UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

DONGHEE AMERICA, INC. and DONGHEE ALABAMA, LLC,

Petitioners

v.

PLASTIC OMNIUM ADVANCED INNOVATION AND RESEARCH,

Patent Owner

U.S. Patent 9,079,490
Issue Date: July 14, 2015
Title: Method for Fastening an Accessory to a Plastic Fuel Tank

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CASE: Unassigned

DECLARATION OF DR. DAVID O. KAZMER IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT 9,079,490

I, Dr. David O. Kazmer, hereby declare that the following is accurate and true to the best of my knowledge under the penalties of perjury:

I. BACKGROUND

A. Engagement

1. I have been retained by Orrick, Herrington & Sutcliffe LLP on behalf of its clients Donghee America, Inc. and Donghee Alabama, LLC ("Donghee") to provide my opinion concerning the validity of claims 1-2, 7-9 and 12-14 (the "challenged claims") of U.S. Patent No. 9,079,490 (hereafter referred to as "the '490 Patent").

2. I am being compensated for my time at my normal rate of $500 per hour. My compensation is not contingent on the outcome of this matter or the specifics of my testimony.

B. Personal Qualifications

3. My curriculum vitae is provided in Appendix A. I completed a bachelor's degree in Mechanical Engineering at Cornell University (December, 1989) and a master's degree in Mechanical Engineering at Rensselaer Polytechnic Institute (May, 1991). Subsequent to my work at GE, I received a doctoral degree in Mechanical Engineering at Stanford University (June, 1995), where my research led to a method for dynamic control of melt flow at multiple locations in an injection mold and led to a commercial product called Dynamic Feed.

4. I am currently a tenured Full Professor in, and the Chair of, the Department of Plastics Engineering at the University of Massachusetts Lowell. As a faculty member, my teaching and research focuses on plastic product design and plastics manufacturing process development. Currently, I am teaching undergraduate and graduate courses in product design, mold engineering design, and process analysis, instrumentation, and control. My current research projects include plastics feedscrew design for extrusion and molding applications, modeling of polymer flow and structural behavior in plastics manufacturing processes and resultant products, simulation and design of 3D printing processes, and processing of microcrystalline cellulose fibers in polymer melts including the copolymer ethylene-vinyl alcohol (EVOH).

5. I joined the faculty of the University of Massachusetts Amherst in 1995 as an Assistant Professor in the Department of Mechanical and Industrial Engineering. I received tenure in 2000, and in 2001, I took a leave of absence to be Director of Research & Development for Dynisco HotRunners, a supplier of plastics molding machine and injection mold systems, to assist in the commercialization of the Dynamic Feed melt control system. After returning from my leave of absence in 2002, I relocated to the University of Massachusetts Lowell where I was promoted to Full Professor in 2005 and have served as the Associate Dean for the College of Engineering.

6. Prior to my academic appointment, I was a practicing engineer in industry. During 1991 and 1992, I was a Design and Process Development Engineer at General Electric ("GE") Plastics. During 1990 and 1991, I was a Mechanical Engineer at GE Research and Development. During 1988 and 1989, I was an Application Engineer at GE Plastics. My work at GE focused primarily on the design and manufacture of engineered plastic products; I have personally worked on the design and manufacture of injection molded, thermoformed, and blow molded plastic products as well as their associated molds and molding processes. Since 2003, I have also been the President of Kazmer Research LLC, which is involved in technology development and strategic consulting related to product development, manufacturing, simulation software development, and quality control system design.

7. I am a member of the American Society of Mechanical Engineers, the Institute of Electrical and Electronics Engineers, the International Polymer Processing Society, and the Society of Plastics Engineers, among others. I am the past chair of the American Society of Mechanical Engineering's Technical Committee on Design for Manufacturing, the focus of which is to improve the performance, quality and cost aspects of plastic products and plastics manufacturing processes. I am also an Associate Editor for the Journal of Polymer Plastics Technology and Engineering as well as the Journal of Advances in Polymer

Technology. I have also served as an Associate Editor for the Journal of Mechanical Design.

8. As an active researcher, I have authored more than two hundred juried publications in journals and conference proceedings related to plastics product design and manufacturing as well as the books Injection Mold Design Engineering (Hanser Publishers, 1st edition 2007 and 2nd edition 2016) and Plastics Manufacturing Systems Engineering (Hanser Publishers, 2009). The former book, while directed specifically to injection molds, is relevant to blow molding and provides a Chapter on variant molding processes including injection blow molding and insert molding.

9. The quality of my work has been recognized by more than twenty awards including my election to Fellow by both the American Society of Mechanical Engineers and the Society of Plastics Engineers, and being the 2012 recipient of the Kos Ishii-Toshiba Award for "Sustained and Meritorious Contributions to Design for Manufacturing and Life Cycle, particularly in the areas of plastic product design and plastics manufacturing process development."

10. I am a named inventor of multiple U.S. Patents, including, Nos. 5,556,582, 6,254,377, 6,287,107, 6,309,208, 6,343,921, 6,343,922, 6,361,300, 6,436,320, 6,464,909, 6,514,440, 6,585,505, 6,589,039, 6,632,079, 6,638,049, 6,713,002, 6,767,486, 6,769,896, 6,824,379, 7,175,418, 7,408,551, 8,753,553,

9,446,544. The technology described in these patents all pertain to the design and manufacture of high quality plastic products.

11. I have personally designed injection and blow molded plastic products including the molds and machinery that produces them. My expertise is directed to advanced products and process design including analysis of structural performance; design of assemblies, fits, and tolerances; modeling and control of molded part dimensions; simulation of production processes, shrinkage, and long-term performance; among others.

II. METHODOLOGY

A. Claim Construction

12. I understand that the claims of a patent define the invention to which the patentee is entitled exclusive rights. The first step in considering the validity of the claims is to determine how the words of each claim should be construed.

13. I understand that claims in an inter partes review ("IPR") before the Patent and Trademark Appeal Board ("PTAB") are given their broadest reasonable interpretation that is consistent with the patent specification. I understand that the words of a claim are generally given their ordinary and customary meaning, which is the meaning that the term would have to one of ordinary skill in the art in question at the time of the invention. I understand that the specification is the single best guide to the meaning of a claim term.

14. I understand that extrinsic evidence, which "consists of all evidence external to the patent and prosecution history, including expert and inventor testimony, dictionaries, and learned treatises," can also be considered in the claim construction analysis. While less significant in determining the meaning of a claim term than intrinsic evidence, dictionaries and treatises can be used to better understand the underlying technology and construe claim terms as long as the dictionary definition does not contradict any definition found in or ascertained by a reading of the intrinsic evidence. It is my understanding that extrinsic evidence in the form of expert testimony can be useful for a variety of purposes, such as to provide background on the technology at issue, to explain how an invention works, to ensure that the PTAB's understanding of the technical aspects of the patent is consistent with that of a person of ordinary skill in the art, or to establish that a particular term in the patent or the prior art has a particular meaning in the pertinent field.

15. Below, I provide my opinion as to the proper broadest reasonable interpretation of the terms "accessory," "parison," "concave relief," "convex relief," and "counterform" each of which is recited in various claims of the '490 Patent.

16. The specification at 3:11-21 of the '490 Patent provides the following definition of the term "accessory": "Within the context of the invention, the term 'accessory' is understood to mean: any functional object or device which is generally

associated with the fuel tank in its usual mode of use or operation and which cooperates with the latter in order to fulfill certain useful functions; or a support for one or more such devices. Non-limiting examples of such devices are: liquid pumps, level gauges, delivery tubes, reservoirs or baffles internal to the fuel tank, ventilation devices (valves, pipes, etc.), electronic units and stiffening bars." Based on this definition, it is my opinion that the broadest reasonable interpretation of "accessory" is "any functional object or device which is generally associated with the fuel tank in its usual mode of use or operation and which cooperates with the latter in order to fulfil certain useful functions, or a support for one or more such devices."

17. The specification at 4:63-5:2 of the '490 Patent provides the following definition of the term "parison": "The moulding of fuel tanks generally starts with a parison. The term 'parison' is understood to mean a preform, generally extruded, which is intended to form the wall of the tank after being moulded to the required shape and dimensions." Based on this definition, it is my opinion that the broadest reasonable interpretation of "parison" is "a preform, generally extruded, which is intended to form the wall of the fuel tank after being molded to the required shape and dimensions."

18. The specification at 3:61-66 of the '490 Patent provides the following definition of the term "concave relief": "The term 'concave [relief]' is in fact understood to mean a hollow shape without a cover, the base of which is formed by

the part of the accessory surrounding the orifice or orifices and which is pointing towards the inside of the tank." This meaning of "concave relief" is therefore adopted.

19. The term "convex relief" is not formally defined but supported at Col. 6:4-8 of the specification of the '490 Patent: "This tool has, for this purpose, an excrescence (convex relief) firmly attached to the core and capable of cooperating with the concave relief present on (the fastening tab of) the accessory." This written description is consistent with how this term is used in the claims and so "convex relief" is understood as plain and ordinary meaning of a positive or outwardly projecting shape.

20. Claims 1 and 12 recite that the convex relief of the tool comprises a "counterform" that is used to mold an upper part of the rivet. The term "counterform" is not formally defined in the patent, nor does it have a specific meaning in the art. However, consistent with the claims, the specification at 6:1-11 states that the tool "generally comprises a counterform or hollow shape intended for moulding the upper part of the rivet (snap rivet).". Accordingly, the broadest reasonable interpretation of counterform is "a portion of the convex relief of the tool that is used to shape the top of the rivet".

B. Legal Standards for Patentability

21. I understand that in order for a patent to be valid, the invention must meet the requirements of novelty and nonobviousness, among other requirements.

22. I understand that a claim is invalid if it is anticipated or obvious.

23. I understand that anticipation of a claim requires that each and every limitation recited in a claim must be disclosed either expressly or inherently in a single prior art reference. I further understand that, to be considered anticipatory, a written prior art reference must be enabling and describe the applicant's claimed invention sufficiently to have placed it in possession of a person of ordinary skill in the field of the invention. Thus I further understand that the disclosure of prior art is considered from the perspective of one of ordinary skill in the art.

24. I understand that obviousness of a claim requires that the claim be obvious from the perspective of a person of ordinary skill in the relevant art at the time the invention was made. In analyzing obviousness, I understand that it is important to understand the scope of the claims, the scope and content of the prior art, the differences between the claims and the prior art, the level of ordinary skill in the relevant art, and any relevant secondary considerations. In determining whether the subject matter of a claim would have been obvious, one or more prior art references may be combined in order to encompass the claimed invention in such a

way that the combination of elements, features or limitations would have been obvious at the time the invention was made to one of ordinary skill in the art.

25. I understand that secondary considerations can include evidence of commercial success caused by an invention, evidence of a long-felt need that was solved by an invention, evidence that others copied an invention or evidence that an invention achieved a surprising result. I understand that such evidence must have a nexus, or causal relationship to the elements of a claim, in order to be relevant to the obviousness or non-obviousness of the claim.

C. One of Ordinary Skill In The Art

26. I understand that the application that led to the ‘490 Patent was filed on July 10, 2008, as U.S. application 12/668,186, claiming priority to PCT Application No. PCT/EP2008/059042. I understand that the ‘490 Patent purports to claim ultimate priority to a French application 07 56411 filed on July 11, 2007. I have therefore analyzed the validity of the ‘490 Patent as of that day or somewhat before, understanding that as time passes, the knowledge of a person of ordinary skill in the art (hereafter referred to a “POSITA”) will increase. In forming my opinion, I have relied on the ‘490 Patent, its claims and specification, its prosecution history, and my own experience and expertise of the knowledge of one of ordinary skill in the relevant art in this timeframe.

27. With respect to understanding and applying the claims of the ‘490 Patent, I believe one of ordinary skill would be a degreed Mechanical or Plastics engineer with three years of experience directly related to plastics product design and molding. Alternatively, I believe that a non-degreed practitioner with ten years of experience directly related to plastics product design and molding could also be considered one of ordinary skill in the art.

28. I believe that I would qualify as at least one of ordinary skill in the art in the relevant timeframe of the ‘490 Patent, and that I currently have a sufficient level of knowledge, experience and education to provide an expert opinion in the field of the ‘490 Patent. My testimony in this declaration is given from the perspective of one of ordinary skill in the art at the time of the July 11, 2007 priority date of the ‘490 Patent unless otherwise specifically indicated. This perspective is true even if the testimony is given in the present tense.

D. Materials Considered

29. In forming my opinion, I have considered my own knowledge and experience as well as the materials referred to in this declaration including:

- The ‘490 Patent, its claims, specification, and prosecution history (Exs. 1001 and 1002);

- U.S. Patent Pub. No. 2008/0006625 A1, filed on July 3, 2007, and claiming priority to a provisional application filed on July 6, 2006 (hereinafter referred to as “Borchert”, Ex. 1003);
- U.S. Patent No. 6,866,812 issued on March 15, 2005 (hereinafter referred to as “Van Schaftingen”, Ex. 1004);
- U.S. Patent No. 8,122,604, filed February 12, 2007, and claiming priority to foreign application filed on February 13, 2006 (hereinafter referred to as “Jannot”, Ex. 1005);
- U.S. Patent No. 6,699,413, issued March 2, 2004 (hereinafter referred to as “Kachnic”, Ex. 1006); and

E. Approach

30. All of the opinions provided in this report are: (a) based upon sufficient facts and data to allow me to reach the opinions contained in this report; (b) the product of reliable principles and methods; (c) a reliable application of those principles and methods to the facts of the case; and (d) based upon information of a type reasonably relied upon by experts in the arts applicable and analogous to the ‘490 Patent, including but not necessarily limited to technical dictionaries, technical descriptions, technical publications, product data sheets, schematics, patent specifications, and patent claims.

31. This report also considers the validity of the '490 Patent in light of the prior art listed above in Section II.D.

32. In order to reach the opinions set forth hereafter, I have reviewed the language of each claim of the '490 patent. For undefined terms within the challenged claims, I considered what a POSITA (previously defined in Section II.C) would understand the term to mean in light of the '490 Patent's claims, specification, and prosecution history and according to the ordinary knowledge and practices by one of ordinary skill in the art. I then reviewed the materials cited above and performed my own independent analysis of the '490 Patent's claim language and considered whether each claim element was expressly anticipated by the prior art or otherwise obvious given the understanding of one of ordinary skill.

33. I reserve the right to supplement or amend this Report if additional information becomes available.

III. THE '490 PATENT

A. Claims and Prosecution History

34. 24. I understand that the application that led to the '490 Patent was filed on July 10, 2008, as U.S. application 12/668,186 that claims priority from International Application No. PCT/EP2008/059042. I understand that the '490 Patent purports to claim ultimate priority to a French application 07 56411 filed on July 11, 2007. The '490 Patent claims a method for fastening an accessory to a wall

of a plastic fuel tank, this fastening taking place by snap-riveting using a tool at the same time as the tank is manufactured by molding. There are two independent claims, 1 and 12, each with depending claims.

35. Claim 1 claims a "method for fastening an accessory to a wall of a plastic fuel tank," with the method comprising two elements. One element (referred to hereafter as "1a") requires "fastening by snap-riveting using a tool, at the same time as said tank is manufactured by moulding with a mould, the accessory including at least one orifice through which the snap-riveting is carried out by material of the tank protruding from the orifice and being deformed to mould the rivet." A second element (referred to hereafter as "1b") requires the accessory to be provided, "the snap-riveting orifice is at least partially surrounded by a concave relief that protrudes towards an inside of the tank into which a convex relief of the tool presses in order to force the material through the orifice, the convex relief of the tool comprising a counterform to mould an upper part of the rivet." These elements are enumerated simply for identification and are not intended to denote any requirement for their relative order in the claimed method.

36. The dependent claims 2, 7-9, and 13-14 provide for specific features and methods that depend on claim 1. Claim 2 requires the method of claim 1 in which required snap riveting orifice to be "made in a fastening tab moulded as one part with the accessory or attached thereto." Claim 7 requires the method of claim 1 in

which the required tank is "blow-moulded from a parison that is made up of two separate parts obtained by extruding a single parison that is cut over an entire length along two diametrically opposed lines." Claim 8 requires the method of claim 1 in which the required moulding is "carried out using a mould comprising two cavities and a core which at least partly incorporates the snap-riveting tool, and wherein the accessory is fastened to an inner wall of the tank." Claim 9 requires the method of claim 1 in which the required core is "equipped with a camera allowing visual control of the snap riveting quality."

37. Independent Claim 12 requires method for fastening an accessory to a wall of a plastic fuel tank, comprising six elements. One element (hereafter referred to as "12a") requires "fastening by snap-riveting using a tool, at the same time as said tank is manufactured by moulding with a mould, the accessory including at least one orifice through which the snap-riveting is carried out by material of the tank protruding from the orifice and being deformed to mould the rivet." A second element (hereafter referred to as "12b") requires "wherein the snap-riveting orifice extends through a base portion of a concave relief formed in the accessory." A third element (hereafter referred to as "12c") requires "wherein the concave relief is formed by the base portion and a wall portion that protrudes away from the base portion towards an inside of the tank." A fourth element (hereafter referred to as "12d") requires "wherein an area of the base portion surrounds the orifice and faces

towards the inside of the tank." A fifth element (hereafter referred to as "12e") requires "wherein the wall portion at least partially surrounds the area of the base portion that surrounds the orifice such that the wall portion is spaced apart from the orifice by the area of the base portion that surrounds the orifice." A sixth element (hereafter referred to as "12f") requires "wherein a convex relief of the tool presses into the concave relief in order to force the material through the orifice, the convex relief of the tool comprising a counterform to mould an upper part of the rivet, which upper part contacts the area of the base portion that surrounds the orifice."

38. Dependent claims 13 and 14 provide for specific features and methods that depend on claim 1. Claim 13 requires the method of claim 1 in which the required concave relief is "sized and shaped to cooperate with the convex relief of the tool and to ensure correct positioning and self-centering of the convex relief of the tool." Claim 14 requires the method of claim 1 in which the required the concave relief includes "a substantially cylindrical wall that is substantially perpendicular to the wall of the tank."

39. In reading the file history of the '490 Patent, it is my understanding that the Examiner identified the contact surface 6 in Borchert as corresponding to a concave relief of the accessory, and the rivet head 5 in Borchert as corresponding to the convex relief of a tool. The Applicant correctly indicated that the contact surface 6 could not be the claimed concave relief because (1) the contact surface 6 does not

point towards the inside of the tank (as described in the specification and required by amended claims), and (2) the rivet head 5 as a convex relief of the tool does not press into it, as required by the claims. The Examiner later changed position and did not cite to Borchert in rejecting and then later accepting the issued claims. It is my opinion that Borchert is anticipatory prior art given features that were not analyzed by the Examiner.

IV. INVALIDITY ANALYSIS

Overview

40. I have reviewed the '490 Patent and related prior art in view of the knowledge of one of ordinary skill in the art. It is clear to me that this type of fastening method was well known in the prior art and there were many examples of such fastening methods that were used to provide accessories within fuel tanks. As set forth below it is my opinion that:

- Claims 1, 2, 8, 12, 13, and 14 are anticipated by Borchert.
- Claim 7 is rendered obvious by Borchert in view of knowledge of a POSITA.
- Claim 7 is rendered obvious by Borchert in view of Van Schaftingen.
- Claim 2 is obvious to a POSITA given Borchert in view of Jannot.
- Claim 9 is obvious to a POSITA given Borchert in view of Kachnic.

Claim 1, preamble) A method for fastening an accessory to a wall of a plastic fuel tank, comprising:

41. As stated at ¶0008, Borchert is directed at "secur[ing] fixing of built-in fitment components in the hollow body in the course of the production thereof." A POSITA would understand that Borchert's "built-in fitment components" correspond to the "accessories" required by this claim element. Borchert provides a specific example of attaching a surge pot (an accessory under the broadest reasonable interpretation) in a fuel tank. Borchert's abstract states: "The invention concerns a process for the production of an article enclosing built-in fitment components in the form of a hollow body of thermoplastic material. The hollow body is preferably in the form of a fuel tank." A POSITA would thereby understand that Borchert provides a process (method) for attaching a fitment component (accessory) to a hollow body (fuel tank) made of a thermoplastic material (plastic).

42. Borchert at ¶0028 states: "The built-in fitment component 1 shown in FIG. 1 is pressed with its foot element 2 against the wall 4 of the hollow body to be produced, more specifically when the plastic material of the wall 4 is still or again in the plastic state. In the production process described hereinafter, the join is made in the first heat in production of the hollow body so that the material of the wall 4 is still in the molten state and, when sufficient pressure is applied to the foot element 2 in the direction of the arrow shown at the right in FIG. 1, the material of the wall forms the head 5 shown in FIG. 2, which engages behind the through opening 3 in

the fitment component 1." A POSITA would thereby understand that Borchert's process attaches the accessory to the wall of the plastic fuel tank as shown in FIGS. 1 and 2 and described in the specification.

43. As indicated in the preceding two paragraphs, Borchert discloses "a method for fastening an accessory to a wall of a plastic fuel tank."

