBLE FOR R&D WORK.]

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

* ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:

The original work described in the previous example that was required to reduce the weight of the soft drinks bottle qualified as SR&ED. When the operator later had problems with achieving the top load condition, she already knew that the bottle could achieve the required specification when processed properly, so there was no technological uncertainty when the experiments were run.

Although the work required to return the bottle making process to its original specified conditions was carried out in a systematic manner, it is not considered to be SR&ED, since there was no need to advance the technology. It was quite clear to all parties concerned that the work only required the application of known process technology. If the operator had to develop the technology further in order to achieve the specified heating profile, a technological advancement would have been made and the work could qualify as SR&ED.

Project 6 – Ejection Detection

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

To correct a problem of frequent “stoppages” on an injection moulding machine by identifying its root cause.

Technology or Knowledge Base Level:

Getting moulded parts out of the tool and "down the spout" is a critical part of any mass-production moulding operation, including the more esoteric processes like rotational moulding and hand lay-up. But in injection moulding, failure to eject reliably is more than an inconvenience.

The eight-cavity mould produced a dimensionally non-critical (this was before Six Sigma) small cylinder which was ejected conventionally then blown into a hopper which gravity fed into a small conveyor for the "second op" process. Sprues fell into a barrel where they could be carted away periodically.

The system worked well enough but every once in a while, mis-ejection would cause a “stoppage”. The operator would have to hit the panic button when the mould made that characteristic dull thud that suggested ejector pins that were not cycling in a straight line. If they didn't, it usually meant a crash, bent pins, and lots of expensive downtime.

After re-startup, the machine always checked out O.K. Run the process at or near an economically viable speed, however, and the problems reappeared.

Fields of Technology:

- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: Overcoming the root cause.

Whether we can find the root cause, and then overcome it.

Description of Work in this Taxation Year:

Activity #1 - 1: Looking for the problem.

Description:

- The first step was to manually check for binding or roughness. The parts slid freely.
- Loading the cavity with spray-on mould release and adding a little heat showed there was no kind of build-up or gumming action.
- The pins were removed for a visual check that showed that the heads had sufficient clearance to keep them floating behind the retainer plate.
- There were no witness marks on the parts and ejection seemed trouble-free at moderate speeds. Use of a strobe or high-speed camera to watch the action was considered but there seemed to be no way to adequately see the pins cycle.
- The short-term solution was simply to slow the machine down, since the investigation consumed production time too.
- A little later the tool went back to the mould shop for a slight modification. After the mild rework, the mould behaved perfectly. It turned out that the bores for the worst offenders were short, very short, at what seemed like not much more than the diameter of the already slender pins.

Technical Documents:

- * XXXX
Equipment List.xls (size: 15.9 kb)

Project: Ejection Detection.
Number: 6

Start Date: 2004-09-22
Completion Date: 2004-10-04

Conclusions:

* At a later date the engineer noticed that serious bellmouthing on the parts had been ignored. This telltale sign should have given away the cause; "It came like that and the other shop says it made 1.2 million parts with no problem".

Rebushed, with new drylubed pins, the mould worked as advertised. Manually sliding those nails back and forth and wiggling side to side failed to produce the lash that was not noticed because at the extremes of the pin's motion, the head gave it extra lateral support, which isn't a realistic operating condition.

* **ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:**

Despite the engineer's oversight, the work described here is clearly carried out in a systematic manner, meeting one of the criteria for SR&ED eligibility. The problem was solved using existing technology so there is no technological advancement and the work does not qualify as SR&ED. Again, as in the previous example, if the operator had had to develop the technology further in order to solve his problem, then the work could have qualified as SR&ED.

Project 7 – Compression moulding of abrasion resistant liners

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

Development of a steel filled UHMW-PE abrasion resistant liner for the pulp & paper industry.

- To use steel powder as a filler in a UHMW-PE sheet intended as an abrasion resistant liner.
- To develop a mixing process for high density fillers such as steel powder.
- To control the thickness of steel filled UHMW-PE liners and meet the tolerance requirements through the use of process conditions (temperature, pressure) to control the shrinkage.

Technology or Knowledge Base Level:

In an attempt to expand its market share and better meet its customer's needs by offering a broader product line, the plastic company embarked on the development of a new steel filled UHMW-PE4 for use as an abrasion resistant lining material in the pulp and paper industry.

[AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD ILLUSTRATE THE COMPANY'S CURRENT STATE OF STANDARD PRACTICE.]

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: Effects on properties and processing.

The addition of even a small quantity of an additive to UHMW-PE can have large unpredictable adverse effects on the properties and processing of the polymer.

Steel powder is extremely dense and has very different properties from any filler that we have previously used with this polymer.

Description of Work in this Taxation Year:

Activity #1 - 1: Experimentation and Result Analysis.

Description:

- A set of designed experiments were conducted on small scale compression moulding equipment to determine the effects of the addition of several types of metal powders (material and morphology) on the properties of UHMW-PE (Ultra High Molecular Weight Polyethylene).
- Once a material was selected that could be added to UHMW-PE to give the required properties and economics, another series of experiments were carried out to evaluate the processing requirements.
- During production trials several processing problems were encountered. The unusually high bulk density of the additive gave rise to mixing problems that had to be overcome.
- The new formulation had a much lower coefficient of thermal expansion and therefore did not shrink as much as standard UHMW-PE material would upon cooling. This made it difficult to remove the product from the moulds. We therefore had to experiment to find a way to remove the finished product from the moulds. This was achieved by modifying the temperature profiles.
- To obtain the required thickness, standard practice is to mill the material down. This new product could not be milled as it quickly wore the carbide tipped milling blades away. Experimentation was initiated to determine how to meet the thickness specification.

