

## OPTIMISATION DESIGN OF WORKING TOOLS SHAPE FOR A CONCRET MIXING EQUIPMENT WITH PALETTES

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**Abstract:** The article presents the evaluation of two design variants of mixer tool. The new obtained solution was the result of an optimisation process of geometrical parameters, such as: dimension, thickness, mass and shape. The initial parameters were acquired from concrete mixer in operation in Romania. The objective was to decrease the overall mass of mixer tools while improving its structural integrity. In addition, the new shape of equipment arms increases the process quality for the blending of mixture components.

**Keywords:** concrete mixers, design, palette, mixing, resistance force.

### 1. INTRODUCTION

Mixing is a complicated process that is affected by the type of mixer, the mixing cycle, the loading method, and the energy of mixing [1]. There are two main types of mixers: batch and continuous. After mixing method, the mixers can be divided in two groups: with compulsive and gravitational mixing [2]. Concrete production consists of multiple interrelated steps, formatted by batching, mixing, consolidation, finishing, and curing. Each step of the entire process brings a unique contribution to the quality of the final concrete product.

The literature does not report problems with the mixers commercially available today. The main innovations that are currently being worked can be summarized as follows: producing mixers that reduce energy consumption and the time of mixing without affecting the quality of the concrete produced.

This paper brings contributions on mixing performance growing up of an mixer equipment with two horizontal axis, with compulsive mixing, by optimisation of the working tools on view reducing our mass, resistant force per pallets (through changing the mounting angle on arm). All these diminish the power needed for equipment operation. Many researchers [3-5] was developed multi-criteria optimisation tasks in order to evaluate geometrical variants of the solid body defined by design functionality requirements (e.g. minimizing mass, maximizing stiffness etc) and, financier requirements (e.g. cost of material etc.).

### 2. CHARACTERISTICS OF COMPULSIVE MIXING EQUIPMENTS

Compulsive mixing equipments (Figure 1) are composed by the main parts as follows: vat, palletes, electric engine and transmission, hole for discharging and drive system for their manoeuvre. With these equipments we obtain in short time a very good quality of mixture but with more specific consumption ( $1.0 - 1.6 \text{ kW/m}^3$ ) because of high resistance force which is developed on mixing at tools-aggregates interface. Unfortunately, their structural configurations are more complex than others and concur both to the working tool damage increasing,

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and the exploitation expenses. Hereby a greater specifically power and mass results. Mixing resistance increasing is supply by the friction between aggregates-pallets, and by the occlusion between pallets and vat.

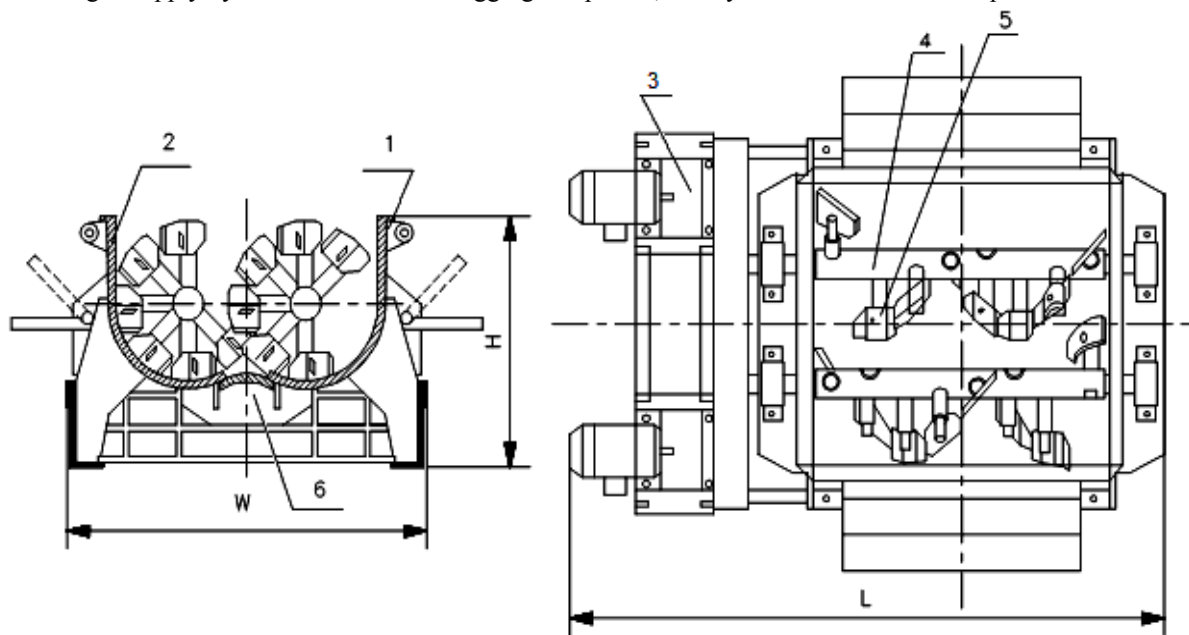


Fig. 1. Constructive scheme of the mixer with horizontal axes:  
b. vat; 2. Plate; 3. Drive system; 4. Axes with arms; 5. Palette; 6. hole for discharging.

