P.A.D. REVIEW

Polymer Analysis Division
Society of Plastics Engineers

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IN THIS ISSUE

Chairman's Message

Hello Fellow PAD Members

I hope that the summer season is starting out well for all of you. Our thoughts and prayers are with those in Texas and anywhere else that have been affected by the heavy spring rains. We hope you will be able to get your lives back to some sense of normalcy in a short time.

It's already been a couple of months since the ANTEC meeting in Orlando. The PAD Division had a successful technical program, with 20 presentations, including a couple of excellent keynote speakers. We had a couple of talks that were attended by over 60 people each, and, on average, had a respectable 25 or so attendees for each talk. Neil Doll, from the Polymer Engineering Center at the University of Wisconsin – Madison, was awarded the Best Paper by the Best Paper committee. Congratulations to Neil and to all the presenters on a job well done. We sincerely appreciate your efforts.

No sooner than we look back for the last time at ANTEC 2015, we must start looking ahead to ANTEC 2016 in the centrally located city of Indianapolis. The dates are May 23-25, which is the usual time for ANTEC, not like the March dates when we collocate with NPE. A notice will be coming out in the near future about the Call for Papers. Please consider writing a paper and presenting for PAD at ANTEC 2016.

It is a ways off, but we typically install new officers at ANTEC. At our last Board meeting, which was held at ANTEC 2015, I was glad to offer Joel Lischefski the Chairman's position of PAD, effective May, 2016, and Joel graciously accepted. Joel has become one of

(Continued on page 4)

The PAD webpage is: http://www.4spe.org/technical-groups/divisions/polymer-analysis

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From the Editors

Starting with this issue, Dr, Changdeng Liu will be my co-editor for the PAD newsletter. This is his first issue and we will probably be alternating issues for a bit. This will give us more time to manage our LinkedIn group and other communication activities.

The PAD Board of Directors can always use willing members. Consider joining us and helping the division out.

Mint Julep

Mint   1 tsp sugar   3 ounces bourbon   ice   1 ounce rum (opt)

Place 5 or 6 leaves of mint in the bottom of a pre-chilled, dry 12-ounce glass or silver beaker. Add sugar and crush slightly with a muddler. Pack glass with finely cracked ice. Pour a generous 3 ounces of bourbon over the ice. Stir briskly until the glass frosts. Add more ice and stir again before serving. Stick a few sprigs of mint into the ice so that the partaker will get the aroma. An optional addition is to float 1 ounce of dark rum on top.

Treasurer's Report
F. Cao

BALANCE AS OF	**12/31/2014**
	$23,506.97
CREDITS	
SPE Rebate	$915.94
SPE - Philadelphia Section	
TMS Conference	
Award	
Interest	$1.62
ANTEC Keynote sponsors	
Newsletter Adds/Sponsorships	$1,000.00
Total Credits	**$1,917.56**
EXPENSES	
RETEC	
TMS Conference	
Newsletter	
Teleconference Meetings	
Awards	$69.70
ANTEC	
Board Meetings	
Councilor travel	
Bank fees, Postage	$0.30
Web Site	
Total Debits	**$70.00**
	$25,354.53
BALANCE AS OF	**4/30/2015**

Best Paper Award

Polymer Analysis Division—ANTEC 2015

Methodology for Quasi-Viscoelastic Simulation of Polymer Gears Made from PEEK Using ANSYS.

Presented by Neil P. Doll

Polymer Engineering Center, University of Wisconsin-Madison

Congratulations!

(Continued from page 1)

our most active Board members and is the main Technical Program Chair for ANTEC 2016. We are fortunate to have a person like Joel that is willing to assume this responsibility. Joel will represent PAD well in the Chair's position.

We are fast approaching the time when people start taking vacations with their families. If you are taking some time to unwind from the pressures of everyday life, I hope you come back refreshed and ready to contribute to the plastics industry . And start thinking about a paper for ANTEC 2016.

All the best,

Greg Kamykowski

PAD Chair 2015-2016

METHODOLOGY FOR QUASI-VISCOELASTIC SIMULATION OF POLYMER GEARS MADE FROM PEEK USING ANSYS®

Neil P. Doll(1), Anthony J. Verdesca(1), Eduardo Bastos(1), Tim A. Osswald(1), and Rod Kleiss(2)
(1) Polymer Engineering Center, University of Wisconsin-Madison
(2) Kleiss Gears, Inc., Grantsburg, WI

Abstract

Beginning in March 2014, a small group of students at the Polymer Engineering Center at the University of Wisconsin-Madison collaborated with Kleiss Gears, Inc. in an effort to provide a fundamental understanding of the viscoelastic behavior of high-speed polymer gearing in heavy-duty applications. The project has the following ongoing objectives: material characterization, injection molding simulation, thermal-mechanical simulation, and experimental validation. The goal of this paper is to present the first look at a methodology for creating a robust viscoelastic material model that can be utilized by ANSYS® for precise simulation of thermal and mechanical behavior in polymer gears made from polyetheretherketone (PEEK).

Introduction

Polymer gears are continually making their way into applications that were once thought only fit for metallurgical gear designs. Potential applications include vibrating platens on earth tamping equipment for road construction, engine counterbalance systems, superchargers, alternatives to metal anti-backlash gears, and many high volume automotive applications, to name a few [3]. A deeper understanding of the design of these gears is essential in proving their capacity in industry.

Perhaps the biggest flaw in modern analysis of polymer gears is quantification of their performance through metal gearing standards, such as those outlined by the American Gear Manufacturers Association [1]. Metal gearing standards fail to accurately depict the time-dependent material properties, or viscoelasticity, that govern the operating mechanisms of polymer gears. Therefore, in order to optimize the efficiency of future polymer gearing, it is necessary to derive a new set of standards tailored towards polymer specific manufacturing processes and operating conditions.