[AUTHOR'S NOTE; QUANTIFY AND SPECIFY VALUES OF PARAMETERS ENCOUNTERED. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE

Project: Compression moulding of abrasion resistant liners.
Number: 7

Start Date: 2001-11-01
Completion Date: 2001-12-31

MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Technical Documents:

- * Lab reports

- * research notes.

- * • Production trial documentation.

- * • Samples

Conclusions:

* The required thickness tolerances were not met for this type of steel filled UHMW-PE lining material. It was not possible to mill the material even with carbide tips. Currently modifications to the compression moulding process are being developed to allow processing of tighter tolerance sheet. This would eliminate the need for subsequent milling to meet the thickness tolerances.

* **ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:**

This experimental work to produce steel filled liners is carried out in a systematic manner in an attempt to remove uncertainty and advance the technology. It is thus SR&ED. In this case one business project is presented as a sequence of technological problems. In other cases it may be more appropriate to break the project into a number of sub-projects.

Project 8 – Material Substitution

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

Identify a lower cost alternative to ABS as part of our cost reduction program. To develop a process that produces extruded profiles for the appliance market using lower cost mass polymerized ABS in place of ABS produced by compounding technology. The initial application was for a breaker strips for a refrigerator. Decorative extruded profiles can be manufactured in a similar process.

Technology or Knowledge Base Level:

Our company is producing extruded profiles for the appliance market from ABS (Acrylonitrile-butadiene-styrene) produced with compounding technology. As a result of cost pressures in this extremely competitive market, the company was looking for alternative materials, which would provide a similar property balance at a lower price. After looking at several alternatives, and talking to our suppliers we decided to investigate the possibility of using a mass polymerisation grade of ABS. Since a similar grade was chosen, the initial expectation was that the resin switch would be seamless. As part of the manufacturing routine the new profiles were put through the testing procedures to ensure performance was achieved. Although the resins had almost identical specifications, the shrinkage behaviour of the parts made from the new resin was different.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: Mass Polymerisation.

We are presently using ABS produced via compounding technology to manufacture extruded profiles for the appliance market. Our supplier has suggested that we can obtain similar results with ABS produced in a different process (mass polymerisation). Although we chose a material with similar specifications, as in this case, they will often behave differently.

Description of Work in this Taxation Year:

Activity #1 - 1: Testing of new material.

Description:

The new ABS (Acrylonitrile-butadiene-styrene) was chosen because it had a similar molecular weight and was expected to have similar thermal properties (die swell, thermal conductivity, shrinkage, flow).

400 meters of product were produced in an experimental run that took four hours. This time was required to stabilize the line and allow the production of consistent material.

Testing of the parts produced showed that they met the mechanical requirements, but that the shrinkage was different from that which was predicted and hence the size of the parts was not correct.

The dies had to be modified by trial and error, since there was no way to predict the shrinkage with the accuracy required.

In the third trial, parts were obtained which consistently had the correct dimensions.

Technical Documents:

No technical documents have been uploaded for this activity.

Project: Material Substitution.
Number: 8

Start Date: 2000-02-02
Completion Date: 2000-05-14

Conclusions:

* [AUTHOR'S NOTE; AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY. CAN WE PROVIDE ANY FURTHER TECHNICAL CONCLUSIONS AS TO WHY THESE "RESULTS" AND RELATED "INTEGRATED ISSUES" WERE NOT "READILY PREDICTABLE" TO YOU FROM A TECHNICAL STANDPOINT.]

* [ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:
REPLACEMENT OF ONE RESIN BY ANOTHER OR USING THE SAME RESIN PRODUCED IN A DIFFERENT PROCESS WILL OFTEN REQUIRE EXPERIMENTAL DEVELOPMENT. SUBSTITUTING A RESIN FOR A COMPETITIVE MATERIAL PRODUCED BY A DIFFERENT SUPPLIER (OR MANUFACTURED BY THE SAME SUPPLIER AT A DIFFERENT LOCATION) CAN REQUIRE SR&ED BUT IS MUCH LESS LIKELY.

IN THIS CASE SR&ED WAS REQUIRED. IN THE ABSENCE OF SCIENTIFIC PREDICTIONS, A SYSTEMATIC PROCESS OF TRIAL AND ERROR WAS USED TO MODIFY THE EXTRUSION DIES.

THE PROJECT CLAIM SHOULD INCLUDE THE LABOUR REQUIRED TO RUN THE TRIALS AND CARRY OUT THE PRODUCT TESTING. THE RESIN USED IN THESE TRIALS SHOULD ALSO BE PART OF THE CLAIM AS "MATERIALS CONSUMED". DISPOSAL COSTS OF SCRAPPED MATERIAL MIGHT ALSO BE INCLUDED IN THE CLAIM.

WHETHER OR NOT THE PROJECT IS SUCCESSFUL, WORK ON THE DIES CAN BE CLAIMED AS PART OF THE PROJECT. ANY DIES THAT ARE SCRAPPED AS PART OF THE SR&ED WORK CAN ALSO BE INCLUDED IN THE CLAIM AS "MATERIALS CONSUMED". IF THE DIES THEMSELVES ARE USED IN PRODUCTION THEN THEY BECOME "MATERIALS TRANSFORMED".]

Project 9 – Dual Injection

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

- Develop the capability of dual injection to allow the use of recycled polymer in the core of a product, and virgin material on the outside.
- Develop an understanding of the capabilities and limitations of dual injection technology.

Technology or Knowledge Base Level:

A company wished to make use of a new technology called dual injection, which they had never used before. They believed that this technology would allow them to use recycled polymer in the core of a product, and virgin material on the outside. Performance requirements are that the outside material must be of sufficient quality to pass impact tests without surface blemish or cracking.

[AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD ILLUSTRATE THE COMPANY'S CURRENT STATE OF STANDARD PRACTICE.]

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: To achieve objectives with present technology.

