January - February 2020
ISSN: 0193 - 4120 Page No. 4766 - 4769

Optimization and Analysis of Micro needle

Dr. S. Sunithamani, D. Guru Prasad Reddy, G. Tarunkumarreddy, K. Reshma
Department of ECE,KoneruLakshmaiah Education Foundation (Deemed to be University),
Green Fields, Vaddeswaram, Guntur, A.P- 522502, India.

Article Info
Volume 82
Page Number: 4766 - 4769
Publication Issue:
January-February 2020

Article History
***Article Received**: 18 May 2019*
***Revised**: 14 July 2019*
***Accepted**: 22 December 2019*
***Publication**: 23 January 2020*

Abstract:
The principle that involves the disruption of skin with microneedle is that it creates a path of micron size which is used to deliver the drug directly into the epidermis or the upper layer of dermis without any interrupt. Though it overcome the problems of hypodermic needle it has some limitations. Many researches done on the microneedle and increased the length of the needle to deliver the drug more deeper into the skin, but it results in the buckling and stress which may cause damage to the cells or tissues. So it is very important to consider the geometrical parameters like length, diameter and material property of the microneedle to overcome those limitations of mechanical stability of the needle and efficient drug delivery. This review guides you to know about the various microneedle with different parameters and different materials(PMMA,Silicon) and their results of stress which helps in choosing the better microneedle for delivering the drug without any damages of tissues and effective delivery.

Keywords:*Drug delivery, Micro needle, Transdermal.*

I. INTRODUCTION

The most used technique for delivering the drug into the skin is Hypodermic needle drug delivery. Skin mainly consists of 3 layers the outermost layer stratum corneum and the middle layer epidermis and the outermost one dermis. The main problem related to hypodermic needle drug delivery is that the required amount of drug is not able to enter into the body for therapeutic action. Stratum corneum acts as a barrier that allows the drug which has less molecular weight only. To overcome those limitations various researchers have studied microneedle transdermal drugs for delivering drugs. The delivery of drugs using microneedle allows more amount of drug molecules into the skin for necessary therapeutic action.

Theoretical Frame work:

Microneedle structures are exposed to 3 major types of loading when embedded into the body, namely bending, axial and buckling. Therefore in a view of all these types of loadings, it is important to accommodate structural safety considerations to develop a hearty microneedle. Axial and bending loading requirements are defined by maximum deflection in the structure as well as total tension under them(usually von Misses stress). A component called a critical load factor is determined to determine the structure's strength under buckling. Also, this parameter is the proportion of the given applied load to a critical load, above where the microneedle will experience instability.

$$\lambda = \frac{P_{critical}}{P_{applied}}$$

The development of microneedle geometry and material is important to maximize the critical load factor for a given load applied. Critical Euler's load buckling(P critical) is also defined as :

$$P_{critical} = \frac{\pi^2 EI}{(KL)^2}$$

Where E is the Modulus of elasticity, I is the minimum area moment of inertia of the cross-section

January - February 2020
ISSN: 0193 - 4120 Page No. 4766 - 4769

of microneedle structure, L is the unsupported length of the column, and K is the column effective length factor depending upon the boundary conditions.

Simulation approach:

In this paper, the COMSOL Multiphysics version 5.3 dynamics module is used to perform the above-mentioned analysis. The new microneedle is considered as solid, made with PMMA (Polymethyl methacrylate) material properties which are imported from the system Material Library.

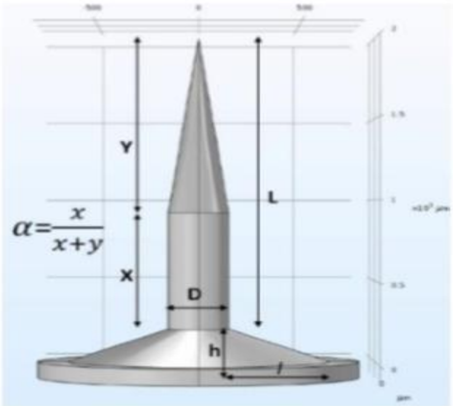

Figure 1: Illustration of the design parameters considered in this study

Microneedle parameters include the total length (L), diameter(D), flange base diameter(l), base height(h), and also the ratio of cylindrical to conical section of the needle is noted as alpha.

Table 1: Parameters of microneedle

Parameters

Name	Expression	Value	Description
ALPHA	0.1	0.1	um
D	150	150	um
l	100	100	um
H1	200	200	um
L	1000	1000	um

Absolute length of the microneedle changes between 1000 um to 2500 um to be long enough to arrive at the dermis layer. This is significant for the transdermal conveyance of macromolecules, for example, the conveyance of antibodies utilizing microneedles. The greatest weight of 3.18MPa is applied to the needle tip to direct hub stacking to the infiltration compel required to puncture the skin, while the base is completely obliged.

