ASPECTS REGARDING THE DESIGN OF THE PORTABLE MOWING MACHINES, USING THE FINITE ELEMENTS METHOD

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Abstract. The vibrations produced in the operating state of portable mowing machines have notable effects on the human organism, and has to be reduced as much as possible, starting from the design stage. The papers proposes a modelling method with elements finite (using I-DEAS SDRC software), which allow the topological optimization of these equipments. The model calculates the first four resonance frequency, the shape of the tool in these duty points, as requirements elements for settlement of the nominal working stage. In the last part of the paper, it is considered a case of impact between a hard body and the cut-off device, studying also the behaviours of the elastic structure and its impact on human body.

Keywords: Vibrations, portable mowing machines, finite element

1. Introduction

General reasons regarding the stress produced by vibration with local action transmitted through the system hand-arm by the portable mowing machines.

A special attention is according now (on research level, applied and legislative level) work conditions specific to the new technique and technologies, professional stress and health issues associates with work processes.

Human being is a bio-psychosocial entity, no matter of nature and action way of an external factor, negative, aggressive of benefice, the human, his organism react like a unitary at the whole acting levels: physical, physiological, neuroendocrine, psychological, social behaviour.

Scientific investigations address first to ergonomically, psychology and work hygiene aspects, these results being base for special programs for actions realized by some international organism committee (International Office of Work, National Organization of Health), national committee and restricted interest (region, departmental, by factory).

The stress supported by human operator in an environment obedient to vibrations is limited by the maximum level accepted of vibrations, level specified by „Work protections norms foresaw by specific order, norms belong to Work and Social Protection Minister".

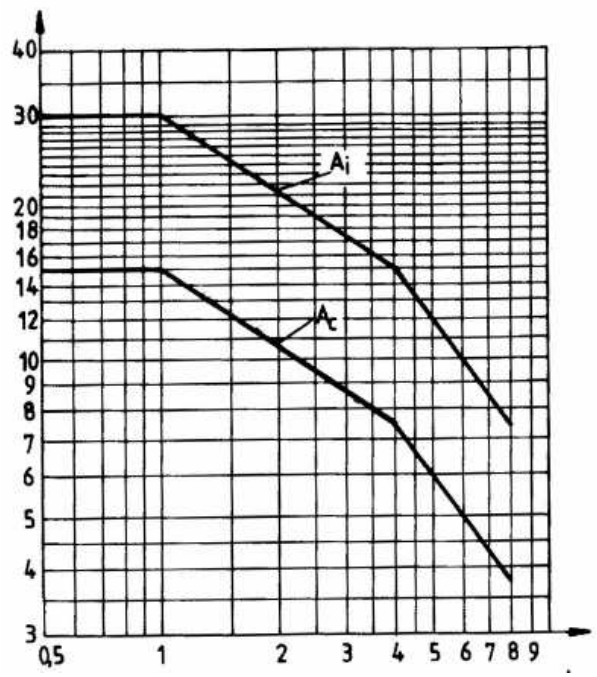
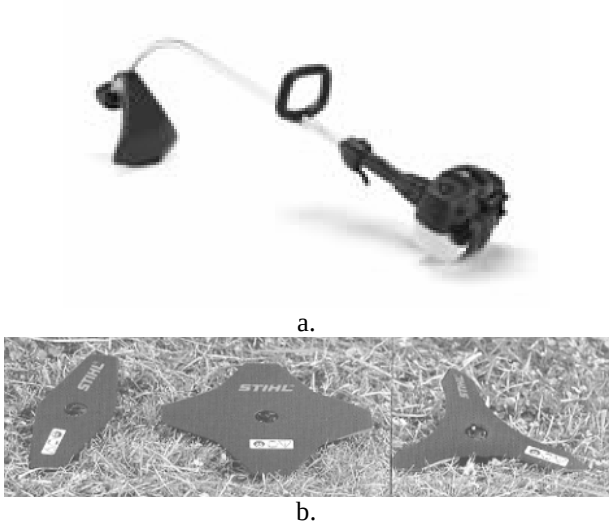


Figure 1. Maximum admitted limits for equivalent acceleration produced by vibration with local action

In the same norms are showed too (figure 1) the maximum admitted limits for equivalent acceleration depending on time (h) produced by vibration with local action trough the hand-arm system (At-for long time exposure; Ai-for intermittent exposure), specific by portable mowing machines work. [1]

2. The portable mowing machines modelling using finite elements method

From constructive point of view, the portable mowing machines present a large variety of forms, which have to assure the ergonomic mode and the functionality during the work period (figure. 2).

