

Upper Midwest Section Board of Directors 2012 - 2013

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SPE THE SPECIALIST

2013 SECTION MINITECH Tuesday, April 23, 2013

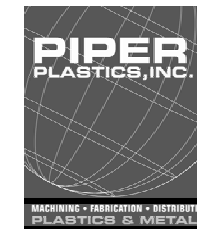
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12:30 PM REGISTRATION 1:00 – 3:30 PM SEMINAR

POLYMER SOLUTIONS THROUGH SCIENCE

Piper Plastics is one of the country's premier polymer engineering, molding, and machining companies with manufacturing facilities located both domestically and internationally. The proposed presentation will cover conventional processes technologies used to convert high performance materials into various geometries and why these technologies can lead to substandard material performance and product failure if not properly vented. We will also discuss unique and advanced molding technologies that produce thick wall moldings with up to 2.50" cross sections without porosity or sink, near net shape processes to dramatically reduce costs, advanced material development, and polymer structure manipulation that can increase component reliability. This process technology has a special emphasis on high performance polymers and composites. In addition, the discussion will cover suggested methods to ensure you are receiving the product quality you need and the use of analytical testing to validate product characteristics and performance.



David Wilkinson is the Materials Engineering Manager at Piper Plastics Inc, and runs their Advance Polymer Processing Division. Dave has a degree in Engineering and has been in the polymer field for over 20 years holding various technical roles and managing businesses for companies such as Furon and Saint-Gobain. He holds various patents in polymer components and has developed various polymer processing technologies.

Lehvoss North America, LLC is the US subsidiary of Lehmann & Voss & Co., a global provider of high performance thermoplastics compounds and solutions. For over 30 years LUVOCOM® tailor made compounds have been served to meet individual customer requirements. The materials are based on a broad range of thermoplastic resins with a special emphasis on high performance polymers.



Michael Sandeen is Sales & Business Development Manager at Lehvoss North America, LLC. Michael has 25 years of plastics industry experience serving in various product development, technical service, and sales leadership roles with companies such as Ticona, GE Plastics, and Victrex plc. He is responsible for sales development of LUVOCOM® high-performance compounds.



Innovative and Practical Manufacturing Concepts - Mr. Martin Neff

After an apprenticeship as an industrial mechanic for machinery and assembly lines Mr. Martin Neff graduated as Mechanical Engineer from University Karlsruhe in 1996. Started with ARBURG 1996 (16 years ago) as a Project Engineer, responsible for the project management of complete automated production cells, which he did over 7 years From October 2003 till June 2007 he worked in the international technical support department as a technical consultant for the ARBURG international sales organization with focus in the Asia pacific area. In July 2007 he joined ARBURG, Inc. as Project and Engineering Manager responsible for the US engineering department. In January 2010 he moved to the ARBURG Midwest Tech Center in Elgin, IL which he is heading as Sales and Engineering Manager.



CALENDAR OF EVENTS

- MINITECH.....April 23, 2013
- ANTEC 2013.....April 22, 2013
- TOUR at ASPEN RESEARCH.....June 20, 2013
- EUROTEC 2013.....July 4, 2013
- SPE GOLF OUTING.....August 6, 2013



SOCIETY OF PLASTICS ENGINEERS

Upper Midwest Section
 Mahin Shahlari
 P.O. Box 69, Circle Pines, MN 55014

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OPEN Invitation to all Upper Midwest Section Schools/Colleges to JOIN the Society of Plastics Engineers (SPE)

Top 10 reasons to join the SPE

Student Members of SPE have all the privileges of SPE membership afforded to other member grades, including:

- Reduced SPE membership dues – ONLY \$31.00 per year
- *Plastics Engineering* magazine every month
- Reduced registration for all educational seminars; Reduced registration at ANTEC and other technical conferences
- Discounts on over 100 important publications
- Insurance programs
- 3 free “position wanted” ads in *Plastics Engineering*; Access to *Career Solutions*, SPE’s Online Plastics Employment Network
- Scholarships offered through the SPE Foundation, SPE Sections and Divisions; Cash Awards for Best Paper/Poster at many SPE-sponsored Conferences.
- FREE membership to your local SPE Section; FREE Division affiliation
- Section dinner meetings; technical programs and even Special Events.
- Professional contacts

... and much more!!!