We did not know how to achieve our objectives with our present technology.

Description of Work in this Taxation Year:

Activity #1 - 1: Determine the parameters for a product at minimum cost.

Description:

In order to assess the technical and commercial feasibility of this new technology, the company needed to determine the necessary machine parameters to obtain an acceptable product at minimum cost. A number of trials were performed in a standard format for designed experiments; in this case a Taguchi L9 (a statistical experimental design technique) was used. Optimum conditions were estimated and used in a final confirming experiment. A 300-piece trial was conducted at the optimum conditions to determine process capability. All 300 pieces were scrapped after the trial.

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* [AUTHOR'S NOTE: AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY. CAN WE PROVIDE ANY FURTHER TECHNICAL CONCLUSIONS AS TO WHY THESE "RESULTS" AND RELATED "INTEGRATED ISSUES" WERE NOT "READILY PREDICTABLE" TO YOU FROM A TECHNICAL STANDPOINT.]

* ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:

This example illustrates how the use of new technology enabled the company to reach its technical objectives and such work often involves technological uncertainty. The work was driven by a need to reduce costs. A systematic process of experimentation was used to carry it out. If a company is using a technology for the first time it does not automatically mean that they are carrying out SR&ED. When describing a project like this one, it is therefore important to identify the parts of the technology that are generally available and distinguish these from the "know-how" that the company needs to develop experimentally. In this case the technical content requirement was satisfied with the performance of a designed experiment using accepted methods, and the completeness of the work in performing the 300-piece process validation.

Project 10 – Different Equipment

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

The purpose of the project was to develop procedures that can be used to design and manufacture blow moulds for the production of bottles that have a fill line to indicate the amount of product to be sold in them. These bottles need to have the same dimensions when produced in North America, Europe or South East Asia. The critical requirements were stable and consistent vertical and horizontal wall dimensions as well as consistently located fill lines.

The technological advancement was the establishment of design and manufacture parameters which would ensure that the strict dimensional requirements would be obtained in production, regardless of where either the mould or the bottle was produced. The technological advancement identified the critical parameters and provided a means of determining the variables that were used during the design of the mould to control its volume. The experimental work would provide improved "predictability".

Technology or Knowledge Base Level:

One of the critical issues in the manufacture of blow-moulded containers is ensuring that any fill lines on the finished container are correctly located to control the volume of the product in the container with sufficient accuracy. A blow mould company has been supplying blow moulds for bottles for many years and is now expanding into international markets. Their new customers are expecting moulds of similar configuration to conform to strict packaging criteria, regardless of where in the world the tool is produced. The company must develop methods to design and manufacture moulds that can be used to produce bottles with consistent dimensions.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: Obtaining Products Requirements.

Blow moulding machines can produce different results with the same mould. Humidity, temperature, cooling, cycle, resins and settings parameters can all impact on the shrinkage factors of the material, and hence the dimensions of the plastic products produced in them. It was not certain that verifiable design and manufacturing parameters could be identified that would allow sufficient control over the process to provide products that would meet the strict requirements, independent of the location, the blow mould machine used for production, the resin supply, as well as the local technological capabilities and the climate.

Description of Work in this Taxation Year:

Activity #1 - 1: Design and Manufacture of a Prototype Mould.

Description:

The project began with the design and manufacture of a prototype mould. The mould design was based on the final product design. However it was modified to include measurement indicators, which during test runs could provide precise data about vertical and horizontal shrinkage as well as changes in volume. The prototype mould was built and sent to the first site for testing. Data gathered included information about the resin and the machine used, the resin as well as processing temperatures and other processing parameters. This data was analyzed along with test results from the samples produced.

The mould was then returned to Canada and modifications were made to the mould based on these results. The modifications included changes to the design indicator locations and cnc machining. The mould was retested at the same Canadian site with the same conditions. Further data was collected during the production of samples. The samples were again analyzed and variables determined based on the results of this second test.

A third iteration was carried out before satisfactory results were obtained. Mould tryouts in this experiment were conducted at 4 locations in North America, Europe and Asia as identified above, although all design, machining work and preliminary testing was completed in Canada. Each time the data was collected and modifications made to establish the reliability of the predictions. It was learned from these experiments that variations inherent to processing of a product in various locations through out the world could be predicted in advance with the help of a number of parameters.

Project: Different Equipment.
Number: 10

Start Date: 2003-08-14
Completion Date: 2003-12-23

Technical Documents:

* XXX

Equipment List.xls (size: 15.9 kb)

Conclusions:

* The data collected from the prototype helped to develop a database for model classification based on location, equipment application and material supplied. Much was learned from the project, and the data now provides the ability to predetermine what variables must be applied prior to the design of new tooling.

* ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:

The description of the work carried out explains how the experimental mould was modified and reused for experimentation in the establishment of the dimensional variation database. The development of design procedures can be SR&ED, although only the work carried out in Canada can be claimed. The use of these procedures in subsequent projects to design production moulds may not be SR&ED. In this project the prototype mould met the CRA definition of a prototype. It was a piece of equipment designed and built for the sole purpose of experimentation and data collection. Upon completion of the experiment it was not usable for commercial production.

Project 11 – Extrusion Process

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

The development of technology that will provide a process to produce a PP sheet that meets the technical requirements for a number of novel applications.

- To identify a grade of polypropylene that can be processed to produce a performing product.
- To modify the processing equipment so that a product can be obtained that meets all critical dimensional requirements.
- To develop a dependable process to produce a PP sheet that will consistently meet customer requirements.

Technology or Knowledge Base Level:

Extrusion processes are used to produce a wide variety of products, such as coated wire, blown film, extruded sheet, pipes, tubes and extruded profiles.

The components of the extrusion process usually consist of an extruder (drive, gearbox and screws), the extrusion die, a cooling medium, calibration units, haul-off equipment, a saw or other cutting device and finally devices that provide any treatment required for final finishing.

