

Recent Advancement In Understanding Micro-Shear Banding Polymers

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Introduction

There have been great advancements in the fields of science and technology, and by extension, we have come to know more about the complex and intricate nature of polymers. In this paper, we will discuss a little about what polymers are and explore the fields in which polymers are used for different purposes. There are three fields that we will discuss, try to understand, and ascertain more about polymers. We will discuss the deformation and shear banding of polymers at the microscopic level in various fields, so in the end, we will have an understanding of these gigantic materials and how the small deformation affects the molecular and physical structure of polymers.

The three areas in which the study of polymers will be done in this paper consist of, firstly, the understanding of polymers and how much the deformation, done on polymers at a microscopic level, which is done through micro-shear banding, results in the deformation of these polymers at a higher level, i.e., macroscopic level. In this theory of understanding the polymers and how their deformation at a small and microscopic level produces changes macroscopically, we will look at some theories that result in the rate of shear strain in the physical model, and one of the theories that will be discussed is the singular surface of order one theory, which helps us understand more about the physical and mathematical changes in the model to produce changes at a higher level. We will also look at some of the mathematical and theoretical formulas and derivations that helped cause those micro-shear bandings to happen.

The second field that we will explore in this paper is the micro-shear banding of polymers, which is caused by the solution of polymers. This area of micro-shear banding is also observed and discussed in this paper, where the changes and results of micro-shear banding cause in the solutions of various polymers. The recent understanding in the theory of polymers is that there must be a relationship between the rate of shear and the shear stress, which should be contrary to the notion of a relationship that is monotonic in liquid, which is both elastic and viscous when the strain and deformation take place in them. This was an understanding of the researchers that the strain or deformation is only possible physically if the relationship between the two, i.e., rate of shear and shear stress, is of nature monotonic. However, as new advancements are taking place in this field, multiple experiments have been conducted that have given the notion that micro-shear banding is very much possible in polymer solutions.

The third area that this paper discusses regarding the micro-shear banding of polymers is the understanding of polymers, which are tangled and entwined quite complexly and intricately, that the

shear banding is produced in these types of polymers. The shear banding is caused by the smallest of gaps at the smallest scale of a micron. There was a perception in this field of deformation and strain in polymers that the deformation is only caused when there is a slip of walls, which is also interfacial in nature. There was an understanding that it is not only limited to this kind of deformation but also that there is another way in which the deformation can be executed. This part and section of the paper include the study and experimental results done by different scientists and researchers to explain the micro-shear banding of complex, entwined, entangled, and highly intricate polymers.

Discussion

The first area of polymers, in which micro-shear banding is discussed, is the results and impacts that happened to a polymer at a macroscopic level of study by the smallest deformation in the structures of polymers, which is also called micro-shear banding of polymers. The theory of continuum of materials is the source from which we come to know and understand the micro-shear banding of polymers, which is done on a large scale and physically huge materials but requires a decent atmosphere and conditions environment to carefully and diligently notice the impacts of the micro-shear banding in the polymers, which all come under the umbrella and domain of the theory of continuum. This is still an open discussion and debate, and there are many queries and questions yet to be proven and asked about the theory that completely and quite accurately describes and demonstrates the effects and impacts of changes and deformation at a microscopic level, which is done by micro-shear banding, on a macroscopic level on these polymers. (Argon, 1973)

The basic purpose of this theory is to examine the effect of distortion, bending, and changes on the kinematics of solids, which are metals, by the distortion, bending, and changes, which are also plastic and elastic in nature. The mathematical and theoretical derivations and calculations for the impact on the large molecules of polymers caused the smallest deformation and bending of the particles at a microscopic level through micro-shear bending are done on the basis of the concepts and understandings of the characteristics and traits of the vortex sheet, to produce the bending at the smallest level through the proposed theory of singular surface, which is of the order one. This is the cluster system, done on the basis of the idealization of theoretical calculations and mathematics. After the theoretical calculations, this results in the making of the model, which is drawn physically in nature. This model helps to make the case of the changes on the vortex sheet by the identification of changes in velocity to correlate the structural characteristics and traits of deformations at a microscopic level of these materials done by the bandings pertinent to the shear microscopically, with the rate of shear strain, done on a large scale. Finally, the third conceptual basis of this shear banding, which is microscopic in nature, deals with the propagation of the respective elements, known as RVE, i.e., representative volume element, on the vortex sheet, which is of the surface having single and one dimension.

The suggestion and concept given by Thomas that the likelihood to model the localized area, which is small and thin, for the discontinuation of the fields of velocities and to take it to the next stage, Valais

employed the concepts and ideas of Thomas to apply those notions. The researchers of this theory noticed that the changes are very sporadically caused when some of the planes are slipped and disturbed, where the quantity is, to some extent, more, and these sporadic fluctuations, of large and strong magnitude, on the fields of velocities. Furthermore, the interesting aspect to notice is that the fluctuations are caused on an extremely small scale, and these fluctuations at a micro level can make the jumps in velocities, which will be observed and noticed on a large scale.