Upper Midwest Section (S22) Membership

October 17, 2011

Section Total 415

WHO CAN HELP YOU

SOCIETY OF PLASTICS ENGINEERS, INC.
PO BOX 0403, BROOKFIELD, CT 06804-0403
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SOCIETY OF PLASTICS ENGINEERS MEMBERSHIP APPLICATION

13 Church Hill Road, Newtown, CT. 06470 USA
Tel: +1 203-775-0471 Fax: +1 203-775-8490
membership@4spe.org www.4spe.org

European Member Bureau
Tel: +44 7500 829007
speeurope@4spe.org www.speeurope.org

Applicant Information: (please print)

My Primary Address is home _____ or business _____ (check one)

Name _____ Phone Number _____ Home ___ Work ___ Cell ___
First MI Last

Organization Name _____ Job Title _____

Address _____ Email(Required Field) _____

Address _____ Alternate Email _____

Address _____

City _____ State _____ Date of Birth _____ Graduation Date* _____

Zip/Postal Code _____ Country _____ Gender: Male ___ Female ___ *Required for Student Membership

Membership Types (please check one)

Student \$31 **Young Professional \$99** **Professional \$144**(includes \$15 new member initiation fee)
 Choose up to 2 Member Groups on the back of this application.

Professional +2 Additional Member Groups \$164 Choose up to 4 Additional Member Groups on the back of this application.

Professional +4 Additional Member Groups \$184 Choose up to 6 Additional Member Groups on the back of this application.

Payment Information: PAYMENT MUST ACCOMPANY APPLICATION-NO PURCHASE ORDERS ACCEPTED

Amount _____ Check Number _____ Cash _____

Credit Card Information (Check One) American Express _____ Visa _____ MasterCard _____

Credit Card Number _____ Exp. Date _____ Security Code _____

Name On Credit Card _____ Amount _____

By signing below I agree to be governed by the Bylaws of the Society and to promote the objectives of the Society. I certify that the statements made in the application are correct and I authorize SPE and its affiliates to use my phone, fax, address and email to contact me.

Signature _____ Date _____

Recommended by _____ ID# _____

The SPE Online Membership Directory is included with membership. Your information will be automatically included.
 Exclude my email from the Online Membership Directory.
 Exclude all my information from the Online Membership Directory.
 Exclude my address from 3rd party mailings.

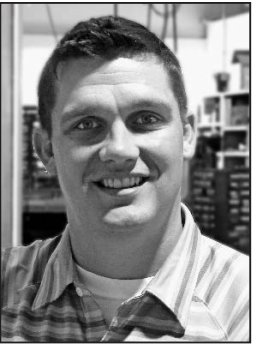
Dues include a 1year subscription to *Plastics Engineering* magazine-\$38.00 value (non-deductible). SPE membership is valid for twelve months from the date your membership is processed.

President's Remarks

Dan Mishek

President's Remarks

It's probably officially too late to wish you a Happy New Year, but I trust it was safe and spent with friends and family. 2012 was a success in the eyes of our SPE local section. We gave away our first scholarship in 5 years, we had local members be awarded with national honors and recognition, we added another person to our local section Hall of Fame, and completed another great year of local events. Hosted items were two MiniTechs, a MegaTech, a tour, a golf tournament and networking / awards events.



2013 is not going to be overshadowed by a great 2012. The events calendar is already filling up quickly! The next MiniTech, tour and golf event are planned. Sign up early and often with friends and co-workers to gain the most with your membership. Feel free to send in requests for topics, events or to participate on the Board or a committee. The SPE prides itself in creating opportunities, generating growth and being diverse to many people and industries. Take advantage of these opportunities to grow in your profession and to grow the plastics industry.

