News

The Society of Plastics Engineers

ENGINEERING PROPERTIES & STRUCTURE DIVISION

August 2007

EPSDIV Recognized

EPSDIV was recognized with a Silver Pinnacle at ANTEC 2007 which was held this May in Cincinnati.

The Pinnacle award is a self-evaluation program that honors Sections that provide outstanding services and programs for their members. It was established in 2005 to recognize Sections and Divisions that successfully create and deliver member value during the year.

Sections and Divisions are reviewed in four categories of achievement: organization, technical programming, membership and communication.

Thank You!

Thank you to the following sponsors' support for our ANTEC 2007 Division presentations. "Our sessions are always well attended, and the quality of the talks this year was exceptionally good," remarked EPSDIV Chair Brian Grady.

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Planning Underway for ANTEC 2008

TPC Chairs, Pierre Moulinié (seen at left) and Murali Rajagopalan, invite EPSDIV members to submit papers for ANTEC 2008. Abstracts are due October 15. For more information, see page 5.

INSIDE THIS ISSUE

The Year Ahead

Brian Grady serves as EPSDIV Chair for 2007-08

Welcome to another planning year with the Engineering Properties and Structure Division. Thank you for your support in our election cycle as I begin this year's role within the Division as Chairperson.

Meet the President

Before telling you about what EPSDIV has planned in the year ahead, I would like to tell you a bit about myself, especially for those of you that I have not had the pleasure of meeting. I grew up in the Chicagoland area, and completed by B.S. at the University of Illinois and PhD at the University of Wisconsin, both in Chemical Engineering. I have been employed as a full-time faculty member at the University of Oklahoma since my PhD for almost 15 years. My research areas include structure/property relationships of thermoplastic composites and blends, as well as characterization of polymers using x-rays.

I have served in leadership roles in SPE in many capacities; at the section level I have been Councilor (a role I still hold), Newsletter Editor, and I have also helped with section programming. At the division and national level, I was ANTEC Technical Chair for EPSDIV in 2006, and have served on the ANTEC and New Technology Forum Committees.

ANTEC

The key to EPSDIV, and SPE in general, is to do the best job we can in providing services for our members. This message attempts to highlight those items geared towards doing just that.

The centerpiece of EPSDIV's service to our almost 1500 primary and secondary members has always been, and will continue to be, the ANTEC program. Our sessions are always well attended, and the quality of the talks this year was exceptionally good. The credit goes to all members that gave and attended talks, but special credit goes to **Hoang Pham**, our TPC for ANTEC 2007.

In this issue, our TPC chairs for 2008, **Pierre Moulinie** and **Murali Rajagoplan** issue a call for papers for next year's ANTEC (see page 5). I personally am looking forward to going to Milwaukee; a city that I visited many times, and an excellent place to have ANTEC.

TopCon 2008

If you have been following EPSDIV for the last few years, you will know that we had a successful TopCon in Akron in the Fall of 2006. As a way to better service our members, we have begun planning another TopCon for Fall 2008 that is tentatively titled "Advances in Polymer Characterization and Analysis".

Our ultimate goal is to make "Advances in Polymer Characterization and Analysis" an every-other-year event and to make this conference as successful as TopCons sponsored by other SPE divisions.

EPSDIV historically has been the birthplace of many other divisions as well as SIGs. Currently, there are two special interest SIGs being formed that owe a great deal to EPSDIV: Polymer Nanotechnology and Bioplastics.

Our Role

One of the important ways EPSDIV services their members is to provide a forum for new subjects that don't clearly fit into another division, which, if they become important enough, can eventually become a SIG or Division. Encouraging these new SIGs is an important thing that we will be doing over the next year.

The last, and perhaps most important, service EPSDIV provides, is communication. This newsletter is an important communication tool; the volunteers that govern this division use this as a tool to communicate with you.

For those of you who are asking "how can I get involved?", my suggestion is to attend our technical program committee meetings that are always held Tuesday during lunch at ANTEC. The technical program is really what we are mostly about and this is a great way for new people to get involved.

Our website, www.4spe.org/communities/divisions/d26.php#di gives detailed contact information for all board members as well as a hotline you can call.

Finally, at anytime, please feel free to e-mail me at bpgrady@ou.edu or call me at 405-325-4369 with your questions, concerns or comments. I look forward to serving you during the next year.