Claim 1a) fastening by snap-riveting using a tool, at the same time as said tank is manufactured by moulding with a mould, the accessory including at least one orifice through which the snap-riveting is carried out by material of the tank protruding from the orifice and being deformed to mould the rivet,

44. Borchert teaches using a tool to snap-rivet the accessory to the tank "at the same time as said tank is manufactured by moulding with a mould." Borchert at ¶0010 states "wherein the built-in fitment component is pressed during or directly after the shaping operation against the inside wall of the article while still plastic so that the plastic material of the hollow body penetrates through at least one recess or opening of the built-in fitment component and flows therebehind." Borchert at ¶0015 states "Desirably two preforms in web form are extruded between the opened halves of a two-part blow molding mold, wherein the mold halves are firstly closed against a fitment carrier frame arranged between them, arranged with the fitment carrier frame are means for the positioning of the built-in fitment components, with which the built-in fitment component is pressed out of the plane of the frame against the inside wall of the article. . ." The "fitment carrier frame" as described above includes

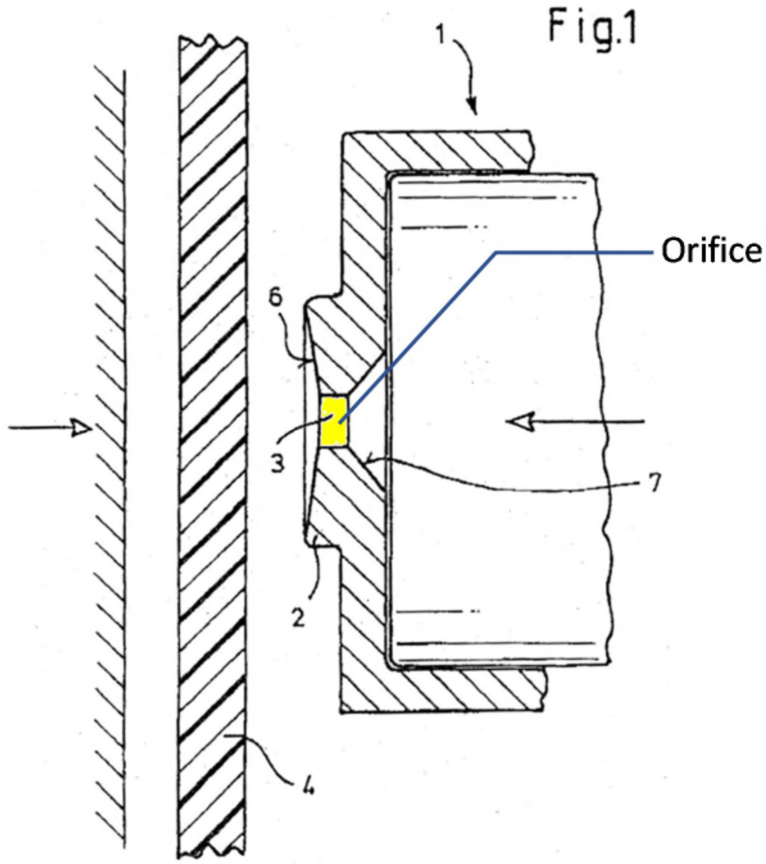
the means (i.e., a tool used for the snap-riveting) to press the accessory against the wall of the tank.

45. Figures 1 and 2 of Borchert highlight an orifice in the accessory, through which snap-riveting is carried out and the rivet formed by deforming the material of the tank protruding from orifice. Borchert further describes the process by which the rivet is formed.

46. Borchert at ¶0032 states: "The process according to the invention includes the production of the article 8 in the form of a fuel tank by extrusion blow molding." From this citation and the previously recited Borchert ¶0010, a POSITA would understand that Borchert provides fastening of the accessory at the required "same time as said tank is manufactured by moulding with a mould".

47. Borchert at ¶0028 states: "The built-in fitment component 1 shown in FIG. 1 is pressed with its foot element 2 against the wall 4 of the hollow body to be produced, more specifically when the plastic material of the wall 4 is still or again in the plastic state. In the production process described hereinafter, the join is made in the first heat in production of the hollow body so that the material of the wall 4 is still in the molten state and, when sufficient pressure is applied to the foot element 2 in the direction of the arrow shown at the right in FIG. 1, the material of the wall forms the head 5 shown in FIG. 2, which engages behind the through opening 3 in the fitment component 1. The through opening 3 is preferably in the form of a

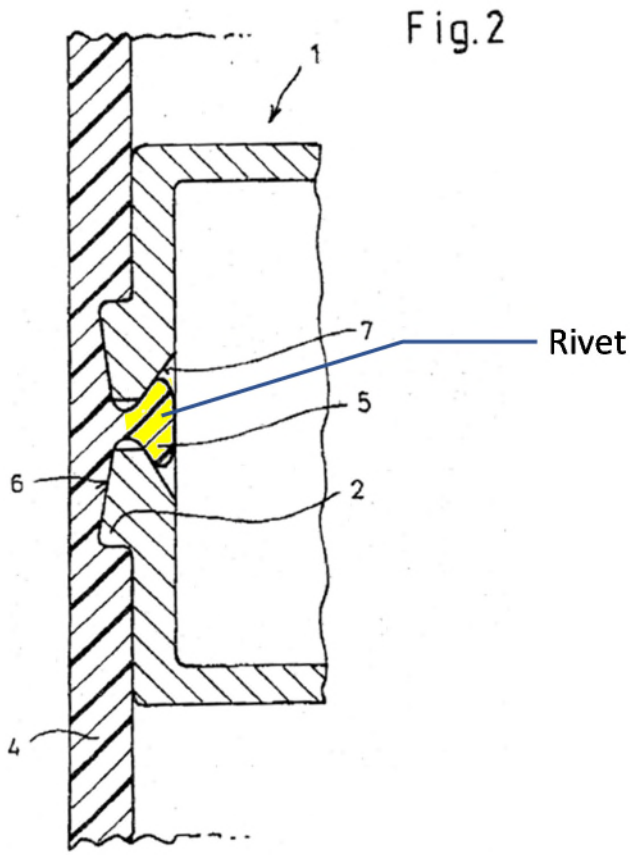
circular round bore which is beveled or undercut at its end remote from the wall 4." Kazmer-1 provides a demonstrative of Borchert Fig. 1 with the opening (3) highlighted in yellow that a POSITA would understand to be the required orifice.



Kazmer-1: FIG. 1 of Borchert showing opening 3 (orifice)

48. Borchert at ¶0012 states: "Due to the configuration of the opening of the fitment component, the material of the wall of the hollow body, which flows through that opening into the fitment component, preferably constitutes a head which holds the join similarly to a rivet head." Kazmer-2 provides a demonstrative of Borchert Fig. 2 with the rivet head highlighted in yellow that a POSITA would understand to be the required rivet. A POSITA would understand that Borchert

provides the required "snap-riveting is carried out by material of the tank protruding from the orifice and being deformed to mould the rivet".

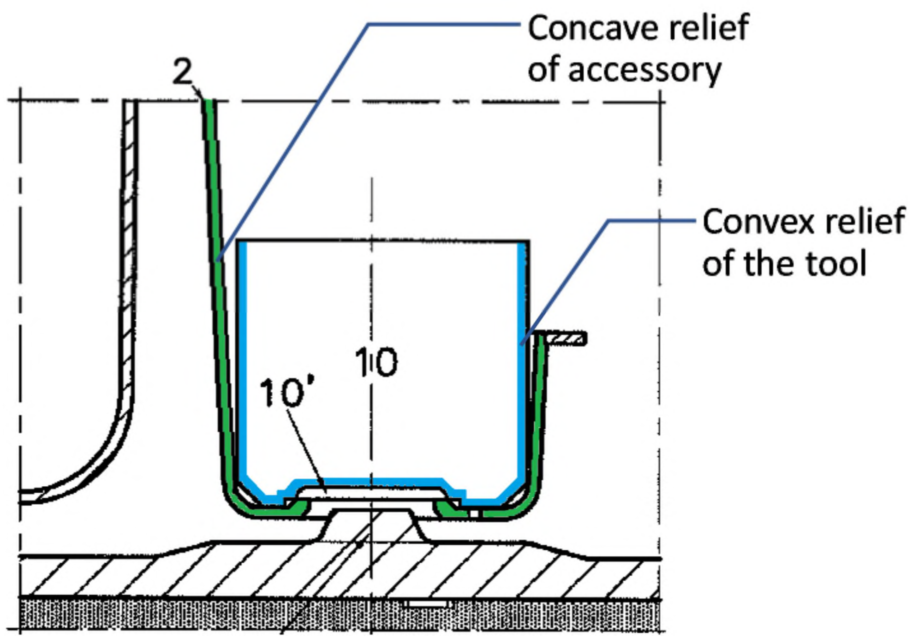


Kazmer-2: FIG. 2 of Borchert showing rivet head (rivet)

49. As described in the foregoing paragraphs, a POSITA would understand that Borchert provides the required "fastening by snap-riveting using a tool, at the same time as said tank is manufactured by moulding with a mould, the accessory including at least one orifice through which the snap-riveting is carried out by material of the tank protruding from the orifice and being deformed to mould the rivet."

Claim 1b) wherein the snap-riveting orifice is at least partially surrounded by a concave relief that protrudes towards an inside of the tank into which a convex relief of the tool presses in order to force the material through the orifice, the convex relief of the tool comprising a counterform to mould an upper part of the rivet.

50. Borchert provides an accessory that includes a concave relief surrounding the orifice that protrudes towards an inside of the tank. FIG. 1 also shows a tool with a convex relief that presses into the concave relief of the accessory in order to force the material through the orifice Borchert's design provides the teaching of a convex relief of the tool engaging a concave relief in an accessory as in the '490 Patent demonstrated in Figure Kazmer-3.

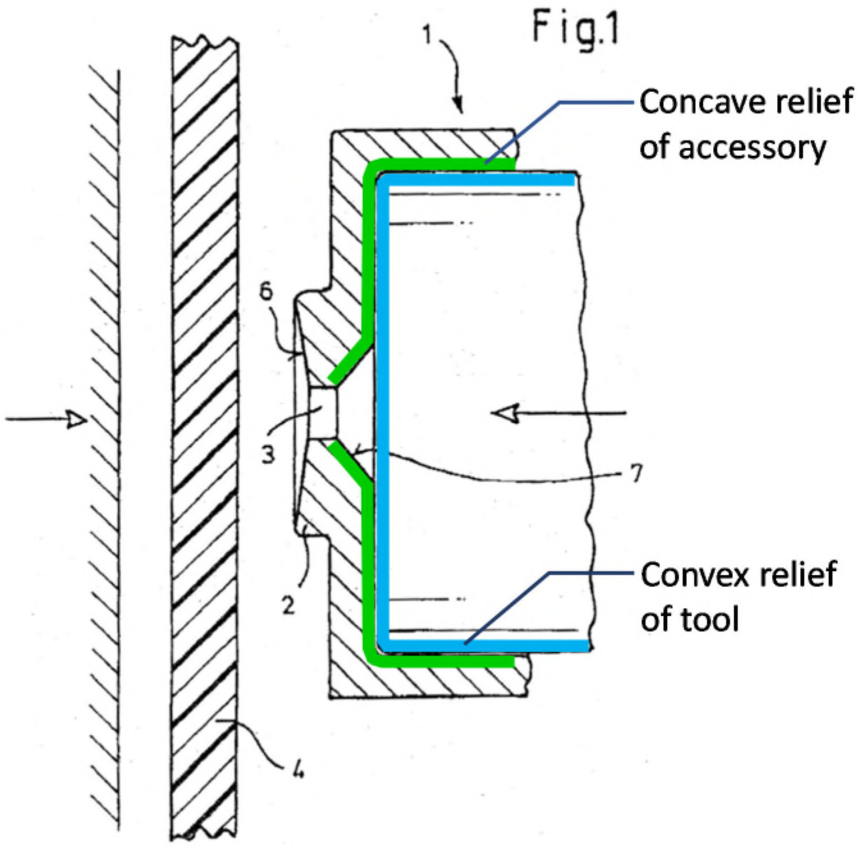


Kazmer-3: FIG. 3 of the '490 Patent showing the convex relief of the tool (colored blue) engaging a concave relief in an accessory (colored green)

51. A POSITA would understand that Borchert also provides the convex relief tool presses into the convex relief of the accessory to force material from the

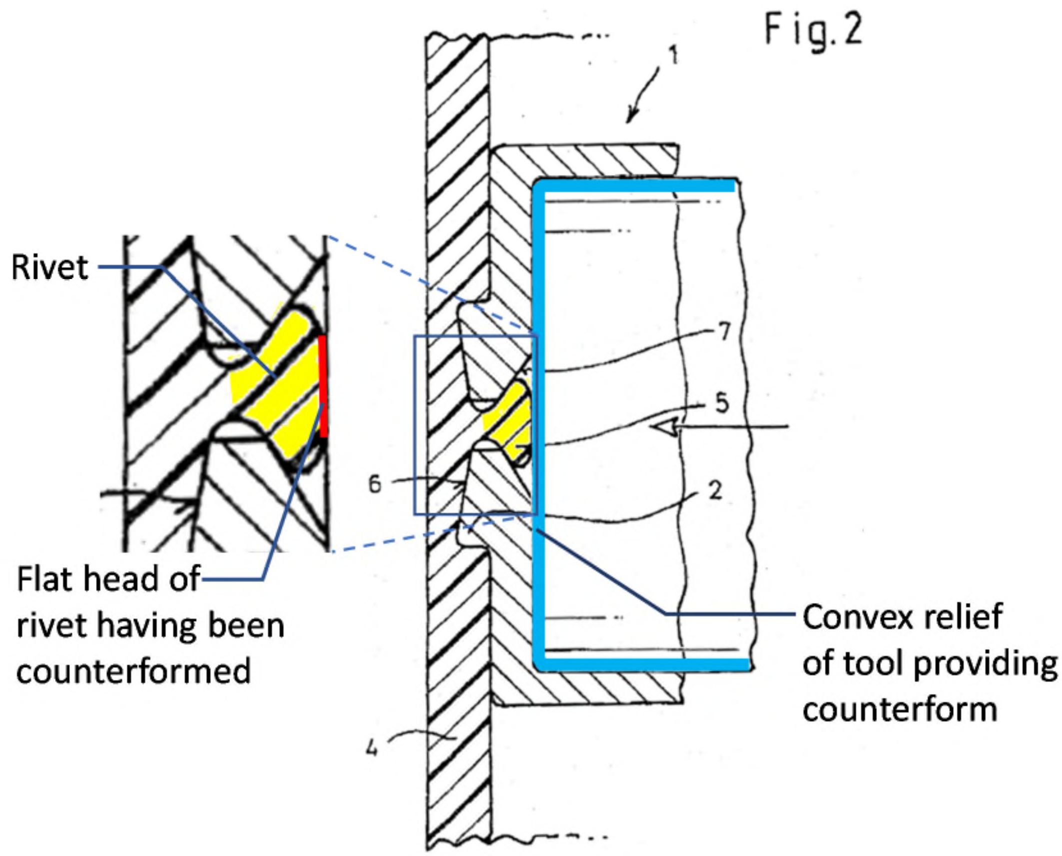
wall of the tank through the orifice. Borchert at ¶0028 states: "The built-in fitment component 1 shown in FIG. 1 is pressed with its foot element 2 against the wall 4 of the hollow body to be produced, more specifically when the plastic material of the wall 4 is still or again in the plastic state. In the production process described hereinafter, the join is made in the first heat in production of the hollow body so that the material of the wall 4 is still in the molten state and, when sufficient pressure is applied to the foot element 2 in the direction of the arrow shown at the right in FIG. 1, the material of the wall forms the head 5 shown in FIG. 2, which engages behind the through opening 3 in the fitment component 1. The through opening 3 is preferably in the form of a circular round bore which is beveled or undercut at its end remote from the wall 4."

52. Kazmer-4 provides a demonstrative of Borchert Fig. 1. A POSITA would understand that Borchert provides a concave relief surrounding the orifice that protrudes towards an inside of the tank (highlighted in green). As indicated in Kazmer-4, a POSITA would understand that Borchert provides a convex relief (i.e. excrescence at 6:4 of the '490 specification) of the tool highlighted in blue.



Kazmer-4: FIG. 1 of Borchert showing the convex relief in the tool (colored blue) engaging the concave relief in an accessory (colored green)

53. The convex relief of the tool also functions as a counterform that presses upon and molds an upper part of the rivet. FIG. 2, highlighted and enlarged below in demonstrative Kazmer-5, illustrates how the rivet (colored yellow) is molded by the counterform of the convex relief tool (colored blue) to form a flat head (colored red) that is level with the interior surface of the accessory. As shown, the upper part of rivet head 5 is flat and level with the interior surface of the accessory because it has been formed by the tool pressed into the accessory. A POSITA would thus understand that the convex relief of the tool in Borchert comprises a counterform that molds the upper part of the rivet.



Kazmer-5: Demonstrative of FIG. 2 of Borchert showing rivet (yellow) with flat head (red) counterformed by the convex relief in the tool (blue)

54. For the reasons set forth above, a POSITA would understand that Borchert provides the required "snap-riveting orifice is at least partially surrounded by a concave relief that protrudes towards an inside of the tank into which a convex relief of the tool presses in order to force the material through the orifice, the convex relief of the tool comprising a counterform to mould an upper part of the rivet."

2. The method according to claim 1, wherein the snap-riveting orifice is made in a fastening tab moulded as one part with the accessory or attached thereto.

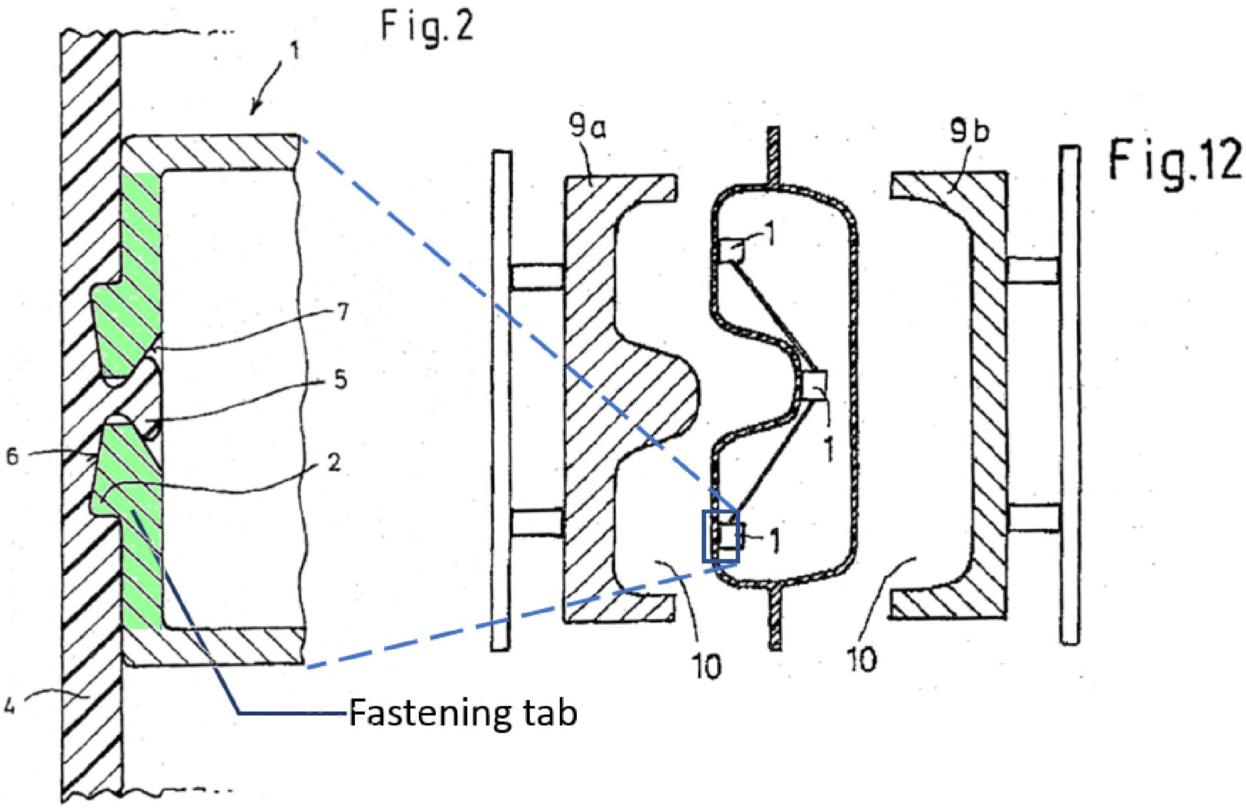
55. Borchert teaches that the snap-riveting orifice is preferably formed in a "foot element," which a POSITA would understand corresponds to the claimed

fastening tab. Borchert at ¶0019 states "In accordance with a preferred variant of the plastic hollow body according to the invention it is provided that the built-in fitment component has at least one foot element which forms a stepped or shouldered contact surface with the wall of the hollow body. In that way the pressure in relation to area against the wall of the hollow body is increased in the region of the contact surface, with the pressing force remaining the same. The foot element or elements produce a ram-like action which boosts the flow of the thermoplastic material of the wall of the hollow body into the through opening. Desirably the through opening passes through the contact surface of the foot element."

56. As can be seen from FIG. 1, the foot element is formed as part of the accessory. Borchert describes an embodiment at ¶0026: "As shown in greatly simplified form in FIGS. 1 and 2 the built-in fitment component 1 which is shown in section has a foot element 2 with a through opening 3."

