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Design and Optimalization of a Combined Machine Supporting Frame

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Abstract: This paper deals with the conception design of a combined machine intended to mow and cultivate lands between rows of planted corn. In the design process there were used and verified Concurrent Engineering Principles and the frame of the machine was conformed to an optimalization using the software system Pro/MECHANICA. This process has resulted in an improved form and strength of the combined machine-supporting frame.

Key words: Combined machine, optimalization, inter-seeding, mowing, row cultivation

Introduction

Success of any future product could be significantly influenced its design and during the period of its production. That is why new design methods and production philosophies are currently so important. In this process CA technologies utilizing Concurrent Engineering Principles that are used in pre-production stages, have become irreplaceable (Papalambros and Wilde, 1988). This strategy is based on time limit and depends on the following three main objectives: to reduce the time required to introduce a new product on the market, to improve product quality and to improve quality of design and reduce production process. However, to achieve the desired level of reliability of a designed device the designers in Slovakia still use mainly excessive overexpansion of machine components and optimalization methods are used very rarely in construction design (Oberle and Grimm, 1989). This has very unfavorable influence on total economical indexes of construction design. Production of such products takes then about 30 B 50% more material than comparable production in industrially advanced countries.

This investigation deals with the conception design of a combined machine intended to mow and cultivate between the rows of corn. In the design process Concurrent Engineering Principles were used and verified. After construction design, frame of the machine was exposed to an optimalization using the software system Pro/MECHANICA' in an integrated mode with CAD system Pro/ENGINEER. This process has resulted in an improved form and better strength of the combined macrone-supporting frame (Anderson *et al.*, 1997).

Materials and Methods

Description of the machine conception: A starting point for the conceptual design of a combined machine were the following agro-technical requirements which the machine has to meet:

- Drive from a power take-off shaft of a universal carrier (tractor)
- Attachment to a three-point suspension
- Exchangeable active elements determined for:
    - Mowing of clover planted between corn rows
    - Cultivation of lands with vertically rotating tools
    - Distribution of industrial fertilizers
    - Engagement width of 50 cm
    - Distance between corn rows 70 B 75 cm

Basic conception of the machine was designed according to agro-technical requirements and for required working engagement. The drive for different functions was designed to use the simple change of working velocity and system of active elements exchange. The machine was designed using concurrent design principles and CAD system Pro/ENGINEER. A virtual model of the machine is shown in Fig. 1. Supporting frame is designed in a form of a welded construction consisting from bent pipes appropriately supplemented with stiffeners and consoles (Medvecky *et al.*, 1997).

Supporting frame optimalization: Optimalization is a process during which we search values of independent variables leading B with some restrictions set on them B to an extreme value of a dependent variable. Independent variables are indicated as an n-dimensional vector of optimalization variables (Baier *et al.*, 1994; Bryson and Ho, 1969). The types of these variables are related to the type of an optimalized object and to the type of problems. In the continuum mechanics this can be variables expressing geometrical, kinematics, mass, material, thermodynamic and other characteristics. Limiting conditions of the independent variables have a form of inequalities $g_k\ (x) \leq 0$, equation $h_k\ (x) = 0$, or natural side conditions $x_{i.min} \leq x_{i.max}$. The dependent variable, which is optimalized, is indicated as goal (object, test, optimalizing) function F(x). This means that the optimalization task is a search for such a vector of optimalization variables x, for which the scalar goal function F(x) reaches the extreme value while meeting limiting conditions for variables x_i. In our case the supporting frame of the machine, a calculated model of which is presented in Fig. 2, was exposed to strength testing by the finite elements method and by optimalization subsequently. Constructions were defined in a three-point suspension, where 5 degrees of freedom were withdrawn from every neck, and in a beam of a supporting wheel, where one degree of freedom was withdrawn. Load was defined in relation to belt tension, while the calculated output power was 5 kW, and speed frequency 9 s^{-1} during the hardest operation 13 land cultivation. In the axis of a working vertical shaft there was also set a vertical force of 1500 N which represents the load caused by machine mass. The supporting frame itself