—Brian Grady

Exciting changes planned for SPE

Don Witenhafer

There have been some exciting changes at SPE either being considered or already in progress.

First our ANTEC was highly successful this year, both financially and attendance wise, and we suspect that part of that was the joining together with Plastics Encounter. We plan to continue this program at least into next year and probably longer. This has contributed to an acceptable financial position for the SPE year to date. The only serious problematic area is Plastics Engineering. Membership is down slightly year to year.

It was announced that SPE will be starting a new web based Encyclopedia of Plastics Technology. It will contain links to much information under selected topics. It is just getting organized and we are looking for technical support for the effort. If you want to help contact Roger Corneliusen (roger@marop.com) or SPE headquarters.

SPE has just completed a member survey to get feedback from our members. There is a wealth of information in this survey. I was amazed that the percentage of members who know what their Division is has fallen substantially over the past five years. We must not be doing a good job of communicating with our division membership. This needs to be improved. Any ideas?

It was also decided that in order to save time and expense, Council will meet only twice in 2008 on a trial basis. We will hold an extended meeting in the fall and will hold our usual two meetings at ANTEC.

The Divisions Committee is focusing on encouraging divisions to try mini-techs and to increase our representation on the SPE Speaker's list. You can now apply to be on the speakers list on line at 4SPE.org. Speakers are encouraged to submit an abstract of a potential presentation as well as a brief biography. We hope to help sections with their technical programming with the speakers list.

The Sections Committee is working hard to come up with a method to streamline their role in society governance. They are considering such things as having one councilor represent a region. Other possibilities might involve sections pooling resources to send a councilor to represent more than on section. As you might imagine, this is all quite controversial and things are only in the talking stage at this time.

—Reported by Don Witenhafer

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SPE is developing a web - based Encyclopedia of Plastics Technology. We are looking for technical support. If you can help, contact Roger Corneliusen at roger@marop.com

Best Student Paper

JOHN O'TOOLE AWARD ANTEC 2007

Each year the Engineering Properties & Structure Division sponsors the John O'Toole Award.

This award recognizes the best student paper presented at ANTEC.

Winners receive a plaque commemorating their achievement and a $1000 cash prize.

This year the John O'Toole Award was presented to Richard Haibach from the Plastics Engineering Department at Penn State University at Erie for his paper *Injection-Molding Degradation of Biodegradable Polylactide*.

To read the winning paper, see page 7.

Richard Haibach, from Penn State University at Erie, (seen center) was the recipient of the Best Student Paper Award at ANTEC 2007. He was congratulated by EPSDIV Chair Brian Grady, left, and Sadhan Jana, Best Paper Chairman.

EPSDIV Membership Update

2005	Primary	Secondary	2006	Primary	Secondary
January	890	406	January	900	405
February	891	418	February	913	415
March	887	420	March	923	436
April	912	437	April	953	451
May	920	447	May	938	456
June	920	446	June	926	476
July	854	381	July	870	456
August	869	388	August	873	466
September	880	389	September	899	476
October	883	398	October	916	476
November	892	402	November	903	476
December	890	400	December	888	476
			2007		
			January	899	481

% Increase in Primary Membership in 2006 = 0
% Increase in Secondary Membership in 2006 = 19

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The SPE Divisions Committee is developing 'Mini-Techs' and wants to increase EPSDIV's representation on the speaker list.

— Apply to be on the SPE speakers' list at www.4SPE.org.

Membership made easy...

Renew your membership online at www.4spe.org

EPSDIV Call for Papers ANTEC 2008

ANTEC 2008 — Plastic Encounter — will be held in Milwaukee Wisconsin, May 4-8, 2008

KEY TOPICS

- Recent Developments in Polyolefins
- Structure and Property Relationships in Engineering Resins and Blends
- Polymer Nanocomposites
- Films and Packaging
- Fracture Mechanics of Polymers
- Tissue Engineering Polymers
- Materials for Biological Applications
- Polymers Useful in Alternate Energy Sources
- Smart Materials
- Nanotechnology in Electronic and Biological Devices
- Renewable Resources in Engineering Polymers
- *And more....*

Submission Deadline for Abstracts: **October 15, 2007**
Submission Deadline for Papers: **December 3, 2007**
Final Paper Revision Deadline: **January 9, 2008**