An early attempt at a universal standard for thermoplastic gearing was made by the German guideline VDI 2545 in the 1980's, but this guideline only addressed a limited number of thermoplastic materials and was eventually cancelled [1]. Today, another thermoplastic gearing guideline, VDI 2736, is slowly being created to replace VDI 2545, but the rapidly changing market of polymer/composite derivatives and hybrid gear shapes will make it difficult for any design standard to maintain relevancy. Therefore, what is most valuable to the polymer gearing engineer is a design methodology that describes the process of material characterization, finite element analyses, and experimental validation.

Material Characterization

Advances in polymer gearing are largely due to the development of higher strength materials and increasing precision of manufacturing processes. One material in particular, polyetheretherketone, or better known as PEEK, has proven itself as a superior choice for high strength polymer gears over the last decade. Experimental data has proven that gears made from PEEK offer up to a 3db noise reduction, a 69% mass reduction, and a 9% reduction in power consumption over metals gears [3]. For the research presented in this paper, PEEK 450G from Victrex® is used for all material measurements and simulation inputs. The material properties for PEEK are displayed in Table 1 [11].

Table 1 – Material Properties for PEEK

MATERIAL PROPERTIES FOR PEEK			
Property	**Conditions**	**Value**	**Units**
Tensile Strength	Yield, 23°C	100	MPa
Tensile Modulus	23°C	3.7	GPa
Poisson's Ratio	23°C	0.37	-
Melting Point	-	343	°C
Glass Transition	Onset	143	
Specific Heat Capacity	23°C	2.2	kJ kg^{-1} $°C^{-1}$
Coefficient of Thermal Expansion	Average below Tg	55	ppm $°C^{-1}$
Thermal Conductivity	23°C	0.29	W m^{-1} $°C^{-1}$
Density	Crystalline	1.3	g cm^{-3}

Viscoelasticity

Viscoelasticity is likely the most neglected material property in analyses of polymer gears made of PEEK and other thermoplastics. There are several reasons why engineers choose to avoid applying viscoelastic effects to structural simulations with PEEK. First, PEEK has a reasonably high modulus of elasticity in comparison to other thermoplastics, which makes its behavior more relatable to that of a soft metal. Furthermore, since viscoelasticity is strain rate and temperature dependent, it requires extensive dynamic mechanical analysis (DMA) in order to have enough data to cover the wide range of operating temperatures and frequencies that a PEEK gear might encounter. Lastly, once all material measurements have been transformed into a robust material model that can be accepted by an FEA software, the computational time required to perform a transient thermal-mechanical analysis with this data may be quite cumbersome and costly.

Regardless, in order to truly understand the wear mechanisms that ultimately cause PEEK gears to fail, the viscoelastic components must be thoroughly examined so that localized material heating on PEEK gear teeth surfaces can be properly simulated. Previous experiments performed on acetal gears have shown that shock loading and torque transitions imposed on a gear operating at constant frequency can cause the gear surface to nearly reach the melt temperature, 175°C for acetal material, and cause localized plastic deformation [9]. In Figure 1, a closer look at the shear storage modulus and loss shear modulus for PEEK as a function of temperature shows an abrupt change in the stiffness of PEEK as the glass transition temperature is approached. Using a DMA instrument to obtain frequency specific and temperature specific elastic moduli near the glass transition temperature is a primary step in predicting wear mechanisms in PEEK gears.

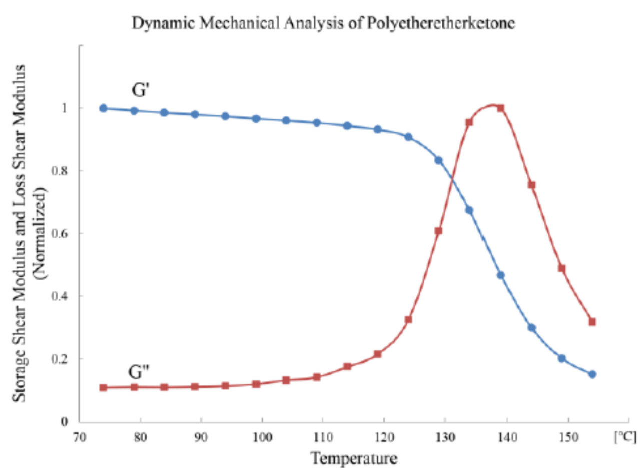

Figure 1 – Normalized DMA data for storage shear modulus and loss shear modulus as a function of temperature (6.2 Hz, 0.2% strain, $G'_{max} = 1.26\ GPa$, $G''_{max} = 0.11\ GPa$)

One foreseen challenge with acquiring the DMA data for PEEK is that modern testing equipment is normally limited to strain input frequencies of 1000 Hz. High-speed PEEK gears are used in applications that reach 9,000 rpm, or 150 Hz. For a gear with 30 teeth, that gives a tooth loading time equivalent to a frequency of 4500 Hz, which is outside the operating range of standard DMA instruments. Ultrasonic DMA instruments can measure frequencies as high as 10 MHz, but their sensitive transducers make them limited to temperature measurements under 100°C [7]. Overcoming this obstacle can also be achieved by time-temperature superposition principles which can be used to shift the time scales of several DMA tests in order to produce a master curve for the PEEK material. One well known model for performing this superposition is the William-Landel-Ferry (WLF) equation [10], which is given by

$$\log a_T = -\frac{C_1(T - T_{ref})}{C_2 + (T - T_{ref})}$$

where C_1 and C_2 are material dependent constants.