In the extruder, material is added to the hopper as either powder or pellets. The hopper continuously feeds the material to a heated barrel, which contains a rotating screw. This screw simultaneously heats, mixes, pressurizes and meters the material as it transports the polymer to the die head. At the die, the polymer takes up the approximate shape of the part and is then cooled either with water or air to give the final shape. As the polymer cools, haul-off devices draw it along so that the product can either be coiled or cut to length.

The material selection process requires balancing a number of properties of the resin. These might include density, tensile strength, flexural modulus, UV Stabilizer levels, coefficient of thermal expansion, coefficient of friction, melt index, shrinkage and gloss levels. At the start of the project it is not always clear what are the important performance criteria and the levels of these are required. Experimentation is often required to determine these.

The performance of the product usually depends on the conditions under which the material was processed. Relevant process parameters can include melt temperature, barrel temperatures, die zone temperatures, back pressure, velocity and mass flow rate.

The type of equipment used to process the polymer can also impact on product performance. For example the cooling bath, its inlet and outlet temperatures and flow patterns, can modify the product performance.

After extensive market research and an economic trend analysis, the company has decided to produce a polypropylene (PP) sheet product which they hope will fulfill its customers' needs and allow them to expand their market share. Since they had no experience of the use of PP in this type of application, extensive experimentation is required so that they can develop a viable manufacturing process and gain control the many parameters and their interactions.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: Variable Product and Unstable Process.

The resin system and process conditions that were chosen based on previous experience gave a product that was too variable. The process was unstable.

Project: Extrusion Process.
Number: 11

Start Date: 2004-01-01
Completion Date: 2004-05-28

Description of Work in this Taxation Year:

Activity #1 - 1: Performing Experiments to Meet Criteria.

Description:

- In conjunction with material suppliers, several experiments were conducted on the production line with various compositions and melt index to identify a grade that could meet dimensional criteria at an acceptable mass flow rate.
- Traditional processing techniques were not satisfactory because variations in melt strength and coefficient of thermal expansion caused freezing of the material, variation in hardness of the material and irregular shrinkage. These variations gave an inherently unstable process.
- Rolls were replaced with flame hardened rolls that were annealed at higher temperatures to prevent damage caused from the freezing of the new material on the rolls.
- The corona treater roll was replaced with a smaller roll to allow for the higher shrinkage of the new material and the amperage of the treater was increased as the PP material proved to be more difficult to treat than the conventional material run on these lines.

[AUTHOR'S NOTE; QUANTIFY HOW MANY EXPERIMENTS AND SPECIFY THE MATERIAL COMPOSITIONS. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* The processing issues have been resolved and the first product in the new range has been accepted in the marketplace. Further SR&ED work is anticipated in order to produce sheets with different thickness for similar applications.

* ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:

This experimental work to develop a process to manufacture polypropylene sheets meets the criteria for SR&ED since it is carried out in a systematic manner attempting to remove uncertainty and advance the technology.

Simple selection of materials without the development of new technology is not SR&ED. In this case the required know-how is not available in the public domain and must be developed by the claimant.

The claimant correctly recognises that the market research and an economic trend analysis (which are certainly an essential part of the business project) are not part of the SR&ED project.

Although there are three separate technological advancements required, the interactions between the materials, the equipment, the process conditions and the final end product properties means that this work must be treated as a single project. This does not however mean that all expenses will be accepted as eligible.

The labour required to identify the best grade of PP is clearly a part of the SR&ED project; the material that is scrapped as a result of the trials and which cannot be recycled is "consumed".

The work on the rolls is also a part of the SR&ED project, but the rolls themselves will be used in production and so cannot be claimed as part of the SR&ED project. An exception would be if experimental rolls are ordered for a trial and are scrapped after the trial.

Project 12 – Screw Design

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

The development of an improved screw design that will allow us to increase the impact resistance of the product and at the same time increase productivity without increasing production costs.

A new screw design that will offer: Improved dispersion, without changing the process conditions, consistently improved impact properties, shot repeatability with reduced variations in part weight, the ability to include a higher percentage of regrind materials without sacrificing performance properties and enhanced particulate dispersion without irregularities of colour.

Technology or Knowledge Base Level:

Mixing plays a critical role in plastics processing. At low stress, distributive mixing occurs. When more stress is applied, dispersive (intensive) mixing occurs. Dispersive mixing ruptures the cohesive forces that cause components to agglomerate into droplets or particles and thus gives more uniform distribution of the components.

The use of all polymers requires the addition of materials that confer the required performance properties. These can include thermal and UV stabilizers, plasticizers, organic or inorganic pigments, regrind or even physical blowing agents to produce evenly distributed uniform cell structures. To be as effective as possible, these additives need to be dispersed as evenly as possible within the polymer matrix. The technological challenge of uniform pigment and additive dispersion can be addressed by systematically modifying screw designs.

Design of a screw for a specific application will depend on the requirements, which will vary according to the composition of the compound, the equipment and the end application. A host of technological uncertainties may arise during this design process. For example if we need to introduce new mixing elements into a screw designed for an injection machine, special challenges can arise because the plasticating unit (the plastic melting and conveying section) of an injection machine is relatively short. Moreover, the new screw design may fail to produce the expected dispersion, to the detriment of the end product.

Screw designs must provide the best combination of distributive and dispersive mixing in order to produce the required properties in the product. The screw of an injection-moulding machine is typically a single stage and single flighted conveying screw. Studies have shown that the shear flow generated by screws of this type is inefficient for dispersive mixing. Instead, generation of elongational flow, in which particles such as filler agglomerates undergo a stretching type of deformation without rotational movement, helps in efficient dispersive mixing.

