EFFECT OF CONSOLIDATION PRESSURE ON THE DEFORMATION AND VOID CONTENT REDUCTION WITHIN A STOCHASTIC ARRAY OF FIBRILS

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Introduction

- UHMWPE has become an important material for many applications due to its stiffness and strength.
- Fibrils array modeling provides insight into information about failure and energy-dissipating mechanisms for the single fiber of PE.
- The influence of consolidation pressure on fibrils' array is a key factor that significantly impacts the modeling, underscoring our research's depth and practical implications.
- The geometry for the stochastic model was based on the statistical data observations. Figure (1) shows AFM images of the fiber cross-section and statistic repression of the fibril's diameters.

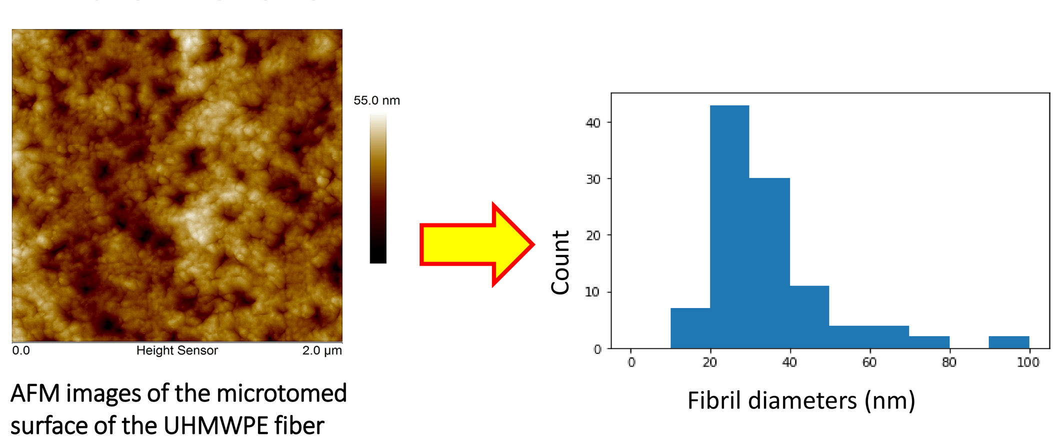


Figure (1) AFM images and statistic distribution of the fibrils on a single fiber of PE

Objectives

- To understand how consolidation Pressure(p_o) influences composite microstructure (Reduce voids, Increase fiber volume fraction, Minimize filament damage).
- To identify the smallest representative volume element (RVE) that can mimic the continuum fiber of PE.
- To improve composite performance (Reduce weight, maintain performance, reduce dynamic deflection, maximize energy absorption).

Develop the model for the uniform fibrils array.

- The model is for uniform fibril diameters and hexagonal fibril packing.
- Due to the symmetric and repeating patterns, the RVE was taken for the *RED* region in Figure (2).
- For the FEA boundary conditions and the ABAQUS model, see Figure (3).
- The results are shown in Figure (4).