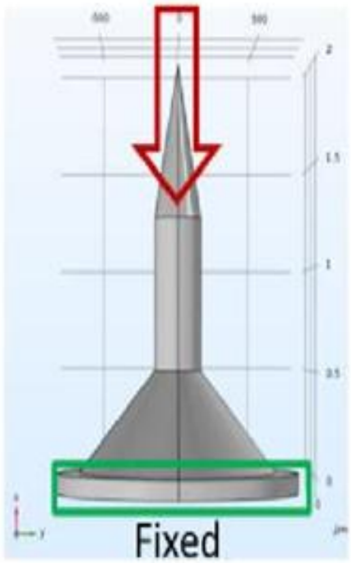

Figure 2:Indicates the structure and pressure direction on micro needle(axial loading)

EIGEN FREQUENCY ANALYSIS:

In this paper Eigen frequency analysis is performed to identify the stress variations in the material. Eigen Frequencies are the discrete frequencies at which the system is subjected to vibrate. When a structure vibrates at certain Eigen Frequencies the structure changes into a corresponding shape of the Eigen mode. The true size of deformation can be determined only when an actual excitation is known together with damping properties.

Eigen frequency analysis:

Ensure that periodic excitation does not result in resonance that may result in excessive stress or noise emission. Provide knowledge into how configuration changes can influence a specific Eigen frequency by contemplating its mode shape.Stress variations for different Eigen frequencies:

January - February 2020
ISSN: 0193 - 4120 Page No. 4766 - 4769

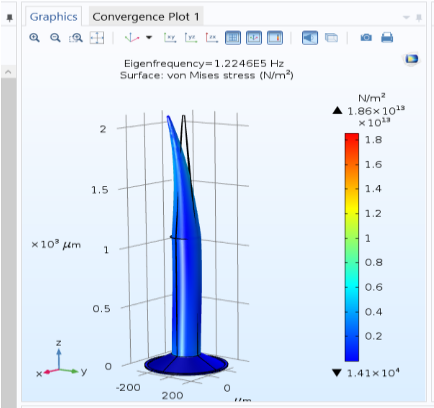

Figure 3: Stress variation of needle obtained when Eigen frequency =1.2246*10^5 Hz.

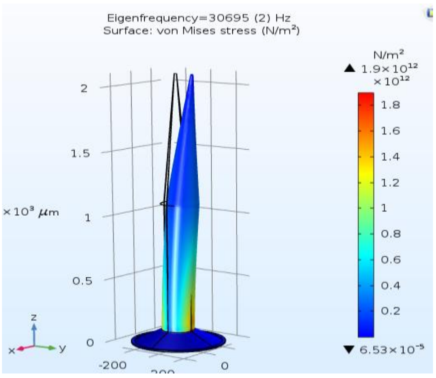

Figure 4: Stress variation of needle obtained when Eigen frequency =30695 Hz.

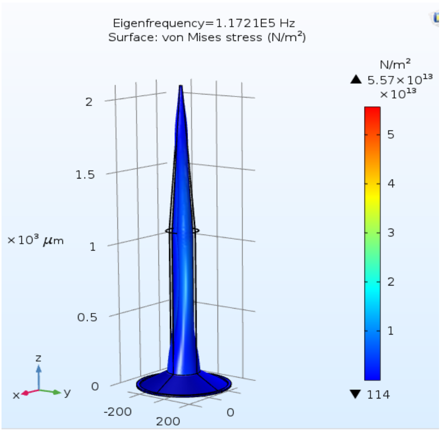

Figure 5: Stress variation of needle obtained when Eigen frequency =1.1721*10^5 Hz.

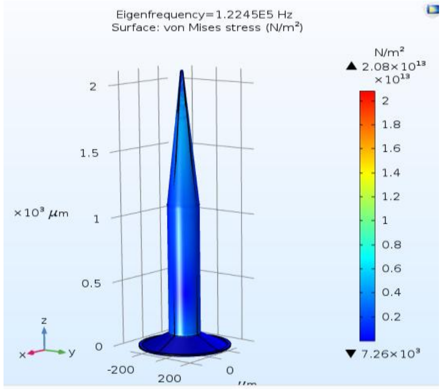

Figure 6: Stress variation of needle obtained when Eigen frequency =1.2245*10^5 Hz.

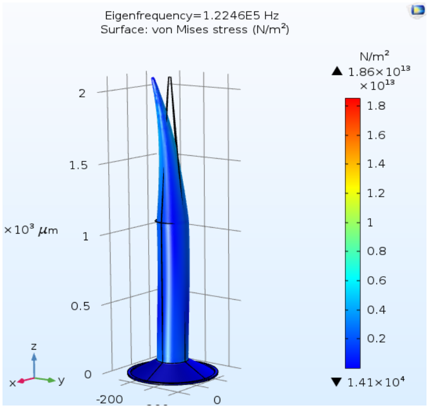

Figure 7: Stress variation of needle obtained when Eigen frequency =1.2246*10^5 Hz.

In this study five different structures are designed with different alpha parameters and materials. The table shows the complete analysis of stress for different alpha and diameter.

Table 2:Stress values obtained for differentparameters and different materials of micro needle.