The company is using injection moulding to manufacture a product for the construction market. If a product can be made with a higher impact resistance, then a new application would be possible, which would result in a new product line and increased sales.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: Performance of the Screw Design.

Our new product line demands parts with better impact resistance. This means that a new ingredient must be mixed efficiently. For this injection moulding application, we would like to insert the mixing elements into the screw of the injection moulding machine. Although this new design might improve mixing, the process conditions could thereby be changed, giving a process window that might not allow cycle time adjustments. The use of regrind use might be restricted and costs might rise.

The current process produces a commercially viable product, but variations in part weight and inconsistent impact properties have been reducing productivity. Mixing elements are available that can improve the relative amounts of dispersive and distributive mixing. The available technology allows us to make directional predictions, but the science is not available to make quantitative predictions. Thus experimental development work is required to improve the performance of the screw in this application.

Description of Work in this Taxation Year:

Activity #1 - 1: Design of the Non-Return Valve.

Description:

- The output of the injection screw was found to be much less than its theoretical (calculated) output. Possible reasons for this discrepancy included: a feed problem, wear of the screw or barrel, or insufficient melting of the ingredients at high screw speeds.
- Measurements of the barrel and screw did not uncover any wear related issues. Changing the barrel temperature settings did not improve the output or the variability of the parts.
- Different chemical measurements (viscosity, solvent extractions and thermo-gravimetric analysis) and measurements of surface properties on different sample parts showed that the dispersion of solids was not uniform. Un-melted resin pellets were even observed occasionally.

The design of the non-return valve (NRV) was changed to improve mixing. This was achieved by adding a CRD (Chris Rauwendaal Device) mixing element to an injection screw as follows: mixing pins were placed inside the slide ring of the NRV. The pins were elongated in the axial direction in order to accelerate the melt fluid as it passed between two pins. This gave elongational flow, which resulted in effective dispersive mixing. Adding similar pins to the outside of the stop subjected the mixture a second time to elongational flow. The large number of pins induced many splitting and reorientation events and the result was efficient mixing.

Technical Documents:

- * Calculated structure for system - testing proformance levels
MTD overview of eligible activities.xls (size: 21 kb)

Conclusions:

- * [AUTHOR'S NOTE; AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

Activity #1 - 2: Using Precipitated Calcium.

Description:

Instead of ground calcium carbonate (GCC), precipitated calcium carbonate (PCC) was used in the composition. Although PCC is costlier than GCC, PCC's particles are much finer and their high specific area and controlled structures make them more effective nucleating agents. A set of experiments was designed and carried out, in which the percentages of PCC and GCC were varied in a systematic way to discern their effects on product properties. After incorporating the CRD mixer onto the NRV, several runs were carried out and the resulting impact properties were measured. Using more pins allowed the proportion of regrind to be doubled and surface gloss improved considerably. To check weatherability, specimens were placed under QUV panel and their impact properties determined after various exposure times. Samples containing GCC showed marked loss in impact properties while samples containing PCC did not.

[AUTHOR'S NOTE; QUANTIFY HOW MANY EXPERIMENTS WERE AND HOW MANY RUNS WERE CARRIED OUT. REMEMBER THAT THE TAX COURT'S CONTINUALLY REITERATE THE FACT THAT, "SYSTEMATIC INVESTIGATION MUST INVOLVE EXTREMELY ACCURATE MEASUREMENTS AND SUBSEQUENT ANALYSIS OF THOSE MEASUREMENTS." WE SHOULD THEREFORE ATTEMPT TO PROVIDE REVENUE CANADA WITH SUCH EVIDENCE WHENEVER POSSIBLE.]

Conclusions:

- * As a result of this work we were able to improve the impact resistance of parts. In addition we produced less scrap and regrind content was doubled from 5 to 10%. Since the work has taught us that mixing can be improved, we anticipate continuing this work in the next year to further increase the regrind cycled content.

* ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:

The description shows that work was carried out in a systematic manner to advance both screw design technology and to improve the technology available to use regrind in our processes. The work meets the criteria for Experimental Development.

Project 13 – Development of an UHMW-PE Abrasion Resistant

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

The development of a new product, which maintains abrasion and impact resistance while offering increased flexural modulus.

To find a way to increase the flexural modulus without loss of abrasion resistance and impact resistance.

Technology or Knowledge Base Level:

A company launched a new cross-linked sheet to meet their customer's need for improved abrasion resistance. After launching the product the company received a customer feedback indicating a liking for the abrasion resistance and impact resistance of the new material but a higher flexural modulus was desired. The company decided that it was necessary to try to develop a product that would maintain the abrasion resistance and impact resistance achieved through cross-linking as well as meet this new primary requirement of an increased flexural modulus.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology

Scientific or Technological Advancement:

Uncertainty #1: To provide a less flexible product.

Increasing the cross-linking of a polyethylene resin increases both the abrasion resistance and the impact resistance. At the same time this increased cross-linking will reduce the flexural modulus of the polymer. The obvious way to provide the customer with a less flexible product (by reducing the cross-linking) cannot be used since this will reduce abrasion resistance and impact resistance of the product. Hence a more creative solution must be found to meet these seemingly contradictory requirements.

Description of Work in this Taxation Year:

Activity #1 - 1: Performing Experiments.

Description:

- The company carried out an extensive series of small scale laboratory experiments to determine what effect a variety of additives have on the flexural modulus of the cross-linked product. Several additives were found that increased the flexural modulus of the product to the required levels.
- The flexural modulus, abrasion resistance and all of the other secondary properties including: tensile strength, izod impact strength, coefficient of thermal expansion and coefficient of friction were tested on several blends of each of these additives at a variety of loading levels. These experiments provided an optimum blend.
- A production trial was carried out to determine what effect this formulation had on the processing of the product. Using standard processing parameters problems were encountered during both the mixing of the blend and compression moulding of the new material formulation. Laboratory experimentation in addition to several production trials were carried out to determine how to obtain thorough mixing of the product and what the optimum pressure and temperature cycles are for the new formulation.