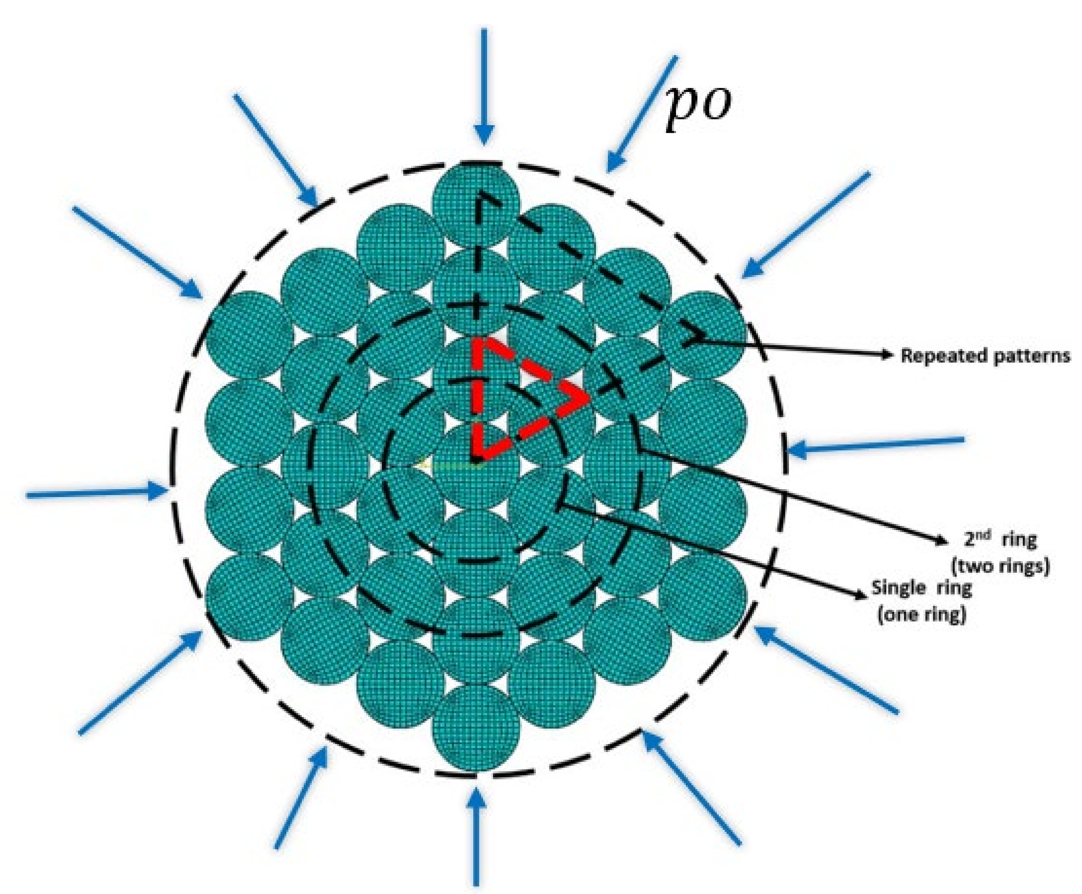


Figure (2) Modeling of uniform fibrils array under consolidation pressure.