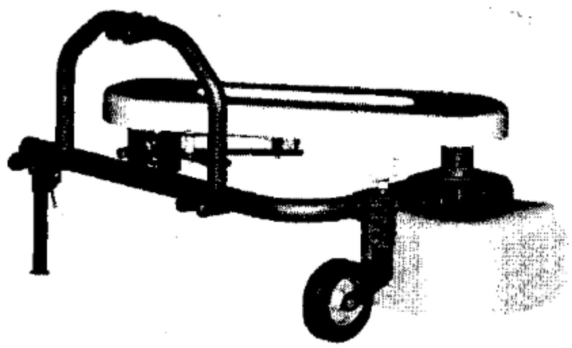

Fig. 1: Virtual model of the combined machine

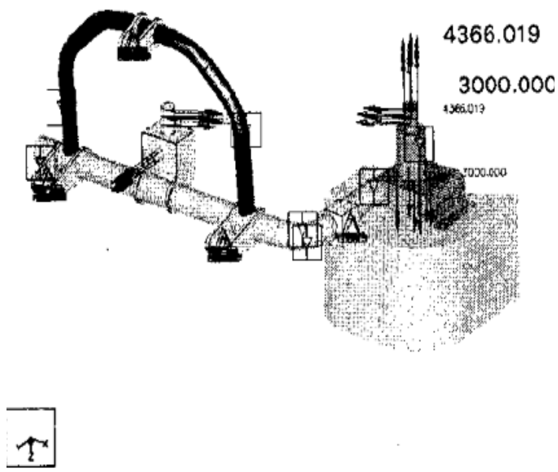

Fig. 2: Calculated model of the supporting frame

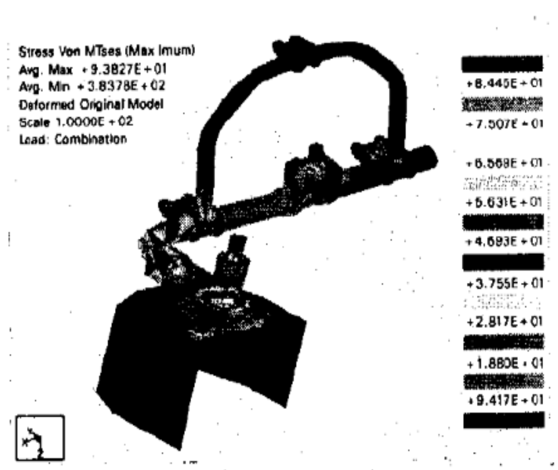

Fig. 3: Distribution of reduced stresses

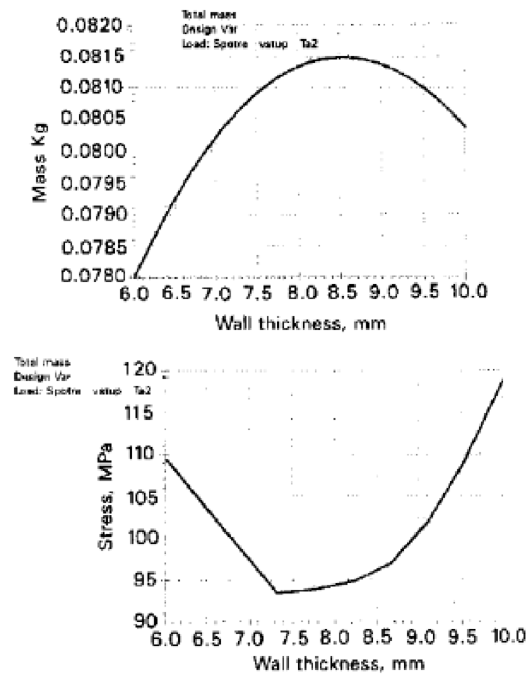

Fig. 4: Results of optimalization

is designed to be made from a steel weldless tube with the diameter of 80 mm, the wall thickness of 6 mm, i.e. from the 11 523 material according to Slovak Technical Standard (STN 42 6711) (Kolar *et al.*, 1997; Iljin, 1977).
The goal function for the supporting frame optimalization can be expressed in the following symbolic way:

$$F = F\ (m, \sigma)$$

As basic input parameters for the optinnalizition were chosen the following ones:

Design geometric parameters: Thickness of the supporting frame tube in the range: t = 4 to t = 7,5 mm.

Boundary limits: Bend stress limit for the material: σ_{DO} = 150 Mpa.

Results

The thickness of the supporting frame tube has met the goal function, i.e minimum mass at the stress achievinig maximum value of 160 MPa, was determined on the basis of a static analysis by means of finite elements method (Fig. 3) followed by optimalization. In our case, where in the original design a tube with the wall thickness of 6 mm was used, the frame had mass of 55 kg. After optimadization it was possible to use a tube with the wall thickness of 4.5 mm and so the mass was lowered to 47 kg (Fig. 4).

Discussion

The case of the design of the combined machine supporting frame, dealt with in this paper enabled us to point out an important and irreplaceable role of strength testing with subsequent optimalization in the process of new products designing. In our case we achieved 8 kg material saving, which resulted in lower total production costs and the construction with its parameters almost matches the world standards in the ratio mass/power output.

References

Anderson, B., E. Colleen and A. Waller, 1997. Pro/mechanica. Using structure with pro/engineer. Release 18.0. Parametric Technology Corporation, USA.

Baier, H., C. Seebelberg and B. Specht, 1994. Optimierung in der Strukturmechanik. Vieweg+Teubner Verlag, Wiesbaden.

Bryson, A.E. and Y.C. Ho, 1969. Applied Optimal Control. Ginn and Company, Waltham, Massachusetts.

Iljin, V.N., 1977. Navrhovani Elektronickych Obvodu Pocitacem. SNTL., Praha.

Kolar, V., I. Nemec and V. Kanicky, 1997. FEM B Principy a Praxe Metody Konecnvch Prvku. Computer Press, Praha.

Medvecky, S., A. Hrcekova, S. Haasova, J. Hromada and M. Malina, 1997. Konstruovanie so Systemom Pro/Engineer. Stredisko ZU, Zilina.

Oberle, H.J. and W. Grimm, 1989. BNDSCO a program for the numerical solution of optimal control problems DL R/B 515-89/22. Report Deutsche Luft and Raumfahrt.

Papalambros, Y.P. and D.J. Wilde, 1988. Principles of Optimal Design. Cambridge University Press, Cambrige.