57. Kazmer-6 provides a demonstrative of Borchert FIG. 2 as a detail to the larger fuel tank shown in Borchert FIG. 12. A POSITA would understand that the foot element provides a fastening tab with the snap-riveting orifice. Specifically, a POSITA would understand that the fitment component 1 itself may be a fastener or a fastening tab with the snap-riveting orifice. A POSITA would understand that multiple fitment components 1 may be used to locate and secure a larger assembly or accessory. For example, Borchert at ¶0033 states "In the present case the fitment

components 1 are connected together by way of a conduit (no identified in greater detail).” A POSITA would thus understand that the diagonal lines connecting the fitment components 1 in FIG. 12 are conduits attached to the inside wall of the tank by the fitment components 1.

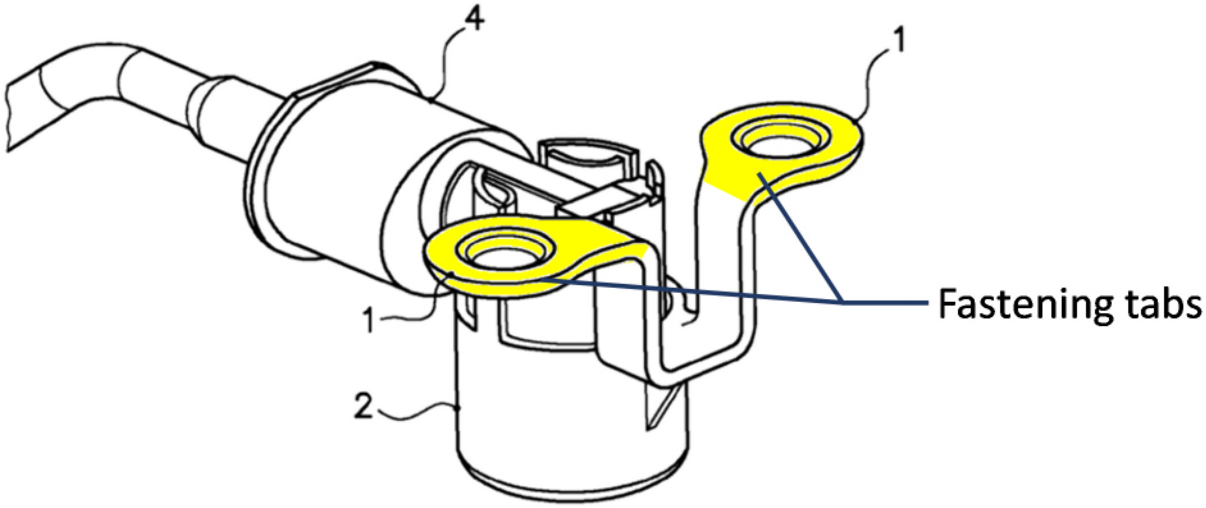


Kazmer-6: FIG. 2 and FIG. 12 of Borchert showing fastening tab (light green)

58. For the reasons set forth above, a POSITA would understand that Borchert provides the required “method according to claim 1, wherein the snap-riveting orifice is made in a fastening tab moulded as one part with the accessory or attached thereto”.

59. To the extent that the PTAB finds that Borchert's foot element is not a fastening tab, claim 2 is rendered obvious in further view of Jannot. The reason is that Jannot at 3:55-65 discloses the snap-riveting orifice made in a fastening tab molded as one part with the accessory or attached thereto: "According to the invention, at least one of the two points for fastening the accessory is provided with a fastening part. By this is meant both an additional part, attached to the accessory, and an excrescence moulded as one part with the accessory. This may be a fastening tab (i.e. an excrescence on its overall envelope) moulded as one part with the accessory or attached thereto." A POSITA would thereby understand that Jannot explicitly teaches snap-riveting using a "fastening tab (i.e. an excrescence on its overall envelope) moulded as one part with the accessory or attached thereto."

60. Jannot at 4:52-57 further describes one embodiment where the tabs are flexible: "An accessory (2) that may be suitable within the context of the invention is also illustrated in FIG. 5. This accessory (2) is a support for a valve (4) and it comprises two flexible tabs (1), which are moulded as one piece with it and each is provided with an orifice (for snap-riveting, but also other types of riveting, etc.)." As described and shown in FIG. 5, Jannot's fastening tabs 1 (highlighted in yellow in demonstrative Kazmer-7) each include a snap-riveting orifice.



Kazmer-7: FIG. 5 of Jannot showing fastening tabs 1 (yellow)

61. It would have been obvious to a POSITA to combine the teachings of Borchert with those of Jannot to make the invention of claim 2. A POSITA would consider Borchert and Jannot as analogous art since they both involve blow molding of vehicle fuel tanks and riveting accessories to the tank interior. *See* Jannot at 5:4-7, 5:61-6:6. A POSITA would have been motivated to use Jannot's flexible fastening tab, molded as one part with the accessory, with Borchert at least to achieve the benefits disclosed in Jannot of mitigating stresses caused by differential shrinkage of the tank and accessory after molding. *See* Jannot at 4:58-62. Specifically, a POSITA would have been motivated to combine Borchert with the flexible fastening tab disclosed in Jannot at least to achieve the benefits disclosed in Jannot at 4:58-62 to "compensate for the post-moulding shrinkage which, in the case of HDPE tanks, is about 3%." In the combination, a POSITA would have been motivated to use

Borchert's snap-riveting tool with a convex relief to press into the concave relief of Jannot's fastening tab to provide the manufacturing benefits of Borchert.

62. As described above, a POSITA would understand that Borchert in view of Jannot renders obvious the limitations recited in claim 2.

Claim 7. The method according to claim 1, wherein the tank is blow-moulded from a parison that is made up of two separate parts obtained by extruding a single parison that is cut over an entire length along two diametrically opposed lines.

63. Claim 7 depends on claim 1. For the reasons stated above for claim 1, Borchert expressly discloses each limitation of claim 1. A POSITA would understand that the additional limitation of claim 7 is obvious in view of Borchert alone or from Borchert in view of Van Schaftingen.

64. Borchert discloses that the tank may be blow-molded from a parison that is made up of two separate parts obtained by extruding a single parison that is cut over an entire length. Borchert at ¶0003 states "A very wide range of different production processes are known for the production of hollow bodies of thermoplastic material, for example extrusion blow molding, deep drawing or injection molding. In the extrusion blow molding process the hollow body can be seamlessly produced for example from a single tubular preform. It will be noted that there is also the possibility of dividing up a tubular preform in respect of length into webs, placing the webs separately in a two-part or multi-part tool and expanding or shaping the webs within the tool by means of a reduced pressure or by the action of gas pressure."

A POSITA would thus understand that Borchert discloses the required limitation that “a parison that is made up of two separate parts obtained by extruding a single parison that is cut over an entire length”.

65. While Borchert does not explicitly disclose cutting “along two diametrically opposed lines”, a POSITA would understand that such cutting is implied by or at least obvious from Borchert’s provided embodiments. Specifically, FIGS. 3-12 provide a diagrammed view of the process and formed tank. A POSITA would understand that the two separate parts are used to mold the two sides of the tank. Since the two sides of the tank are the same width, they would normally be molded from parison portions that are the same width. Accordingly, it would be obvious to a POSITA to cut the parison “along two diametrically opposed lines” to obtain to equal portions.

66. For the reasons set forth above, a POSITA would understand that Borchert renders obvious the required “method according to claim 1, wherein the tank is blow-moulded from a parison that is made up of two separate parts obtained by extruding a single parison that is cut over an entire length along two diametrically opposed lines.”

67. Cutting the parison along two diametrically opposed lines is also obvious in light of Van Schaftingen, which expressly teaches blow-molding a tank from a parison that is made up of two separate parts obtained by extruding a single

parison that is cut over an entire length along two diametrically opposed lines. Specifically, Van Schaftingen at Col. 3:9-23 states: "Preferably, the parison is cut longitudinally, along a generatrix of the latter. In this case, it is particularly advantageous that this cut be made in the direction of flow of the parison. One particularly preferred technique is that in which the parison is cut twice over its entire length, that is to say along two separate lines, so as to produce two separate sheets. Cutting along two parallel generatrices is very particularly preferred."

68. A POSITA would be motivated to split the parison to reduce machinery and processing costs associated with multiple extruders and extrusion dies, as well as potential quality gains associated with maintaining consistent material and geometric properties of a single parison rather than two parisons or sheets. A POSITA would also be motivated to cut the parison along two diametrically opposed lines to obtain sheets of equal width for use in Borchert's equal-width mold halves 9a and 9b, and because, as taught by Van Schaftingen, such cuts are "very particularly preferred." Accordingly, it would be obvious for a POSITA to combine Borchert's "dividing up a tubular preform" with the parison cutting methods disclosed by Van Schaftingen to provide the required "cut over an entire length along two diametrically opposed lines."

69. Accordingly, this element is obvious in light of Borchert alone or from Borchert in view of Van Schaftingen.

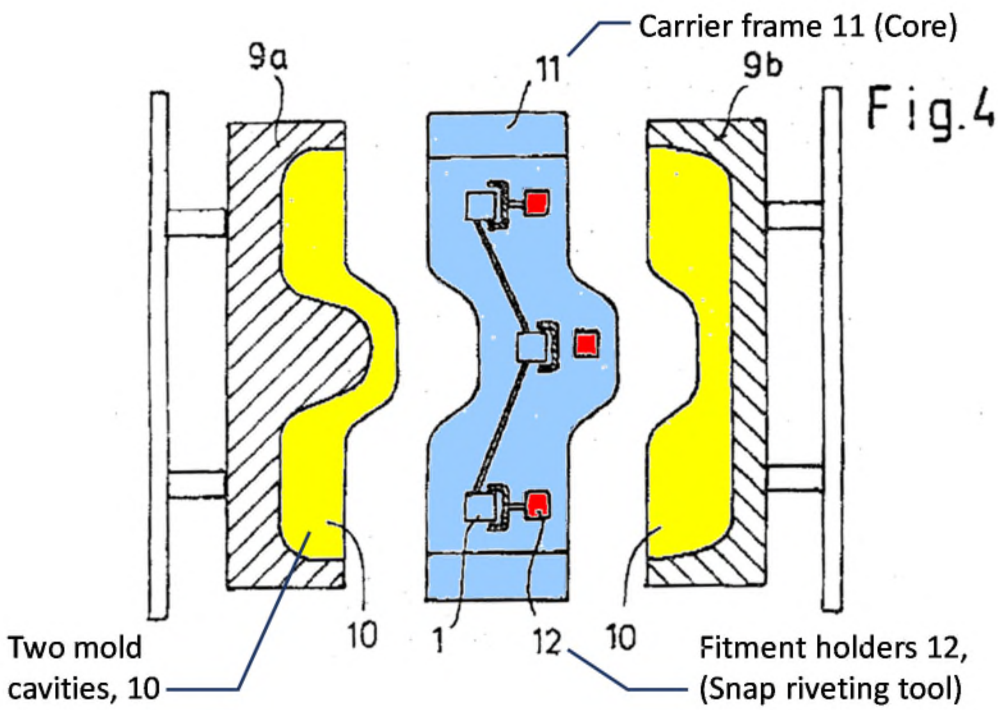
Claim 8. The method according to claim 1, wherein the moulding is carried out using a mould comprising two cavities and a core which at least partly incorporates the snap-riveting tool, and wherein the accessory is fastened to an inner wall of the tank.

70. Borchert discloses the moulding of the tank is carried out using a mould comprising two cavities and a core which at least partly incorporates the snap-riveting tool, and wherein the accessory is fastened to an inner wall of the tank.

71. Borchert at ¶0033 states "The mold tool comprises two mold halves 9a, 9b which are of a mutually complementary configuration and which in the closed condition define a mold cavity 10 which determines the external configuration of the article 8 to be finished. Placed between the mold halves 9a, 9b is a fitment carrier frame 11 which is arranged displaceably between the mold halves 9a, 9b. Fitment component holders 12 are arranged variably in position within the fitment carrier frame 11. The holders 12 are displaceable or movable within the fitment carrier frame 11 hydraulically or pneumatically in the plane of the fitment carrier frame and transversely relative thereto. As shown in FIG. 4 the holders 12 are equipped with fitment components 1. In the present case the fitment components 1 are connected together by way of a conduit (no identified in greater detail). Each of the fitment components is approximately of the configuration shown in FIGS. 1 and 2."

72. Kazmer-8 provides a demonstrative of Borchert FIG. 4. A POSITA would understand that Borchert's two "mold halves 9a, 9b" each have a "mold cavity 10" that provide the two cavities (colored yellow in Fig. Kazmer-8 below) required

by this claim. Borchert's "fitment carrier frame 11" (colored blue in Fig. Kazmer-8) provides the required "core which at least partly incorporates the snap-riveting tool", and that Borchert's "fitment component holders 12" (colored red in Kazmer-8) provide the required "snap-riveting tool".



Kazmer-8: FIG. 4 of Borchert showing two mold cavities (colored yellow), carrier frame 11 (mold core, colored blue), and fitment component holders 12 (snap-riveting tool, colored red)

73. Borchert at ¶0037 states: "The component holders 12 then move out of the plane of the frame and press the fitment components 1 against the wall 4 of the article 8 or against the preforms which are bearing against the mold cavity 10. (See FIG. 7.) The above-described anchorage of the fitment components 1 to the wall 4 of the article 8 takes place accordingly." Reading this written description in view of

FIG. 7 of Borchert, a POSITA would understand that Borchert provides the required "accessory is fastened to an inner wall of the tank."

Claim 9. The method according to claim 8, wherein the core is equipped with a camera allowing visual control of the snap-riveting quality.

74. Claim 9 depends from claims 1 and 8. For the reasons stated above for claims 1 and 8, Borchert expressly discloses each limitations of claims 1 and 8. A POSITA would understand that Claim 9 is obvious over Borchert in view of Kachnic.

75. Although Borchert teaches "a core which at least partly incorporates the snap-riveting tool" as required by claim 8, it does not disclose that the core is "equipped with a camera allowing visual control of the snap-riveting quality." However, this claim limitation is rendered obvious by Borchert in view of Kachnic. The reason is that Kachnic at 3:57-61 discloses a blow molding system equipped with a camera that can be mounted at various locations within the mold for visual control of the quality of the molded parts: "According to its major aspects and broadly stated, the present invention is a part-forming machine having an in-mold integrated vision sensor and method therefor for verifying the presence, absence and quality of molded parts therein." Although the detailed embodiments described in Kachnic are for an injection molding system, Kachnic at 10:58-61 teaches that its "in-mold sensor system may be utilized with any part-forming machine (*id*.), and

identifies "extrusion blow molding" as an exemplary method of the objective of "forming a part via a mold" described at 1:30-35.

76. Kachnic discloses an electronic camera (sensor device 330) that may be placed inside the mold. Kachnic, at 8:14-57, describes some embodiments: "However, it should be noted that in alternate embodiments image capture source 310 may be positioned at various locations within the mold such that various parts or specific areas of parts may be imaged at a substantially parallel angle. It is also contemplated that any number of image capture sources 310 may be positioned at various positions within the mold to increase resolution and/or to improve the image analysis process. Image capture source 310 is, preferably, a coherent fiber optic bundle, wherein light waves and/or radiation can be captured thereby and allowed to travel therethrough to sensor device 330 via linking member 320. Linking member 320 is also preferably coherent fiber optic bundles. The coherent fiber optic bundles allow the image of the mold half 16 and/or part 22 to be viewed remotely by sensor device 330, thus preventing the sensor device from being exposed to the high temperatures of the mold. Preferably the sensor device 330 is positioned on the exterior of the mold half 14; however, in alternate embodiments, the sensor device 330 may be positioned at a further remote location or within one of the mold halves 14, 16 at a lower temperature point from the part-forming area such that the sensor device 330 is not damaged by the high temperatures. It is also contemplated that the

sensor device 330 may be thermally insulated and/or have various known heat removal systems to protect the sensor device 330 and thus allow it to be positioned within the mold. The sensor device 330 is preferably a charge coupled device (CCD) array electronic camera. However, in alternate embodiments, the sensor device 330 may be any sensing device such as, for exemplary purposes only, an infrared or near infrared camera or infrared heat sensor. In the preferred embodiment, the analyzing means 340 receives an electronic representation of the acquired image from the sensor device 330, analyzes said image and communicates the presence or absence of molded parts within the mold 12 to the part-forming machine controller 72. Given known parameters, one skilled in the art would be able to develop software for analyzing the images of the mold 12. The analyzing means 340 is preferably integrated with the part-forming machine controller 72; however, a separate controller/computer may be utilized that is communicationally linked with the part-forming machine controller 72." A POSITA would understand that in this embodiment the image capture source is an extension of the camera because it enables the camera to capture an image.

77. It would have been obvious for a POSITA to combine the teachings of Borchert with those of Kachnic to provide the required "camera allowing visual control of the snap-riveting quality." With regard to motivation to combine, Borchert and Kachnic are analogous art since they are directed to the same technical field of

blow molding plastic articles. Furthermore, a POSITA would have been motivated to combine Borchert with the camera system disclosed in Kachnic at least to achieve the benefits disclosed in Kachnic of being able to verify the presence, absence, and quality of the molded parts (e.g., Kachnic at 3:57-61).

78. Although Kachnic does not specifically disclose attaching the camera to a core, when combining Kachnic's in-mold vision sensor with Borchert's extrusion blow molding process, Kachnic at 8:30-36 teaches placing the camera within one of the mold halves, facing the other mold half: "the sensor device 330 may be positioned at a further remote location or within one of the mold hales 14, 16"). Kachnic at 8:9-14 also teaches "Image capture source 310 is positioned preferably at the center of mold half 14 facing to the surface of mold half 16 such that mold half 16 and any parts therein are generally at an approximately parallel angle relative to the image capture source 310." Because Borchert's core is placed between the mold halves, it would be obvious for a POSITA to place the camera(s) on the core to capture images showing the quality of the molded parts as taught by Kachnic. Otherwise, the core itself would block the camera's view of the molded parts.

79. As described above, Kachnic at 3:57-61 teaches that one use of its in-mold camera is to visually verify the quality of the molded parts. It would be obvious that when Kachnic's in mold camera is used with Borchert's blow molding process,

this could include the quality of the snap-riveting. Thus, a POSITA would understand that Borchert in view of Kachnic renders the limitations recited in claim 9 obvious.

Claim 12. A method for fastening an accessory to a wall of a plastic fuel tank, comprising:

80. Borchert teaches this element for the same reasons stated above for claim 1-preamble.

Claim 12a. fastening by snap-riveting using a tool, at the same time as said tank is manufactured by moulding with a mould, the accessory including at least one orifice through which the snap-riveting is carried out by material of the tank protruding from the orifice and being deformed to mould the rivet,

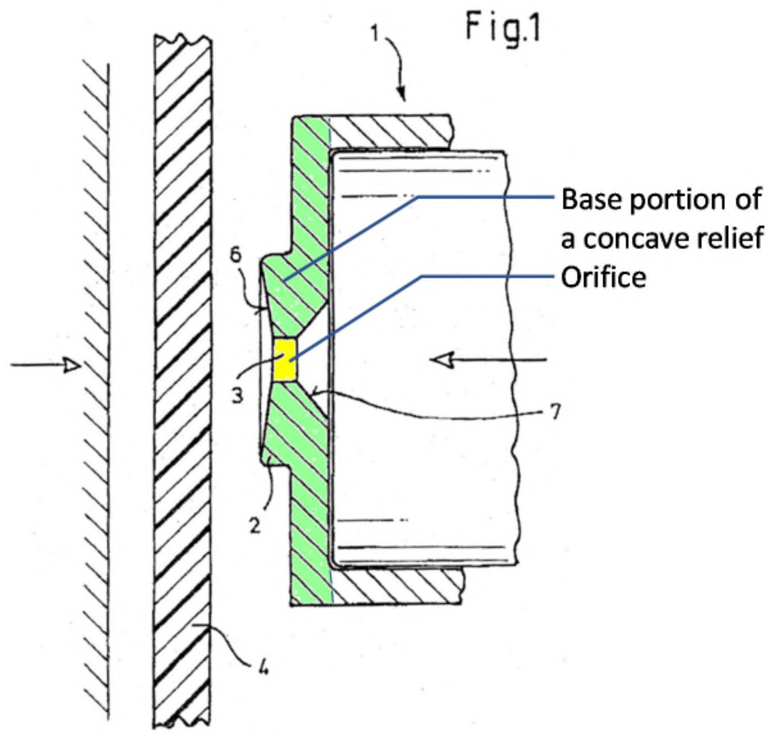
81. Borchert teaches this limitation element for the same reasons stated above for claim limitation 1-a.

Claim 12b. wherein the snap-riveting orifice extends through a base portion of a concave relief formed in the accessory,

82. FIG. 1 and 2 of Borchert shows a built-in fitment component 1 (the accessory) with an opening 3 (the snap-riveting orifice) that extends through a foot element 2.

83. Borchert at ¶0026 states "As shown in greatly simplified form in FIGS. 1 and 2 the built-in fitment component 1 which is shown in section has a foot element 2 with a through opening 3." The concave relief formed in the accessory is colored green in Kazmer-4 above for claim element 1-b. The bottom part of this concave relief corresponds to the required "base portion of a concave relief formed in the

accessory" as highlighted in light green in Kazmer-9, below, which also shows orifice 3 extending through the base portion, highlighted in yellow. Accordingly, a POSITA would understands that Borchert provides every required limitation of this claim element.



