Alexandria Engineering Journal (2016) 55, 983–989

HOSTED BY

Alexandria University

Alexandria Engineering Journal

www.elsevier.com/locate/aej
www.sciencedirect.com

ORIGINAL ARTICLE

The Application of Gorman's Eigen Values to The Industrial Sewing Machine's Needle Vibration

S.H. El Gholmy *, I.A. El Hawary

Textile Engineer Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt

Received 19 March 2015; revised 17 February 2016; accepted 20 February 2016
Available online 11 April 2016

KEYWORDS

Free vibration;
Sewing needle design;
Working speed of sewing needle

Abstract The free vibration of the sewing needle is divided into lateral free vibrations and an axial free vibration. In this work a theoretical study that concerns the free lateral vibrations will be applied to the sewing needle by the use of Gorman's Eigen values (Daniel, 1975) technique. The study will be divided into the following: needles with constant cross-section (with classical and non classical boundary conditions) and needles with variable cross-section (conical and stepped). For all the different shapes of needles (Gorman's classifications) the linear natural frequency in stitches per min (SPM) will be calculated by the use of Gorman's Eigen values via special tables and graphs. It was found that the linear fundamental natural frequencies of the following: clamped free sewing needle (CF) is 21,548 SMP, clamped simple sewing needle (CS) is 94,522 SMP while for free–free needle (FF) for $n = 2$ is 137,130 SMP. For each type the Eigen value β was selected due to the sewing needle boundary conditions. The ratio between the lowest (CF) linear natural frequency and the highest (FF) one is 16%. In this work the selected sewing needle material was steel with $E = 206$ GPa and specific weight 785,000 N/m^3.

1. Introduction

Panovko [7] in his work has stated that it is difficult to indicate a domain of Engineering in which the study of elastic vibrations would not be urgent problem. Much attention is given by investigators to vibrations of structures of widely differing purposes: turbine rotors, aircraft, turbine blades, etc. Nowadays the garments and apparel industry are considered vital Engineering areas that require an emphasizing on its mechanical – machines – side such as the industrial sewing machines that have an important element i.e. the sewing needle where, it is a metallic bar from steel with a special configuration and structure. It is the highly accelerated part in the sewing machine where it has max allowable speed = 15 k SPM. The sewing needles have been subjected to too little studies that concern its vibration free, forced, modes, etc., to calculate the working speed of sewing needle. It is necessary to study its free vibration frequencies; in certain cases the vibrations impede the normal service or even directly endanger the strength by gradually promoting fatigue failure. In such cases the theory may indicate ways of reducing detrimental vibrations [7]. It is expected the security quality of the sewn fabric could be deteriorated as a result of the sewing needle vibrations [9]. The free vibrations mean the mechanical vibrations which are performed by a mechanical system (as sewing

* Corresponding author.
E-mail address: Sh_gholmy@yahoo.com (S.H. El Gholmy).
Peer review under responsibility of Faculty of Engineering, Alexandria University.

http://dx.doi.org/10.1016/j.aej.2016.02.028
1110-0168

needle) having no energy supply from outside but they take place when the system is disturbed from its position of equilibrium and then suddenly released [7]. Gorman [3] has written that there are two commonly analyzed methods for having solution to the problem of free vibrations of bars (needles) and beams. The method, most frequently used was to solve the bar–beam-differential equations that express equilibrium between inertia forces and elastic restoring force, subject to prescribed boundary conditions. The second method is an energy method which consists essentially of utilizing the fact that in free vibration the sum of the beam-sewing needle-potential energy and the kinetic energy is constant. The Gorman method is highly applied in our work. Feodosev [2] has stated that the theory of vibrations is of special importance for applied problems: encountered in Engineering practice, among others in the designs of the machine – industrial sewing machines and structures.

There have been cases when an engineering structure designed for a large of safety to withstand static loading failed under the action of very small (relatively) small periodically acting force. In many cases stiff and very strong structures have proved unserviceable in the presence of varying forces whereas a similar lighter structure and not so strong at first glance – industrial sewing machines – sustain the same forces absolutely safely.