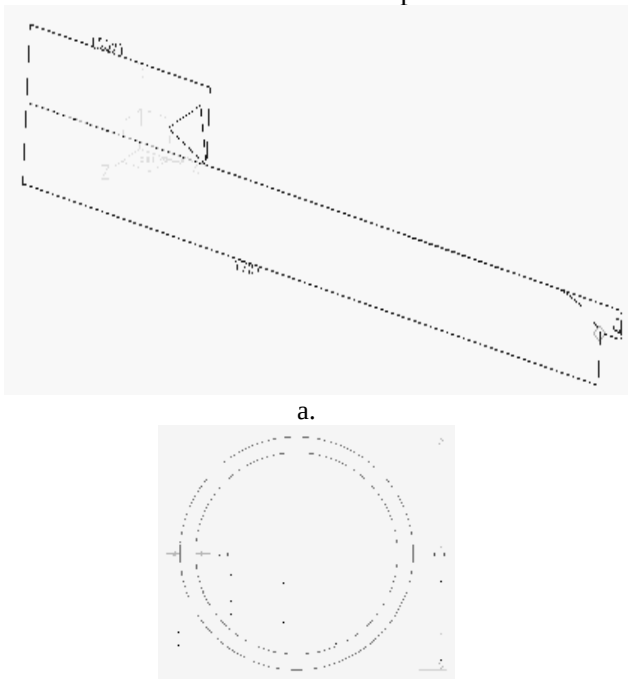


a.

b.

Figure 2. Constructive option of portable mowing equipment (a) and of cutting device (b)

Engine and cutting devices emplacement can be different, but, in all variants the elastic structure induces vibrations in the human operator arm.



a.

b.

Figure 3.Geomertical model of the mowing machine STHK FS 38
a.- sustaining frame dimensions; b.- transversal sections dimensions (D = 30 mm; d = 26 mm)

The vibrations are generated by engine working and by the impact of the cutting device and the cut-off material. A special case is the variant which the mowing machine is fitting-out with a blade or knife cutting device and when this hit a hard body it are producing vibrations which are conveying in the whole elastic structure. Conveying transitory mode analysis of these vibrations is essentially for function security and safety of human operator. The sustain points emplacement, overall size of mowing machine, transversal section geometry influence the vibration level felled of the worker arm. Using the finite elements modelling for such a structure is possible, still from the design phase, the level of equivalent acceleration felled evaluation. At the same time is calculating the own structure vibration mode and is possible to establish a functional mode outside of resonance field.

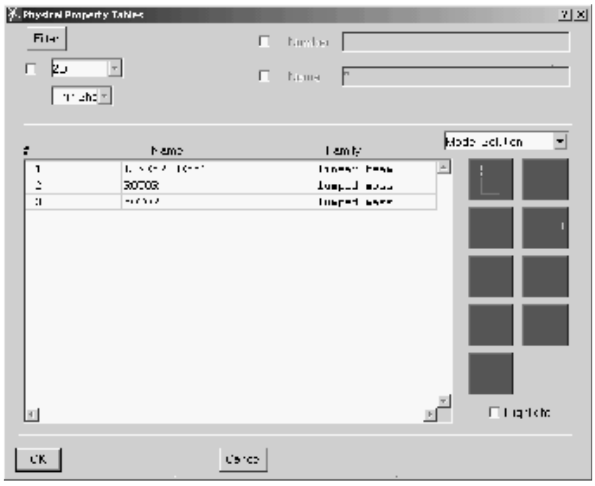


Figure 4. Defining of concentrate mass for:
Rotor: 0.7 kg; Engine: 2,5 kg

For a case study was considerate the situation of a STIHL FS 38 mowing machine, with the following technical characteristics [2, 3]:

- cylindrical capacity: 27.2 cm^3;
- power: 0.65 KW/0.9 CP;
- weight: 4.1 kg.

The whole model was realized using I-DEAS SDRC application. The structure geometry is presented in figure 3 [4].

The presence simulation of engine and cutting device was realized trough concentrate mass elements. The whole structure was discrete using beam one-dimensional (figures 4, 5).

A first analysis had the purpose to define the own vibrations frequencies (figure 6).