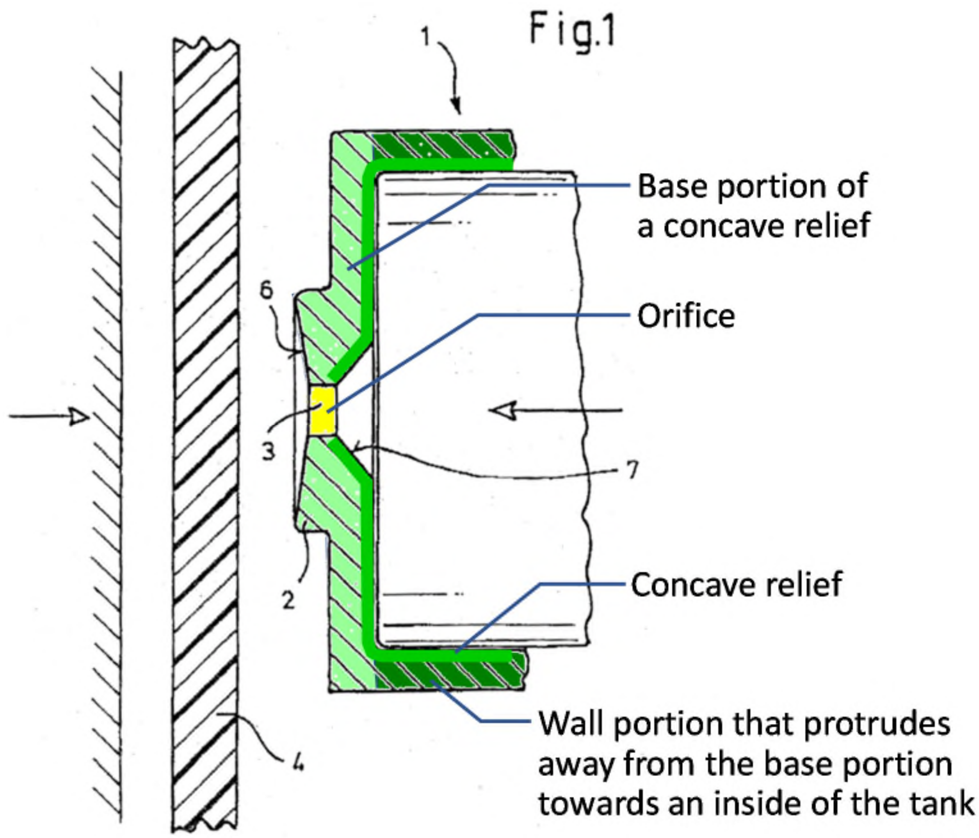
Kazmer-9: FIG. 1 of Borchert showing orifice (yellow) through base portion of concave relief (light green)

Claim 12c. wherein the concave relief is formed by the base portion and a wall portion that protrudes away from the base portion towards an inside of the tank,

84. A POSITA would understand that Borchert FIG. 1 provides the concave relief formed by the base portion and a wall portion that protrudes away from the base portion towards an inside of the tank. Kazmer-10 provides a demonstrative of

Borchert FIG. 1. Below, the "concave relief" is colored green, the base portion is colored light green, and a wall portion is colored dark green.

85. As can be seen in Fig. Kazmer-10, the "wall portion" of the concave relief "protrudes away from the base portion towards an inside of the tank" (i.e., away from the wall (4) of the tank) as required. Thus, a POSITA would understand that Borchert provides every limitation of this claim element.



Kazmer-10: FIG. 1 of Borchert showing the concave relief (green) is formed by the base portion (light green) and a wall portion (dark green) that protrudes away from the base portion towards an inside of the tank

Claim 12d. wherein an area of the base portion surrounds the orifice and faces towards the inside of the tank

86. Figure Kazmer-10 above also shows that an area of the base portion (colored light green) surrounds the orifice (colored yellow) and faces towards the inside of the tank (i.e., away from the wall (4) of the tank). A POSITA would understand from the specification that "faces towards" means "pointing towards": "The term 'concave' is in fact understood to mean a hollow shape without a cover, the base of which is formed by the part of the accessory surrounding the orifice or orifices and which is pointing towards the inside of the tank." At least one area of the base portion surrounding the orifice faces in the direction of the concave relief (colored green) that is pointing towards the inside of the tank. A POSITA would thus understand that Borchert provides the required "base portion surrounds the orifice and faces towards the inside of the tank."

Claim 12e. wherein the wall portion at least partially surrounds the area of the base portion that surrounds the orifice such that the wall portion is spaced apart from the orifice by the area of the base portion that surrounds the orifice, and

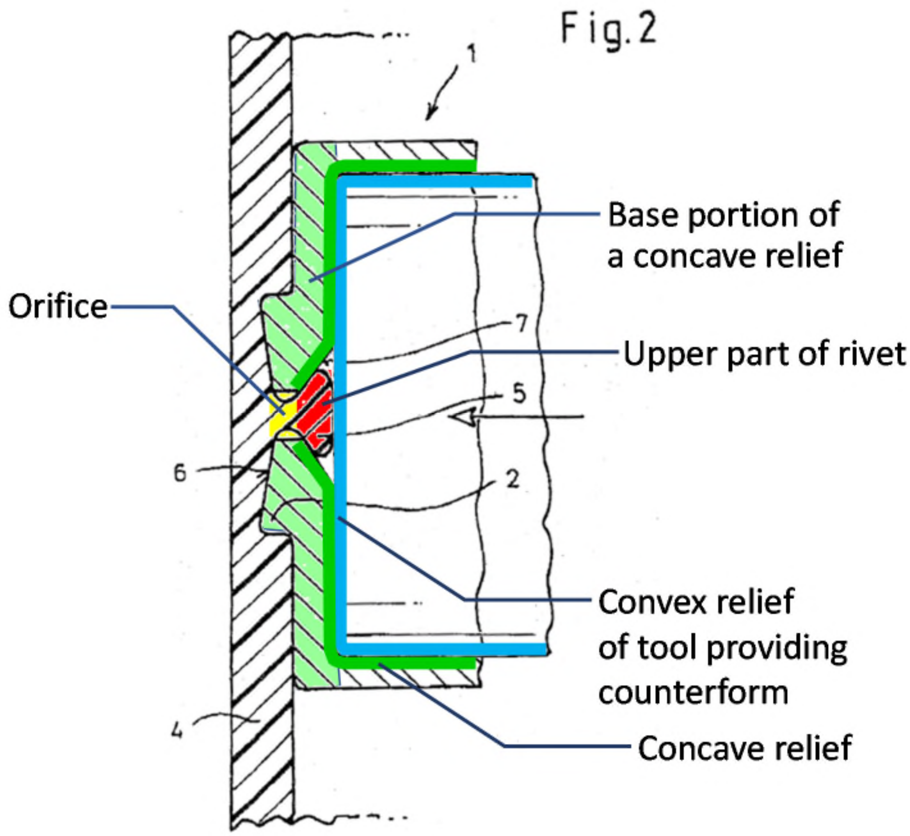
87. Figure Kazmer-10 also shows that the wall portion (dark green) at least partially surrounds the area of the base portion (light green) that surrounds the orifice (yellow). As described below for claim 14, a POSITA would understand that the wall portion of the concave relief is substantially cylindrical and thus at least partially surrounds the base portion and the orifice. As can be seen from FIG. 1, the

wall portion (dark green) is spaced apart from the orifice (yellow) by the area of the base portion (light green) that surrounds the orifice.

88. Accordingly, a POSITA would understand that Borchert provides every required limitation of this claim element.

Claim 12f. wherein a convex relief of the tool presses into the concave relief in order to force the material through the orifice, the convex relief of the tool comprising a counterform to mould an upper part of the rivet, which upper part contacts the area of the base portion that surrounds the orifice.

89. Figure Kazmer-11 provides a demonstrative of Borchert FIG. 2. A POSITA would understand that Borchert provides a tool with a convex relief (highlighted in blue) that presses into the concave relief (colored green) of the accessory in order to force material from the wall of the tank through the orifice (colored yellow) as described above for claim element 1-b. The convex relief of the tool also functions as a counterform that presses upon and thus molds an upper part of the rivet (colored red) as also discussed above for claim element 1-b. A POSITA would understand that Borchert FIG. 2 shows that the upper part of the rivet contacts the area of the base portion (colored light green) that surrounds the orifice as shown in Kazmer-11.



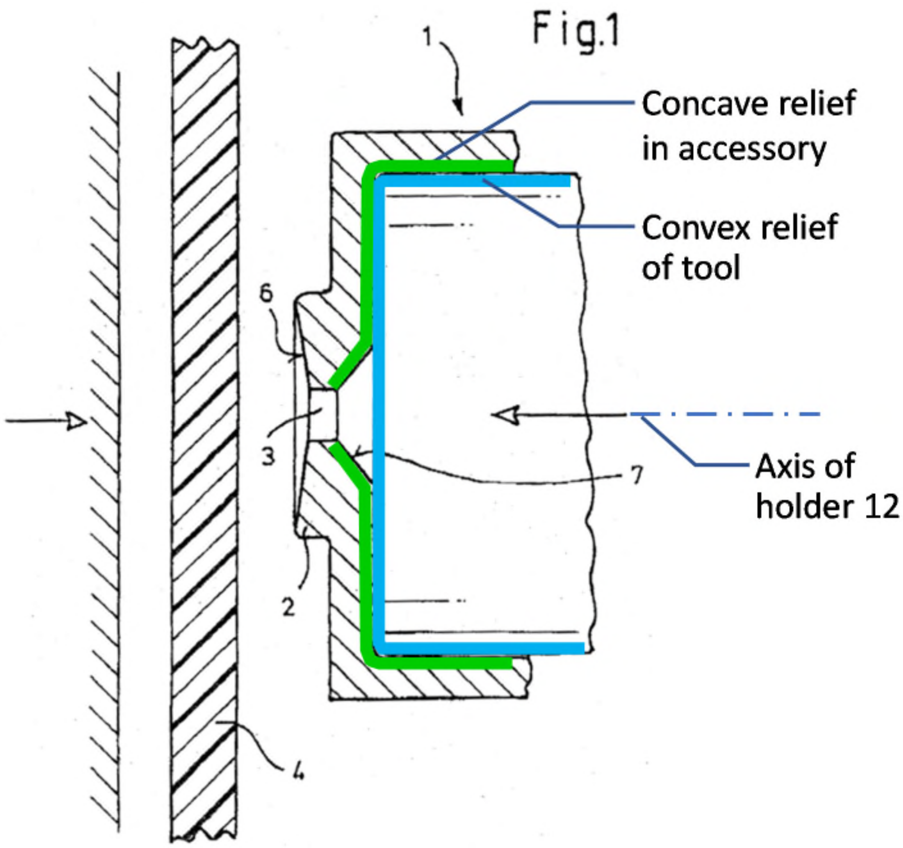
Kazmer-11: FIG. 2 of Borchert showing convex relief of the tool presses into the concave relief in order to force the material through the orifice, the convex relief of the tool comprising a counterform to mould an upper part of the rivet, which upper part contacts the area of the base portion that surrounds the orifice

90. Accordingly, a POSITA would understand that Borchert provides every required limitation of this claim element.

Claim 13. The method according to claim 1, wherein the concave relief is sized and shaped to cooperate with the convex relief of the tool and to ensure correct positioning and self-centering of the convex relief of the tool.

91. Kazmer-12 provides a demonstrative of FIG. 1 of Borchert showing the concave relief of accessory (colored green) that is sized and shaped to cooperate with the convex relief of the tool (colored blue). Because the size and shape of the concave relief of the tool matches the size and shape of the convex relief, it will

"ensure correct positioning and self-centering of the convex relief of the tool." I note that the specification of the '490 Patent does not provide any more information or detail as to how the size and shape of the concave relief cooperates with the convex relief of the tool to perform this function. As shown in the highlighted figure below, the geometry of the concave relief and the convex relief are such that the convex relief of the tool self-centers and correctly positions itself in the concave relief of the accessory.



Kazmer-12: FIG. 1 of Borchert showing the concave relief of accessory (green) sized and shaped to cooperate with the convex relief of the tool (blue)

92. The sizing and shaping claimed here follows systems of fits and tolerances, e.g. ANSI and ISO standards, and would typically be practiced by a

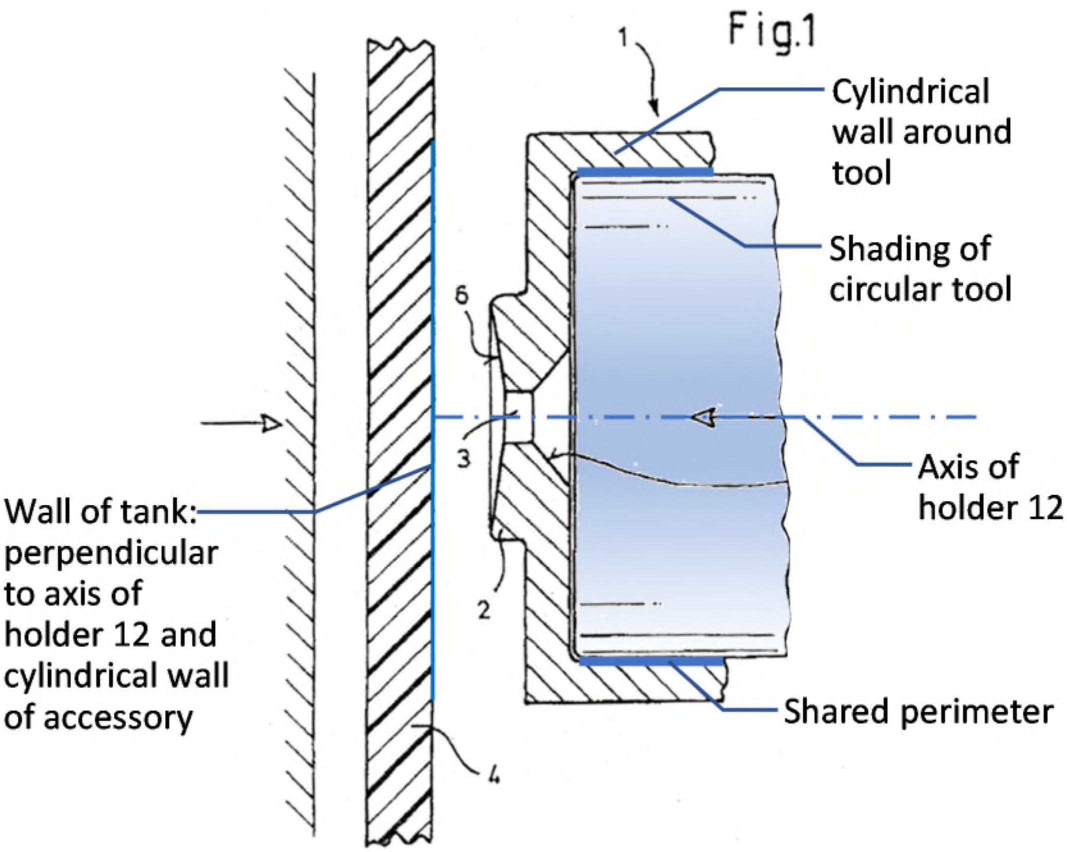
POSITA when designing molds. For example, my book Injection Mold Design Engineering was completed by June 1, 2007 (the date in the preface). It provides a section 12.4.1 Fits, which is relevant in that (1) it acknowledges common systems of fits in the footnote at page 333, and (2) provides an example of a location-interference fit on pages 334-335. *See* Appendix B attached hereto. The required limitations of claim 13 are demonstrated in Borchert and practically any insert molding process.

93. For the reasons provided above, a POSITA would understand that Borchert provides the required "method according to claim 12, wherein the concave relief is sized and shaped to cooperate with the convex relief of the tool and to ensure correct positioning and self-centering of the convex relief of the tool."

Claim 14. The method according to claim 1, wherein the concave relief includes a substantially cylindrical wall that is substantially perpendicular to the wall of the tank.

94. FIG. 1 of Borchert provides an accessory with a concave relief that includes a substantially cylindrical wall that is substantially perpendicular to the wall of the tank. FIG. 1 (highlighted and annotated below in Figure Kazmer-13) provides a cut-away section of fitment component 1 (the accessory) and holder 12 (the convex relief tool). A POSITA would understand that the three horizontal lines near the top and bottom of the drawing for holder 12 indicate shading of a cylindrical surface. Since holder 12 is designed to hold fitment component 1, a POSITA would

understand that the concave relief of fitment component 1 shown in FIG. 1 "includes a substantially cylindrical wall."



Kazmer-13: FIG. 1 of Borchert showing the wall of the tank perpendicular to the center axis of holder 12 and cylindrical wall of accessory

95. As shown in FIG. 1, this cylindrical wall is substantially perpendicular to the wall of the tank.

96. For the reasons provided above, a POSITA would understand that Borchert provides the required "method according to claim 1, wherein the concave relief includes a substantially cylindrical wall that is substantially perpendicular to the wall of the tank."

V. SECONDARY CONSIDERATIONS OF NONOBVIOUSNESS

97. I am of the opinion that there are no secondary considerations that would support a finding of nonobviousness. In the event that the patentee presents evidence of secondary considerations, I reserve the right to supplement my opinion to rebut patentee's evidence.

VI. CONCLUSION

98. I am therefore of the opinion that claims 1, 2, 7-9, and 12-14 of the '490 Patent are invalid for the reasons given above.

99. I hereby declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements and the like are punishable by fine or imprisonment, or both (18 U.S.C. § 1001).

Executed on June 20 2017

David O. Kazmer

Dr. David O. Kazmer, P.E., Ph.D.

APPENDIX A

DAVID O. KAZMER, P.E., PH.D.

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Principal Areas of Technology Leadership:

- Polymer Processing
- Plastics Product Design
- Machine and Control Systems Design
- Product Design for Manufacturing and Assembly
- Robust/Optimal Design/Manufacturing Strategies

Functional Areas of Expertise:

- Product design and manufacturing process development, especially related to polymer processing such as injection molding, extrusion, blow molding, thermoforming, and 3D printing;
- Mechanical design including concept design, materials selection, layout design, stress and thermal analysis, detailed design, assembly, fits and tolerances, testing, failure analysis;
- Design for manufacturing and assembly including needs analysis, specification, process selection, cost and value analysis, robust design, quality function deployment, design of experiments, response surface analysis, failure modes and effects analysis, and design for X (machining, molding, assembly, etc.);
- Simulation including constitutive modeling of materials, development and solution of differential equations using finite difference and finite element methods, numerical methods, sensitivity analysis, stochastic and Monte Carlo methods, and interfaces;
- Manufacturing process development including system decomposition, axiomatic systems design, partitioning, process instrumentation, signal conditioning, data acquisition, systems integration, hierarchical control systems, development and tuning of control laws, validation, commissioning, deployment, and training;
- Operations management including manufacturing strategy, forecasting, aggregate planning, inventory control, supply chain management, production control systems, operations scheduling, project scheduling, facilities design, quality and assurance, lean;
- Software development including ANSI C, C++, Visual C#, Visual Basic, Fortran, MySQL, Java, Javascript, PHP, Pascal, LabView, and others.

Education:

- Ph.D., 1995, Stanford University, Mechanical Engineering Design Division. Dissertation: Dynamic Feed Control for Injection Molding. Committee: P. Barkan (Chair, deceased), W. Hausman, K. Ishii (deceased), F. Prinz.

- 1991 M. Sci., Rensselaer Polytechnic Institute, Department of Mechanical Engineering, Thesis: Development and Validation of a Radial Flow Analysis Tool. Advisor: D. Lee.
- 1990 B. Sci., Cornell University, Sibley School of Mechanical Engineering, with Distinction.

Experience:

- August, 2016 – present: Professor & Chair, Plastics Engineering, Univ. Mass. Lowell
  Teaching and research related to plastics product design and manufacturing. Current research projects include extrusion screw design, 3D printing processes, and materials constitutive modeling. Service as Chair includes strategic planning, faculty performance review, course scheduling, faculty hiring, student advising, accreditation, and alumni/outreach.
- May, 2012 – present: Professor, Plastics Engineering, Univ. Mass. Lowell
  Teaching and research related to plastics product design and manufacturing. Current research projects include multivariate sensing, thermoplastic composites, and roll to roll manufacturing. Current service projects include accreditation, engineering leadership for Service-Learning and STEM teaching minor.
- January, 2011 – April, 2012: Associate Dean, James B. Francis College of Engineering, Univ. Mass. Lowell
  Responsible for program development, including undergraduate and graduate academic and research programs. See service section for specific contributions.
- September, 2005 – present: Professor, Univ. Mass. Lowell, Plastics Engineering
- January, 2002 – August, 2005: Associate Prof., Univ. Mass. Lowell, Plastics Eng.
- 2001, Director of Research & Development, Synventive Molding Solutions (Peabody, Massachusetts)
  Responsible for invention, implementation, and support of advanced melt delivery systems for the plastics industry, including: 1) Dynamic Feed Control for multi-gate closed loop pressure control, 2) hot runner molding of molten magnesium, and 3) an all-electric melt delivery system. Responsibilities included engineering design and management, budgeting responsibilities, market development, and field support.
- June, 2000 – June, 2001: Associate Professor, Univ. Mass. Amherst, Department of Mechanical and Industrial Engineering
- September, 1995 – May, 2000: Assistant Professor, Univ. Mass. Amherst, Department of Mechanical and Industrial Engineering
- 1992-1995, Future Professor of Manufacturing Fellow, Stanford Integrated Manufacturing Association (Stanford, CA)
  Performed coursework and research related to manufacturing competitiveness in a joint doctoral business/engineering program funded by the Sloan Foundation. Invented and validated a novel molding process, Dynamic Feed, which was recognized by the U.S. Department of Energy as an Innovative Industrial Process and was licensed and commercialized by Dynisco/Synventive.
- 1992-1994 (part time), Technology Programs Manager, GE Plastics Commercial Development Center (Pleasanton, California)
  Developed design methodologies and manufacturing technologies to position GE Plastics as a value added supplier. Translated relevant technology to regional development centers for commercial application. Provided design and processing support on critical applications.
- 1991, Design and Process Development Engineer, GE Plastics Advanced Design Engineering Group (Pittsfield, Massachusetts)
  Developed design methodologies and manufacturing technologies to position GE Plastics as a

value added supplier. Translated relevant technology to regional development centers for commercial application.