Lastly, another valuable parameter that is obtained from the DMA data is the fraction of energy dissipated as heat from the viscous effects of the PEEK. The fraction of heat dissipated during cyclic operation of a PEEK gear is a function of the material's temperature and strain rate, which is proportional to the gear's rotational frequency and number of teeth [6]. The complex shear modulus, G^*, combines the viscous and elastic contributions of the input energy by

$$G^* = \sqrt{(G')^2 + (G'')^2}$$

where G' represents the storage shear modulus and G'' represents the loss shear modulus. The shear elastic modulus is related to the storage elastic modulus, E', and loss elastic modulus, E'', through the Poisson's ratio, v, by

$$E' = \frac{G'}{v}$$

$$E'' = \frac{G''}{v}$$

The hysteresis, H, is the fraction of energy that is dissipated as heat, which is given by

$$H = \frac{Lost\ Energy}{Total\ Energy} = \frac{G''}{G^*}$$

From the DMA data, a hysteresis function can be fit to the hysteresis values with inputs of temperature and frequency. The use of this function is described in the finite element model description.

Friction

Some of the earliest studies performed on heat generation in thermoplastic gearing from the 1980's claimed that heat generation due to friction is significantly larger than heat generation due to hysteresis through a numerical analysis, though it should be noted that material properties in these models were not considered to be a function of temperature or strain rate [4]. Recently, there has been significant advancement and experimental validation of heat generation on the flanks of polymer gear teeth, with numerous studies performed specifically on PEEK. In one case, a special testing apparatus was built to simulate rolling and sliding contact of PEEK cylinders at various temperatures, contact pressures, and slip ratios [2]. The slip ratio is an important parameter for understanding the frictional interfaces between two rotating cylinders and is a percent defined by

$$slip\ ratio = 2 * \frac{V_2 - V_1}{V_1 + V_2}$$

where V_1 and V_2 are the respective velocities of the two cylinders. From the $slip\ ratio$, a relationship between relative sliding velocities of two surfaces can be conceptualized.

The friction occurring within the meshing of PEEK gear teeth operate in a similar manner to the study of the rolling cylinders. The point at which the most sliding friction occurs between two gears is when the tip of a pinion tooth just meets the lower flank on the tooth of the driven gear, as shown in Figure 2. The tip is traveling at a greater velocity and different relative direction that the lower flank of the opposing tooth, which creates a highly stressed sliding contact, which results in frictional heat generation. Another point to be taken from this same moment in time is the loading scenario among the meshed teeth. A PEEK gear mesh is unique when compared to metal gear meshes, because the reduced stiffness allows for higher contact ratios within the mesh which actually better distributes the load among the two gears.

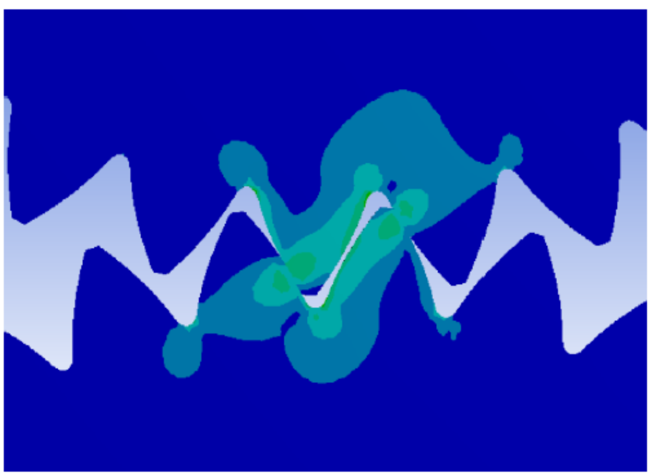

Figure 2 – Equivalent stress results of the finite element model operating in a transient thermal-mechanical coupled simulation with frictional sliding contact. Notice that four teeth are sharing the load which is reflective of high contact ratios of PEEK gears (15 N-m, 60 rpm).

Finite Element Model

Since June 2014, the Polymer Engineering Center at the University of Wisconsin-Madison has been developing a thermal-mechanical finite element model (FEM) of two PEEK gears using ANSYS® Workbench and Ansys Mechanical APDL. Initial gear geometry for the study was provided by Kleiss Gears, Inc., but the FEM is not limited to the simulation of these specific gear geometries. The FEM is still in its early stages, but will serve as the basis for all subsequent gear studies performed at the Polymer Engineering Center.

The FEM consists of two identical 30-tooth pinion gears made from PEEK, as shown in Figure 3. In practice, the gears are manufactured via injection over-molding PEEK around a steel hub. In order to simplify the initial FEM, the cavity that forms the web of the gear was filled in, and the steel insert was removed from the gear. The same stiffness of the steel hub was applied to interface of the joint in the model to compensate for the hub's absence. The involute tooth profile remains in the as designed state. The pitch diameter of the gear is approximately 2.5 inches and the face width is about 0.5 inches. All other dimensions are not stated, as they are not necessary to understand the context of the simulation.

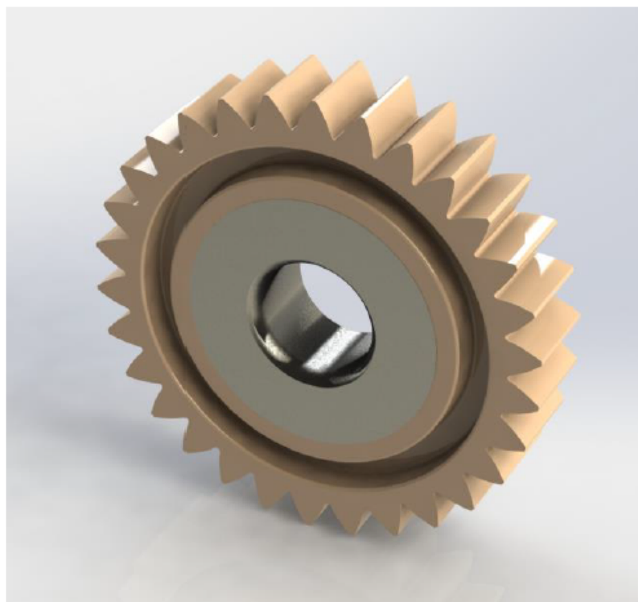

Figure 3 – Pinion gear used in FEM

There are two goals with the current FEM. The first is to predict the steady-state operating temperature of the gears given an initial set of boundary conditions. The second goal is to predict the time it takes to reach the steady-state operating condition (i.e. the duration of the transient phase). The FEM is currently meshed as a 3D solid body, though a 2D mesh would be preferred to help reduce computing time. Certain commands that allow the numerical method to converge are not available in the 2D model. Also, the 2D model is not able to capture the true behavior of 3D stress and temperature gradients within the tooth.