Presentation Opportunities at Your Site

On February 21st, I was asked to present to 3M employees (engineers to buyers) to educate them on SPE and all of its offerings. Fifty 3Mer's were in attendance and asked great questions. The goal is to share the value add that SPE can offer. By doing this, the section can grow and become an even better organization to become a member of. If you would like me to present to your group, company or staff regarding the upside of SPE, please email me at danny@vistatek.com. I will share stats on who are members, outlets to gain education, info or webinars. There are so many ways to gain benefits within the SPE and I would be happy to help you and your team discover them.

I would like to pass on a special thanks to 3M and to Steve Turch and Jaime Willoughby who reached out to bring the SPE local chapter in to 3M. Many thanks!

SAVE THE DATE

ASPEN RESEARCH

TOUR

JUNE 20, 2013

3:00 pm

Followed by

Networking Social Hour!

SAVE THE DATE

SPE

GOLF EVENT

AUGUST 6, 2013

OAK MARSH!

Spotlight on the Board

Matt Havekost - Director of Sales - Advanced Technology Systems

Matt Havekost is the Director of Sales for Advanced Technology Systems, the Authorized Distributor for Stratasys, covering 6 states in the Midwest. With over 15 years of experience in the industry, Matt has had the opportunity to be intimately involved with hundreds of installations and ongoing support for 3D Printers and Production Systems. Over this time, he has had the pleasure of experiencing and sharing how manufacturers, teachers, engineers, and individuals have leveraged additive manufacturing to revolutionize the way they do business and the benefits to their bottom line. Most recently, Matt has worked with manufacturers to leverage additive manufacturing technology beyond traditional uses for concept models and functional prototypes, and into new applications for manufacturing tooling and end-use parts. Matt grew up in Omaha, NE and now lives in St. Louis Park, MN with his wife and two children

Eric Cybulski - Senior Product Development Engineer - 3M Company,

Displaying a desire to build and design products at a young age, Eric Cybulski chose a career in Engineering. He graduated from the University of Minnesota with a degree in Mechanical Engineering. Eric has held plastic product development and commercialization positions for over 15 years, accounting for revenues well over \$1 billion. His unique understanding of plastic product development and conversion processes has resulted in the filing of 26 US Patents to date. Currently, he is a Senior Product Development Engineer in the Corporate Research Laboratory at 3M Company, headquartered in St. Paul, MN.

As a strong advocate of education, he taught numerous Tech Education classes within 3M and SPE, including chairing both a 1 day and 2 day Molding Technology Exchange and winning the 3M Corporate Educator of the Year award in 2010. Eric is the author of the book *Plastic Conversion Processes – A Concise and Applied Guide*.

WELCOME TO OUR NEW MEMBERS - Mahin Shahlari, Membership Chair

We are pleased to welcome our newest members of the Upper Midwest Section. As of March 1st, our section has 415 active members! Tell your friends and co-workers about the SPE Upper Midwest Section and help us grow.

