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FIELD DISTRIBUTION ANALYSIS OF OPTICAL FIBER USING LINEAR FINITE ELEMENT METHOD

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ABSTRACT

Propagation properties, Field Distribution, and its dependency on manufacturing parameters must be understood in order to optimise optical waveguide performance. The necessity for computer analysis grows and gets more challenging as the variety of guiding structures and the dependent factors become more complex. Therefore, theoretical approaches to waveguide analysis are of tremendous importance. The waveguide problems are elaborately and in-depthly analysed in all dimensions using the Finite Element Method (FEM). An approach for calculating an optical fiber's propagation modes is presented in this study. Maxwell's equation is reduced by finite element method analysis to a common eigen value equation requiring symmetric tri-diagonal matrices.

Keywords: FEM; Eigen value; Eigen vector; Field distribution;

1. INTRODUCTION

Numerous academics have become interested in a technique that uses Finite Element Aanalysis for examine the propagation properties of Circular-Waveguides with adjustable Refractive Index profiles. Maxwell's equation is reduced by the finite element approach to a common eigen value equation requiring symmetric tri-diagonal matrices. To determine the waveform, propagation constant, and delay per unit length of the modes, routine figureout their eigenvalue and eigenvector. An approach develops into a potent tool for engineers [9]. Typically, optical fibre functions as a dielectric waveguide at optical Frequencies. which limits light-based EM energy. Light is guided by an optical cable in the direction analogous to its axis.

2. TYPES OF ANALYSIS-

Analysis for optical waveguide (Fiber) is divided into two types.
i) Analytical method
ii) Numerical method

i) Analytical Method

This method provides the analysis's precise solution. This approach uses Maxwell's equations to derive the scalar wave equation. The Maxwell's equation can be used to resolve the mode field distribution in optical fibre. Even though the method provides an accurate result, it is more complex than a numerical approach.

ii) Numerical Method

Second technique used for the analysis is the numerical method. In this method, analysis is the finite element method. Numerous academics have recently become interested in a technique that uses Finite Element to examine the propagation properties of Circular waveguides with adjustable Refractive Index profiles. Maxwell's equation is reduced by the finite element approach to a common eigen value equation requiring symmetric tri-diagonal matrices.

An numerical methodology for solving a Integral or differential or integrodiffenetial problems is the finite element method (FEM). Where the governing differential equations are accessible, it has been use to solve number of physical issues. This method basically entails assuming the piecewise continuous function for the answer and locating the parameter of the function in a way that minimises answer mistake. An overview of the finite element approach is given in this article. The equation for plane stress and plane strain is used to explain the procedure.

3. BRIEF HISTORY AND DESCRIPTION OF FEM-

In 1960, Clough was the first to use the term "finite element." For approximative solutions to issues in stress analysis, fluid flow, heat transfer, and other fields in the early 1960s, engineers adopted the approach. In 1967, Zienkiewicz and Chung released their first book on the FEM. A wide range of engineering issues were addressed using the FEM in the late 1960s and early 1970s.

FEM divides a structure into its constituent parts, or "elements," and then rejoins them at "nodes" as if the nodes were pins or droplets of glue holding the elements together. A group of algebraic equations are created as a result of this operation. Maxwell's equation is reduced by finite element technique analysis to a common Eigen value equation requiring symmetric tridiagonal matrices. The approach is practical and affordable. Both single-mode and multimode fibres can use it.

An integral or differential equation can be solved numerically using the finite element method (FEM). It is used to solve variety of issues where underlying Differential equation is known. For a linear differential equation, use FEM. The following is an example of a linear differential equation:

$$Lu + q = 0 \qquad \text{--(1)}$$

Where L - differential operator, q - vector of known function, and u is the problem's principal variable vector, which is a collection of coordinate-based variables. Boundary conditions, which typically come in two varieties, will be applied to this differential equation.

(i) The necessary Boundary condition - Necessary boundary condition is a group of boundary condition which is sufficient to fully solve the differential equation.

1) The natural boundary conditions- This boundary condition is that involve higher order derivative terms and are not enough to completely solve the differential equations; at least one necessary boundary condition is needed.

Consider the differential equation:

$$\frac{\mathrm{d}}{\mathrm{d}x}\left(EA\frac{\mathrm{d}u}{\mathrm{d}x}\right)+q=0 \qquad \text{-- (2)}$$

One of the following two circumstances will result in a complete solution to this issue:

At both ends, (i) u is prescribed.

(ii) At one end, u is prescribed, and either the same end or the other end is where du/dx is prescribed.

Only prescribing du/dx at both ends, however, will not address the issue. We therefore need a boundary condition that specifies u. Since * denotes the prescribed value, du/dx=(du/dx)* is a natural boundary condition for this problem, and u= u* is an essential boundary condition.

Finally, think about the differential equation:

$$\frac{d^2}{dx^2}\left(EI\frac{d^2w}{dx^2}\right)-q=0 \qquad \text{-- (3)}$$

4. ALALYTICAL METHOD USED FOR THE ANALYSIS

The precise solution is provided by the analytical method employed for the mode field distribution study. Scalar wave equation is created by analytically reducing Maxwell's equation. We can get varied field and contour distributions for modes like LP 01, LP 11, LP 21, and LP 31 by varying the values of core radius (a).