Technical Documents:

- TEST A
- Testa.xls (234 kb)

Project: Development of an UHMW-PE Abrasion Resistant
Number: 13

Start Date: 2003-09-01
Completion Date: 2003-12-20

Conclusions:

* [AUTHOR'S NOTE; AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY. CAN WE PROVIDE ANY FURTHER TECHNICAL CONCLUSIONS AS TO WHY THESE "RESULTS" AND RELATED "INTEGRATED ISSUES" WERE NOT "READILY PREDICTABLE" TO YOU FROM A TECHNICAL STANDPOINT.]

* ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:

Through these trials & experimentation we developed the knowledge that allowed us to develop a product that met both the primary property requirements of improved abrasion resistance and higher flexural modulus as well as the secondary property requirements of maintained tensile strength, izod impact strength, coefficient of thermal expansion and coefficient of friction.

Project 15 – The Bevel Gear

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

- To develop a manufacturing process to produce small, plastic injection-moulded precision straight bevel gears to replace conventional machined metal Gleason gears.
- To demonstrate this technology by moulding a paired set of two trial gears and verifying their dimensional accuracy and their meshing performance using a special test fixture.
- The main technological advancement sought and achieved in this project was the development of a moulding process to produce small, precision straight bevel plastic gears. Being of glass-filled nylon, these alternative gears offer superior toughness, durability, low operating noise, and freedom from lubrication while still having a performance matching metal gears. Being injection moulded, they can also be produced rapidly in large volumes.
- Parts shrink after they have been moulded. The normal manufacturing process for injection moulding requires that the shrinkage be estimated with the help of a mathematical model. The model requires the input of equations that describe the geometry of the part; in the case of the Gleason gear the shape is complex and the needed equations are not available.
- A process must be developed to provide a part with the required tolerances without the use of these shrinkage predictions. This work resulted in an increase in the company's technology base, giving them the capability to mould complex geometric parts.

Technology or Knowledge Base Level:

Our Company was incorporated in 1990. It is a recognized leader in designing and producing complex and innovative moulded plastic parts for several OEM industries.

The company was approached by a potential customer who wanted to purchase a mould that would produce a plastic bevel gear set that would match the performance of an original metal straight bevel gear set. The gear set included a 2-inch diameter, 16-tooth gear and a 1-3/8 inch diameter, 11-tooth pinion.

The customer offered us an opportunity to design and build the required mould. This potential customer was not contracting us to perform SR&ED. However, we had to perform SR&ED to satisfy the customer and win the business.

We decided to mould the gear set out of 6,6 nylon with a 33% glass fill. For the project to be economically viable, we needed to create a single mould with two cavities, allowing the gear and the pinion to be produced at the same time. Producing gears out of plastic provides considerable benefits in several areas such as drive smoothness, low noise in operation, durability, balanced tooth strengths for both pinion and driven gear, and freedom from interference in meshing.

Conventional bevel gears are machined with special machine tools. In the present example the specified tooth type is Gleason straight bevel, with a 20-degree pressure angle. This modified tooth form is automatically produced on the Gleason machine and is difficult to reproduce by other methods. The complex geometry of the Gleason gear cannot readily be described by simple equations.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Scientific or Technological Advancement:

Uncertainty #1: Gear Tooth geometry.

The information provided to the company or available through technical reference sources was not enough to establish the data needed to cut the tooth forms in a mould through processes applicable to building a mould (as opposed to cutting teeth on a gear blank with a Gleason machine).

Description of Work in this Taxation Year:

Activity #1 - 1: Test Fixture Design and Fabrication.

Description:

Experienced engineers and technicians studied the crude samples and incomplete data made available to us by the potential customer. They developed alternate scenarios and preliminary strategies on how the two gears could be produced via a moulding process.

Project: The Bevel Gear
Number: 15

Start Date: 2002-02-25
Completion Date: 2002-06-15

Extensive literature searches and professional contacts were initiated to discover what means could be employed to precisely determine the gear geometry, tooth profiles, and related dimensional data, so as to establish baseline information for designing the mould for each gear.

Computer modeling of tooth geometries and dimensions was performed. Simulated meshing of the gear pair was studied for engagement and disengagement action.

In parallel, an instrumented test fixture was designed and fabricated for a physical evaluation of the actual meshing behavior of the supplied sample gear pair, and later of trial gears.

When a preliminary workable set of 3-D dimensional data appeared to have been finally evolved, a trial pair of aluminum gears was cut using this data on a CNC Wire-EDM set-up at a specialist shop. Meshing trials of the experimental aluminum gears were conducted on the test fixture. This generated information that could be used to correct the electronic 3-D data.

A second set of experimental aluminum gears was cut using the corrected data, and meshing trials were repeated on the test fixture. Another iteration of electronic 3-D data correction was performed. Final corrections were determined using information based on actual tooth contact signatures obtained by using "machinists' blue" on gear tooth engagement areas.

The electronic data was adapted to CNC Wire-EDM cutting a set of electrodes for a Plunge-EDM process to make the mould cavities. This required extensive work with Solids and Surface programs for developing precision cutter paths to achieve the desired accuracy and finish.

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* [AUTHOR'S NOTE; AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

Uncertainty #2: Manufacturing process.