These changes are not reversible, but instead, when these changes are made and caused at a small level, these changes have ramifications and implications on a macroscopic stage that cannot be reversed. They are irreversible. This is what plastic deformation is: when the application of a force on a material causes changes that are irreversible in that material. Olmsted, along with other researchers, came up with a concept that was theoretically developed by these researchers, which involved the shear bands, and the considerations that were made on these bands were the discontinuous nature of the surfaces. These discontinuous surfaces have velocity jumps on them, as well as the slope of stress. The temperature and the aforementioned parameters were also taken into account. These necessary steps were taken to solve the problem, which had a single dimension, and the shearing that was done on the slab was one-directional, not bi-directional. The physical properties of materials are enhanced to a greater degree when subjected to deformation. For instance, the outcomes of the reflections on metallography shed light on the area of research that replaces numerous slips of crystallography by the modes of concentrations of large-scale hierarchical shear. This is primarily done or results in this form if there occurs a change in the way or path of strain and deformation. The shear banding formed a particular pattern, a dominantly defined pattern that travels through the planes without deviating from the path.

Shear bending in polymer solutions is also possible, and there has been much research going on around this concept. It was one thing to produce deformations in the polymer materials. Still, it was completely another concept of producing large-scale changes in the properties of the solution, involving the polymers. The micro-shear banding in polymers has been done, but the debate and the questions on the deformation or shear banding in the solutions of polymers have still not been resolved and come to a conclusion. (Haward & Young, 1997) While stating this point theoretically, when subjected to shear, there is a velocity profile that is formed by the curve, which is in nature constitutively, not monotonic, and exhibits nothing but unpredictability and variability. But this is the main problem that lies with the theory of deformation or shear banding in the solutions of polymers because there has been or was no indication of this kind and level of variability in these solutions. This evidence forced the researchers to make the conclusion that the shear banding is most probably representative of the notion that it takes a considerable period of time to go through this transience. There are recent theories that have been backed by theoretical and mathematical calculations and models that can make predictions about the bandings by employing equations that are constitutively monotonic.

In order for the prediction about bandings to happen, the primary thing to take into consideration is to be able to discern the likelihood of the nonuniformity of polymer concentration during the process of

the flow. A number of theories usually make the assumption that the concentration continues to be homogenous instead of assuming the nonuniformity of the flow. Nevertheless, Fredrickson, along with Helfand, managed to come up with a technique to show that the solutions of polymers were subjected to a flow that was not homogenous in nature. It involves the concentration coupling with the stress. This mechanism shows the instability of the flow if the coupling between the stress and the concentration of the polymer is done.

Polymeric materials, which include actin filaments, DNA, textiles, plastics, elastomers, and rubbers, have arisen as a glaring category of soft matter, which is ubiquitous and can be found in industry and nature. Large molecules, having great length, can be tangled in their disorganized state, which is liquid in nature and can exhibit incredible viscoelastic properties. Their lethargic slackening at a macroscopic level rises from the uncrossability of the chain, which restrains chains from forming a reputation in a tube, which is unidirectional in relaxation. During the deformation, which is of high and large magnitude, the pulling of the entwining chains will occur. The unraveling of the chains is done when the rate of deformation increases as compared to the reciprocal of the time of reputation. That will result in distortion in the molecular structure. The pulling of these chains will continue unless there is no misbalancing of force. When this stage is reached, the chains will be untied. This result will also yield a tangled and entwined network. The important point in the nonuniformity of the polymers' rheology is the problem of the unraveling of the chains, which is done when the distortion of high magnitude results in a homogenous shear field or not.

The shear rheometer of rotation is the driving force from where the information about the behavior of rheological nonuniformity of the polymers that are entwined and are in the form of entanglement. Recently conducted tests and experimentations provide great insight into the knowledge of the chain of polymers as to how they will react to a certain shear when they are subjected to these experimentations in combination with the conventional way of measuring, employing the characterization of the PTV. It is the acronym for particle tracking velocimetric characterization.

When the number is very big, taking into account the Weissenberg, this will result in the shear distortion and banding as well as the slipping of the walls. This happened to the liquids, being in the form of entanglement, for instance, deoxyribonucleic acid or solution of F-actin or poly-butadiene, etc. The large value of the number is the combination of the time of reputation, which is known to be the time of great relaxation, and the rate of bulk shear. Other than the liquids or the fluids exhibiting the slipping of the walls, there are polymers also in which the slipping of the walls is apparent, and these include the likes of polyethylene oxide and styrene butadiene. However, this kind of banding can be circumvented by employing the technique and method of gradually and steadily ramping up the rate of shear that is applied to the polymers. There is no rule that the slipping of the walls or the shear banding necessarily takes place when the solution of the polymer is subject to insufficient entanglement.

References

- Argon, A. S. (1973). A theory for the low-temperature plastic deformation of glassy polymers. *Philosophical Magazine*, 28(4), 839–865. <https://doi.org/10.1080/14786437308220987>
- Haward, R. N., & Young, R. J. (1997). *The physics of glassy polymers* (2nd ed.). Springer. <https://doi.org/10.1007/978-94-011-5850-3>