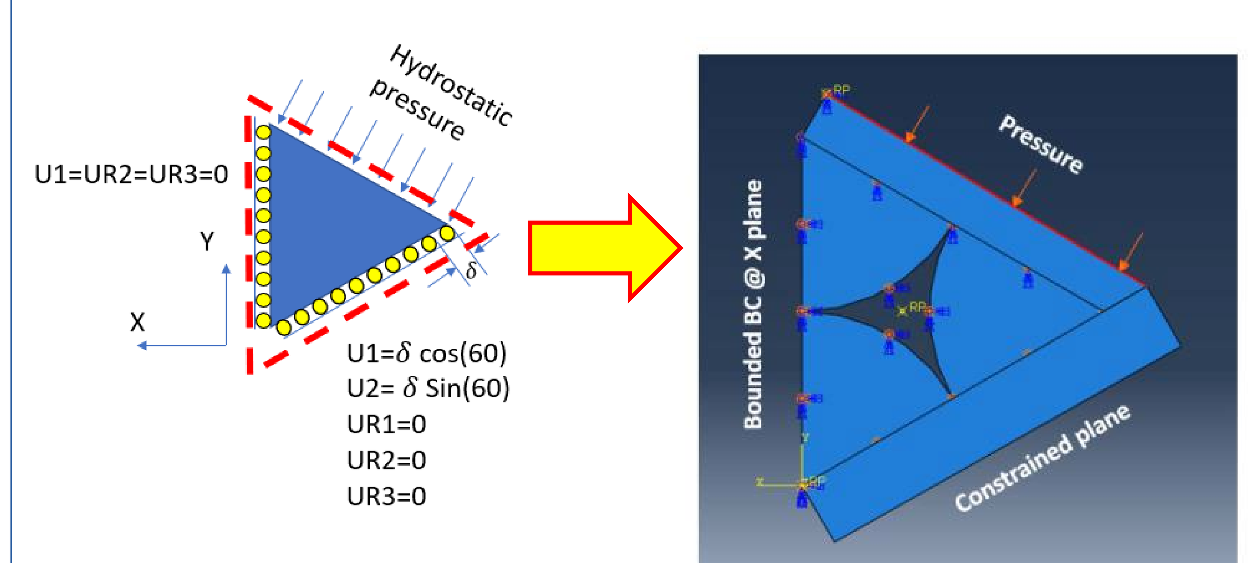


Figure (3) RVE boundary conditions for the uniform fibrils array.

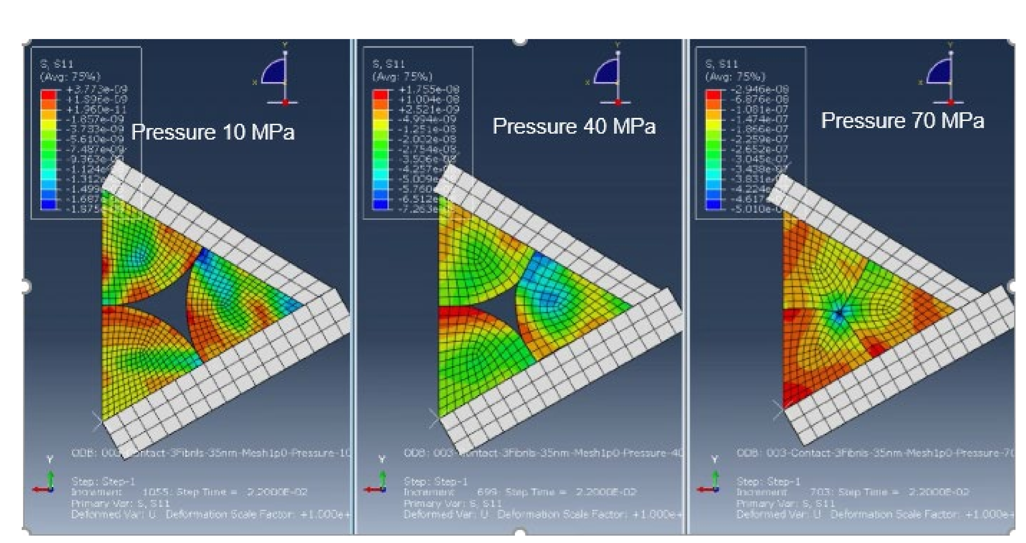


Figure (4) RVE for uniform fibrils array results for different consolidation pressures.

Develop the model for the stochastic fibrils array.

- Conducted with the actual geometry.
- The reported diameter distributions were for 103 fibrils. Figure 5 shows two different configurations for different distributions.