Boundary Conditions

The gears are fixed in all translational degrees of freedom, and are only permitted to rotate about their respective z-axis, as shown in figure 4. The gears are surrounded by an infinitely large control volume, which is modeled as air at 23°C. The free convection heat transfer coefficient is currently set to h_{conv} = 1 [W/m^2*K]. Heat transfer due to radiation has not yet been considered. The initial temperature of the gear bodies is set uniformly to 23°C. All PEEK material properties from Table 1 are applied to the engineering data for the FEM. A forced angular velocity of 1,000 rpm (clockwise) is applied to the left gear in Figure 4, and a constant moment of 8 N-m (clockwise) is applied to the right gear, which replicates a constant load. All contact is considered non-lubricated with a constant friction coefficient, $\mu = 0.15$.

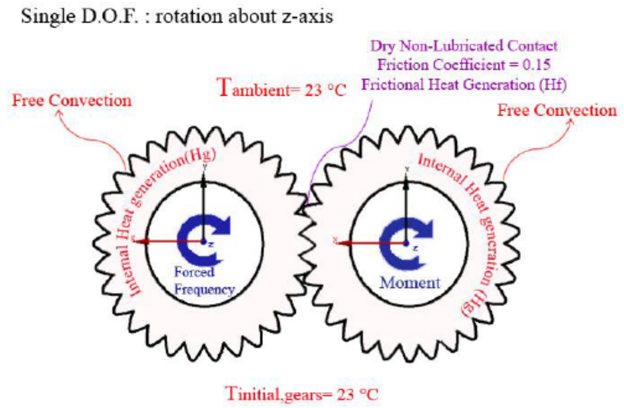

Figure 4 – FEM boundary conditions

Heat Generation

There are two sources of heat generation within the FEM. The first is internal volumetric heat generation due to viscoelastic heat dissipation. The viscoelastic heat generation is calculated for each finite element once per revolution of the gear. The hysteresis, or percent heat loss, varies only as a function of each element's temperature since the gear is assumed to be operating at a constant frequency. Each element within the model is strained and unstrained once per revolution of the gear, though the magnitude and duration of that strain will vary based on the element's size and location within the mesh. An example of this strain behavior is shown in Figure 5. The maximum value of the strain energy density is obtained for each element per cycle and the energy loss is calculated as follows

$$Energy_{loss} = H * U_{max}$$

where U_{max} is the maximum strain energy density per revolution per element and H is the hysteresis [6]. The heat loss rate is calculated as an average power over the duration of one revolution of the gear described by

$$H_G = f * Energy_{loss}$$

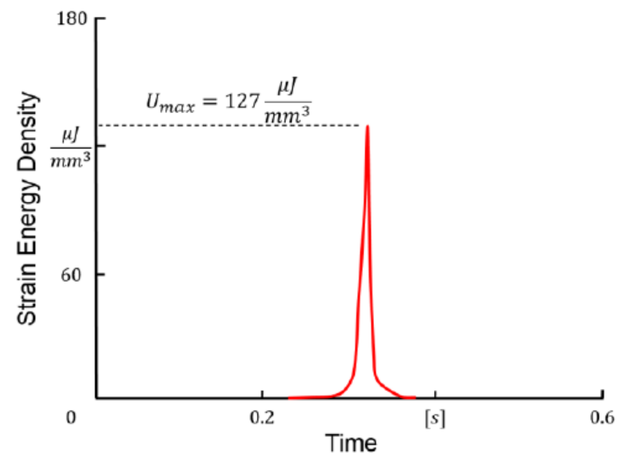

Figure 5 – Plot of strain energy density for one revolution of the gear at 1,000 rpm and 10 Nm torque for an arbitrary element located within a gear tooth

The second source of heat generation within the model comes from the sliding friction at the flanks of the gear teeth [8]. The heat generation due to sliding friction is calculated by

$$H_f = \mu * P * V_s$$

where μ is the coefficient of friction, P is the pressure distribution, and V_s is the relative sliding velocity of the two gear teeth in contact.

Experimental Validation

The FEM results were evaluated at Kleiss Gears, Inc. using a recently built gear test bench capable of simulating the loading conditions and frequencies that these gears will be subjected to in their end environment. Since the FEM does not yet consider the effects of lubrication, the gears were tested in a state of dry surface contact. Two identical 30 tooth production gears were used in each experiment with one gear being driven at a constant frequency, while the adjacent gear applied a near constant load. Each test began by installing a new pair of gears within the test bench. The gears were powered for approximately 15 minutes, which was determined a sufficient time for thermal equilibrium based on several trial runs. During each experiment a FLIR E40 infrared (IR) camera was used for gear surface temperature measurements and a Photron high-speed camera provided visualization of contact ratios [5]. Figure 6 shows the overall layout of the gear test bench and instrumentation.

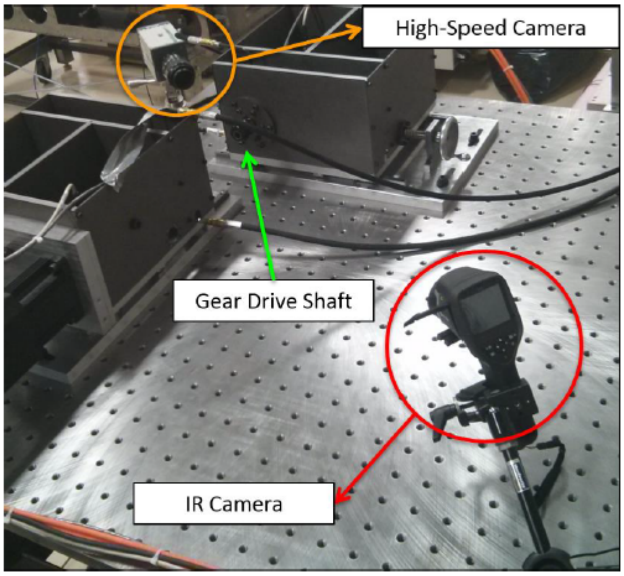

Figure 6 – Gear test bench used for experiments at Kleiss Gears, Inc.