Information and online submittal: www.4sp.org... and select Division D26-EPSDIV

FOR MORE INFORMATION CONTACT:
Pierre Moulinié at pierre.moulinie@bayerbms.com
Murali Rajagopalan at Murali_Rajagopalan@AcushnetGolf.com

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Engineering Properties & Structure Division

FINANCIAL REPORT FROM JULY 1, 2006 TO June 30, 2007

Emmett Crawford is the EPSDIV Treasurer for 2007/2008

Transaction Summary for 2006/2007 Budget Year

STARTING BALANCE as of July 1, 2006		
Citzens Bank	$	5013.44
SPE Investment Plant	$	27654.93
TOTAL Bank Accounts	**$**	**32668.37**
INCOME		
SPE Rebate	$	5295.52
Interest	$	1214.87
TOPCON	$	4608.58
Newsletter Sponsorships	$	2500.00
Award Sponsorships	$	1000.00
ANTEC Sponsorships	$	7000.00
Misc. Income	$	44.42
TOTAL INCOME	**$**	**21663.39**
EXPENSES		
BOD Meetings	$	645.93
TOPCON	$	2989.25
ANTEC	$	3305.00
Newsletter	$	1070.00
Awards	$	4260.48
Scholarships	$	500.00
Councilor Travel	$	1599.26
BOD Travel	$	574.62
TOTAL EXPENSE	**$**	**14952.04**
NET CHANGE	**$**	**6711.35**
ENDING Balances as of June 30, 2007		
Citizens Bank	$	10509.92
SPE Investment Plan	$	28869.80
TOTAL Bank Accounts	**$**	**39379.72**

Mark your calendars with these upcoming events...

Nanocomposites Workshop: September 5, 2007, Las Vegas. This event is specifically designed for business executives, engineers, and scientists to gain essential and wide-ranging knowledge about the state-of-the-art of nanotechnology, especially polymeric nanocomposites. See www.executive-conference.com

Seminar Series at PolyTech 2007: September 24-27, 2007, Hyatt Regency Irvine, California.
Engineering & Structure Seminars:
September 24: Fundamentals of Plastic Materials & Processing / Jean-Michel Charrier
September 24-25: Crystallization & Mechanical Behavior of Polymers / Pravin Soni
September 25: Flame Retarding Plastics / Joseph Green
September 26: Plastic Parts Failure Analysis & Product Liability / Vishu Shah

INJECTION-MOLDING DEGRADATION OF BIODEGRADABLE POLYLACTIDE

Richard Haibach
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Abstract

The effects of degradation on the mechanical and aesthetic properties of injection-molded biodegradable polylactide (PLA) parts were studied. Standard tensile test specimens were molded from NatureWorks® 3051D injection-molding grade PLA. Barrel residence time, machine nozzle temperature, and shear rate were varied during the injection-molding process. The resulting specimens were analyzed in a tensile testing machine. Tensile strength, tensile modulus and visual inspection were used to characterize the extent of degradation that occurred during each process.

Introduction

When injection-molded thermoplastics pass through the heated barrel of an injection-molding machine there is a gradual decay in the molecular weight of the polymer. This is referred to as degradation. When polymers degrade the covalent bonds holding the polymer chain together break and result in shorter chains, therefore reducing the average molecular weight.

There are several factors that can accelerate degradation during an injection molding process. Excessive barrel or hotrunner temperatures will increase the rate of the polymer degradation. High shear rates caused from fast injection speeds or small orifices can also cause the bonds in polymer chains to break. Residence time, the length of time that a polymer is exposed to the heated barrel and/or hotrunner system, is another factor that can cause degradation if excessively high.

Degradation often results in visible defects in injection-molded specimens. Black specks or streaks in the molded parts are often seen as a result of degradation. Yellowing of the polymer can also result from degradation.

The decrease in molecular weight caused by degradation can adversely affect the mechanical properties of the finished part. A decrease in molecular weight will result in a decrease in tensile strength and an increase in stiffness (modulus) [1]. For this reason, tensile strength and modulus are the key properties analyzed in this study.

PLA was chosen because it is unique in that it is not petroleum-based, rather it is corn based. The molecular structure is made primarily of a repeating chain of lactic acid, which can be biodegraded with a combination of moisture, heat and microorganisms [2].