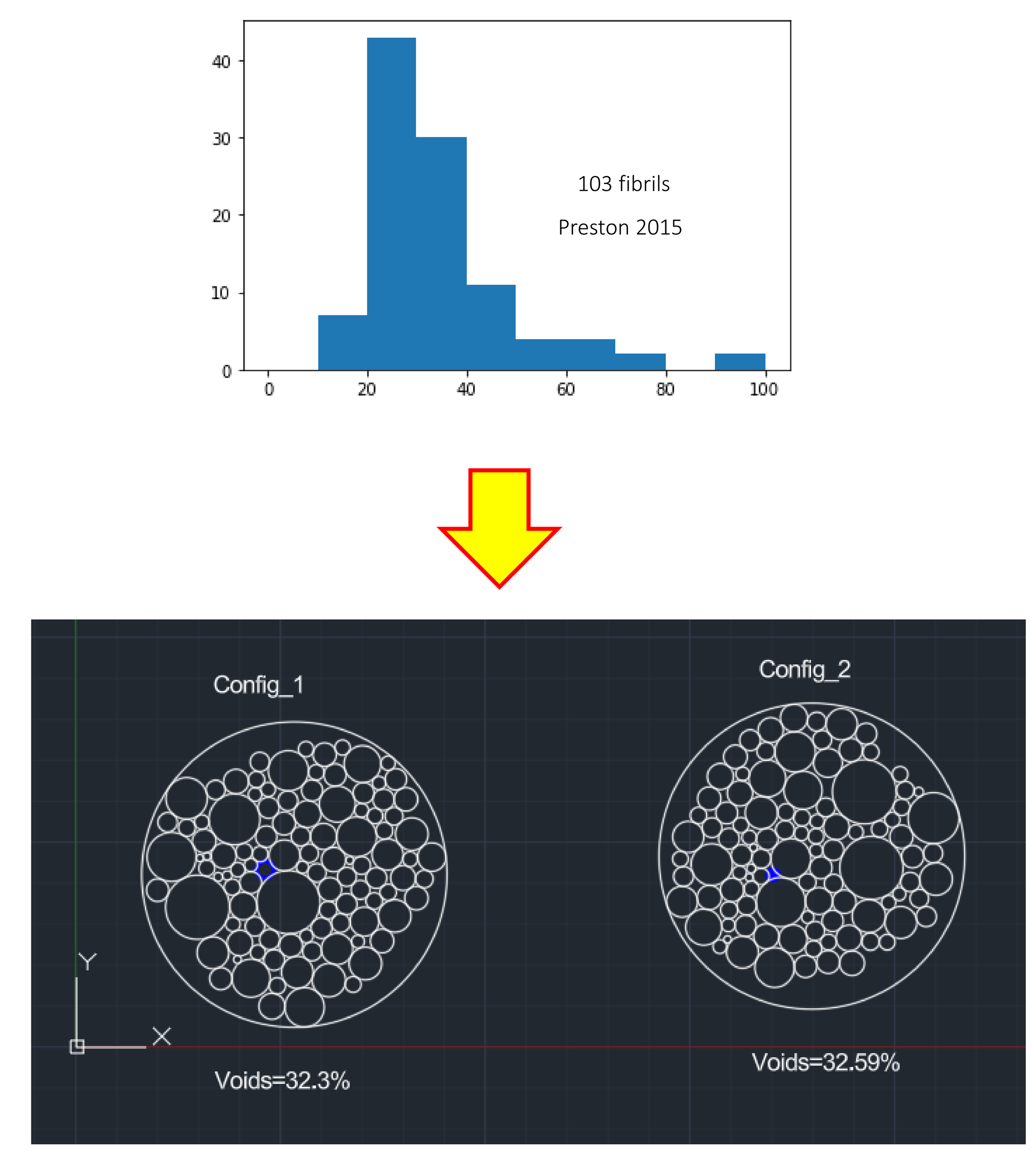


Figure (5) Stochastic 103 fibrils data and configurations.

- To reduce computational time, the Monte Carlo procedure was used to reduce the number of statistically representative fibril data from 103 to 50, 25, and 15. Due to void content convergence, the 25 fibrils were the smallest possible configurations.