The experiments had some limitations due to time, resources, and the calibration of the test bench. Therefore, the experiments only focused on two different operating conditions. For the first experiment, the gears rotated at 2,000 rpm with an applied load of 4 N-m. As shown in figure 7, the FEM has the ability to accurately predict thermal behavior of the gears for this these test conditions. Over the 15 minute time frame, an average error of 1.9 °C existed between the experimental and simulated temperature data. The majority of the error occurred in the rapid warming stage during the first few minutes of operation and then stabilized through the rest of the experiment's duration.

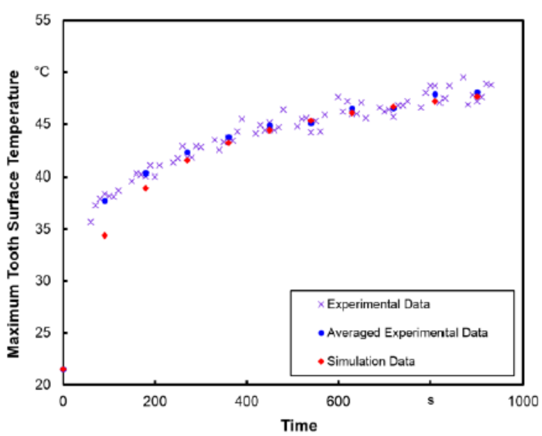

Figure 7 – experimental results versus simulated results of maximum gear tooth surface temperature for 2,000 rpm and 4 N-m of torque over a time frame of 15 minutes

The goal of the second experiment was to compare an operating condition of equal power transmission using a higher torque value and a lower rotational frequency. Thus, the gears were rotated at 1,000 rpm with an applied load of 8 N-m. The FEM was not able to predict the temperature rise of the gear tooth surface as accurately for the second experiment. As seen in figure 8, over the 15 minute test duration an average temperature difference of 29.4 °C existed between the experimental and simulated results. Also, the temperature error between experimental data and simulated data saw an increase in error throughout the test duration, which is the opposite of the first experiment, which decreased.

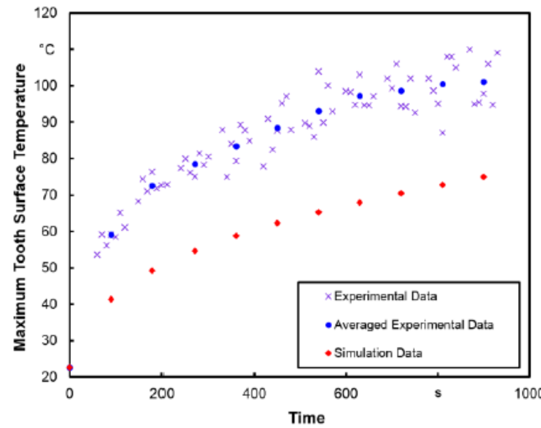

Figure 8 – experimental results versus simulated results of maximum gear tooth surface temperature for 1,000 rpm and 8 N-m of torque over a time frame of 15 minutes

Conclusions and Outlook

A series of brief experiments were conducted to validate the accuracy of the FEM. From the initial experiments, one may infer that the FEM accurately predicts thermal behavior of polymer gears at higher rotational frequencies and lower torques. On the other hand, the FEM appears to have several error sources when predicting the thermal behavior of PEEK gears operating at a higher torque. Higher torques produce larger strain energy densities, which should result in a larger amount of viscous heat dissipation. As mentioned previously, not enough DMA data has yet been obtained for use in the FEM over a wide range of temperatures and frequencies, which can be a cumbersome process. DMA data provides the essential hysteresis factors that are solely responsible for predicting the energy converted to heat during the gear's operation. This is probably the largest contributing factor to the error. Also, a more in depth study of PEEK on PEEK wear needs to be carried out to discover how frictional heating may change during transient thermal operation of gear surfaces. Moreover, if the resources can be summoned, it would be highly beneficial to perform these same tests on another gear test bench as a comparison. It is possible that resonance within the gear test bench may have caused excessive vibration during testing that could also be responsible for unpredictable thermal behavior.