Graphical representation:

Diameter VS Stress

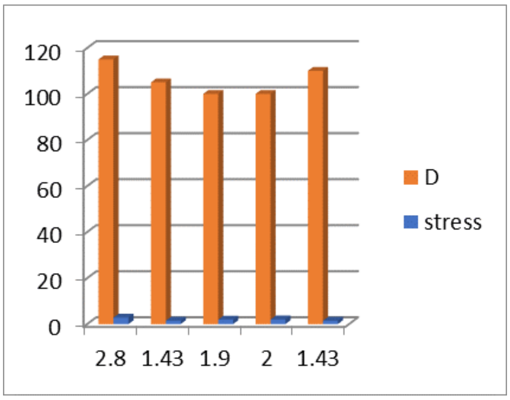

Figure 8:Graphical representation of stress obtained for different diameters of micro needle.

TEST Engineering & Management
January - February 2020
ISSN: 0193 - 4120 Page No. 4766 - 4769

Length VS Stress

structure	Material used	Length (L)	Diameter (D)	stress
1	PMMA	1700	115	2.8*140^12N/m2
2	silicon	1900	105	1.43*10^13N/m2
3	Structural steel	2000	100	1.9*10^12N/m2
4	silicon	2100	100	2*10^12N/m2
5	PMMA	2500	110	1.43*10^12N/m2

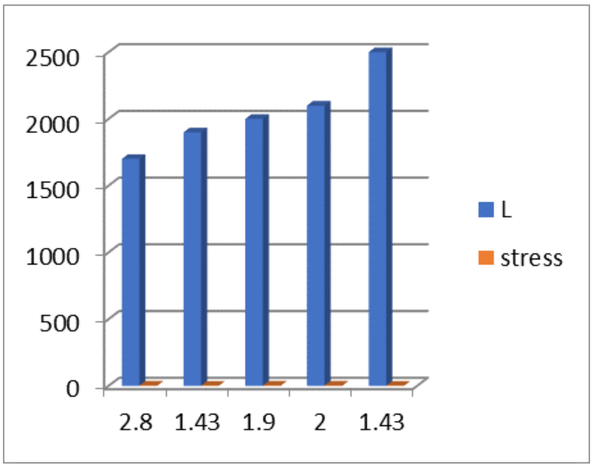

Figure 9:Graphical representation of stress obtained for different lengths of micro needle.

CONCLUSION:

The first microneedle was comprised of silicon. A study was directed to investigate if microneedle can be utilized to convey sedates through the skin more effectively or not. A legitimate material must be chosen in the manufacture of these needles, which has sufficient mechanical quality and inclusion power. The fundamental target of this examination is microneedles that can be created with an assortment of alterations to shrewdly convey the medication through the skin giving another heading and unrest in the field of transdermal medication conveyance frameworks to expand the saturation without causing pain.

ACKNOWLEDGMENT

Authors wish to thank Dr.KSrinivasaRao,Head of MEMS design centre, ECE dept., KLEF for providing COMSOL Multiphysics software for academic use and for its help and support.

REFERENCES

[1].M.Sarmadi, K. McHugh2, R. Langer1, A.Jaklenec “Multi-objective Optimization of Microneedle Design for Transdermal Drug Delivery”

[2] Shojaeefard, Mohammad Hassan, AbolfazlKhalkhali, MortezaSarmadi, and NaqiHamzehi. "Investigation on the optimal simplified model of BIW structure using FEM."Latin American Journal of Solids and Structures 12, no. 10, 1972-1990 (2015).

[3] Firouz-Abadi, R. D., H. Moshrefzadeh-Sany, H. Mohammadkhani, and M. Sarmadi. "A modified molecular structural mechanics model for the buckling analysis of single layer graphenesheet."Solid State Communications 225, 12-16 (2016).

[4]Jayavardhani K., NoureenFathima S.K., BhimaSankar K., Kavya Sri K., Sunithamani S. .," Design and simulation of low actuation voltage RF MEMS shunt capacitive switch with serpentine flexures & rectangular perforations “, 2018, International Journal of Engineering and Technology(UAE) ,Vol: 7 ,Issue: 1.5 ,pp: 237 to:: 244 .

[5] Vikas K., Sunithamani S., Yagnika M., Siva Krishna S., Avanthi S. .," Study and analysis of novel RF MEMS switched capacitor “, 2018, International Journal of Engineering and Technology(UAE) ,Vol: 7 ,Issue: 1.5 ,pp: 37 to:: 41.

[6]Shameem S., Prasad G.R.K., Kalyan G., Sri varun H., Babu P.S.S. .," Design and analysis of MEMS based capacitive pressure sensor for the detection of colon cancer “, 2018, Journal of Advanced Research in Dynamical and Control Systems ,Vol: 10 ,Issue: 2 ,pp: 1434 to:: 1438.

[7]Kumar M.S., Rao K., Tulasi S.K., Prasad G., Kishore K.H. .," Cantillever based MEMS pressure sensor “, 2018, International Journal of Pharmaceutical Research ,Vol: 10 ,Issue: 4 ,pp: 74 to:: 79.