5. RESULTS

Analytical approach is used to examine the mode field distribution for the following modes. Below is a picture of the mode field distribution plot and its contour map.

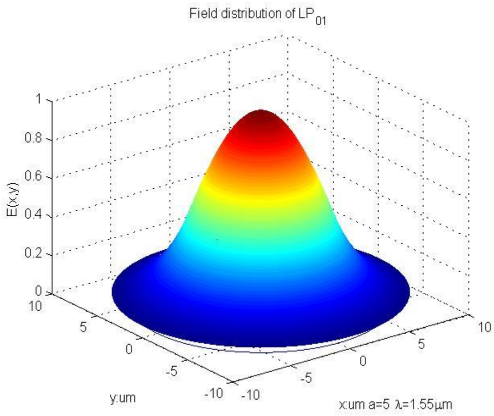

Fig. 4.1 Mode for LP- 01 Mode

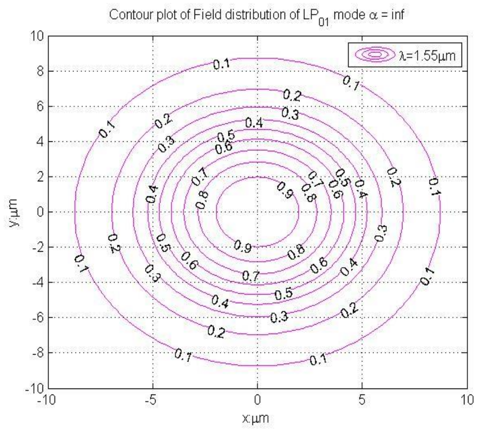

Fig. 4.2 Contour plot for LP-01 mode

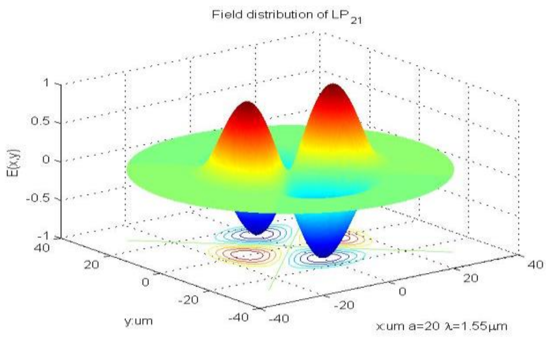

Fig.4.3. Mode For LP 21 Mode

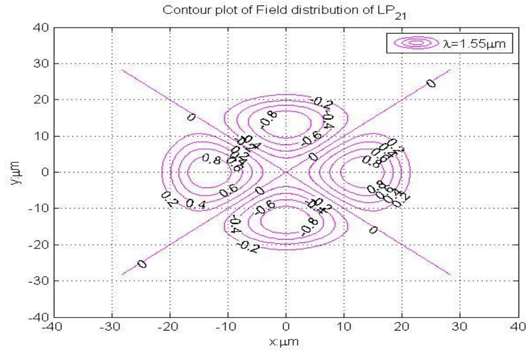

Fig.4.4 Contour plot for LP 21 mode

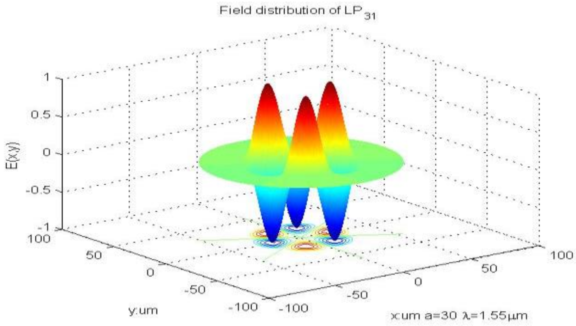

Fig. 4.5 Mode For LP 31 Mode

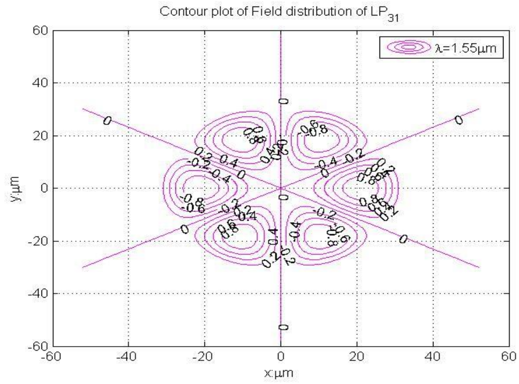

Fig.4.6 Contour plot for LP 31 mode

6. CONCLUSION

The precise solution is provided by the analytical method employed for the mode field distribution study. Scalar wave equation is created by analytically reducing Maxwell's equation. We can get varied field and contour distributions for modes like LP 01, LP 11 and LP 31 by varying the values of core radius (a). The modal quantities of an optical fibre are examined using the finite element technique (FEM). The conventional Eigen value equation is created from the Maxwell's equation using FEM analysis. The scalar wave equation has an approximation provided by the FEM. When switching from linear to quadratic FEM and adding more elements, accuracy improves. The complex and thorough study of waveguide problems in all dimensions is provided by the Finite Element Method (FEM).

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