- 1990, Mechanical Engineer, GE Corporate Research & Development Mechanics of Materials Laboratory (Schenectady, New York)
  Investigated industrial plastic conversion processes. Developed process simulations which became part of GE Plastics' design methodology. Examined material characterization techniques to estimate molded product consistency.
- 1988-1989, Applications Engineer Intern, GE Plastics Advanced Design Engineering Group (Pittsfield, Massachusetts)
  Performed process simulations to ensure product manufacturability as well as structural analyses to predict and optimize part performance.

Professional Memberships:

- Fellow, American Society of Mechanical Engineers (ASME)
- Fellow, Society of Plastics Engineers (SPE)
- Member, Polymer Processing Society
- Member, Institute of Electrical and Electronics Engineers
- Member, American Society for Engineering Education
- Member, American Association for the Advancement of Science
- Registered Professional Manufacturing Engineer, State of California, License # MF004751

Honors and Awards:

- 2015, Dandeneau Professorship for Sustainable Manufacturing
- 2013, College of Engineering Service-Learning Award
- 2012, ASME Kos Ishii-Toshiba Award (for sustained, meritorious contributions to the use of optimization and other modeling techniques for design and manufacturing)
- 2012, Best Paper Award, ASME International Symposium on Flexible Automation
- 2012, Outstanding Service as Conference Chair, American Society of Engineering Education
- 2011, Fellow, Society of Plastics Engineers
- 2011, Best Paper Award, Society of Plastics Engineers' Injection Molding Division
- 2007, Fellow, American Society of Mechanical Engineers
- 2004, Best Paper Award, 10th ASME Design for Manufacturing Conference
- 2000, University of Massachusetts Amherst, College of Engineering Outstanding Young Faculty Award
- 2000, College of Engineering Outstanding Advisor Service Award
- 1999, Lilly University Teaching Fellowship
- 1998, Office of Naval Research Young Investigator Award
- 1998, Best Paper Award, Society of Plastics Engineers' Design Division
- 1997, College of Engineering Outstanding Advisor Service Award
- 1997, National Science Foundation Career Award

- 1996, College of Engineering Outstanding Advisor Service Award
- 1995, Future Professor of Manufacturing, Stanford Integrated Manufacturing Association
- 1994, Innovative Industrial Process Award, U.S. Department of Energy
- 1993, Best of Program, Lincoln Electric National Design Competition
- 1992, Management award for outstanding achievements in process simulation, GE Plastics Advanced Design Engineering Group
- 1989, Management award for outstanding contributions in application design engineering, GE Plastics Advanced Design Engineering Group
- 1985, Hawken School Coach's Award, to the athlete best exemplifying the School's values of teamwork and fair play

Sponsored Research - Currently Active:

- REU Site: Advanced Materials and Manufacturing, $356,668, May 1, 2015- April 30, 2018, MSF IUSE Program (led by Carol Barry, with others).
- HEROES: Bi-component Fibers with Nanostructured FR Additives. To United States Army Natick Soldier Research, Development and Engineering Center (NSRDEC) for $51,469, January 1 – June 30, 2017 (with Ram Nagarajan, Steve Johnston, and Javier Vera-Sorroche).
- Partnership Service Agreement: PlastIndia University Replication Model To United States Army Natick Soldier Research, Development and Engineering Center (NSRDEC) for $407,245, October 7, 2017 – December 31, 2017 (with Ram Nagarajan and Joe Hartman).
- Planning I/UCRC University of Massachusetts Lowell: Center for Science of Heterogeneous Additive Printing of 3D Materials (SHAP3D). NSF Award Number:1650517 for $15,000 (January 1, 2017 –). Principal Investigator: Joey Mead; Co-Principal Investigator: Carol Barry, Nese Orbey, David Kazmer, Christopher Hansen.
- UMass Office of Technology Venture grant for commercial and technical feasibility analysis of Fractal Screw Design, $25,000 (present – June 30, 2018).
- Research Experiences for Undergraduates: Advanced Materials and Manufacturing, National Science Foundation ($356,668 w/ C. Barry)

Sponsored Research - Proposals Currently In Review:

- HEROES: Soldier Lightweight Integrated Multifunctional Materials" (SLIMM): The Enhancement of Thermoplastic Materials Through the Incorporation of Micro-Cellulose Forms. To United States Army Natick Soldier Research, Development and Engineering Center (NSRDEC) for $223,419 (with Ram Nagarajan), submitted March 23, 2017. In review.
- Metal-Loaded Plastic Scintillators for Gamma-Ray Spectroscopy and Pulse-Shape Discrimination. To Radiation Monitoring Devices in response to ERBAA16-VOL1-RTA-01A-FP-01, $249,994, September 1, 2017 – December 1, 2020 (with Javier Vera-Sorroche). In Review.

Sponsored Research - Past:

- 3D Printing of Engineering Thermoplastics (3DPET), Univ. Mass. President's Office Science & Technology Fund ($150,000, w/ J. Mead and S. Krishnamurthy)

- Next Generation materials and processes for 3D Printing (NG3DP), Univ. Mass. Presidents' Science and Technology Initiatives Fund for $25,000
- UTeach STEM Replication Grant (Massachusetts Department of Higher Education, $1,600,000, with A. Greenwood and K. Levasseur, awarded AY2012)
- NSEC Center for High-rate Nanomanufacturing Center for Enabling Tools (NSF- EEC/0832785, ($10,030,017, with J. Mead of UML, A. Busnaina of Northeastern, et al., awarded AY2008)
- Collaborative Research: Multivariate Remote Process Sensing for Improved Observability in Injection Molding (NSF-CMMI/1000551, $591,983, with R. Gao of Univ. Connecticut, awarded AY2010)
- Engineering Faculty Engagement in Learning Through Service (EFELTS) (NSF- DUE/1022738, $274,983, with J. Duffy, awarded AY2011)
- MRI-R2: Acquisition of a Focused Ion Beam - Scanning Electron Microscope (FIB-SEM) for Nano/Micro Fabrication/Characterization (NSF-ECCS/0960022, $1,150,000 with Xingwei Wang et al, awarded AY2010).
- MKS Instruments, Multivariate Statistical Process Controls for Polymer Processing, $250,000, funded 2005-2011.
- D. Kazmer and S. Johnston, "FREE: Freshmen Engagement in Engineering," Univ. Mass. Exploration in Teaching and Learning Grant, $2,300, funded 20008.
- National Science Foundation, Sensors: Self-Powered Spatial Sensing Array for Injection Molding Process Monitoring (with R. Gao of UMass Amherst), UML Budget: $218,364, Status: funded 2004-2008.
- Mold-Masters Ltd., Technical Feasibility of a Self-Regulating Melt Valve, UML Budget: $40,000 plus $20,000 in kind, Status: funded 2004.
- National Science Foundation, Synthesis of Melt Pumps & Brakes for Polymer Processing, UML Budget: $213,508, Status: funded 2003-07.
- Mold Masters Ltd., Technical Feasibility of Decoupled Gating, UML Budget: $80,000 plus $120,000 in kind, Status: funded 2003.
- Thermo-CeramiX LLC, Technical Feasibility of Isothermal Molding, UML Budget: $15,000 plus $20,000 in kind, Status: funded 2002.
- National Science Foundation, Remote Sensors for Injection Molding (with R. Gao), Budget: $310,000, Status: funded 1999-2002.
- GE Plastics, Design for Six Sigma: Phase III, (with T. Blake), Budget: $35,000, Status: funded 1999.
- Office of Naval Research, Dynamic Cooling for Injection Molding, Budget: $298,000, Status: funded 1998-2001.
- GE Plastics, Optical Molding Process Development (w. K. Danai), Budget: $42,000, Status: funded 1998.
- GE Plastics, Tight Tolerance Thermoforming Extension, Budget: $25,000 with $10,000 in-kind, Status: funded 1999.
- GE Plastics, Design for Six Sigma: Phase II (with T. Blake), Budget: $35,000, Status: funded 1998.
- GE Plastics, Tight Tolerance Thermoforming, Budget: $35,000 with $10,000 in-kind, Status: funded 1997.
- Sloan Foundation, Integrated Manufacturing Paradigms, Budget: $35,000, Status: funded 1997.

- GE Plastics, Design for Six Sigma: Phase I, Budget: $35,000, Status: funded 1996.
- National Science Foundation, Process Tuning and Optimization (with K. Danai), Budget: $198,000, Status: funded 1996-1999.
- National Science Foundation, CAREER: Synthesis of Engineering Analysis Methods into the Design Process, Budget: $310,000, Status: funded 1996-1999.
- Univ. Mass. Amherst (research initiation project), Cost of Complexity in Product Design and Manufacture, Budget: $5,000, Status: funded 1995.
- Industry Consortium (GE Plastics, Hewlett Packard, Dynisco Instruments): Moldability Program, Budget: $25,000 with $250,000 in kind, Status: funded 1994-95.
- U.S. Dept. of Energy, Innovative Industrial Processes, Budget: $40,000, Status: funded 1994.

Graduate Advising (principally advised students only):

- T. Coogan, Ph.D., Plastics Engineering, Real-Time Simulation of Fused Deposition Modeling, May, 2018
- B. Weidnecht, Ph.D., Plastics Engineering, Dynamic Extrusion Molding, December, 2018
- T. Coogan, M.S., Plastics Engineering, Simulation of Fused Deposition Modeling, December, 2015
- Amir Moshe, Ph.D., Plastics Engineering, 2015, Transient Constitutive Modeling of Polymer Melts
- Mary Elizabeth Moriarty, M.S., Plastics Engineering, 2014, Induction Heated Roll Molding for Imprinting of Multi-Scale Features in Polymeric Films
- Guthrie Gordon, Ph.D., Plastics Engineering, 2014, A Multivariate Sensor for Indication of Polymer Melt Temperature, Pressure, Velocity, and Viscosity
- G. Geyne, M.S., Plastics Engineering, 2013, Mechanistic Signal Conditioning for Improved Process Observability
- T. Deak, Ph.D., Polymer Engineering, University of Budapest, 2012, Characterization of Thermosets for Electronics Encapsulation
- M. Fisches, MS, Plastics Engineering, Darmstadt University, 2012, In-Situ Viscosity Estimation of Polymer Melts during Injection Molding
- Louay Abou-Shady, M.S., Plastics Engineering, 2010, On-Line Process Monitoring of Extrusion. Supported but graduated with non-thesis option.
- Rahul Panchal, Ph.D., Plastics Engineering, 2009, “In-situ shrinkage sensor for injection molding,” University of Massachusetts Lowell, 2009, 166 pages; AAT 3374311.
- Shang Yingrui, Ph.D., Plastics Engineering, 2008, “Numerical simulation for the self-assembly of polymer blends with nano-scaled features,” University of Massachusetts Lowell, 2008, 219 pages; AAT 3343449.
- Comparison of switchover methods in injection molding, by Velusamy, Suganya, M.S.Eng., University of Massachusetts Lowell, 2007, 102 pages; AAT 1448354.
- Comparison of surging in conventional extrusion and gear pump assisted single screw extrusion, by Amba, Rakshit, M.S., University of Massachusetts Lowell, 2007, 70 pages; AAT 1442061.
- Instrumentation, analysis, and on-line simulation for improved process control of injection molding, by Johnston, Stephen Paul, Ph.D., University of Massachusetts Lowell, 2007, 121 pages; AAT 3277038.

- Multivariate process analysis utilizing Six Sigma methodologies for the prediction of injection molded part quality, by Westerdale, Sarah, M.S.E., University of Massachusetts Lowell, 2007, 75 pages.
- Multivariate process analysis for the prediction of injection molded part quality, by Hazen, Daniel, M.S.Eng., University of Massachusetts Lowell, 2007, 78 pages.
- Verification of common mold design practices: Cooling time and runner sizing, by Zombade, Nivant, M.S.Eng., University of Massachusetts Lowell, 2007, 56 pages; AAT 1449478.
- Optimizing the injection molding process, by Knepper, Peter, M.S.Eng., University of Massachusetts Lowell, 2006, 72 pages; AAT 1436004.
- Pressure prediction verification studies using 3D CAE injection molding simulation software, by Marin, Ana Maria, M.S.Eng., University of Massachusetts Lowell, 2006, 171 pages; AAT 1439504.
- Analysis of plastics manufacturing processes for low production quantities, by Karania, Ruchi P., M.S.Eng., University of Massachusetts Lowell, 2005, 74 pages.
- Analysis and characterization of the dynamic behavior of a polymer lubricated bearing, by Panchal, Rahul R., M.S.Eng., University of Massachusetts Lowell, 2005, 100 pages; AAT 1428539.
- An investigation into hesitation defects from oscillating flows, by Garnavish, Kathryn Elise, M.S.Eng., University of Massachusetts Lowell, 2005, 68 pages, AAT 1425719.
- Design and validation of a self-regulating melt valve for injection molding, by Kudchadkar, Vijay J., M.S.Eng., University of Massachusetts Lowell, 2005, 82 pages; AAT 1430568.
- Development of a 1-D flow code for on-line simulation, by Johnston, Stephen Paul, M.S.Eng., University of Massachusetts Lowell, 2005, 75 pages.
- Effect of shear stress and velocity profile development on hot runner flow bore wall slip, by Rousseau, William, M.S.Eng., University of Massachusetts Lowell, 2005, 44 pages.
- Online flow rate estimation in injection molding, by Nageri, Ranjan, M.S.Eng., University of Massachusetts Lowell, 2005, 83 pages; AAT 1425522.
- Design and validation of melt valves in polymer processing, by Gupta, Dheeraj M., M.S., University of Massachusetts Lowell, 2004, 139 pages; AAT 1418806.
- Development and validation of process windows for injection molding, by Mundhra, Hitesh, M.S., University of Massachusetts Lowell, 2004, 131 pages; AAT 1423671.
- 3D flow analysis of a self-regulating melt pressure valve, by Munavalli, Mahesh Virupaxappa, M.S.Eng., University of Massachusetts Lowell, 2004, 81 pages; AAT 1423457.
- Active thermal control of melt flow in nozzles, by Balasubrahmanyan, Gautam, M.S.Eng., University of Massachusetts Lowell, 2003, 55 pages; AAT 1416204.
- Concept design of platenless molding machine, by Doshi, Nirmal K., M.S.Eng., University of Massachusetts Lowell, 2003, 59 pages; AAT 1416208.
- Dynamic braking of a melt pump for improved extrusion consistency, by Dave, Yash Uday, M.S.Eng., University of Massachusetts Lowell, 2003, 59 pages; AAT 1415957.
- Prediction of production yields in injection molding, by Manek, Kaushik Ashwinkumar, M.S.Eng., University of Massachusetts Lowell, 2003, 82 pages; AAT 1416925.
- Effects of process conditions on in-mold film decorating, by Cahill, Brendan Joseph, M.S.Eng., University of Massachusetts Lowell, 2002, 128 pages; AAT 1409440.

- Charles Theurer, Ph.D., Mechanical Engineering (Amherst), 2004, “Extraction and digitization of a process signal for self-powering a wireless pressure sensor,” University of Massachusetts Amherst, 2004, 191 pages; AAT 3136783.
- Binfeng Fan, Ph.D., Mechanical Engineering (Amherst), 2002, “Process simulation and quality prediction for manufacturing of optical media,” University of Massachusetts Amherst, 2003, 150 pages; AAT 3110484.
- Prasanth Ambady, M.S.E., Mechanical Engineering, 2001, “Adaptive control of the injection mold cooling process.”
- Ian Stuart, M.S.E., Mechanical Engineering, 2001, “Production quality improvements in plastics processing.”
- Liang Zhu, Ph.D., Mechanical Engineering, 2001, “A performance-based representation for engineering design,” University of Massachusetts Amherst, 2001, 195 pages; AAT 3027280.
- Charles Theurer, M.S.E., Mechanical Engineering, 2001, “Conceptual design of a remotely energized pressure sensor.”
- Christoph Roser, Ph.D., Mechanical Engineering, 2000, “A flexible design methodology,” University of Massachusetts Amherst, 2000, 256 pages; AAT 9978545.
- Adekunle Fagade, Ph.D., Industrial Engineering, 1999, “The role of complexity in product life-cycle cost,” University of Massachusetts Amherst, 1999, 143 pages; AAT 9932308.
- David Hatch, M.S.E., Mechanical Engineering, 1999, “Modeling and optimization for processing of optical media.”
- Haoyu Xu, M.S.E., Mechanical Engineering, 1999, “Cooling considerations for injection molding.”
- Haihong Xu, M.S.E., Mechanical Engineering, 1999, “Shrinkage prediction of thermoformed parts.”
- Sally Carter, BS, Mechanical Engineering, 1998, “Structural design of bosses for molded plastic parts.”
- Deepak Kapoor, M.S.E., Manufacturing Engineering, 1997, “Multi-cavity melt control in injection molding.”
- Tatiana Petrova, M.S.E., Mechanical Engineering, 1997, “Hybrid neural network models for prediction of molded part quality.”

Books

1. D. O. Kazmer, Injection Mold Design Engineering, 2nd Edition. Published: 2016. Pages: 553. Publisher: Carl Hanser Verlag GmbH & Co. (Munich, Germany). eISBN: 978-1-56990-571-5. Print ISBN: 978-1-56990-570-8. DOI: 10.3139/9781569905715.
2. Kazmer, D.O., Plastics Manufacturing Systems Engineering, Hanser Publishers, 517 pages, 2009.
3. Kazmer, D.O., Injection Mold Design Engineering, Hanser Publishers, 443 pages, 2007.

Book Chapters:

4. Kazmer, D. O., “Three Dimensional (3D) Printing of Thermoplastics,” Chapter 28 of Applied Plastics Engineering Handbook: Processing and Materials, ed. Myer Kutz, publ. Elsevier, 10,049 words, pp. 617-634.

5. Kazmer, D. O., "Design of Plastic Parts," Chapter 27 of Applied Plastics Engineering Handbook: Processing and Materials, ed. Myer Kutz, publ. Elsevier, 11,650 words, pp. 593-616.
6. Yingrui S and Kazmer DO, "Modeling and Simulation," Chapter 15 in Characterization of Polymer Blends: Miscibility, Morphology, and Interfaces, Edited by S. Thomas, Y. Grohens, and P. Jyotishkumar, Wiley–VCH (Weinheim, Germany), ISBN: 3527331530, pp. 457-521, 2015.
7. Kazmer, D. O., "Design of Plastic Parts," Chapter 31 of Applied Plastics Engineering Handbook: Processing and Materials, ed. Myer Kutz, publ. Elsevier, ISBN: 978-1-4377-3514-7, pp. 535-552, 2011.
8. Kazmer, D.O. and S. C. Johnston "Chapter 22: Instrumentation and control of plastics moulding processes," Advances in polymer processing: macro- to nano- scales, S. Thomas and Y. Weimin, Eds. Cambridge: CRC Press/Woodhead Publishing LTD, pp. 655-680, 2009.
9. Kazmer, D.O., "Injection Molding," Encyclopedia of Chemical Processing, Marcel Dekker, Sunggyu (K.B.) Lee, Ed., pp. 1401-1410, 2005.
10. Kazmer, D.O., "Precision Process Control," Precision Injection Molding, Hanser Publishers, R.W. Friedl, J. Greener, Ed., pp. 265-298, 2005.
11. Kazmer, D.O., "Computer Flow Simulations," Society of Plastics Engineers' Molding Toolbox, 2002.
12. Roser, C. and D. O. Kazmer, "Defect Cost Analysis," Plastics Failure Analysis and Prevention, J. Moalli Ed. , pp. 63-72, 2001.
13. Kazmer, D.O. and K. Danai, "Control of Polymer Processing," in The Mechanical Systems Design Handbook: Modeling, Measurement, and Control, edited by Y. Hurmuzlu, O.D.I. Nwokah, published by CRC & IEEE Press, 2001.
14. Kazmer, D. O., "Dynamic Feed Control for Injection Molding," PhD Dissertation, Mechanical Engineering Design Division, Stanford University, 1995.
15. Kazmer, D. O., "Development and Validation of a Radial Flow Analysis Tool", MS Thesis, Department of Mechanical Engineering, Rensselaer Polytechnic Institute, 1991.