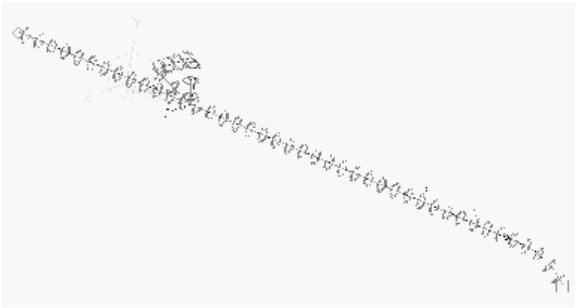


Figure 5. Discrete structure with BEAM elements of mowing machine

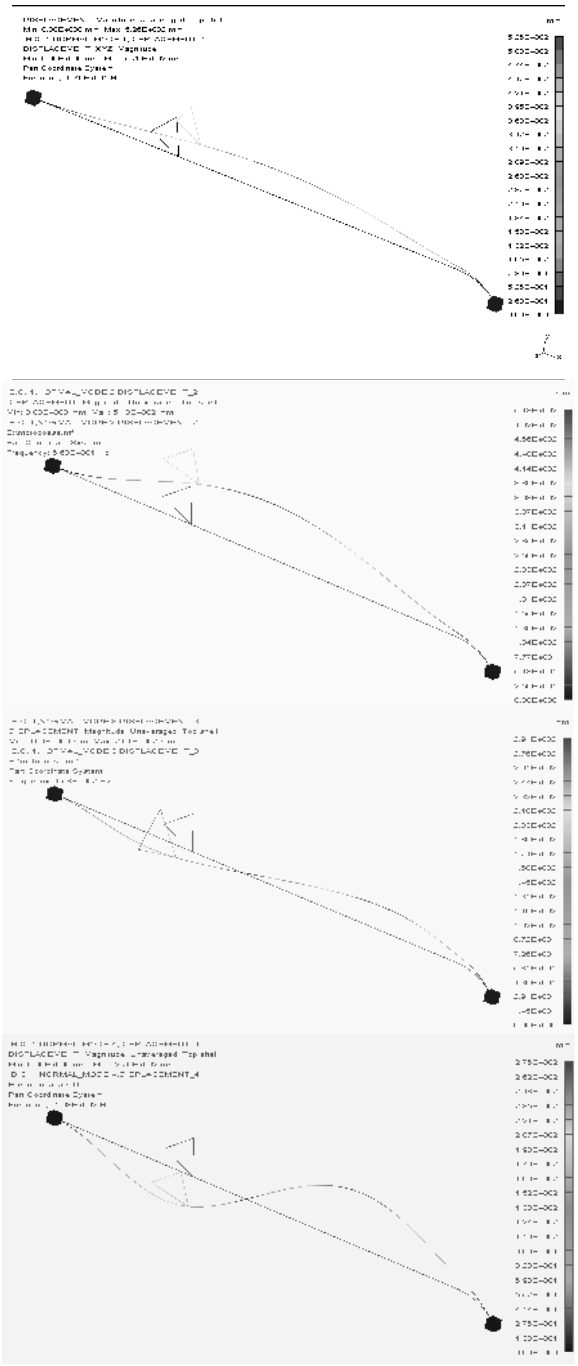
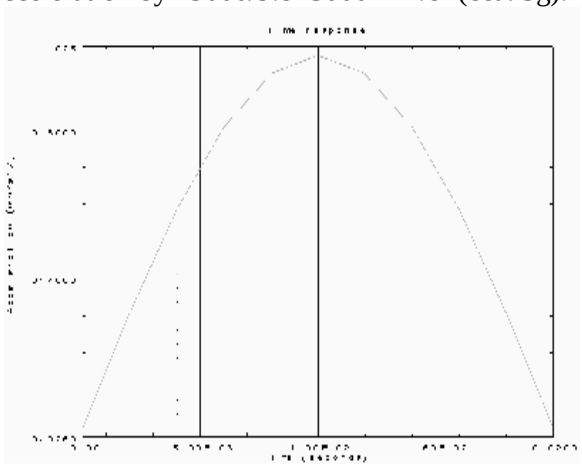


Figure 6. The first four own vibration modes of mowing machine

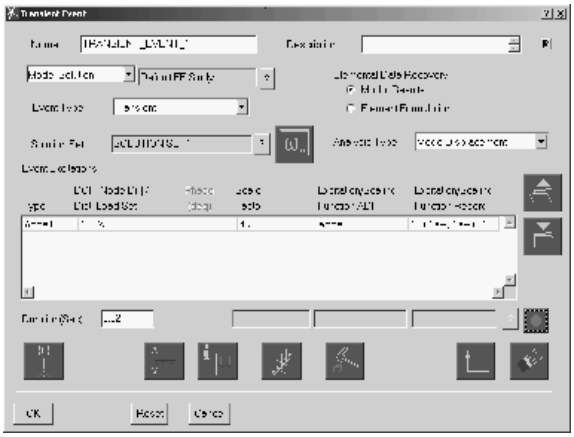
These are:

- the first vibration mode: 64 Hz;
- the second vibration mode: 66 Hz;
- the third vibration mode: 158 Hz;
- the fourth vibration mode: 168 Hz.