Experimental Procedure

A Boy 35A Model 69212 injection-molding machine was used to mold standard ASTM tensile test specimens. A single cavity cold runner mold with an edge gate leading to the part cavity was used (see figure 1). Process settings for the baseline were determined using a standard 2-stage startup procedure. Process guidelines provided by the resin manufacturer were used to determine baseline barrel, nozzle, and cooling temperatures [2].

Baseline Process:

Injection Speed	50% (27cc/s)
Shot Size	55mm
Transfer Position	15mm
Hold Time	14s
Hold Pressure	41.4MPa
Decompression	5mm
Cushion	5.4mm
Cooling Time	28s
Injection Time	.57s
Injection Pressure	81.4MPa
Cycle Time	46s
Feed Throat Temp	170°C
Nozzle Temp	205°C
Coolant Temp	29°C

The baseline process was cycled for 10 minutes to allow the process to stabilize before collecting 15 specimens.

After baseline parts were collected, a barrel residence time study was performed. Cooling time was modified to achieve a 72 second cycle time. Once the process was stabilized, 15 specimens were collected. The cooling time was then adjusted to achieve a 100 second cycle, and specimens were collected using the same method. The

Continued on next page

above procedure was then used for a final 126 second cycle time.

Residence Times:

Baseline	2.8min
72s cycle	4.4min
100s cycle	6.0min
126s cycle	7.6min

A shear rate study was performed next by adjusting the injection speed. Specimens were collected at 4 different injection speeds: 25% (13.5cc/s), 50% (27cc/s), 75% (40.5cc/s), and 100% (54cc/s). Before collecting specimens, the process was stabilized for 10 minutes. Moldflow analysis was performed to obtain shear rates.

Shear Rates:

25% (13.5cc/s)	2365/s
50% (27.0cc/s)	4731/s
75% (40.5cc/s)	6307/s
100% (54.0cc/s)	9460/s

The final study was a thermal degradation study. Specimens were collected at 4 different machine nozzle temperatures: 190∝C, 205∝C, 220∝C, and 235∝C. Before collecting parts, the process was stabilized for 10 minutes.

Each tensile test specimen was visually inspected for any signs of degradation after molding.

Tensile testing was performed using an Instron 4400R model T45-119 tensile test machine using the ASTM D 638 method. All tensile specimens were normalized at room temperature for 24 hours before testing. A sample size of 8 parts was tested for each scenario. Gage length was set at 10.2cm and a draw rate of 5.1cm/min was used for all tests. Tensile strength and tensile modulus were recorded and later used to characterize the extent of polymer degradation with respect to the baseline process specimens.

Results and Discussion

The Boy injection-molding machine provided a stable process, relatively free of variation. Within each set of tensile specimens the tensile strength range was less than 1MPa. Each of the factors studied had an impact on the tensile strength and modulus when varied. The baseline specimens had a tensile strength of 72.6MPa and a tensile modulus of 2082MPa.

Throughout the range of residence times studied, there was little to no change in the visual properties of the specimens. Tensile test results showed a decrease in tensile strength and an increase in modulus corresponding to an increase in residence time. When residence time was increased from 2.8 minutes to 7.6 minutes, the tensile strength decreased 3.49MPa (4.7%) and the modulus increased 608MPa (29%) (see figures 2 and 3). The results suggest a decrease in molecular weight caused by polymer degradation.

Shear rate had very little impact on the strength of the molded specimens. Visual inspection revealed slight gate blush at the 9460/s shear rate. At the 9460/s shear rate, tensile strength decreased .63MPa (.9%) compared to the baseline specimens with a shear rate of 4731/s (see figure 4). The modulus increased 352MPa (16.9%) from the baseline (see figure 5).

Nozzle temperature had very slight effect on the tensile strength and modulus between 190∝C and 235∝C. The tensile strength was the highest at the baseline of 205∝C. At 235∝C the tensile strength decreased .93MPa (1.2%) (see figure 6). The modulus increased 431MPa (20.9%) at 235∝C (see figure 7).

Summary

The molded PLA specimens showed only slight evidence of degradation from the injection-molding process. Visually there were no defects, with the exception of slight gate blush when the shear rate was 9460/s. The tensile strength showed very little change with varying process conditions. Tensile modulus changed more rapidly with varying process conditions.

The residence time study showed the most significant evidence of degradation, with a 4.7% decrease in tensile strength, and a 29% increase in tensile modulus at 7.6 minutes of residence. This evidence emphasizes the importance of proper injection molding machine sizing. An oversized barrel molding thick, slow cooling parts could easily surpass 7.6 minutes of residence time.