- In conventional bevel gear manufacturing, handbook references are available to specify the critical gear blank dimensions, cutter parameters, and the appropriate Gleason machine settings required to produce the required bevel gears. However, this approach was not applicable to mould manufacture. Hence the first problem in this example was to determine the absolute 3-D tooth geometry and related dimensional data for both pinion and gear in terms of spatial coordinates, which could then be used to generate data to CNC machine the (mould) surfaces.
- For mould dimensioning, compensation would have to be provided for material shrinkage, draft angles (if applicable), etc. Completely unknown were the distortions that would arise through the moulding process and how to correct for them. Tight tolerances were specified for backlash, TIR runout, etc. on the finished gear set. All of these were inter-related to the integrity of the tooth form and the roundness and face perpendicularity of the gears after moulding. Large local mass variations in material existed in the tooth areas, and it could not be foreseen how much, and where, sinking and other moulding-related distortions would appear to cause still further difficulties in the performance of the meshed gear set.
- Furthermore, glass-filled nylon is a highly abrasive moulding material that flows only with difficulty. It was clear that an even filling of the mould would be problematic to achieve in any event, let alone with all the complex part geometry features discussed above.

Description of Work in this Taxation Year:

Activity #2 - 1: Mould Design and Injection Moulding Trial.

Description:

In the mould design, a deliberate strategy was adopted to place the bulk of the critical areas of one gear as a core detail, and that for the other gear as a cavity detail. This would enable a comparative determination to be made on which approach was better for making the final, exact adjustments to achieve the minute details required.

A trial injection mould was made and experimental plastic gear samples were produced. Evaluation with the test fixture showed that corrections were required to local mould tooth geometry/dimensions to minimize backlash.

After the injection moulding trial and a detailed gear sample evaluation, corrections were made to both core and cavity in the mould, and moulding trials were repeated. With three iterations of this procedure, it was found that the process would deliver parts with the required precision, and sample gears were then shipped to the OEM customer for approval.

Project: The Bevel Gear
Number: 15

Start Date: 2002-02-25
Completion Date: 2002-06-15

Technical Documents:

- * . Electronic logs of all iterations performed are available.

- * Mould tryout logs for plastic gears, for all iterations.
As in (6), (9), and (10) above, but for trial moulded plastic gears, for all iterations.

- * Retained physical evidence includes: trial gear samples (aluminum and moulded plastic), test fixture, rejected plunge EDM electrodes, rejected mould components, dated photographs of moulds and internal details (illustrating iterations).

Conclusions:

- * The potential customer granted approval after extensive inspection and tests, and the mould stands were accepted for regular part production in an offshore factory.

* **ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:**

This project is an example of a case in which the need for a technological advancement is identified at the outset. A significant amount of effort is required in preparation for “first try-out.” This work meets the definition of SR&ED. The subsequent work is also eligible since it is required to achieve the technological advancement. Accordingly, all work in the actual claim was deemed eligible, other than a few initial business meetings between the claimant and potential customer when non-technical matters were discussed.

This case is a good example of why in many (if not most) situations the “first try-out” is a poor indicator of project eligibility.

Since the designing and building of the mould involved experimental development, the portion of the costs incurred for SR&ED would be allowed. The costs incurred for the experimental development, in this case, could include the costs of labour and materials.

The costs of any materials that were destroyed or rendered virtually valueless as a result of the SR&ED may be claimed as costs of materials consumed. The costs of materials that were incorporated into the mould as a result of the SR&ED may be claimed as costs of materials transformed. If the mould is sold, converted to commercial use, or used for demonstration purposes, the costs of the materials transformed would be subject to recapture.

Project 16 – Cast Figurines

Scientific or Technological Objectives:

[AUTHOR'S NOTE: THESE EXAMPLES HAVE BEEN ADAPTED FROM THE "PLASTICS MATERIALS, PROCESSING, EQUIPMENT & TOOL MAKING GUIDANCE DOCUMENT & CASE STUDIES" - APRIL, 2004. THESE DOCUMENTS ARE AVAILABLE FOR DOWNLOAD AT (www.cra.gc.ca/sred). THIS DOCUMENT WAS PREPARED BY A JOINT CANADA REVENUE AGENCY (CRA)-INDUSTRY SECTOR COMMITTEE.]

- To develop a manufacturing process that produces small, highly-detailed cast plastic figurines faithfully reproducing fine surface detail and geometrical features.
- To demonstrate this technology by producing samples covering a range of figurines representing a range of action movements.

The main technological advancement sought and achieved in this project was to develop a casting methodology and technique to produce a range of highly detailed miniature cast plastic figurines with an unprecedented level of surface detail and delicate geometrical features. The technology also had to be compatible with a high rate of production.

Achieving this objective would open up a technical capability to reproduce levels of fine detail and geometry in cast figurines that was previously unobtainable in the industry.

Technology or Knowledge Base Level:

Our company was incorporated in 1985. It produces complex and innovative moulded plastic parts for several OEM industries. The business initially concentrated on the decorative figurines market sector and has achieved considerable success over the years in this specialized area. Over time, as consumer tastes have become more sophisticated, figurines have come to require an increasingly finer level of detail. Until recently, the manufacturing techniques established by the company had been able to sustain this increasing product refinement.

This example looks at the scenario created when a dealer in collectible figurines approached the company to develop a line of highly realistic sports and military miniatures. Extremely detailed features were to be reproduced, and the postures of the figurines were to accurately show examples of action movement (such as shooting a hockey puck, kicking a soccer ball, parrying a sword thrust, leading a bayonet charge or riding a horse into battle).

This requirement for extreme detail meant that the facial expressions, drape of the clothing, body stance, tensing of muscles, and all other visual cues had to be completely faithful to the action being represented. The new figures were 5cm tall and included details that were less than 1mm across; some of the more demanding details included a gun site on the end of a rifle, collar buttons and buckles and holes on a belt. The level of detail was far in advance of anything the company had attempted before.

Handcrafted specimens of the figurines were made available by the company.

Sample handcrafted figurines are used as patterns for making the moulds. The moulds are cavities in a block of silicone rubber, and are created by pouring a liquid silicone compound over the patterns. The compound sets into a shape that conforms to the outer contours of the pattern. The pattern is removed and the hollow cavity then becomes the mould for producing a cast figurine. Liquid casting resin is then poured into the moulds to produce the figurine.