The impact simulation between rotor and a hard body was realized through a semi sinusoidal acceleration at node 1 level application. After was defined a transitory event with 0.02 s timing base on function described by curve from figure 7, with a 49000 scale factor, equivalent of a maximum acceleration by 49000/9.8=5000 mm/s^2 (cca. 5g).



a.



b

Figure 7. Defining of impact acceleration with a hard body and the correspondent transitory event

The results show a vibrations amortization during a time of approx. 0.2 s and a maximum value of acceleration of 1.7 m/s^2 by superior haft level and 1.2 m/s^2 inferior haft level.[5]

The amplitude were:

- 5000 mm/s^2 at the rotor level;
- 1758 mm/s^2 at the 37 node level (superior sustaining point);
- 1212 mm/ s^2 at the 52 node level (inferior sustaining point).

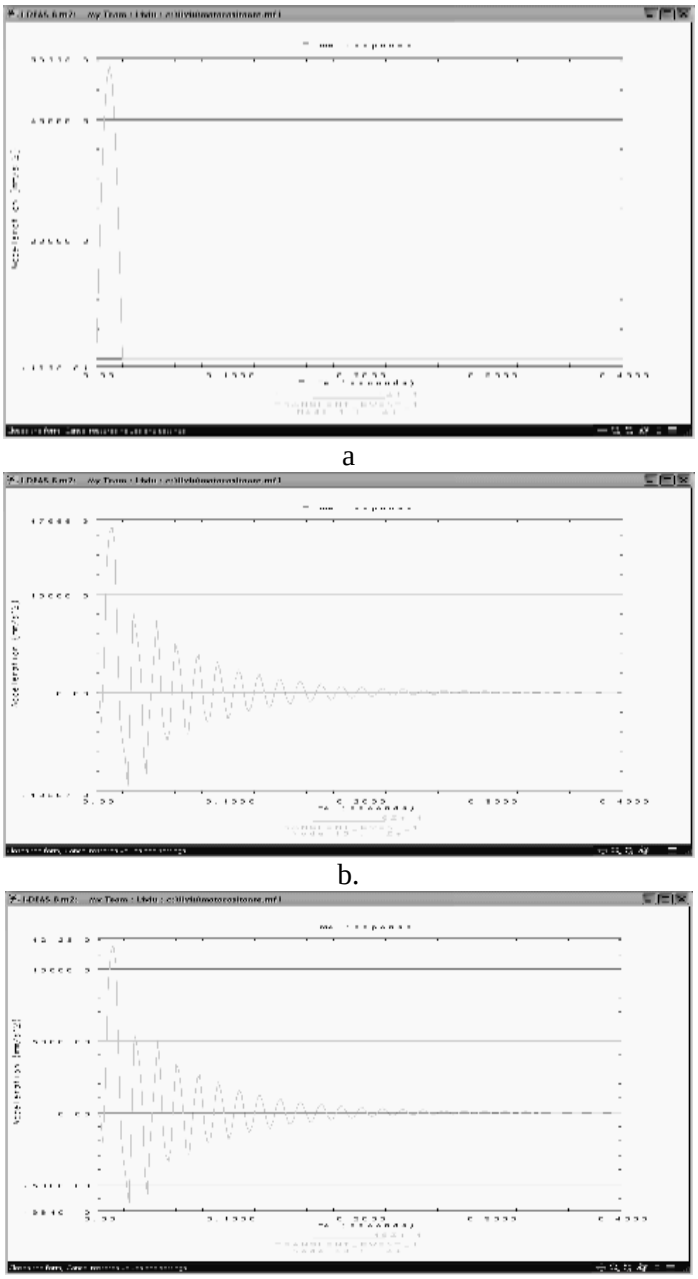


Figure 8. The acceleration vs. time at the rotor, 37 node level (superior sustaining point) and 52 node level (inferior sustaining point)

4. Conclusion

The portable mowing machines modelling, using the finite elements represent an efficient method in order to define an optimal functional mode, from structure solicitation point of view and from these equipments behaviour in transitory work conditions, by impact of machine parts with hard bodies.

In this way it can be make an objective evaluation to a constructive solution, still from design phase, with important effects on launch time decreasing of a new product on the market.

References

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