Reviewed Articles:

16. L. Barrington, J. Duffy, E. Raynaud, D. Kazmer, M. Hereida, Engineering the Common Good: ten years of integrated service-learning, Submitted to *Michigan Journal of Service-Learning*, 7,252 words, In Review.
17. T. J. Coogan and D. O. Kazmer, Bond and Part Strength in Fused Deposition Modeling (FDM), *Submitted to Rapid Prototyping Journal*, 4,857 words. Accepted.
18. G. Gordon, S.P. Johnson, R. Gao and D.O, Kazmer, Validation of an In-Mold Multivariate Sensor for Measurement of Melt Temperature, Pressure, Velocity, and Viscosity, *Submitted to International Polymer Processing*, 5,907 words, Accepted.
19. A. Moshe, D. O. Kazmer, M. Sobkowicz-Kline, S. Johnston, S. Kenig, Transient Modeling of Viscosity, *Submitted to Polymer Engineering and Science*, 7,601 words, Accepted.
20. T. J. Coogan and D. O. Kazmer, Healing simulation for bond strength prediction of Fused Deposition Modeling. *Rapid Prototyping Journal*, Volume: 23 Issue 3 ISSN: 1355-2546 (2017).
21. A. Moshe, D. O. Kazmer, S. Johnston, R. Malloy, S. Kenig, Analysis of Variance in Capillary Rheometry, Polymer Engineering and Science, *Polymer Engineering & Science*, 56 (8), 895-904 (2016).

22. Johnston, S.P., Mendible, G.A., Gao, R.X. and Kazmer, D.O., Estimation of Bulk Melt-Temperature from In-Mold Thermal Sensors for Injection Molding, Part A: Method. *International Polymer Processing*, 30(4), pp. 460-466. doi: 10.3139/217.3019, 31(3), 278-284 (2016).

23. Kazmer, D.O., Gordon, G.W., Mendible, G.A., Johnston, S.P., Tang, X., Fan, Z. and Gao, R.X., 2015. A Multivariate Sensor for Intelligent Polymer Processing. *IEEE/ASME Transactions on Mechatronics*, 20(3), pp. 1015-1023. DOI: 10.1109/TMECH.2014.2363691.

24. Johnston, S.P., Mendible, G.A., Gao, R.X. and Kazmer, D.O., 2015. Estimation of Bulk Melt-Temperature from In-Mold Thermal Sensors for Injection Molding, Part A: Method. *International Polymer Processing*, 30(4), pp. 460-466. doi: 10.3139/217.3019.

25. Johnston, S., McCready, C., Hazen, D., VanDerwalker, D., & Kazmer, D. (2015). On-line multivariate optimization of injection molding. *Polymer Engineering & Science*, 55(12), pp. 2743-2750. DOI: 10.1002/pen.24163.

26. Gordon, Guthrie, David O. Kazmer, Xinyao Tang, Zhoayan Fan, and Robert X. Gao. "In-mold multivariate sensing of colored polystyrene." *Polymer Engineering & Science* 55, no. 12 (2015), pp. 2794-2800. DOI: 10.1002/pen.24170.

27. D. O. Kazmer, M. Berry, and Y Ishiwata, "Novel approach for achieving tight injection molding tolerances", *SPE Plastics Research Online*, DOI: 10.2417/spepro.005953. May 28, 2015.

28. Gordon, G., Kazmer, D. O., Tang, X., Fan, Z., & Gao, R. X. (2015). Quality control using a multivariate injection molding sensor. *The International Journal of Advanced Manufacturing Technology*, 78(9-12), 1381-1391. DOI 10.1007/s00170-014-6706-6.

29. Kazmer, David Owen (2014). "Manufacturing outsourcing, onshoring, and global equilibrium." *Business Horizons* 57.4 (2014): 463-472. doi:10.1016/j.bushor.2014.03.005.

30. Kazmer, David O. "System identification and modeling of viscoelastic behavior from capillary melt rheological data." *Polymer Engineering & Science* 54.12 (2014): 2824-2838. DOI: 10.1002/pen.23840.

31. Gao, Robert X., et al. "Online product quality monitoring through in-process measurement." *CIRP Annals-Manufacturing Technology* 63.1 (2014): 493-496. http://dx.doi.org/10.1016/j.cirp.2014.03.041

32. Paterson, Kurtis G., Angela R. Bielefeldt, Christopher W. Swan, Greg Rulifson, David Kazmer, and Olga Pierrakos. "Designing value into engineering learning through service activities using a blueprint model." *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship* (2014): 64-83.

33. Tucker, Bowa George, David O. Kazmer, Angela R. Bielefeldt, Kurt Paterson, Olga Pierrakos, Annie Soisson, and Chris Swan. "Principles of sustaining partnerships between higher education and their larger communities: Perspectives from engineering faculty engaged in learning through service." *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship* (2014): 48-63.

34. Fan, Zhaoyan, Robert X. Gao, Navid Asadizanjani, and David O. Kazmer. "Acoustic wave-based data transmission for multivariate sensing." *Instrumentation and Measurement, IEEE Transactions on* 62, no. 11 (2013): 3026-3034.

35. Tucker, Bowa George, et al. "The Reflective Learner: Perspectives of Engineering Faculty Engaged In Learning through Service." *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship* 9.2 (2014): 29-46.

36. B.G. Tucker, D.O. Kazmer, A.R. Bielefeldt, K. G. Paterson, O. Pierrakos, A. Soisson, C. Swan, "Principles of Sustaining Partnerships between Higher Education and their Larger Communities: Perspectives from Engineering Faculty Engaged in Learning through Service," International

Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship, v. 8, n. 3, p. 48-63, 2013.

37. K. G. Paterson, A.R. Bielefeldt, C. W. Swan, G. Rulifson, D. O. Kazmer, O. Pierrakos, "Designing Value into Engineering Learning Through Service Activities Using a Blueprint Model," International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship, v. 8, n. 3, p. 48-63, 2013.
38. Z. Fan, R. X. Gao, and D. O. Kazmer, "Acoustic-based wireless data transmission for process monitoring," in CIRP Annals-Manufacturing Technology, 2013, pp. 1449-1452.
39. Z. Fan, R. X. Gao, N. Asadizanjani, and D. O. Kazmer, "Acoustic Wave-Based Data Transmission for Multivariate Sensing," IEEE Transactions on Instrumentation and Measurement, vol. 62, pp. 3026-3034, 2013.
40. D. Kazmer and L. Zhu, "A Product Quality and Process Feasibility Modeling System," International Journal of Performability Engineering, vol. 8, n. 6, p. 615-624, 2012.
41. Z. Fan, R. Gao, N. Asadizanjani, and D. Kazmer, "Acoustic-based Wireless Signal Transmission for Precision Metrology: Accuracy and Reliability." CIRP Annals-Manufacturing Technology (2013).
42. Fang, Liang, Ming Wei, Yingrui Shang, David Kazmer, Carol Barry, and Joey Mead. "Precise Pattern Replication of Polymer Blends into Nonuniform Geometries via Reducing Interfacial Tension between Two Polymers." Langmuir 28, no. 27 (2012): 10238-10245.
43. Kumar, Arun, David O. Kazmer, Carol MF Barry, and Joey L. Mead. "Pulsed electric field assisted assembly of polyaniline." Nanotechnology 23, no. 33 (2012): 335303.
44. Gao, Robert X., and David O. Kazmer. "Multivariate sensing and wireless data communication for process monitoring in RF-shielded environment." CIRP Annals-Manufacturing Technology, v. 61, n. 1, 523-526, 2012.
45. Shang, Yingrui, and David Kazmer. "A MATLAB programme for quantitative simulation of self–assembly of polymer blend films with nanoscaled features." International Journal of Computer Aided Engineering and Technology 4, no. 2 (2012): 181-192.
46. Fang, Liang; Wei, Ming; Shang, Yingrui; Kazmer, David; Barry, Carol; Mead, Joey, "Directed Assembly of Polymer Blends into Non-uniform Nanoscale Geometries" Submitted to Nano Letters, 2011.
47. K., Danai, T. Currier, and D.O. Kazmer, "Validation of Dynamic Models in the Time-Scale Domain", ASME J. of Dynamic Systems, Measurement, and Control, 132, no. 6 (2010): 61402.
48. Yingrui S and Kazmer DO. A MATLAB programme for quantitative simulation of self–assembly of polymer blend films with nanoscaled features. International Journal of Computer Aided Engineering and Technology. v 4, n. 2, 181-192, 2012.
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317. Kazmer, D. O., "Advanced Design Methodologies for the Blow Molding Process," *20th Annual Structured Products Conference,* Society of the Plastics Industry, 1991.

318. Kazmer, D. O., “Application of an Axisymmetric Element for Injection Molding Analysis,” *Proceedings from the Society of Plastics Engineers Regional Technical Conference*, Boston, MA, 1990.

Invited Presentations:

319. D. O. Kazmer, "Multivariate Modeling of Injection Molding", Symposium in Honor of S. Kenig at the Society of Plastics Engineers' Annual Technical Conference, Anaheim, CA, May 8-10, 2017.
320. D.O. Kazmer, “Opportunities and Challenges for 3D Printing”, Technology Innovation for Physicians & Surgeons (TIPS), Cleveland, OH, 12-14 October 2016.
321. T. Coogan and D. O. Kazmer, “FDM Bond Strength: Experiments and Simulations Based on Healing Models,” 32nd Annual Meeting of the Polymer Processing Society, Lyon, France, July 25-29, 2016.
322. D.O. Kazmer, “3D Printing of Plastics: Overview & Benchmarks”, 11th Annual Auto Epcon: Engineering Plastics in High Gear, Troy, MI, May 10, 2016.
323. D.O. Kazmer, “3D Printing of Plastics: Overview & Benchmarks,” Shenkar College of Engineering and Design, Ramat Gan, Israel, March 15, 2016.
324. D.O. Kazmer, “Current & Future Research on Rheological Constitutive Modeling,” Shenkar College of Engineering and Design, Ramat Gan, Israel, March 15, 2016.
325. D.O. Kazmer, “Single Pellet Extrusion with a Fractal Screw Design,” Shenkar College of Engineering and Design, Ramat Gan, Israel, March 16, 2016.
326. D. O. Kazmer, “Modeling of Polymer Rheology”, Hochschule Darmstadt University of Applied Sciences, December 11th, 2015, Darmstadt, Germany.
327. D. O. Kazmer, “3D Printing of Polymers: A Constructive Review”, Institute of Plastics Processing (IKV) in Industry and the Skilled Crafts at RWTH Aachen University, December 9th, 2015, Aachen, Germany.
328. D. O. Kazmer, “Low Volume Production Strategies: From 3D Printing to Injection Molding,” Society of the Plastics Industry Business of Plastics Conference, March 24th, 2015, Orlando, FL.
329. D. O. Kazmer, “Strategies for Teaching Large Classes,” UMass Lowell Faculty Development Seminar, April 9, 2014, Lowell MA.
330. D. O. Kazmer, “System Identification and Modeling of Capillary Melt Rheological Data,” Northeastern University Chemical Engineering Department Seminar, October 3, 2013, Boston, MA.
331. D. O. Kazmer, “System Identification and Modeling of Capillary Melt Rheological Data,” Symposium in Honor of A. Isayev at the SPE Annual Technology Conference, April 23, 2013, Cincinnati, OH.
332. D. O. Kazmer, “Opportunities in the Hot Runners and Plastics Industry,” MKS Global Markets Meeting, March 11, 2013.
333. D. Kazmer, “Challenges in Process Simulation,” Keynote to the 2012 Molding Innovation Day, September 4-5, 2012, Lowell, MA.
334. D. Kazmer, “Career Strategy: In or Out of the Box?” UML Honors Program, April 2, 2012.
335. D. O. Kazmer, “Why We Need to Improve STEM Education in the Merrimack Valley,” Keynote Speaker, STEM Education Summit, Merrimack College, November 7, 2011.
336. D.O. Kazmer, “Explore! Investigate! Invent! Engineering,” Professional Development Seminar, The Museum Institute for Teaching Science, Clark University, February 28, 2012.
337. Kazmer, D., “BioModular Multi-Scale Systems,” Joint US-Ireland Conference on Bio-Nano Systems, 2010, Lowell, MA.

338. Kazmer, D., “Macro to nano control in plastics molding,” University of Akron Polymer Engineering Department Seminar, October 31, 2008, Akron, OH.

339. Kazmer, D. “Comparison of Switchover Methods for Injection Molding,” Primaus Users' Group Annual Meeting, September 30th, 2008, Cleveland, OH.

340. Kazmer, D. “Towards Controllability of Polymer Processing,” Louisiana State University Mechanical Engineering Seminar, April, 2008.

341. D. Kazmer, “Domain-Centric Education Delivered On-Line,” UML College of Engineering Seminar, December 15, 2006.

342. D. Kazmer, “A Data Driven Approach to Attaining 100% Automatic Quality Assurance,” Society of Plastics Engineers E-Live Seminar, April 6, 2006.

343. D. Kazmer, “Instrumented Molding Cells”, Priamus Users' Group Annual Meeting, October 5, 2005.

344. D. Kazmer, “Advanced Methods for Plastic Product Design and Process Control,” Toyota Motor and Suppliers Meeting, Lowell, MA, April 22, 2005.

345. D. Kazmer, “What’s the big deal about something very small? The Business of Nano”, Rotary Club Meeting, Dracut, MA, May 17, 2005.

346. D. Kazmer, “Self-Regulating Melt Valves for Polymer Processing,” SPE Merrimack Valley Meeting, National Plastics Center, May 12th, 2005.

347. D. Kazmer, “Simulation of Polymer Processing,” National Science Foundation Center for High Rate Nano-Manufacturing, Lowell, MA, March 26th, 2005.

348. Kazmer, D., “The Economics of Lights Out Manufacturing,” *Society of Plastics Engineers Topical Conference on Injection Molding Systems*, Cleveland, OH, October, 2004.

349. Hayes, C., Wood, W., Mekshat, L., Kazmer, D., ”Design for Manufacturing: Future Directions for DfX,” *ASME Design Engineering Technical Conferences*, Salt Lake City, September, 2004.

350. Kazmer, D., “Advances in Molding Technology,” *Delphi Central Research, Detroit, MI*, August, 2004.

351. Kazmer, D., “Competitive Molding Technologies,” *Society of Manufacturing Engineers EASTEC Lean Manufacturing Conference*, Springfield, MA, May, 2004.

352. Kazmer, D., “Modern Injection Molding,” *Northeast Utilities Energy Conservation Seminar*, Berlin, CT, March, 2004.

353. Kazmer, D., “Competing in the 21st Century,” *Plastics Institute of America Quarterly Meeting*, Lowell, MA, February, 2004.

354. Kazmer, D., “Fundamentals of Plastic Part Design and Manufacture,” *National Manufacturing Week* Workshop, Chicago, IL, 2003.

355. Kazmer, D., “Advanced Process Control Techniques,” *PlasticsUSA Molding Technology* 2001, Chicago, IL, 2001.

356. Kazmer, D. O., “CAE & Polymer Processing Monitoring & Control: A Design Perspective,” *2001 Gordon Conference on CAE in Polymer Processing*, March 2001. Ventura, CA.

357. D. Kazmer, K. Danai, “Virtual Search Method for Injection Molding,” GE Plastics, 2000.

358. D. Kazmer, “Decision Based Design: Some Questions,” *NSF Open Workshop on Decision Based Design*, 2000. Baltimore, MD.

359. D. Kazmer, “Interactive Learning: Simulating The Design Process,” *Symposium on Manufacturing Education*, Stanford University, 2000.

360. D. Kazmer, “Fundamentals of Polymer Processing,” *Proceedings of the Annual Technical Meeting of the Society of Plastics Engineers*, Orlando, FL, 2000.

361. D. Kazmer, "Trends in the Plastics Industry: Product Development Paradigms and Impact on Human Resources," *Society of Manufacturing Engineers Plastics Molding & Manufacturing Annual Trends Report*, 2000.

362. D. Kazmer, "Quality Control Capability Assessment," *Society of Manufacturing Engineers Plastics Molding & Manufacturing Annual Trends Report*, 2000.

363. Kazmer, D. O., "Engineering Systems Design: Gaining Controllability of Dynamic Processes," *Dartmouth Thayer School of Engineering Jones Seminar*, May 2000.

364. Kazmer, D. O., "Synthesis and Analysis of Quality Control Methods for Intelligent Processing of Polymeric Materials," *Canada National Research Center*, Montreal, Quebec, February 2000.

365. Danai, K., Kazmer, D. O., and B. Kim, "Polymer Part Design & Processing," University of Massachusetts Polymer Science & Engineering Symposium, 1999.

366. Kazmer, D. O., "Manufacturing Process Design: Towards Controllability of Injection Molding," *Lehigh University Mechanical Engineering Departmental Seminar*, November 1999.

367. Kazmer, D. O., "Manufacturing Process Design," *Massachusetts Institute of Technology Design Research Seminar*, 1998.

368. Kazmer, D. O., "A Theory of Constraints for Molded Part Design and Manufacture," *GE Research & Development*, 1998.

369. Kazmer, D. O., "Commanding the Technical Frontier: Engineering Education for the 21st Century," *50th Anniversary Celebration of the University of Massachusetts Amherst College of Engineering*, 1998.

370. Kazmer, D. O, "Dynamic Feed Control: Technology for Injection Molding Flexibility & Capability," *GE Plastics*, 1997.

Patents:

371. D.O. Kazmer, "Extrusion Apparatus and Methods", PCT/US16/64527, EFS ID 27761792, Filed December 2, 2016.

372. Gao Robert X., Fan, Zhaoyan , and D. O. Kazmer, "Method and system for multivariate remote monitoring of polymer processing", United States Patent No. 9,446,544 issued September 20, 2016.

373. D. O. Kazmer, "Extrusion Screws with Multiple Channels", U.S. Provisional Patent Application EFS ID No. 24270854, December 4, 2015.

374. Kazmer, D. O., Panchal, R., and S. P. Johnston, "Methods for forming injected molded parts and in-mold sensors therefor," 8,753,553, June 17, 2014.

375. Gao, R.X., Zhaoyan, F., and D. O. Kazmer. "Method and System for Multivariate Remote Monitoring of Polymer Processing." WIPO Patent 2013006468, issued January 11, 2013.

376. Kazmer, D. O., "Apparatus and Methods for Multi-Scale Alignment and Fastening," WIPO Patent 2012162369, issued November 30, 2012.

377. Kazmer, D. O., Panchal, R. and S. Johnston, "Methods for forming injected molded parts and in-mold sensors therefor", PCT Publication No. WO/2009/129230, October 22, 2009.

378. D. Kazmer and L. Zhu, "Performance-based representation for support of multiple decisions," U. S. Patent No. 7,408,551, August 5, 2008.

379. D. Kazmer "Melt control system for injection molding," U. S. Patent No. 7,175,418, February 13, 2007.

380. D. Kazmer, "Methods and devices for melt pressure regulation," International PCT Publication No. WO/ 2005/113215, April 25, 2005.

381. Doyle, M., Kazmer, D. O., Moss, M. D., Doyle, M., Galati, V., “Apparatus for utilizing an actuator for flow control valve gates”, US Patent No. 6,824,379, November 30, 2004.
382. Kazmer, D. O., Moss, M. D., Doyle, M., van Geel, H., “Manifold system having flow control”, US Patent No. 6,769,896, August 3, 2004.
383. Doughty, M. A., Firisin, W. D., Hume, W. J., Moss, M. D., Kazmer, D. O., “Controlled injection using manifold having multiple feed channels,” U.S. Patent No. 6,767,486, July 27, 2004.
384. Kazmer; D. O., Moss, M., Doyle, M.; van Geel, H., “Manifold system having flow control,” U.S. Patent No. 6,713,002, March 30, 2004.
385. Moss, M., Kazmer, D. O., “Apparatus and method for proportionally controlling fluid delivery to readily replaceable mold inserts,” U.S. Patent No. 6,638,049, October 28, 2003.
386. Kazmer, D. O., Moss, M., Doyle, M., “Dynamic feed control system,” U.S. Patent # 6,632,079, October 14, 2003.
387. Doughty, M. A., Firisin, W. D., Hume, W. J., Moss, M. D., Kazmer, D. O., “Controlled injection using manifold having multiple feed channels,” U.S. Patent # 6,589,039, July 8, 2003.
388. Kazmer, D. O., Moss, M., “Machine for proportionally controlling fluid delivery to a mold,” U.S. Patent # 6,585,505, July 1, 2003.
389. Kazmer, D. O., Moss, M., Bassett, B., Doyle, M., “Apparatus and method for purging injection molding system,” U.S. Patent # 6,514,440, February 4, 2003.
390. Doughty, M. A., Firisin, W. D., Hume, W. J., Moss, M. D., Kazmer, D. O., “Controlled injection using manifold having multiple feed channels,” International Application No. WO 02/36324, October 25, 2002.
391. Kazmer, D. O., Moss, M., Doyle, M., van Gee, H. “Manifold system having flow control,” U.S. Patent # 6,464,909, October 15, 2002.
392. Kazmer, D., Moss, M., “Method using manifold system having flow control,” U.S. Patent # 6,436,320, August 20, 2002.
393. Kazmer, D., Moss, M., “Manifold system having flow control using pressure transducers,” U.S. Patent # 6,361,300, March 26, 2002.
394. Fuller, N., Moss, M., Kazmer, D. O., Galati, V., “Apparatus and Method for Proportionally Controlling Fluid Delivery to Stacked Molds,” International Application No. WO 02/074516, March 19, 2002.
395. Kazmer, D., Moss, M., “Manifold system having flow control using pressure transducers,” U.S. Patent # 6,343,922, February 5, 2002.
396. Kazmer, D., Moss, M., “Manifold system having flow control using separate cavities,” U.S. Patent # 6,343,921, February 5, 2002.
397. Kazmer, D., Moss, M., “Apparatus for proportionally controlling fluid delivery to a mold,” U.S. Patent #6,309,208, October 30, 2001.
398. Kazmer, D., Moss., M., “Electric actuator for a melt flow control pin,” U.S. Patent #6,294,122, September 25, 2001.
399. Kazmer, D., Moss, M., Doyle, M., “Dynamic Feed Control System”, International Application No. WO/2001/060580, August 23, 2001.
400. Kazmer, D., Moss, M., “Apparatus for proportionally controlling fluid delivery to a mold,” U.S. Patent #6,287,107 , September 11, 2001.
401. Kazmer, D., Moss, M., “Manifold system having flow control using extended valve pin,” U.S. Patent # 6,254,377, July 3, 2001.
402. Kazmer, D., Moss, M., “Manifold system having proportional flow control,” International Application No. WO/2001/034364, May 17, 2001.