The company believed that the basic method would work for the new line of figurines as well. However, as discussed below, trials revealed that the standard techniques could not reproduce the level of detail that was demanded.

The company did eventually succeed in establishing a suitable process for making this new line of highly-detailed figurines, but only after a considerable effort in experimental development.

Fields of Technology:

- 104 -- Chemical Engineering
- 106 -- Materials Science and Technology
- 107 -- Mechanical Engineering

Project: Cast Figurines.
Number: 16

Start Date: 2002-10-25
Completion Date: 2002-11-30

Scientific or Technological Advancement:

Uncertainty #1: Material to conform.

The technological uncertainty stems from the inability of the previous established company techniques to achieve the results that were needed in the as-cast figurines. In other words, standard practice was inadequate. Specifically, the technological problems were: the ability of the mould material (silicone compound) to faithfully conform to the surface detail and delicate geometry of the figurine. The choice of a parting surface for the mould that would allow the cast figurine to be extracted without damaging the delicate features.

Description of Work in this Taxation Year:

Activity #1 - 1: Performing try-outs.

Description:

Engineers and technicians studied the sample figurines and made a preliminary selection of an item for tryout to see whether the company's existing casting method would succeed. A single cavity trial mould was made. Trial castings were made. Results were very far from acceptable. Facial and clothing details were not adequate and the extremities were not filled. Internal meetings were held, and it was realized that the problems revealed by the first tryout failures could not be solved with knowledge that existed in the company.

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* [AUTHOR'S NOTE; AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

Uncertainty #2: Choosing a casting resin.

Choosing a casting resin related to its fluid flow properties, and then to the cure regime, outgassing, and as-cured mechanical properties.

Description of Work in this Taxation Year:

Activity #2 - 1: Discussions with casting resin suppliers.

Description:

Discussions were held with casting resin suppliers and mould material suppliers to find better materials for filling the moulds. Special choices were made, particularly for low-shrinkage casting resins.

Technical Documents:

No technical documents have been uploaded for this activity.

Conclusions:

* [AUTHOR'S NOTE; AN IDEAL DESCRIPTION WOULD CONTAIN A CONCLUSION FOR THE CURRENT ACTIVITY.]

Uncertainty #3: Resin to reach all the features.

- The ability of the liquid casting resin to actually reach all the extreme delicate features in the mould and properly fill the mould cavity, and any external arrangement to assist the mould-filling process.
- The gating and feeding arrangements for sustaining multiple-cavity moulds to suit volume production.
- The curing process – Would a room-temperature cure be adequate, or would a heating arrangement be required?
- The possible need for mould release agents to facilitate part release. Would these be compatible with the mould material and the casting material (in its initial liquid and cured stages)?

Description of Work in this Taxation Year:

Activity #3 - 1: Performing Trials and obtaining Results.

Project: Cast Figurines.
Number: 16

Start Date: 2002-10-25
Completion Date: 2002-11-30

Description:

Several trials were conducted with these low shrinkage casting resins, but the extremities of the moulds were still not filled.

Centrifugal assist was employed, using a motorized turntable to rotate the mould.

Difficulties were still encountered with mould filling, along with new problems caused by venting and outgassing.

A vacuum draw was added.

Eventually, after several iterations to adjust the cooling conditions, satisfactory castings were obtained.

To define limits to the process, the method was extended to selected figurines in the dealer-requested range.

Technical Documents:

* . Minutes of internal meetings recording discussions on dealer-supplied handcrafted samples and decisions on initial choices to develop castings. Minutes of meetings that discuss poor test results. Action items on individuals to investigate parameters.

* Records of phone discussions, faxes, and brief notes based on supplier information on mould materials and casting resin issues.

* . Experimental records on tests with different combinations of mould and casting materials. Records of experiments that show formulations and cure times

* . Record of further discussions on unsatisfactory test results.

* . Meeting minutes laying out experimental plan specifying figurine type, mould design (sketch), venting arrangement.

* Test results (still unsatisfactory) – notes on verbal discussion with plant manager.

* Minutes of meeting discussing vacuum assist and motorized turntable. Sketches of possible alternatives.

* . Further experimental test results. Some improvement noted.

* . Meeting minutes with sketches of finalized vacuum draw and turntable arrangement. Aluminum feed runners suggested for incorporation in next test run.

* Meeting minutes on further experimental test results. Samples apparently almost satisfactory. Heated curing suggested.

* Further test results and minutes of meeting to discuss and finalize heating chamber.. Test results now satisfactory. Meeting suggests heater controls to refine process.

* . Final experimental casting ad test results, with material formulations, weight and viscosity of casting resin used, vacuum draw level, cure time and temperature, technician name, Q.C. visual assessment, and photographs. Meeting minutes record decision to send samples to dealer. 16. Dealer response (fax). Approved.

Project: Cast Figurines.
Number: 16

Start Date: 2002-10-25
Completion Date: 2002-11-30

Conclusions:

* Through the extensive experimental development work described above, the company did achieve the capability to cast a completely new class of highly-detailed figurines, and it established a technology base that could be applied to other figurines with similar levels of fine surface detail and complex geometrical features.

* **ADDITIONAL CRA COMMENTS REGARDING ELIGIBILITY:**

In most real-life examples, eligible work can be found before the first-tryout event. However, in this case, the SR&ED project actually did commence only after the first try-out, because that is when the company established that its existing technology base was inadequate to handle the complex new requirements and therefore began an experimental development process.

In this case the work described after the first try out was found to be eligible.

SR&ED is not required for every new figurine. It was required for the first example and then for any others that had special requirements such as finer details than any previously produced or for figurines with longer narrower parts.