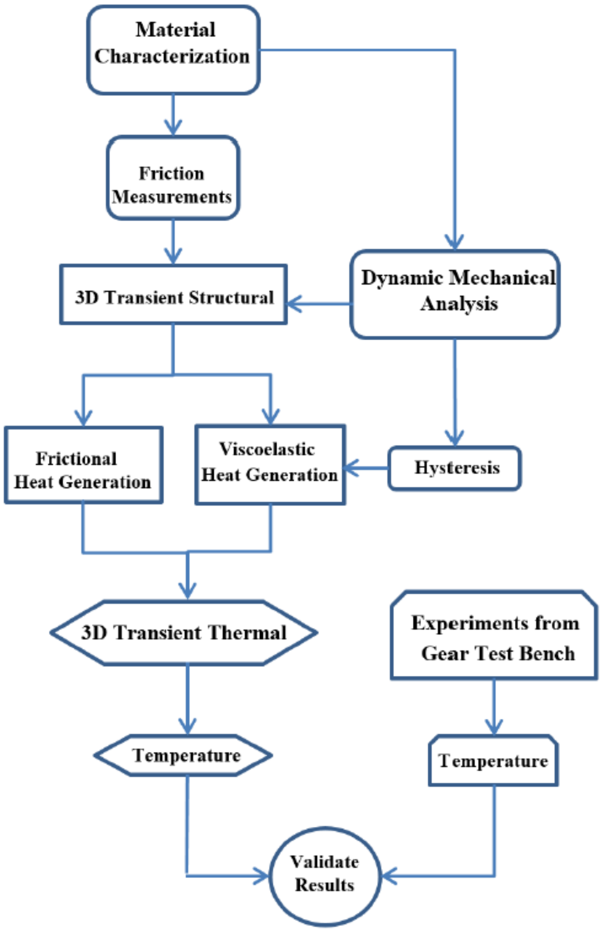

Figure 9 – Flow chart of objectives

This paper explains an outline for a methodology of simulating viscoelastic effects in polymer gears made of PEEK. The ideas presented in this paper are applicable to simulations of other polymer gears made of thermoplastic materials. Figure 6 outlines the future work and research objectives for this project. Initial results have been provided for many of these objectives, but this is only the start. The simulation parameters for these specific gears (i.e. frequency and load) need to be refined to more accurately predict the physical operating conditions of the gears. This means that successive DMA tests must be conducted to obtain a more accurate estimation of the hysteresis at the gear's operating conditions. Also, more work must be done to predict the heat transfer coefficients and mechanisms within the model, which have the ability to significantly alter the temperature error at different operating speeds from phenomena such as forced convection. Once the FEM is found to be sufficiently robust, the results will be compared to another trial of experiments, perhaps using a different test bench from the initial experiments. As time persists and more objectives are completed, fully developed material models will be utilized for input into the FEM and a more in depth look into friction and wear mechanisms, shock loading scenarios, and helical gear designs will ensue. Lastly, a continuous effort will always exist to improve the computing efficiency of the FEM.

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ANTEC 2015 Summary

Joel Lischefski

ANTEC 2015 went very well for the Polymer Analysis Division this year. Overall we had a higher number of paper submissions, presentations, and attendees to our talks than we had in 2014.

The division held 21 total talks over 3 sessions with 3 keynote speakers in the areas of Innovative Methods, Morphology and Optical analysis, Rheology and Kinetic Analysis, and Thermal and Aging analysis. Attendance to the talks was strong with an average of around 20-25 people per talk.

Keynote talks were well attended and presented by Steve King, a senior fellow with Dow Chemical, William Degroot, a fellow with Dow Chemical, and Mike Sepe, an independent consultant and regular author of a Polymer Analysis Feature in Plastics Technology Magazine.

Looking forward to ANTEC 2016 we look to build off a successful 2015 meeting and continue to improve the value we provide to the members of our division and the plastics community as a whole.

I would ask our members to already begin planting the seeds with their fellow coworkers and colleagues to prepare for paper submissions to ANTEC 2016. While the paper submission deadline is still many months away, the work that needs to be done to produce a successful paper will need to be underway soon, so now is the time to promote the conference and encourage those paper submissions for later in the year.

Message of ANTEC 2016

- ANTEC 2016 will be held on May 23-25, 2016, at the JW Marriott Indianapolis.
- TPC kickoff meeting is June 18th.

ANTEC Council Meeting Minutes

Sanjiv Bhatt

In Memoriam:

A moment of silence was taken to remember these fellow members at the ANTEC 2015 Council meeting.

Bret Baumgarten – Active member of the Golden Gate Section and student sponsor of the University of CA-Chino

Patsy Beall – SPE Honorary Member, active in Mold Making and Mold Design Division, the Chicago Section, Rotational Molding Division and the Product Design and Development Division.

Pierre Hamel – Past President and Secretary of the Quebec Section

Alva (Al) Whitney – Distinguished member of SPE since 1955, active in the Palisades-NJ sections and Vinyl division. As many of you know, Al turned 100 years old on August 8th this past year.

Andrew Yacykewych – Active board member and Education chair of the Palisades-New Jersey Section.

Report

2014 was again a great year of change for SPE. Investment in the future of SPE continued as we enhanced our digital resources and appointed Russell Broome as Managing Director of the Society. SPE Staff performed extremely well as we undertook more complex tasks and were able to provide better service. As of July 2014, SPE staff now operates from a modern and functional office space in Bethel, CT. SPE's globalization efforts continued with a successful ANTEC in the Middle East (Dubai, January 2014) and seminars in China and Singapore. These events strengthened our brand globally and contributed to overall SPE revenue.

The most important digital enhancement of 2014 was the implementation of a new SPE website. With our new website, we are finally able to provide current and relevant news on plastics technology. In addition, SPE's Technical Library is now fully searchable on our website. This resource is truly the most diverse and comprehensive database of new plastics technology in the world. SPE also made its first steps into the mobile-App world. The new website is mobile-responsive and our new Events App allows members to store all their conference data in one place. The Plastics Engineering magazine is now fully digital and available in a mobile-App version.

The SPE Foundation made considerable progress with Roger Kipp as Chair and new board members such as Bill Carteaux and Sandra McClelland. A new strategic plan for the SPE Foundation is being developed, including a digital process for grant and scholarship applications. A new plan for the Plastivan™ Education Program is already being implemented with three additional instructions to allow the program to educate more students nationwide. The SPE Committees did great work again, and if we have to highlight one of them, it would be the NGAB (Next Generation Advisory Board). Run by young professionals in the plastics industry, this group has continued to flourish with many new activities such as The Plastics Race® and Mission Possible. This group will continue to connect the next generation of plastics professionals with current SPE members. With all of that being said, there are still many challenges ahead. As information and knowledge increasingly become a free resource and with many new digital networking platforms, our 'old' business model faces fierce competition.

The membership dues revenue may continue to decrease and in the future we will have to rely on other sources of revenue. A new business model implementation seems like the only path forward. Facebook and Linked-In are perhaps business models we can learn from. Most activity on these platforms is free and their revenue comes from advertisements and companies looking for market data. Similarly, SPE is an organization where the members create or post content and other members have access to it. Therefore, The Chain, an on-line collaboration and discussion platform for plastics professionals world-wide, is has been launched. Most of the features are accessible for free as SPE introduces a **new zero-dollar "e-Member" grade.** The e-Member will have limited member benefits, but they will have access to The Chain as a resource.