403. Kazmer, D. O., Moss, M. D., Doyle, M., VanGeel, H., "Manifold System Having Flow Control," International Application No. WO 01/21377, March 29, 2001.

404. Kazmer, D. O., Zhu, L., "A performance-based representation for support of multiple decisions," International Application No. WO/2000/072268, November 30, 2000.

405. Kazmer, D. O., Moss, M. D., "Manifold System Having Flow Control," International Application No. WO WO/1999/054109, October 28, 1999.

406. Kazmer, D. O., Moss, M., "Manifold System Having Flow Control," International Application No. WO 99/54109, May 27, 1998.

407. Kazmer, D. O., "Injection molding gate flow control," U.S. Patent #5,556,582, September 17, 1996.

Other Creative Works:

408. D. Kazmer, "AEEE: Analysis of Energy Efficiency in Extrusion", Matlab codes for modeling of polymer plastication and energy consumption in single screw extrusion processes.
409. D. Kazmer, "Single Screw Extrusion Simulation", by C language program developed with Fluidix Smoothed Particle Hydrodynamic (SPH) Solver using NVIDIA CUDA parallel computing platform (1,000+ cores), https://www.youtube.com/watch?v=Ha6KsbYBJgw, Feb. 1, 2016.
410. D. Kazmer, "Single Pellet Extrusion with a Fractal Screw Design", by C language program developed with Fluidix Smoothed Particle Hydrodynamic (SPH) Solver using NVIDIA CUDA parallel computing platform (1,000+ cores), https://www.youtube.com/watch?v=BWPNSYt9ehU, Feb. 1, 2016.
411. D. Kazmer, "Extrusion Screw Design Automation", by VisualBasic program developed with SolidWorks Application Programming Interface (API), https://www.youtube.com/watch?v=gtAtqKPlwAM, Feb. 1, 2016.
412. D. Kazmer, A. Moshe, T. Coogan, M. Akroyd, D. Cacciola, D. Cote, A. Drammeh, K. Hallab, M. Haque, R. Haraja, R. Heckbert, A. Holub, M. Magaletta, C. McRae, G. Misherfi, T. Moy, K. Newland, H. Nguyen, M. Palacios, J. Pancotti, M. Pinard, B. Porter, R. Rodriguez, A. St. James, D. Van Schalkwijk, R. Wong, M. Yuen, "A Study of 3D Printing: from Pellets to Parts," Poster presentation to Next Generation 3D Printing Workshop, March 31st, 2015.
413. D. O. Kazmer, "On Public Speaking," 2 hour workshop to New Hope Tutorials, Boxford, MA, March 18, 2015.
414. D. Kazmer, D. Willis, S. Kuhn, J. Hartman, and J. Lohmeier, "Transforming Engineering Education through Making (TEEM)," Poster presentation to Univ. Mass. Lowell Teaching Symposium, November 5, 2014.
415. D.O. Kazmer, "Changing Paradigms for Teaching Large Courses", Center for Teaching & Learning, Univ. Mass. Lowell, April 14, 2014.
416. D. O. Kazmer, "Design Thinking," 150 minute workshop for 47.473 Social Psychology Seminar, April 7, 2014.
417. S. R. Bell, D.O. Kazmer, and D. Unger, "Know Science? Know Engineering? Putting Science Practices and Engineering Design Together in Your K-8 Classrooms," 2014 National Conference on Science Education, April 3-6, 2014, Boston, MA.
418. D. O. Kazmer, "Vast Viscosity Variances in Polymer Melt Constitutive Modeling," SPE Eastern Regional Meeting, Lowell, MA, December 19, 2013.
419. S. Latham, D. Hewitt, B. Malloy, and D. Kazmer, "Towards a Better Integration of the Classroom and Co-op Experience", UMass Lowell Annual Faculty Symposium, October 17, 2013.
420. D. Kazmer, C. Farmer, L. Nadelson, "K12 Teacher Preparation for Teaching Engineering," Think-Pair-Share Panel, UTeach Annual Conference, May 18, 2013, Austin, TX.

421. D.O. Kazmer, “Supervised Learning,” 3 hour workshop delivered to electrical and computer engineering course no. 16.711 Computational Data Modeling, November 13, 2013.
422. D.O. Kazmer, “Design for Manufacture and Assembly,” 1 hour lecture and three 2 hour labs delivered to plastics engineering course no. 25.108 Introduction to Engineering II, March 4-6, 2014.
423. D.O. Kazmer, B. G. Tucker, L. Barrington, E. Reynaud, and J.J. Duffy, “Faculty Perspectives on Service-Learning,” 2013 ASEE Northeast Section Meeting, March 14-16, 2013, Norwich, VT.
424. D. Kazmer and A. Chann, “Analysis & Application of Tegris: A Self-Reinforced Polyproylene”, report to Milliken Corporation, February 12, 2013.
425. L. Barrington , J.J. Duffy, D.O. Kazmer, E. Reynaud, B.G. Tucker, “Faculty Development and Perspectives on EFELTS & SLICE”, NSF TUES Conference, January 24-26, 2013 (Washington, DC).
426. D. O. Kazmer, F. Martin, and P. Chowdhury, “Streamlining for Efficiencies in Education (SEE)”, Proposal to Mass. Department of Higher Education (2012).
427. R. Gao and D. Kazmer, “Multivariate Remote Sensing for Improved Observability in Injection Molding”, NSF CMMI Conference, July, 2012.
428. David Kazmer, Arun Kumar, and Joey Mead, Invention Disclosure, “Pulsed Field-Assisted Electrophoretic Polymer Self-Assembly.”
429. D. Kazmer, “Engineering Minors Comparison,” for Univ. Mass. Lowell College of Engineering Academic Advising, June, 2012.
430. D.O. Kazmer and K. Bardaro, “Engineering Salary Modeling and Analysis,” American Society of Engineering Education Northeast Section Conference, April 29-30, 2012, Lowell, MA.
431. R. X. Gao and D. O. Kazmer, “A multivariate sensor for injection molding,” NSF Design and Manufacturing Grantees Conference, Boston, MA, July 9-12, 2012.
432. E. Reynaud, J. J. Duffy, L. Barrington, J. L. Rhoads, D. O. Kazmer, and B. G. Tucker, “Engineering Faculty Attitudes Towards Service-Learning,” Community Engagement Poster Session at ASEE Annual Conference, San Antonio, TX, 2012.
433. D. Kazmer, “Incoming Engineering Student Academic Orientation,” presentation and materials for Univ. Mass. Lowell College of Engineering, 2011-2014.
434. D. Kazmer, “Supply and Demand of Engineers,” American Society of Engineering Education Northeast Section Conference, April 29, 2011 (Hartford, CT).
435. David Kazmer, Invention Disclosure 2011-026, “A Fractal Zipper for Multi-Scale Alignment and Fastening”, January 28, 2011.
436. D. Kazmer, R. Panchal, S. Johnston, “Methods for forming injected molded parts and in-mold sensors therefor,” PCT/US2009/040508.
437. R. Gao and D. Kazmer, “Structural Optimization of a Dual-Parameter Sensor and Simulation for Prediction of Unobservable Process States in Injection Molding”, NSF CMMI Research and Innovation Conference, January 4-7, 2011, Atlanta, GA.
438. Kazmer, D., “BioModular Multi-Scale Systems,” presentation to Joint US-Ireland Conference on Bio-Nano Systems, Lowell, MA, October, 2010.
439. Yingrui Shang, Liang Fang, David Kazmer, Ming Wei, Joey Mead, and Carol Barry, “Numerical Simulation of the Phase Separation of a Ternary Systems on a Heterogeneously Functionalized Substrate,” Poster to NSF CHN Site Review, June 2010.
440. D. Kazmer and S. Westerdale, “A Six Sigma Quality Control Methodology,” UMetrics User Group Conference, October 1, 2010 (Boston, MA).
441. D. Kazmer, “Some Thoughts on NSF Proposal Development,” UML Research Conference, October 26, 2010 (Lowell, MA).
442. D. O. Kazmer, S. Velusamy, S. Westerdale, S. Johnston, R. X. Gao, “Robustness of Switchover Methods for Injection Molding,” SPE Plastics Research Online, 2010.

443. Y. Shang, D. Kazmer, M. Wei, J. Mead, and C. Barry "Numerical Simulation of the Phase Separation of a Ternary System on a Heterogeneously Functionalized Substrate," NSF Center for High Rate Nanomanufacturing Industry Workshop, 2009.
444. R. X. Gao and D. O. Kazmer, "Structural Optimization of a Dual-Parameter Sensor and Simulation for Prediction of Unobservable Process States in Injection Molding," NSF Design and Manufacturing Grantees Conference, 2009.
445. Y. Shang, D. Kazmer, M. Wei, J. Mead, and C. Barry "Numerical Simulation of the Phase Separation of a Ternary System on a Heterogeneously Functionalized Substrate," NSTI Nanotech Conference, June 1-5, 2008.
446. Gao, R. X., and D. O. Kazmer, "Design and Analysis of a Self-Powered Sensor Array for Injection Molding Process Monitoring," NSF Design and Manufacturing Grantees Conference, 2008.
447. Shang, Y., D. Kazmer, "Experimental validation of numerical simulation for phase decomposition of a binary polymer thin film on a patterned substrate," 5th New England International Manufacturing Workshop, June 7, 2007.
448. B. Fan and D. Kazmer, "Erratum: Low-temperature modeling of the time-temperature shift factor for polycarbonate," Advances in Polymer Technology, v. 25, n. 1, p. 73, DOI 10.1002/adv.20058, Spring, 2006.
449. D. Kazmer, "Self-regulating valves for dynamic control of molten plastics", Proceedings of 2006 NSF Design, Service, and Manufacturing Grantees and Research Conference, St. Louis, Missouri, 2006.
450. Y. Shang and D. Kazmer, "Simulation of Polymer Morphology in Nano-feature Replication," Sukant Tripathy Memorial Conference, November 13, 2005.
451. K. Garnavish, D. Kazmer, W. Rousseau, and Y. Shang, "Multi-Scale Simulation of Polymer Processing," NSF Workshop on Nano-scale manufacturing, May 23, 2005.
452. D. O. Kazmer, "Lean Development," Flow Front Magazine, Moldflow Inc., April, 2005.
453. D. O. Kazmer, Book Review, Design of Machine Elements by M. F. Spotts, T.E. Shoup, L. E. Hornberger, Eighth Edition, Pearson Prentice Hall, Upper Saddle River, NJ, 2004 (ISBN 0-13-048989-1). Appearing in *Journal of Mechanical Design,* 2003.
454. L. Zhu and D. O. Kazmer, "Engineering Decision Synthesis with an Evolving Feasible Space," Submitted to *Research in Engineering Design*, 2003.
455. Kazmer, D. O., "Dynamic Cooling for Injection Molding," Final Report to Office of Naval Research, 2003.
456. Kazmer, D. O., "An Optimization Primer," paper written for *Introduction to Engineering Course Reader,* August 1, 2003.
457. Kazmer, D., Hatch, D., Zhu, L., "Four Measures of Manufacturing System Performance," ASME Journal of Manufacturing Science, 2002.
458. Zhu, L., and D. O. Kazmer, "An Extensive Simplex Method for Mapping Global Feasibility," UMass Amherst Invention Disclosure, 2001.
459. Fagade, A., Kazmer, D., "Optimal Component Consolidation In Mechanical Systems," Report to GE Plastics Advanced Design Engineering Group, 2000.
460. Fagade, A., Kazmer, D., "Early Cost Estimation for Injection Molded Parts," Report to GE Plastics Advanced Design Engineering Group, 1999.
461. Kazmer, D. O., "Reflection on Teaching and Learning," speech to *University of Massachusetts' Celebration of Teaching and Learning*, March 25, 1999.

462. Kapoor, D., and D. Kazmer, “Comparison of Sequential Valve Gate Molding to Multi-Cavity Melt Control Injection Molding,” Report to GE Plastics, 1998.
463. Kazmer, D. O., “Incorporation of Engineering Analysis into Design Synthesis,” *NSF Division of Design, Manufacturing, and Industrial Innovation, Grantees Conference*, Monterrey Mexico, January 1998.
464. Kazmer, D. O., Danai, K., “Automatic Tuning and Regulation of Injection Molding,” *NSF Division of Design, Manufacturing, and Industrial Innovation, Grantees Conference,* Monterrey Mexico, January 1998.
465. Fagade, A., Kapoor, D., and D. Kazmer, “Analysis of Design and Manufacturing Complexity,” Report to GE Plastics Advanced Design Engineering Group, 1997.
466. Poslinski, A. J., Aslam, S., Kazmer, D. O., “Effects of Viscosity Variation on Injection Molding,” *GE Research & Development Technical Information Series Number 92CRD146*, 1992.
467. Kazmer, D. O., “Diskflow Validation Summary,” GE Plastics Report, 1992.
468. Kazmer, D. O., “Customer Training Manual on Mold Packing Analysis,” GE Plastics Report, 1992.
469. Kazmer, D. O., “Development of a Radial Flow Analysis for Injection Molding,” *GE Research & Development Technical Information Series Number 91CRD195*, 1991.
470. Kazmer, D. O., “Adaptive Meshing of Two-Dimensional Evolving Geometries,” Rensselaer Polytechnic Institute, Advanced Finite Element Methods Independent Study Report, 1990.

Courses Taught:

- Fall 1995, ME415: Mechanical Systems Design, Enrollment: 14.
- Spring 1996, ME415: Mechanical Systems Design, Enrollment: 20.
- Fall 1996, MIE477: Production Scheduling and Control, Enrollment: 15.
- Spring 1997, MIE415: Mechanical Systems Design, Enrollment: 32.
- Fall 1997, MIE760: Advanced Mechanical Systems Design, Enrollment: 15.
- Spring 1998, MIE415: Mechanical Systems Design, Enrollment: 28.
- Spring 1998, MIE395: Engineering Professionalism Seminar, Enrollment: 20.
- Fall 1998, MIE697M: Modern CAD System Development, Enrollment: 16.
- Spring 1999, MIE415: MIE Capstone Systems Design, Enrollment: 25.
- Spring 1999, MIE395: Engineering Professionalism Seminar, Enrollment: 40.
- Fall 1999, MIE113: Introduction to Mech. & Ind. Eng, Enrollment: 24.
- Fall 1999, MIE697P: Manufacturing Process Design, Enrollment: 15.
- Spring 2000, MIE395: Engineering Professionalism Seminar, Enrollment: 45.
- Spring 2000, MIE415: Mechanical Systems Design, Enrollment: 20.
- Fall 2000, MIE113: Introduction to Mech. & Ind. Eng, Enrollment: 21.
- Fall, 2000, MIE760: Advanced Mechanical Systems Design, Enrollment: 8.
- Spring 2000, MIE415: Mechanical Systems Design, Enrollment: 9.
- Spring 2002, 26.373: Mold Engineering I, Enrollment: 21.
- Fall 2003, 26.524: Process Analysis, Instrumentation, and Control, Enrollment: 9.
- Spring 2003, 26.373: Mold Engineering I, Enrollment: 21.
- Spring 2003, 26.521: Lean Plastics Manufacturing, Enrollment: 10.

- Fall 2003, 25.107: Introduction to Engineering I, Enrollment: 288.
- Spring 2004, 26.373: Mold Engineering I, Enrollment: 23.
- Spring 2004, 26.521: Lean Plastics Manufacturing, Enrollment: 12.
- Fall 2004, 25.107: Introduction to Engineering I, Enrollment: 279.
- Spring 2005, 26.373: Mold Engineering I, Enrollment: 14.
- Spring 2005, 26.521: Lean Plastics Manufacturing, Enrollment: 13.
- Fall 2005, 25.107: Introduction to Engineering I, Enrollment: 307.
- Spring 2006, 26.373: Mold Engineering I, Enrollment: 25.
- Spring 2006, 26.524: Process Analysis, Instrumentation, and Control, Enrollment: 12.
- Fall 2006, 25.107: Introduction to Engineering I, Enrollment: 358.
- Spring, 2007, 26.373: Mold Engineering I, Enrollment: 23.
- Spring, 2007, 26.576: Advanced Mold Design, Enrollment: 11.
- Fall 2007, 25.107: Introduction to Engineering I, Enrollment: 410.
- Spring, 2008, 26.373: Mold Engineering I, Enrollment: 21.
- Spring, 2008, 26.576: Advanced Mold Design, Enrollment: 10.
- Fall, 2009, 26.606: Plastics Manufacturing Systems Engineering, Enrollment: 16.
- Fall, 2009, 26.404: Process Control, Enrollment: 21.
- Spring, 2010, 26.515: Lean Plastics Manufacturing, Enrollment: 28.
- Spring, 2010, 26.576: Advanced Mold Design, Enrollment: 11.
- Fall 2010, 26.404: Process Control, 27 students
- Fall 2010, 26.606 Plastics Manufacturing Systems Engineering, 15 students
- Spring, 2011, 26.218: Introduction to Design, 33 students.
- Spring 2011, 26.515: Lean Plastics Manufacturing, 13 students
- Fall, 2012, 26.404: Process Control. 35 students.
- Fall, 2012, 26.618: Structural Product Design. 17 students.
- Spring, 2013, 26.515.201: Lean Plastics Manufacturing. 18 students.
- Spring, 2013, 26.515.202: Lean Plastics Manufacturing. 18 students.
- Fall, 2013, 26.404: Process Control. 21 students.
- Fall, 2013, UTL.301: Project-Based Instruction. 21 students.
- Spring, 2014, 26.218: Introduction to Design, 51 students registered.
- Spring, 2014, 26.618: Structural Product Design. 12 students registered.
- Fall, 2014, 25.107.104: Introduction to Engineering. 58 students registered.
- Fall, 2014, 26.404: Process Control. 24 students registered.
- Spring, 2015, 26.218.101: Introduction to Design. 30 students registered.
- Spring, 2015, 26.218.102: Introduction to Design. 40 students registered.
- Spring, 2015, 26.515: Lean Plastics Manufacturing. 21 students registered.
- Fall, 2016, PLAS 1070 Introduction to Plastics Engineering. 44 students registered.
- Fall, 2016, PLAS 6180 Structural Product Design. 19 students registered.
- Spring, 2017, PLAS 1070 Introduction to Plastics Engineering. 28 students registered.

- Spring 2017, PLAS 5150 Lean Plastics Manufacturing. 27 students registered.