The nozzle temperature and shear rate studies had only very slight signs of degradation. Future studies might include testing at higher nozzle temperatures, and testing with a smaller gate to achieve higher shear rates.

It is important to note that the tensile properties showed evidence of degradation without any visual evidence. Part quality in terms of mechanical properties could diminish slightly, putting parts out of specification, without an operator noticing. For this reason, it is important to test parts if any process parameters are changed that could accelerate degradation.

This study suggests that residence time should not exceed 5 minutes with PLA. Temperature adjustments, if kept below 235∝C should have minimal effect on degradation. The study also suggests that gate shear rates below 9500/s

Continued on page 9

should have a minimal contribution to degradation of PLA.

Acknowledgements

I would like to thank Dr. Paul Koch for his help and guidance throughout the duration of this study.

References

1. Rees, Herbert, Mold Engineering, 2nd Edition, Hanser Gardner Publications, Cincinnati, pp. 589-590 (2002)

2. NatureWorks LLC, NatureWorks PLA Polymer3051D Injection Molding Process Guide pp. 1 (2005).

Appendix

Figure 1. Runner layout and specimen

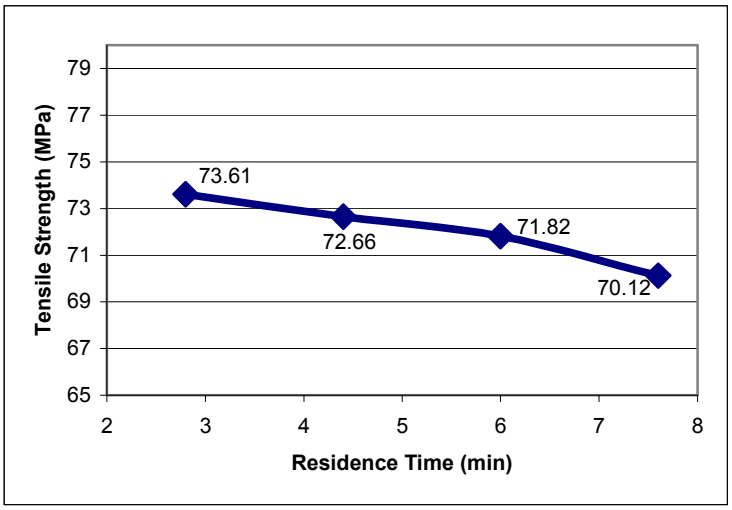

Figure 2. Tensile strength with respect to barrel residence time

Continued on page 10

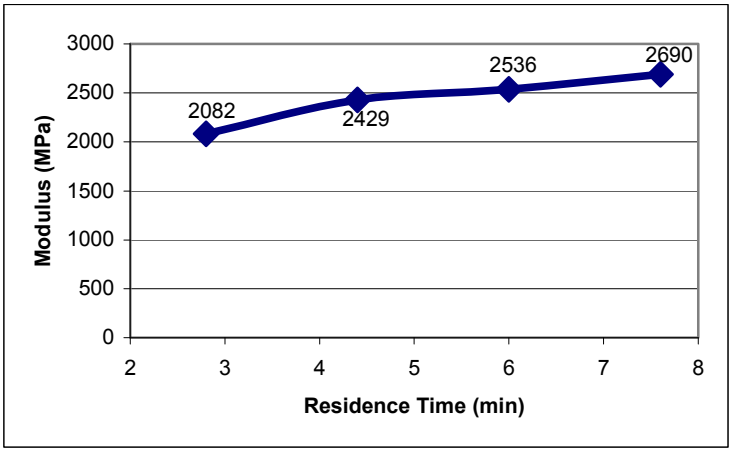

Figure 3. Tensile modulus with respect to barrel residence time

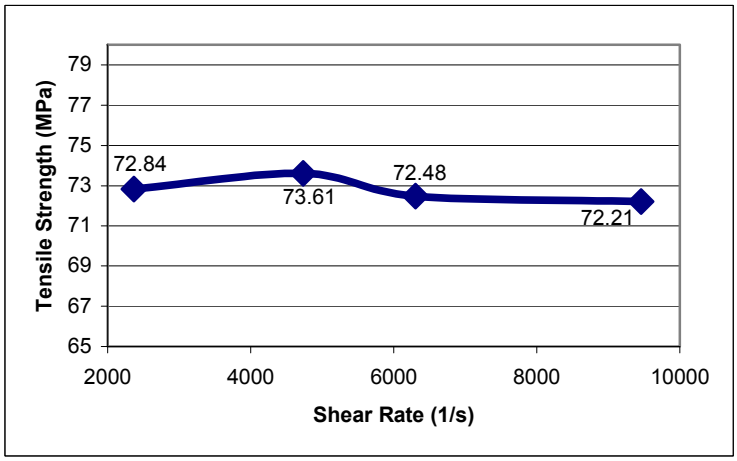

Figure 4. Tensile strength with respect to shear rate

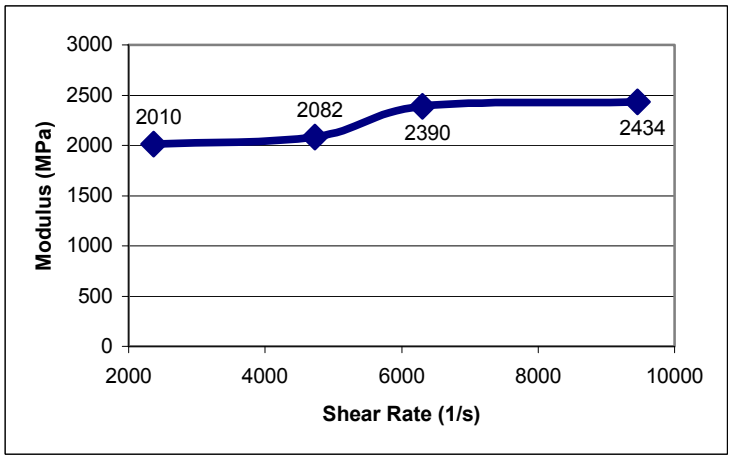

Figure 5. Tensile modulus with respect to shear rate

Continued on page 11

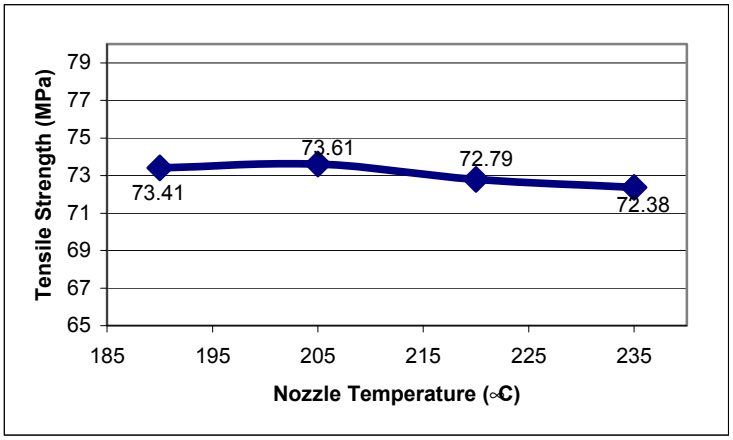

Figure 6. Tensile strength with respect to machine nozzle temperature

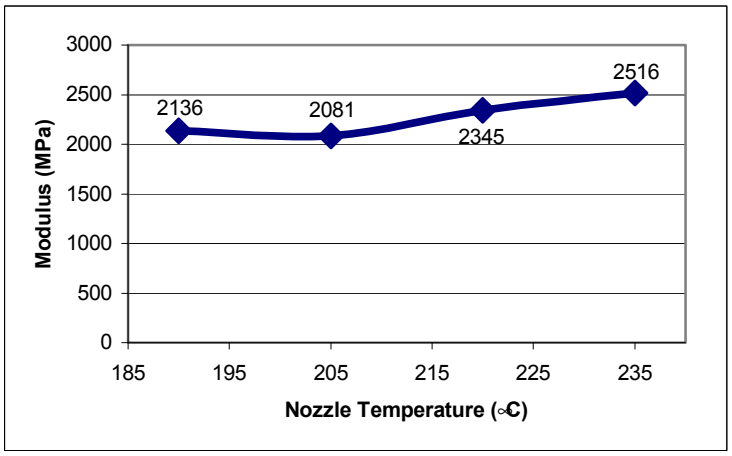

Figure 7. Tensile modulus with respect to machine nozzle temperature

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