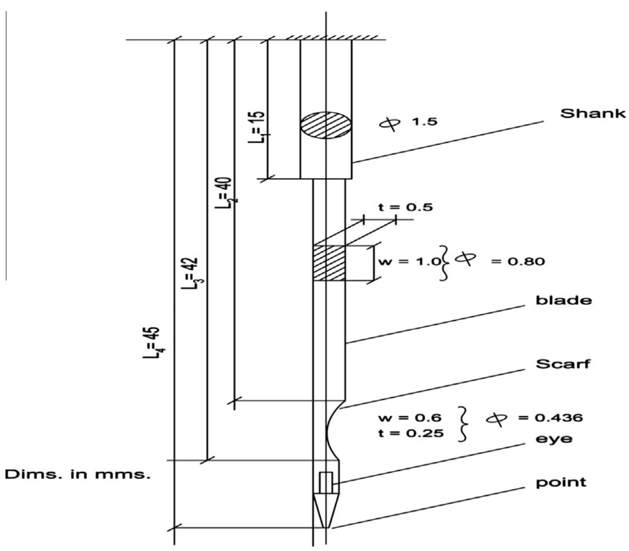

Figure 1 Industrial sewing machine needle.

Varvak [8] has claimed that the special cases of the mechanical elastic system with single and multiple degrees of freedom could be tabulated for practical applications where the table has 3 columns: scheme of the mechanical system, degree of freedom and finally the natural frequency column. The table includes about 52 schemes of vibratory mechanical system.

Belyaev [1] has studied some important topics in the field of vibrations of the mechanical systems as the effect of the vibration resonance on the value of the stress in the machine elements – sewing needle – during the vibration process. In addition the calculation of the equivalent mass of the vibratory system has been carried out where for example sewing needle – as a cantilever beam the equivalent mass is $FL\nu/3g$ [ν – needle's material specific gravity, L – length of the sewing needle and g – gravitational acceleration and F – cross-sectional area].

Panamarev [6] has studied extensively the vibrations of the coil spring as longitudinal (axial) or lateral (transverse) under different boundaries conditions. Also the axial vibration of turbine blades was evaluated by the way all the studies of Panamarev [6] were shifted to the Engineering practical applications and could be efficiently used in the industrial sewing machines as a point of our view [4].

2. Mathematical approach

The actual configuration of the sewing needle [9] is shown in Fig. 1. The first part of the Mathematical Approach will be devoted to the needles with constant cross sections and with classical and non-classical boundaries.

2.1. Sewing needles with circular constant cross section and with classical boundary conditions

The calculation Scheme [line diagram] is shown in Fig. 2a.

The mean value of the needle diameter is calculated by the use of the weighted inertia of cross sections I_i where $i = 1, 2, 3$ and 4

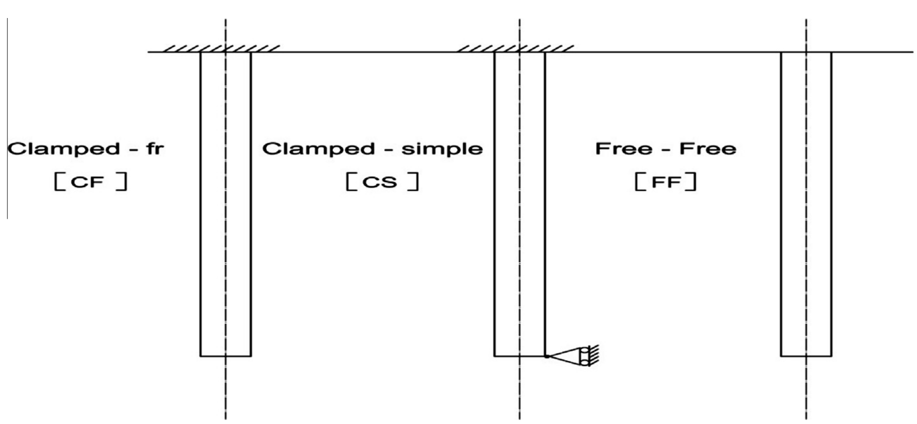

Figure 2a Sewing needles with classical boundary conditions and with constant cross sections.