Service:

- Chair, Department of Plastics Engineering, University of Massachusetts Lowell, 2016-
  - Completed implementation of UML Essential Learning Outcomes (ELO) by aligning course/ABET objectives with UML ELO system. Input course applications to ELO system and responded with revisions and rebuttals for other instructors as appropriate. Worked with other UML administrators to process Plastics ELOs through SIS system.
  - Revised ABET Student Outcome Performance Assessment forms and reported data and procedures to faculty.
  - Led search process for Plastics and Biomedical Engineering faculty, resulting in identification of recommended faculty hires Anne Soucy, Azadeh Sheidaei, and Rosalyn Abbott-Beauregard.
  - Planned and hosted PLASTICS 4.0 faculty recognition event, among other alumni events.
  - Developed and co-leading (with R. Nagarajan) research services agreement with Plastindia Foundation to provide faculty training towards the premier, fully ABET-accredited Plastics Engineering undergraduate program in India
  - Developed articulation agreements with Quinebag Valley Community College (CT) for engineering technology students to enter Plastics Engineering.
  - Developed and implemented faculty survey form to identify faculty teaching & service interests as well as future research opportunities & equipment needs
  - Developing and implementing new department workflows and associated bylaws
  - Reconstituting department Industrial Advisory Board and associated bylaws
- Advisory board member, Pre-Engineering Program, Greater Lawrence Technical High School, 2014-16
  - Assisted in program accreditation with Massachusetts Board of Education
- Chair, Plastics Engineering Faculty Search Committee, 2014-2015. Chair, Biomedical Engineering Faculty Search Committee, 2014-2015.
  - Recommended three faculty hires with unanimous support of faculty.
- Treasurer, Chair of Finance Committee, and Director, 401c(3) Museum Institute for Teaching Science, 2012-2015
  - Provide quarterly review of revenues and expenses, reporting to Board of Directors.
  - Assist in development of strategic plan and actions; implemented MITS dashboard for performance measurement.
  - Reviewed curricular programs, assisting in development of hybrid project-based instruction teaching workshops.
- NEASC Undergraduate Programs Committee, Fall 2012
  - Coordinated undergraduate engineering programs for NEASC site visit.
  - Assisted in authoring and review of NEASC Standard Four: Academic Program
- UML ABET Plastics Engineering Program Accreditation, 2012-2014
  - Prepared draft of department self-study report
  - Planned and implemented the ABET Review Committee (ARC) to review Student Outcome Performance Assessment (SOPA) and ensure continuous improvement

- Served as Chair of the ARC; assessed faculty curricular improvements; prepared draft of thirty day response, final amendment, and supporting exhibits
- UML Engineering Technology Teaching Program Accreditation, Spring 2013
  - Assessed engineering curricula for Department of Higher Education (DHE) review
  - Assisted Dean Anita Greenwood with accreditation report & response
  - Performed DHE Accreditor Review for Fitchburg State Engineering Technology Teaching Program
- Associate Dean, James B. Francis College of Engineering, January, 2011-April, 2012:
  - Conducted faculty interviews and faculty needs analysis of College.
  - Performed student survey of S2011 Welcome Day.
  - Led phone campaign to recruit F2012 Fall Cohort.
  - Developed Women-In-Tech Day with Sciences Associate Dean, Fred Martin
  - Developed one-way and/or two-way articulation agreements with Bunker Hill Community College, Middlesex Community College, Northern Essex Community College, Quinsigamond Community College.
  - Coordinated Deshpande Sandbox activities with CoE faculty.
  - Member of delegation representing UMass Lowell to Deshpande Sandbox in Hubli, India.
  - Analyzed CoE curricula with respect to student failure modes.
  - Analyzed CoE faculty teaching & research workloads.
  - Led $2.5MM STEP proposal development with NECC, MCC, MIT, & Merrimack College.
  - Developed Energy Engineering Minor with broad faculty consensus.
  - Developed Biomedical Engineering Minor with broad faculty consensus.
  - Developed STEM Teaching Minor with Dean Anita Greenwood.
  - Co-Director of UTeach Teaching Minor; advising engineering student participants.
  - Developed doctoral RA/TA funding model and rolled-out to faculty with WebNow.
  - Proposed invention factory, an experiential model for student learning .
  - Member, University Research and Commercialization Committee.
  - Facilitated College of Engineering ABET review meetings with 12 supporting organizations.
- Reviewer, Commonwealth of Massachusetts Department of Higher Education, 2013. Performed reviews of engineering technology teacher certification programs.
- Lead, UML/FIBSEM Outreach Program. Organized and led field trips for 7th and 8th grade students to learn about microscopy, college majors, and science/engineering careers. Over 400 students visited UML between April 8-12 for a half day program. Another 350 students were directly impacted through the offering of teaching modules about scale, from “quarks to galaxies”.
- Chair, American Society of Engineering Education Northeast Regional Section Conference, April 29-30, 2012. *Arranged reviews for 70 papers; organized 120 posters. Registered 424 participants. Managed budgets & expenses. Authored advance and final programs as well as proceedings. Developed conference planning kit for future ASEE conferences.*
- Member, 2012, of Search Committee for Entrepreneurship Director of CVIP.
- Chair, AY2011 Plastics Engineering Tenure Track Faculty Search Committee, hired Margaret Sobkowicz-Kline.
- Chair, AY2011 Plastics Engineering Non-Tenure Track Search Committee, hired Gonca Altuger

- Founding Board Member, University Faculty Development Center, December, 2010-February, 2011. *Developed mission statement: To inspire and assist the faculty to realize their highest potential for teaching, research, scholarship, and service throughout a productive career.*
- Member, University Research and Commercialization Committee, 2011-.
- Chair, Process Instrumentation and Control Symposium, International Polymer Processing Conference, Banff, Canada, July, 2010.
- Member, University 2020 Strategic Planning Graduate Program Committee, 2009-.
- Chair, Society of Plastics Engineers' Process Monitoring & Control Special Interest Group, 2005-2008. Responsibilities included solicitation and review of papers as well as organization and staffing of sessions.
- Associate Editor, Advances in Polymer Technology, 2004-2014.
- Associate Editor, Polymer Plastics Technology and Engineering, 2001-2014.
- Independent Reviewer, 21st Century Jobs Fund for Advanced Manufacturing, Research Competitiveness Service at the American Association for the Advancement of Science (AAAS), 2006-.
- Associate Editor, ASME Journal of Mechanical Design, 2003-2006.
- Chair, ASME Design for Manufacturing Technical Committee, 2003-2005. Responsibilities included staffing conferences for the DFM tracks at annual Design Engineering Technical Conference, International Mechanical Engineering Congress, and National Manufacturing Week. Also responsible for liaison with Design Education and other technical committees as well as tri-annual reports and meetings with the Design Division Executive Committee.
- Chair, Design for Manufacturing Symposium, International Mechanical Engineering Congress, November, 2004.
- Vice-Chair, ASME Design for Manufacturing Technical Committee, 2001-2003.
- Chair, 6th Design for Manufacturing Symposium, ASME Engineering Design Technical Conferences, 2001.
- Program Chair, 5th Design for Manufacturing Symposium, ASME Engineering Design Technical Conferences, 2000.
- Chair, SPE Processing Instrumentation, Process Monitoring, and Control Special Interest Group, 2005-2008.
- Chair, Molding Technology Symposium, International Polymer Processing Conference, June, 2004.
- Liaison, Service Learning Project for the Tsongas Industrial History Center's Innovation Laboratory, 2004-2008. Incorporated service learning project in the Introduction to Engineering course. Project involved liaison with staff at Tsonga, project development, student instructions in both lectures and sections, co-evaluation of projects, post-processing of evaluations, development of exhibit, individual supervision of final student projects, and final exhibition at Tsongas.
- Member, UML Faculty Senate, 2003-2011.
- Author and Administrator, Plastics Engineering Web Site, 2003-2005. Responsibilities have included renovation and deployment of department web site. Surveyed students, faculty, and alumni to characterize requirements. Developed architecture and functionality. Implemented new site with content from Department Chair Robert Malloy and assistance from a computer science graduate student.
- Member, Mold-Masters Advisory Council, 2003-2005.
- Founding Member, ThermoCeramiX Technical Advisory Board, 2003-2005.

- Member, University of Massachusetts' Patent Evaluation Committee, 2000-2001.
- Ad Hoc Reviewer, NSF Small Business Initiative Research Program, 2003.
- Member, Collaboration Catalyst Corp. Technical Advisory Board, 2001-2004.
- Ad Hoc Reviewer, Measurement, 2013-.
- Ad Hoc Reviewer, IEEE Sensors, 2009-.
- Ad Hoc Reviewer, Polymer, 2010-.
- Ad Hoc Reviewer, Proceedings of the Institution of Mechanical Engineers, Part B Journal of Engineering Manufacture, 2010-.
- Ad Hoc Reviewer, IEEE Transactions in Industrial Automation, 2009-.
- Ad Hoc Reviewer, IEEE Transactions on Automation Science and Engineering, 2001-.
- Ad Hoc Reviewer, NSF Manufacturing Processes Program, 2009.
- Ad Hoc Reviewer, NSF Engineering Design Program, 2008.
- Ad Hoc Reviewer, IEEE Transaction on Engineering Management, 2004-.
- Ad Hoc Reviewer, Langmuir, 2004-.
- Ad Hoc Reviewer, International Journal of Food Science, 2003-04.
- Ad Hoc Reviewer, American Institute of Aeronautics and Astronautics, 2003-.
- Ad Hoc Reviewer, Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 2003-.
- Ad Hoc Reviewer, Rheological Acta, 2003-.
- Ad Hoc Review, IEEE Transactions on Industrial Informatics, 2010-
- Ad Hoc Reviewer, Polymer Plastics Technology & Engineering, 2000-.
- Ad Hoc Reviewer, Journal of Polymer Composites, 2000-.
- Ad Hoc Reviewer, NSF Manufacturing Equipment Program, 2000-.
- Ad Hoc Reviewer, NSF Manufacturing Processes Program, 2000-.
- Ad Hoc Reviewer, NSF Operations Management Program, 1999-.
- Ad Hoc Reviewer, International Polymer Processing, 1999-.
- Ad Hoc Reviewer, ASME Journal of Manufacturing Science, 1998-.
- Ad Hoc Reviewer, Research in Engineering Design, 1998-.
- Ad Hoc Reviewer, Polymer Engineering & Science, 1997-.
- Ad Hoc Reviewer, NSF Design Engineering Program, 1996-.
- Ad Hoc Reviewer, ASME Journal of Mechanical Design, 1996-.

APPENDIX B

David O. Kazmer

Injection Mold Design Engineering

HANSER
Hanser Publishers, Munich • Hanser Gardner Publications, Cincinnati

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Distributed in the USA and in Canada by
Hanser Gardner Publications, Inc.
6915 Valley Avenue, Cincinnati, Ohio 45244-3029, USA
Fax: (513) 527-8801
Phone: (513) 527-8977 or 1-800-950-8977
www.hansergardner.com

Distributed in all other countries by
Carl Hanser Verlag
Postfach 86 04 20, 81631 München, Germany
Fax: +49 (89) 98 48 09
www.hanser.de

Library of Congress Cataloging-in-Publication Data
Kazmer, David.
Injection mold design engineering / David O. Kazmer.
p. cm.
ISBN-13: 978-1-56990-417-6 (hardcover)
ISBN-10: 1-56990-417-0 (hardcover)
1. Injection molding of plastics. I. Title.
TP1150.K39 2007
668.4'12--dc22
2007018765

Bibliografische Information Der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie;
detaillierte bibliografische Daten sind im Internet über <http://dnb.d-nb.de> abrufbar.

ISBN 978-3-446-41266-8

Production Management: Oswald Immel
Typeset by Manuela Treindl, Laaber, Germany
Coverconcept: Marc Müller-Bremer, Rebranding, München, Germany
Coverillustration by David O. Kazmer, Lowell, USA
Coverdesign: MCP • Susanne Kraus GbR, Holzkirchen, Germany
Printed and bound by Druckhaus "Thomas Müntzer" GmbH, Bad Langensalza, Germany

Preface

Mold design has been more of a technical trade than an engineering process. Traditionally, practitioners have shared standard practices and learned tricks of the trade to develop sophisticated molds that often exceed customer expectations.

However, the lack of fundamental engineering analysis during mold design frequently results in molds that may fail and require extensive rework, produce moldings of inferior quality, or are less cost effective than may have been possible. Indeed, it has been estimated that on average 49 out of 50 molds require some modifications during the mold start-up process. Many times, mold designers and end-users may not know how much money was "left on the table".

The word "engineering" in the title of this book implies a methodical and analytical approach to mold design. The engineer who understands the causality between design decisions and mold performance has the ability to make better and more informed decisions on an application by application basis. Such decision making competence is a competitive enabler by supporting the development of custom mold designs that outperform molds developed according to standard practices. The proficient engineer also avoids the cost and time needed to delegate decision to other parties, who are not necessarily more competent.

The book has been written as a teaching text, but is geared towards professionals working in a tightly integrated supply chain including product designers, mold designers, and injection molders. Compared to most handbooks, this textbook provides worked examples with rigorous analysis and detailed discussion of vital mold engineering concepts. It should be understood that this textbook purposefully investigates the prevalent and fundamental aspects of injection mold engineering.

I hope that *Injection Mold Design Engineering* is accessible and useful to all who read it. I welcome your feedback and partnership for future improvements.

Best wishes,

David Kazmer, P. E., Ph. D.

Lowell, Massachusetts
June 1, 2007

12.4 Fasteners

The mold design must also include fasteners to rigidly fasten the multiple components of the mold. There are three types of fasteners commonly used in molds. First, fits are used to tightly locate one component within another, such as a cavity or core insert being located within a retainer plate. Second, locating pins or dowels are used to locate one components above another, such as the ejector housing to the support plate. These first two fastening methods only provide fastening across the length and width directions of the mold. To fasten the mold components together in the height direction, socket head cap screws are used wherein the screw's head is retained in a mold plate and the screw's threads engage the component to be fastened. Each of these fastening methods is next analyzed.

12.4.1 Fits

A "fit" refers to the mating of two components. A clearance fit refers to a mating in which a nominal clearance between the surfaces of the two components. While a clearance fit provides for easy assembly with no insertion forces, the clearance between the two components permits the precise location of components to remain unknown. Since tight tolerances are required in molds, interference fits are commonly used to locate the mold components.

Interference fits occur when the male component has a nominal dimension that is larger than the nominal dimension of the female component, as shown in Figure 12.30 for a core insert and a retainer plate. Since metals have a high elastic modulus, a rigid interference fit can result

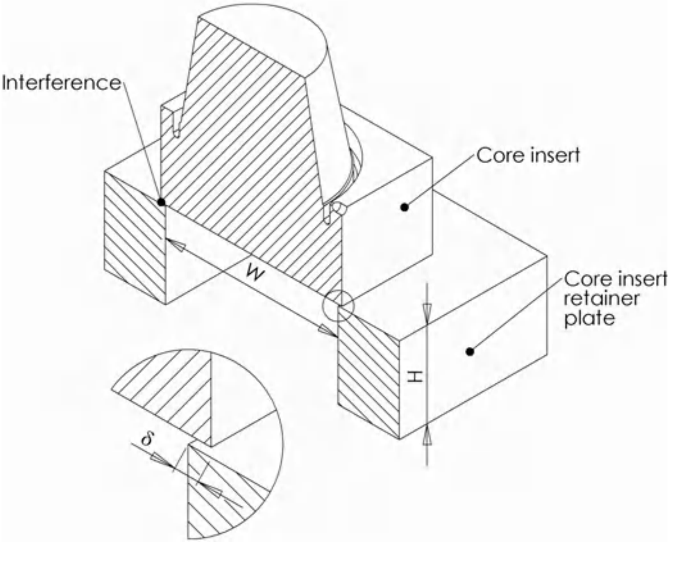

Figure 12.30: Location-interference fit for inserts

when the difference between the nominal dimensions is very small, on the order of 0.01% of the nominal dimension. The tightness and rigidity of the interference fit increases with the amount of interference between the two components. Unfortunately, the implementation of interference fits is impeded by the dimensional variations imposed in the components' machining processes. For this reason, standard systems of fits have been developed to provide limits on the dimensions of the components.

The fits analyzed here are based on a lateral hole basis and have been converted from U.S. customary units to metric units.[4] In this method, rectangular members with width, W, and length, L, are modeled as a circular member with apparent diameter, D, computed as:

$$D = \sqrt{W \cdot L} \tag{12.27}$$

The tolerance limit, λ, on a given dimension is then calculated according to a formula:

$$\lambda = 0.001 \cdot C \cdot D^{\frac{1}{3}} \tag{12.28}$$

where C is a coefficient corresponding to the lower and upper limit for the male or female component provided by international standards. Table 12.1 provides coefficients for locational-interference fits (LN1 to LN3) and drive-interference fits (FN1 to FN3). Locational-interference fits are used when the accuracy of location is critical and the components require lateral rigidity. However, locational-interference fits do not provide significant retention force in the height direction, so the components must be secured in the height direction to another component via screws or other means. FN1 to FN3 correspond to drive fits with increasing interference and requiring increasing insertion forces. While drive fits provide semi-permanent assemblies, mold designs usually provide screws or other means for positively retaining the components in the height direction.

Table 12.1: Location tolerance interference coefficients [mm]

Fit	$C_{interference}$	Female (hole in plate)		Male (insert)	
		Lower limit	Upper limit	Lower limit	Upper limit
LN1	4.89	0.00	4.93	5.67	9.05
LN2	7.14	0.00	7.84	8.59	13.52
LN3	12.22	0.00	7.84	13.67	18.60
FN1	13.57	0.00	4.93	14.34	17.73
FN2	22.02	0.00	7.84	23.47	28.41
FN3	30.85	0.00	7.84	32.30	37.24

[4] Two of the most common standards for fitting include "Preferred Limits and Fits for Cylindrical Parts", ANSI B4.1-1967 (R1999), and "Preferred Metric Limits and Fits" ANSI B4.2-1978 (R1999). ANSI B4.1 is analyzed here due to its relative simplicity and broad applicability, though the mold designer may conform to whatever standard is most appropriate.

Example: The base of the core insert for the cup mold is 88.90 mm on each side. Specify the tolerances for a light drive (FN1) fit.

The apparent diameter of the core insert is:

$$D = \sqrt{88.90\ \text{mm} \cdot 88.90\ \text{mm}} = 88.90\ \text{mm}$$

The lower tolerance limit for the insert dimension is computed with C equal to 14.34:

$$\lambda_{\text{insert}}^{\text{lower}} = 0.001 \cdot 14.34 \cdot 88.9^{\frac{1}{3}} = 0.064\ \text{mm}$$

The upper tolerance limit for the insert dimension is computed with C equal to 17.73:

$$\lambda_{\text{insert}}^{\text{upper}} = 0.001 \cdot 17.73 \cdot 88.9^{\frac{1}{3}} = 0.079\ \text{mm}$$

The lower tolerance limit on the mating hole in the retainer plate is 0:

$$\lambda_{\text{plate}}^{\text{lower}} = 0.001 \cdot 0.0 \cdot 88.9^{\frac{1}{3}} = 0.000\ \text{mm}$$

The upper tolerance limit on the mating hole in the retainer plate is computed with C equal to 4.93:

$$\lambda_{\text{plate}}^{\text{upper}} = 0.001 \cdot 4.93 \cdot 88.9^{\frac{1}{3}} = 0.022\ \text{mm}$$

The minimum and maximum dimensions on the insert are specified as 88.96 and 88.98 mm, respectively. The minimum and maximum dimensions on the hole in the plate are specified as 88.90 and 88.92 mm. These dimensional limits are shown in Figure 12.31.

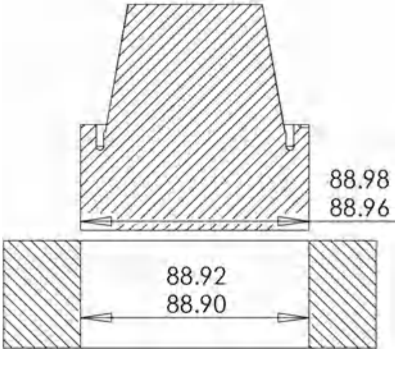

Figure 12.31: Insert and plate dimensions for an FN1 fit

It may be of interest to estimate the insertion force required to achieve various interference fits, so that excessive insertion forces may be avoided. The insertion force may be estimated by the compressive stress required to strain the components during assembly. The expected amount of interference can be computed as the average male dimension minus the average female dimensions. Alternatively, the expected amount of interference, $\lambda_{\text{interference}}$, can be computed using the formula:

$$\lambda_{\text{interference}} = 0.001 \cdot C_{\text{interference}} \cdot D^{\frac{1}{3}} \tag{12.29}$$

where $C_{\text{interference}}$ is a coefficient derived from the limit coefficients provided in Table 12.1.

Assuming that the plate is much larger than the insert, the compressive stress, σ, in the insert is estimated as:

$$\sigma = \frac{\lambda_{\text{interference}} \cdot E}{2\,D} \tag{12.30}$$

where E is the modulus of the material. The factor of 2 in the above equation stems from the fact that the compressive stress in the insert will also drive a tensile stress in the plate. Accordingly, the interference causes equal strain in both the insert and the plate.

The insertion force can then be estimated as the compressive stress multiplied by the contact area and the friction coefficient:

$$F_{\text{insertion}} = f\,\sigma\,(\pi\,D\,H) \tag{12.31}$$

where f is the friction coefficient and H is the height of the contact zone between the two components.

Example: Estimate the insertion force for the core insert for the cup mold. Assume an FN1 fit with a contact height between the plate and the insert of 42 mm.

The expected dimension for the core insert is 88.97 mm while the expected dimension for the hole in the retainer plate is 88.91 mm. The expected amount of interference, $\lambda_{\text{interference}}$, is 0.06 mm. The resulting stress in the steel components is:

$$\sigma = \frac{0.06\text{ mm} \cdot 205 \cdot 10^9\text{ Pa}}{2 \cdot 88.9\text{ mm}} = 69\text{ MPa}$$

Assuming a coefficient of friction of 1.0, the resulting insertion force is:

$$F_{\text{insertion}} = 1.0 \cdot 69\text{ MPa}\,(\pi \cdot 88.9\text{ mm} \cdot 42\text{ mm}) = 808\text{ kN}$$

An insertion force of approximately 808 kN or 180,000 lbs is required to drive the core insert into the retainer plate. If a press is not available with this capacity, the mold designer can utilize a location-interference fit. Also, it is desirable to provide a slight taper along the leading edge of the core insert to assist in alignment during assembly.