New Member	Affiliation	New Member	Affiliation	New Member	Affiliation
Jon Duesterhoeft	Raven Industries	Cal Derleth	Winona State University	Jeffrey Lipetzky	Hennepin Technical College
Dan Smith	Raven Industries	Breanne Larson	Winona State University	Daniel Edquist	Hennepin Technical College
Gregory Yuschak	ATMI	Ben Gerjets	Winona State University	Konstantin Kudin	Hennepin Technical College
Greg Osborn	Synventive Molding Solutions	John Nebbia	Winona State University	Jeremiah Hernandez	Hennepin Technical College
Roy Biederman	Metro Mold and Design	Shawn Dusing	Donnelly Custom Manufacturing	Paul Sanchez	Hennepin Technical College
Sean Crowley		Matt Norman		Michael Nelson	Hennepin Technical College
Darin Grinsteiner	CPI Binani Inc.	Jermaine Stranlund	Hennepin Technical College	Kenneth Mugambi	Hennepin Technical College
Matt Havekost	Advanced Technology Systems	Sean Perkins	Hennepin Technical College	Phil Kastl	Hennepin Technical College
Douglas Darrow	Allied Dies Inc.	Tory Peterson	Hennepin Technical College	Troy Petznick	University of Wisconsin - Stout
Ronald Juedes	University of Wisconsin - Stout	Chris Seaboy	Hennepin Technical College	Aaron Munsinger	
Tharaka Chandanayaka	North Dakota State University	Desmond Sweep	Hennepin Technical College	Jeff Kalish	3M
Sethu Munusamy	Wausaukee Composites	Kirk Grangroth	Hennepin Technical College	Tom Haglund	Al-Cast Mold & Pattern Inc.
Zachary Block		Matthew Kluge	Hennepin Technical College	Attila Molnar	3M Company
Fardad Azarmi	North Dakota State University	Jacob Bartheld	Hennepin Technical College	Grant John	PolySource LLC
Belma Erdogan-Haug	3M	Randall McCarter	Hennepin Technical College	Noel Mattson	Melet Plastics Inc
Thomas Carroll	Xcel Products Inc.	Blake Iverson	Hennepin Technical College	Timothy Koepke	Thermotech
Corey Claussen	Custom Roto-mold Inc.	Charles Claude	Hennepin Technical College	David Taylor	Gemstar Manufacturing
Adam Troy	Winona State University	Joshua Forrest	Hennepin Technical College	Zachery Johnson	University of Wisconsin- Stout
Marcus Taylor	Winona State University	James Ulstrand	Hennepin Technical College	Sharon McCord	McCord Consulting Group Inc.
Dharma Kodali	University of Minnesota	Anthony Hondl	Hennepin Technical College	Brian Ness	Golden Equipment, Inc.
Embar Kumal	3M	Blake Sundeen	Hennepin Technical College	Tim Hebrink	3M Company
Cori Jackson	Winona State University	Nathan Cramer	Hennepin Technical College	James Fredkove	Stratasys Inc.
Barbara Nygaard	Northern Tech. Int. Corp.				

AWARDS COMMITTEE REPORT *by LuVerne Erickson*

Co-Chair Awards Committee

Fourth Annual Awards Event Gala

January 19, 2013 – Fourth Annual Awards Event Gala was held at the Old Log Theater in Greenwood, MN. A social time was followed by presentation of awards. Paul Rothweiler and Richard Bopp received awards for being past presidents of the group. Dan Mishek presented these awards. Dave Erickson was honored with the presentation of the SPE Upper Midwest Section Distinguished Member Hall of Fame award. He is the second recipient of this award. Dick Bopp read a letter from SPE National that honored Dave in his accomplishments over the years and his interaction with SPE National. Dave mentioned several local members that have been honored by SPE National. The event was attended by seven members and thirteen friends and guests. The presentation was followed by a delicious meal. After some additional socializing all attended the comedy “The Perfect Wedding”. Everyone present had a delightful evening.

It's not too early to think about next year's event. The Board is looking for another recipient of the Hall of Fame Award. Please contact any board member with possible candidates for this award.



Requirements of a candidate for

“Upper Midwest SPE Distinguished Member Hall of Fame” Award

- Active Member of SPE for 10 years (minimum) and Upper Midwest section for 6 years (min.)
- Officer/Councilor of SPE Upper Midwest Section for one term (minimum)
- Active in education of SPE members or student members.
- Active in other Divisions or transfer from another Section of SPE.
- Shall have been a Senior Member in good standing for six consecutive years.
- Promoter of the field of plastics within the SPE Upper Midwest Section.
- Have demonstrated long-term, outstanding service to, and support of, the Society and its objectives which may include any of the following: A significant scientific/engineering/equipment invention or breakthrough or Development of an outstanding product / market / end-use niche, or business endeavor or Long and valuable service to a segment / constituency / discipline / association / etc. of the plastics industry or A record of constructive, collaborative action with government / regulatory / academic / environmental / health / trade / or other industry-related groups Shall be sponsored, in writing, by at least one current Board member of the SPE Upper Midwest Section

Councilor's Corner

Paul Rothweiler -
Councilor - Upper Midwest Section



The Councilor's meeting was well organized and covered all the items associated with managing the organization. This included a number of financial topics such as; the revenue for 2012 exceeded the budget of \$3.5MM and a slight increase projected for 2013, along with how Section rebates will be calculated. Should rebates be based on a percentage, or a fixed dollar amount?

