Modeling of Structure of Composite Material with Fiber Components

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Abstract – **Main approaches were developed to create the geometric fiber model for further use in research of composite materials.**

Keywords –**Structure modeling, composite materials, fiber components.**

I. INTRODUCTION

In the recent years new composite materials with unique physical and chemical characteristics have been synthesized. They differ according to the reinforcing member shape: a) multilayered; b) fibered; c) with spheroid inclusions. Composite material fibers can be continuous of discontinuous, rectilinear or curvilinear; they can be located chaotically or in order. Therefore, in order to model composite materials of research their physical and chemical properties it is essential to develop a tool that enables to present the geometrical fiber structure that would take into consideration the location type, structure concentration and anisotropy.

II. FIBER COMPONENT VISUALISATION

Experiments that involve analytical, numeric and analytical numeric methods are of great importance. [1, 2]. The automated composite material modeling system TERMET is designed to distribute the temperature filed in non-homogenous materials with consideration of their thermophysical characteristics, especially thermal conductivity quotient, specific heat-sink capacity and density. [3]. The system considers three interpretation types for composite materials: a) multilayered structures; b) environment chaotically filled with spheroid inclusions; c) environment filled chaotically or directionally with rectilinear or curvilinear fibers.

The research studies the problems of 3-D visualization and fiber components modeling. As fiber components are anisotropic, it is not possible to use two dimensions only when modeling them. Bezier curves are used to present the fibers in the model. Depending on the fiber size, one or two curve sequences are used with tangents preserved. Separate fibers are united into arrays. At the visualization stage each fiber is a cylinder along a curve. As the fibers are not only of rectilinear shape, it is important to consider the fiber curve. Two approaches are used to do that. The fiber curve is broken into a certain number of rectilinear consequent segments that approximate the curve shape. The discretization can be with stable step length or adaptive, i.e. for more curved parts discretization will be greater that for relatively straight parts. The other approach enables to better simulate real with using the least possible number of discretization points. Additional discretization of curve distortion is added to to accumulation of distorted curve upon excess of certain distortion limit, a point or points of discretization are to be added. Discretization decrease in relatively straight parts happens due to discretization does not take place until a minimal angle required for discretization is accumulated.

The structure of approximating net is performed with the method of parallel shots [4] in two steps. Step one – position generation, tangents and normals generation. We need the first control dot of the curve. Tangent and accidental normal for the tangent are calculated. The position, the tangent and the normal are stored in an array. We move on to the next dot of curve discretization. The dot position is located as well as the curve tangent in this dot. Then the smallest angle (Q) is calculated to find out how it is necessary to turn the tangent in the previous dot in order for it to coincide with the tangent in the present point. The angle is the distortion for the current curve part. The perpendicular (P_{tan}) for both tangents is calculated. Around the perpendicular we turn the normal of the previous dot (N_{prv}), in order to form a new normal that corresponds to the current dot (N_{cur}). In order to perform the trn of the normal N_{prv} we create a turn matrix around the perpendicular P_{tan} at Q angle. After calculating N_{cur}, the new position, tangent and normal are added to the buffer. Such actions are performed consequently for each dot along the curve, the results are calculated and store. If fiber consists of several curves, then we only consider an accidental normal for a tangent is only for the beginning of the first curve, whereas for the consequent ones we use the normal of the last discretization of the previous curves.

The second step of building an approximating net is generation of triangles for reflection. We need to generate an apex (positions consequence) and indexes (threes of indexes for elements of the apex buffers for the apexes that form the triangles). For each dot we need to calculate a ring of apexes with a radius that corresponds to the radius of the fiber, to the normal directed along the tangent and with the center in the discretization dot position. To achieve that, we build the turning matrix around the tangent dot with a certain angle (depending on

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the necessary detalization). We make the first dot of the ring through multiplying the normal with the fiber radius. Then we have a cycle of multiplying the ring dot and the created turn matrix until the dot passes 360° and coincides with the first one. We store every intermediate dot that we create and add to it the position of current discretization dot. We do it for each discretization dot we created during step 1.

Then we form an array of indices. For the side surface of each two dots of one ring and the next one we form two triangles with communal apex in the centre or at the end of the curve, while other apexes we have in the first or last apex ring.

We calculate the normals for the generated triangles. For all apexes we use such normals and discretization dots that form current apexes (that we use for the fiber ends).

Image visualization of the given models is performed with Open GL language [5]. The language is oriented at achieving maximal quality of visualization. The visualization takes into consideration simple dot light, the intensity of which depends on the angle between the normal and the angle of light hitting the surface.

The model we achieved can be used for composite material analysis.

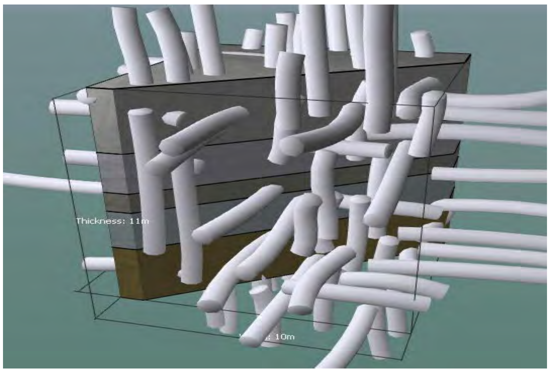

Fig.1. Model visualization result.

III. Conclusion

We performed the modeling of a structure of a composite materials with fiber components. The model we developed takes into account geometric size of the fibers, their location (chaotic or in order), concentration and anisotropy. Further we build a discrete model of the structure in order to analyze it with finite elements method. The model is developed in order to be used in the automated system for composite materials modeling TERMET. It can also be used in other analysis systems for materials physical and chemical properties analysis. The approach we designed is universal. The fiber components can easily be turned into rectilinear, tubular or spherical.

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