(e-membership Benefits table is on the next page)

Financial Update

I, on behalf of our Division, had asked for a Return of Investment (ROI) on the investments that we were making as a society. Following was Wim de Vos's response.

Wim explained that ROI is not easy to calculate for certain investments, particularly for non-financial reasons to invest. He explained that we cannot calculate WACC (Weighted Average Cost of Capital) since we are not a 'for profit' organization. However, we can estimate 'paybacks' for the different projects.

A. AMS $110K

Wim explained that it is impossible to do a ROI on this investment.

Mark Wetzel clarifies that the Avectra System was not brought up to Council as an investment, but as a system that was broken. The systems needed to be repaired and so a ROI should not be needed.

B. WEB SITE $130K

Wim explained that traffic increased dramatically and that our bounce rate (a rate that measures the number of hits that leave the site after 3 seconds) reduced from 60% to 30%. Wim explained that despite the fact that the infrastructure is there to host the Group's web sites, we do not see enough activity. Even those groups that are taking advantage of this platform have information that is very static. It cannot be said if the web site is attracting or not new members.

However, in advertising income, the web site has been a success. We have sold about $90K in advertising that we did not have in the old web site. Hosting for S/D is bringing about $10K as our Groups will have to pay this money to outsiders to host their web sites. Thus, payback for this investment is less than 1.5 years and; therefore, this investment has been recovered.

e-membership Benefits

Benefit	Premium Member	Student Member	e-Member[7]	Honorary Member
Eligible to Join Sections & Divisions	✓	✓	No	No
Participate in SPE Voting / SPE Leadership	✓	✓	No	No
Use of SPE Member Logo	✓	✓	No	No
Discounts on SPE Conferences	✓	✓	No	No
Access to Technical Library	✓	✓	No	No
Access to Abstracts of Papers in Technical Library	✓	✓	Read	Read
Access to SPE Member Directory	✓	✓	No	No
Listed in SPE Member Directory[1]	✓	✓	✓	✓
Receive PE Magazine (paper)	✓	✓	No	No
Receive PE Magazine (electronic)	✓	✓	No[2]	No[2]
Use of PE Magazine APP	✓	✓	✓	✓
Receive Industry email (focused information)	✓	✓	No	No
Access to The Chain				
• Tech Talk	✓	✓	✓	✓
• Café	✓	✓	✓	✓
• Leadership Lane	✓[3]	✓[3]	No	No
• Career Central	✓	✓	Read[4]	Read[4]
• Campus Connection	Read[5]	✓	No	No
• Premium Places (Forums)[6]	✓	✓	No	No

[1] Anyone can opt-out from the member directory list
[2] Yes for current issue, no access to older issues
[3] If serving as SPE Leader
[4] Public will have no access
[5] Full if SPE Member is serving as a Group Facilitator
[6] Planned for Future Release
[7] e-Members to be designated as such in the Member Directory

C. Conference App $20K

A lot of Divisions are using it. Groups receive all the financial benefits and no cost because HQ provides it for free. It also serves to avoid printing costs as the App can be updated even the night before the event. The App provides additional sponsor income from banners. The App also helps avoid expense duplication @S/D TopCons. This product has been paid back in no time

D. The Chain $30K+

Project is ongoing. Sales of advertisement started. Estimated payback ROI < 1 year

Wim de Vos to provide numbers from TopCons by next Council Meeting and a comparison with previous years.

SPE is in the BLACK

Project	count	$$$	revenue	expense
Website - advertisement	12	5,000	60,000 $	0 $
The Chain - advertisement	12	2,500	30,000 $	0 $
Additional HQ Topcons	4	100,000	400,000 $	300,000 $
P2P's	4	60,000	240,000 $	60,000 $
Industry Newsletter	12 x 10	1,500	180,000 $	40,000 $
Directory	1		400,000 $	120,000 $
Industry survey	3	50,000	150,000 $	36,000 $
Innovation partner	3	25,000	75,000 $	0 $
Innovation enabler	5	10,000	50,000 $	15,000 $
Additional people	3			240,000 $
TPR	1	50,000	50,000	25,000
Licensing the TRP app	2	12,500	25,000	0 $
TOTAL			1,660,000 $	800,000

Future Financial Streams

The Executive Committee is evaluating the following potential new products & services and their potential revenues.

Project	Count	Potential Revenue/Unit ($)	Potential Revenue ($)	Potential Cost ($)
Website advertisement	12	5,000	60,000	0
The Chain advertisement	12	2,500	30,000	0
Additional HQ TopCons[1]	4	100,000	400,000	300,000
P2Ps[2]	4	60,000	240,000	60,000
Industry Newsletter	12 x 10	1,500	180,000	40,000
Innovation Partner	3	25,000	75,000	0
Innovation Enabler	5	10,000	50,000	15,000
Additional People	3			240,000
TPR	1	50,000	50,000	25,000
Licensing the TPR app	2	12,500	25,000	0
Total			1,660,000	800,000

[1]We are looking for niche applications where HQ will approach Divisions to organize TopCons on niche applications. For example: use of plastics in bicycles.
[2]P2P is 'Pellet to Part'

Wim presented a financial projection to the year 2020 based on the continuous lose of membership while gaining revenues from other sources.

	2015	2016	2017	2018	2019	2020
Member	1300	1150	1000	850	750	700
Ads Web/Chain	50	70	90	100	100	100
Seminar/Conf.	90	185	280	280	280	280
Directory	0	150	300	400	450	500
Other Rev						
Total	1440	1555	1670	1630	1580	1580

Future financial streams can only be realized if we consider other options such the ability to reach lots of people. He explained that this is another reason why we need e-membership.