Bylaws and policies were also discussed, with the adoption of a change to Section 3.1 to state that if there was a conflict between the Council and the Executive Committee, then the Council will prevail. There were other minor language changes discussed, but the one topic that had the most energy, was whether to change the minimum requirements of Sections to match those criteria for receiving a rebate. While no one wants to eliminate any of the existing Sections, this is a difficult topic to see a clear answer. With that aside, you should know that your Board has always performed the extra work required to meet the conditions for the rebate, so there is no chance either outcome will affect our Section.

Our next Councilor's meeting is on April 21, 2013 in Cincinnati Ohio (before ANTEC). I encourage you to contact me with questions you may have regarding our Section, and/or the management of the national organization. If you are attending ANTEC please look me up so that I can get a sense of how to better represent you and our Section. You should be able to find me around the EPSDiv presentations, or at the Aspen research booth on the show floor.

New Features to the Technical Resources of SPE ONLINE

"SPE has recently added some new features at

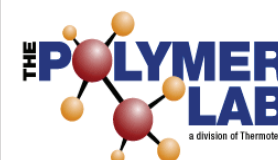
<http://www.4spe.org/technical-resources>

including Plastic Industry Resources, an online source for product and service providers, and Plastic Research Online which provides technical briefs to help you stay current in the latest developments in polymer science and plastic technology. Finally, SPE has created an online plastic encyclopedia for you to share your knowledge with other SPE members."

Congratulations to the Upper Midwest Chapter!

Awarded, 2013 SPE PINNACLE AWARD (SILVER LEVEL)

The award will be accepted at the 71st Antec 2013
Cincinnati, Ohio



The Polymer Lab offers thermal, chemical and rheological testing of polymer raw materials through finished plastic parts.



Our laboratory has plastic testing capability for:

- Material Identification
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- Degradation Analysis
- Crystallinity Verification
- Reverse Engineering
- Product Failure Analysis
- Process Validation
- Ongoing Quality Assurance
- Moisture Analysis



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- Microstructural Analysis-MSA
- Differential Scanning Calorimetry-DSC
- Fourier Transform Infrared Spectrometry-FTIR
- Ash content-Burn-off Testing
- Melt Flow Rate-MI/MFR
- Relative Viscosity-RV
- Capillary Rheometry
- Karl Fischer Titration-KFT



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SCHOLARSHIPS

The Scholarship Committee has been working with the college plastics programs in our Section to assist students with their applications for the Upper Midwest Section's Jerome Formo Award. We are also finalizing the guidelines for Founders Award submissions (all information for the Section's scholarships are on our Section's website at <http://www.uppermidwestspe.org/edu.htm>). If you know any students that meet the requirements for either of these awards, pay close attention to the submission criteria and cut-off dates for the submissions. The cut-off date for the Jerome Formo award is October 26th. Incomplete submissions will not be accepted.

We also want to congratulate David Haakana, the winner of the 2012 Tony Norris Award. David and his sponsor Dan Ralph were present at the May 15th MiniTec to receive the award, and was congratulated by many plastics professionals present, making the award ceremony a very special event. David is a great example of someone with a passion for plastics and we expect he will have a very rewarding career in the plastics industry. We look forward to presenting you the 2013 Tony Norris award winner at our 2013 Spring MiniTech. Cut-off date for 2013 Tony Norris submissions is April 15, 2013.