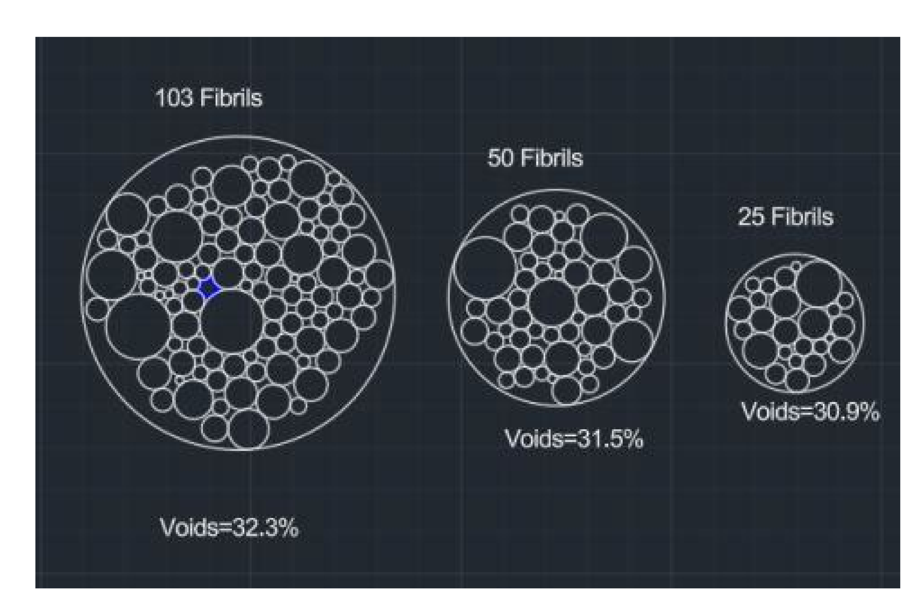


Figure (6) Monte Carlo procedure for 103, 50, and 25 fibrils data.

Modeling the 25 stochastic fibrils distributions.

- An Embedded Self-Consistent Modeling Approach was used to develop the boundary conditions.

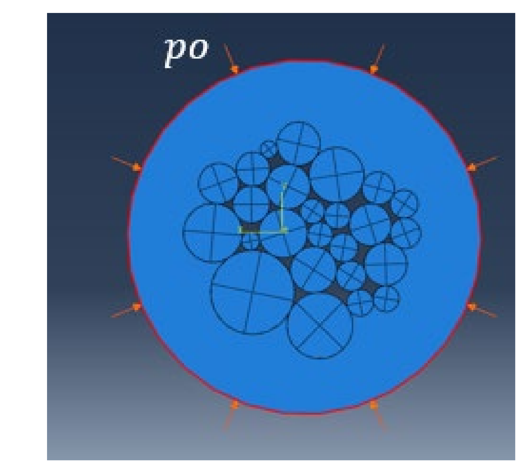
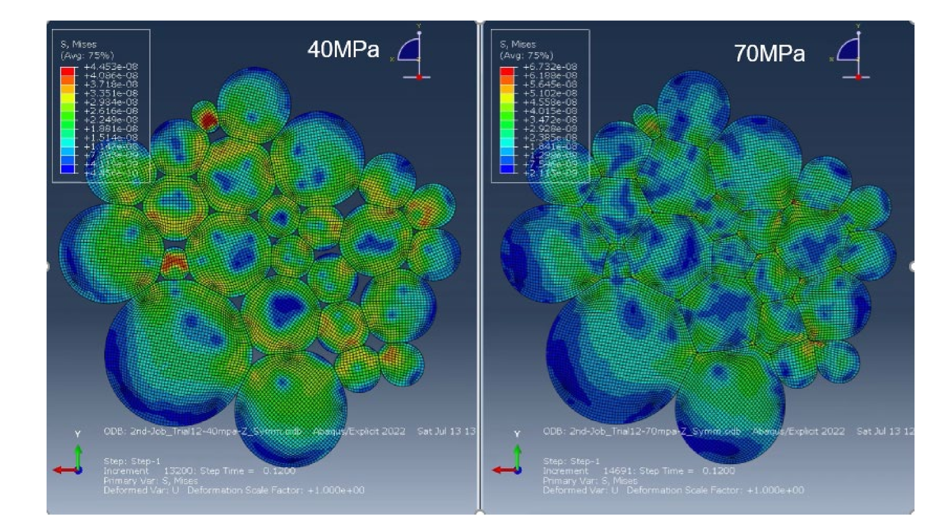


Figure (7) Stochastic 25 fibrils modeling.

- The model results for 40 and 70 MPa as in Figure (8).



Scan for the video

Figure (8) Stochastic 25 fibrils modeling results for 40 and 70 MPa consolidation pressure.

Key Accomplishments

- Develop a scheme for the random fibrils' distributions that are identical to the experimental observations.
- Understanding the relationship between the fibril's distributions, statistical data, and the initial void contents.
- This effort is useful for studying the effect of other consolidation parameters, such as temperature or time.

Acknowledgments

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