Workshop on "Governance Structure" was conducted at the ANTEC council meeting:

The meeting was split up in 8 groups to discuss possible answers to the following three questions:

1. What's the role of governance?
2. How many people do you need for it?

3. What should be the structure?

After 30 minutes every group presented their results but many complained that time was too short. Therefore CEO de Vos announced that the questions will be posted on the Chain for further discussion. He also collected the reports of the 8 groups for review by EC. Update will be provided after the fall council meeting.

BY Law Changes

Many By Laws were changed in the interest of making the society easier to do business with and more nimble to member needs. The Meeting Minutes document containing the by-law changes is available on the chain - http://thechain.4spe.org/home. If you don't find it – please contact, Sanjiv Bhatt, your councilor at bhatt.sanjiv@gmail.com for a copy.

Thank you all for the opportunity to represent Polymer Analysis Division in the SPE council.

Society of Plastics Engineers Membership Application

P.O. Box 403, Brookfield, CT 06804-0403 USA
Tel: +1.203.740.5403 Fax: +1.203.775.8490
www.4spe.org

European Member Bureau
Eric Sasselaan 51, BE-2020 Antwerpen, BELGIUM
Tel: 32 (0)3 541 7755 Fax: 32 (0)3 541 8425 www.speeurope.org

Applicant Information

Name:

first last mi

Company Name and Business Address (or College):

company/college:

job title:

address:

address:

city: **state:**

zip: **country:**

Phone/Fax Format: USA & Canada: (xxx) xxx-xxxx All Others: +xx(xx) x xxx xxxx

Work Phone: **Fax:**

Email: *used for society business only*

Home Address:

address:

city: **state:**

zip: **country:**

Home Phone:

(✓) Preferred Mailing Address: ❑ **Home** ❑ **Business**

Gender: ❑ Male ❑ Female

Birth Date: (mm/dd/yyyy)

Demographics

Job Function *(choose only one)*

- ❑ Consulting
- ❑ Design
- ❑ Education (Faculty)
- ❑ Engineer
- ❑ General Management
- ❑ Manufacturing
- ❑ Marketing/Sales
- ❑ Other
- ❑ Purchasing
- ❑ Quality Control
- ❑ R & D
- ❑ Retired
- ❑ Self-Employed
- ❑ Student
- ❑ Tech Support

Materials *(choose all that apply)*

- ❑ Composites
- ❑ Film
- ❑ General Interest
- ❑ Nylon
- ❑ PET
- ❑ Foam/Thermoplastics
- ❑ Polyolefins
- ❑ Polystyrene
- ❑ TPEs
- ❑ Thermoset
- ❑ Vinyls
- ❑ No Interest

Process *(choose all that apply)*

- ❑ Blow Molding
- ❑ Compression
- ❑ Compounding
- ❑ Engineering Properties
- ❑ Extrusion
- ❑ Fabrication
- ❑ Foam
- ❑ Injection Molding
- ❑ Mold Making
- ❑ Product Design
- ❑ Rotational Molding
- ❑ Thermoforming
- ❑ General Interest
- ❑ No Interest

The SPE Online Membership Directory is included with membership. Your information will automatically be included.

- ❑ Exclude my email from the Online Member Directory
- ❑ Exclude all my information from the Online Member Directory
- ❑ Exclude my address from 3rd party mailings

Payment Information

New Member 1 Year	New Member 2 Years *	Student Member
❑ US ($125.00)	❑ US ($217.00)	❑ US ($28.00)
❑ Canada ($145.00)	❑ Canada ($253.00)	❑ Canada ($33.00)
❑ Euro** (€127.00)	❑ Euro** (€221.00)	❑ Euro** (€24.00)

Students must supply graduation date: ________

Membership Amount ________

My Primary Division is (choose from below) ________

Primary Division FREE

Additional Divisions are available for a fee. Check below to select Additional Divisions.

- ❑ Additives & Color Europe (D45)
- ❑ Automotive (D31)
- ❑ Blow Molding (D30)
- ❑ Color & Appearance (D21)
- ❑ Composites (D39)
- ❑ Decorating & Assembly (D34)
- ❑ Electrical & Electronic (D24)
- ❑ Engineering Properties & Structure (D26)
- ❑ Extrusion (D22)
- ❑ Flexible Packaging (D44)
- ❑ Injection Molding (D23)
- ❑ Marketing & Management (D37)
- ❑ Medical Plastics (D36)
- ❑ Mold Making & Mold Design (D35)
- ❑ Plastics Environmental (D40)
- ❑ Polymer Analysis (D33)
- ❑ Polymer Modifiers & Additives (D38)
- ❑ Product Design & Development (D41)
- ❑ Rotational Molding (D42)
- ❑ Thermoforming (D25)
- ❑ Thermoforming, European (D43)
- ❑ Thermoplastic Materials & Foams (D29)
- ❑ Thermoset (D28)
- ❑ Vinyl Plastics (D27)

Additional Division(s)

costs for each Additional Division

	1yr.	2 yrs.
US	$6.00	$12.00
Canada	$7.00	$14.00
Euros	€5.00	€10.00

____

TOTAL ________

❑ CHECK ❑ VISA ❑ AMEX ❑ MASTERCARD

card number

expiration date (mm/yyyy)

PAYMENT MUST ACCOMPANY APPLICATION
No Purchase Orders Accepted

Checks must be drawn on US or Canadian banks in US or Canadian funds.

Dues include a 1-year subscription to *Plastics Engineering* magazine–$38.00 value (non-deductible).
SPE membership is valid for twelve months from the month your application is processed.
*save over 10%. **European membership dues include a program fee to support SPE's activities in Europe.

By signing below I agree to be governed by the Constitution and 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 member (optional) Id #

WWW

Who Can Help You?

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ANTEC Conference Management	Lauren McCarthy	+1 203-740-5472	lmccarthy@4spe.org
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