FOR MORE INFORMATION, CONTACT:

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Thomas McNamara at 952-933-9438 / thomas.mcnamara@thermotech.com

MARCH SCIENCE CORNER

The article chosen for this issue is from the journal of Polymer Engineering & Science with the title of

“Effect of Molecular Weight and Molecular Weight Distribution on Weld-Line Interface in Injection-Molded Polypropylene”

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Polypropylene (PP) is a commercially important semicrystalline polymer and widely used in injection-molded automotive parts such as bumpers and instrumental panels owing to its highly balanced mechanical properties. The injection molding of such large and complex parts requires the use of a multi-gated molding system. A weld-line, formed when two or more polymer melt flows meet in a cavity, is often the weakest part of an injection-molded or extruded product and thus the initiation of crack propagation. As a result, the presence of weld-lines reduces the mechanical strength and affects the surface appearance of the products. In practical cases, the problems are increased by the need for efficiency in terms of short cooling cycles. With growing demand for high-quality plastic parts, improvement of the weld-line behavior has been strongly required. Although many potential reasons for the weld-line problem have been proposed such as poor intermolecular entanglement across the weld-line, molecular orientation induced by fountain flow, and the stress concentration effect of surface V-notch [1–7], a complete understanding has not yet been achieved. This is mainly because in actual cases they are inter-related in such a way that it is usually hard to correlate experimental findings with one of the factors only.

The material at the flow front is known to experience fountain flow. Molecular chains close to the melt front are stretched parallel to the weld-line, and once the flow fronts meet, this molecular orientation makes the interfacial structure different from the bulk phase. Using polarized optical microscopy, Hobbs [1] found a continuous band of row-nucleated spherulites running completely through an injection-molded specimen at the weld. It was postulated that this interfacial morphology had to be attributed to the molecular orientation owing to the fountain flow. Many optical microscopic studies have been made to observe the micrometer scale structure in those injection moldings, but it is still difficult to determine the molecular orientation quantitatively.

In general, controlling a molecular weight and a molecular weight distribution is one of the most important techniques to obtain desirable properties and processability. Then, if the effects of

molecular weight and molecular weight distribution on the weld-line formation are clarified, these findings would have a significant effect on the polymer processing technology. The objective of this study is to generate a procedure to characterize the microstructure of weld-lines in injection-molded PP and to identify more accurately the cause of weld-line strength. In this study, the effect of molecular weight and molecular weight distribution on the microstructure of weld-line interface was investigated by using a Laser Raman Spectroscopy and microscale mechanical property measurement. Molecular dynamics simulation was also conducted to understand the structure–property relationship.

Molecular Orientation in Weld-line

The molecular orientation along the flow direction was characterized by the Raman intensity ratio. The intensity ratio was higher near the surface and decreased toward the interior for all non-welded specimens. The intensity ratio near the surface increased with increasing molecular weight and reduced more significantly owing to the weld-line. Molecular chains close to the melt front are stretched normal to the flow direction owing to the fountain flow, and these stretched molecules result in an anisotropic molecular orientation in the weld-line. The relaxation of the molecular orientation is less near the surface because the molten polymer solidifies faster [8, 9]. Therefore, these observations suggest that higher molecular weight PP result in anisotropy of the molecular orientation in the weld-line owing to its longer relaxation time.

Stress intensity factor ($K_{I\max}$) of Weld-line

Stress intensity factor ($K_{I\max}$) of nonwelded and welded PP was measured with double-edge-notched tensile (DENT) test. The molecular characteristics of the materials are summarized in Table 1. Figure 1 shows the relationship between $K_{I\max}$ for the test specimen with and without weld-line. For the nonwelded specimens, $K_{I\max}$ increased with increasing molecular weight with the same width of the molecular weight distribution. $K_{I\max}$ increased with decreasing width of the molecular weight distribution for both molecular weights. The same effects of molecular weight and the width of the molecular weight distribution on $K_{I\max}$ were revealed for the welded specimens. However, the reduction of $K_{I\max}$ caused by the weld-line was different within these samples. It was observed that $K_{I\max}$ ratio was significantly reduced with higher molecular weight and broader molecular weight distribution. Several researchers [10–12] pointed out that the weld-line strengths were significantly affected by molecular orientation in the weld-line interface. Comparing with the molecular orientation observed from the laser Raman spectroscopy, it was considered that the effect of molecular weight on the $K_{I\max}$ ratio was related to the molecular orientation in the weld-line interface. However, the molecular orientation was not a dominant cause of the effect of the width of molecular weight distribution on the $K_{I\max}$ ratio. It was found that the fracture area of all sam-

ples was rough on the face inside and the area just below the V-notch was smooth for higher molecular weight and broader molecular weight distribution PP. This observation suggests that the reduction of $K_{I\max}$ ratio of the injection-molded PP with higher molecular weight and broader molecular weight distribution was closely related to the fracture properties in the microscale area just below the surface V-notch in the weld-line interface.

Table 1. Characteristics of sample polypropylene

Sample	M_w ($\times 10^4$)	M_n ($\times 10^4$)	M_w/M_n
LN	19.0	6.4	3.0
LM	19.0	3.5	5.4
HM	40.0	7.4	5.4
HB	41.0	4.2	9.8

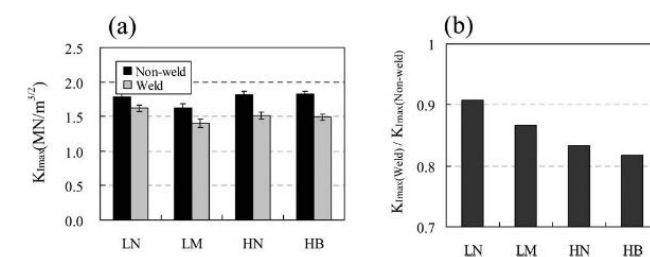


Figure 1. Relationship between $K_{I\max}$ for the test specimen with weld-line and without weld-line (a) and effect of molecular weight and molecular weight distribution on the reduction of $K_{I\max}$ (b).

Polydispersity Effect on Weld-line Structure

It was found that the depletion of longer chains took place at the interface, whereas the shorter chains are preferentially located at the interface. The origin of this result can be understood from the entropy point of view. As loss of conformational entropy owing to the chain orientation at the interface would be larger for the longer chains than the shorter chains, the longer chains are expected to diffuse away from the interfacial region.

Polydispersity Effect on the Deformation Behavior of Weld-line

It is well known that chain length should be sufficiently long to show entanglement after a diffusion process takes place at an interface [3, 4]. Therefore, the reduction of the yielding stress in the weld interface owing to the polydispersity can be explained by the segregation of the shorter chain at the interface. It was suggested that the reduction of the mechanical property caused by weld-line in broader molecular weight distribution PP was considered to be responsible for the lack of entanglement owing to the chain segregation of low-molecular-weight component as would be formed in the weld-line interface. Therefore, it was postulated that decreasing the width of the molecular weight distribution was one of the desirable molecular designs to minimize the reduction of mechanical properties caused by weld-lines in case that the average molecular weight was kept constant.

CONCLUSIONS

In this study, microstructure of weld-lines in injection-molded PP with different molecular weights and molecular weight distribu-

tions was characterized by using polarized laser Raman spectroscopy, micro-cutting analysis, and DENT method. The mechanical property reduction induced by weld-line was evaluated as a $K_{I\max}$ ratio of the weld-line infested specimen to one without weld-line. It was revealed that the $K_{I\max}$ ratio decreased with increasing molecular weight or broadening molecular weight distribution. Using polarized laser Raman spectroscopy, it was observed that the effect of molecular weight on the $K_{I\max}$ ratio was related to the molecular orientation in the weld-line. The molecular orientation was not a dominant cause of the effect of the width of molecular weight distribution on the $K_{I\max}$ ratio. The micro-cutting analysis method revealed that the reduction of the $K_{I\max}$ ratio was closely related to the reduction of the shear strength ratio measured in the area below the surface V-notch. Based on the coarse-grained molecular dynamics simulation, it was suggested that the reduction of the mechanical property caused by weld-line in broader molecular weight distribution PP was considered to be responsible for the lack of entanglement owing to the chain segregation of low-molecular-weight component as would be formed in the weld-line interface. It was postulated that decreasing the width of the molecular weight distribution was one of the desirable molecular designs to minimize the reduction of mechanical properties caused by weld-lines in case that the average molecular weight was kept constant.

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