The initial parameters used in this study were acquired from concrete mixer in operation in Romania. The dates of the mixing equipment model consist on: power  $P_m=30$  kW; productivity  $Q_T=50$  m<sup>3</sup>/h; time per cycle for mixing  $T=1.86$  min.; number of pallets 16; index loading of vat  $k_v=0.6$ ; internal radius of vat:  $R=0.550$  m.

### 3. OPTIMISATION OF THE WORKING TOOL SHAPES FOR MIXING EQUIPMENT

Speciality literature stipulation two major objectives when designing details for a part [6]:

- obtaining the desired shape;
- using the state-of-the-art technology and material;
- accomplishing the function for it was created.

The author considers that alternative design features to obtain better working tool shapes should correct three important aspects:

- diminishing of working tools usury;
- decreasing the resistance force in mixing process by adopting the elliptical shape of mixer arms and pallets form;
- good homogenisation of concrete through choosing the longitudinal shape for the mixer arms.

The mechanical characteristics of the blending components have the influence on resistance at the mixer working tool which are evaluated through instrumental tests and, for the case of proposed equipment is equal with  $K_1=1.5$  daN/cm<sup>2</sup>. In addition, the montage angle of the pallets to the spindle has to be 45° because of the minimal probability of blocking for the blend particles between the end of the palette and the mixer drum.

In Figure 2 are depicted the influence of the palette shape on the stress configuration under the blend resistance action. Finally, the palette shape is optimised for the uniform strain state produced at penetration into the mixture from the equipment vat. This analysis was performed with the help of the finite element method toolbox for Inventor 9 software package.

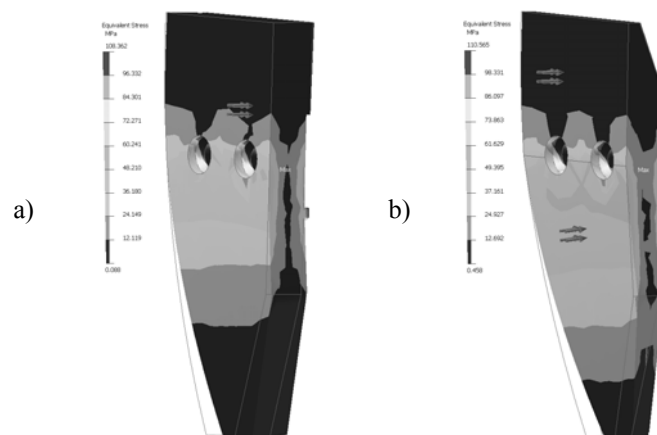


Fig. 2. Optimisation of palette shape:  
a) initial shape; b) final shape.

From constructive considerations, the arm can have several shapes of transversal section such as: rectangular, elliptic, oval etc. Through all these sections, only elliptical shape opposes a minimal resistance force into mixing process. For this motivation, in this study, the author has adopted an elliptical section for mixer arms (Figure 3), with dimensions (on basis)  $a=0.132$  m,  $b=0.064$  m, and the arm length: 400 mm.

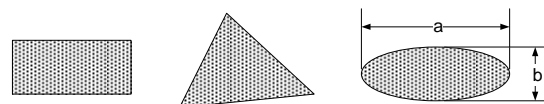


Fig. 3. Usual sections for mixer arms.

The imposed performance requirements of mixer arms must be: resistance, facile technology for it execution, easier maintenance, minimum resistant force developed into mixing process. In addition of these, the objective of this analysis is that the arm shape contribute to dynamics of the aggregates movement into the mixer vat. Taking into account the last requirements, the arm shape had a different design by adopting dynamical longitudinal form, which will be analysed into the modelling software, and the results was shown in Figure 4.

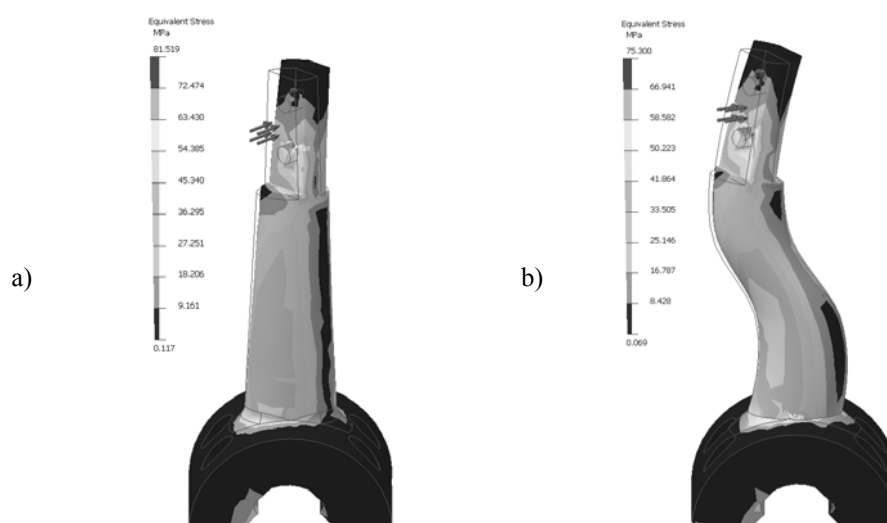


Fig. 4 The analysis of stress state for the mixer arm:  
a) initial shape; b) final shape.

In figure 5, two designs for mixer working tools are presented. In Figure 5.a is given the initial shape of arm-

palette ensemble which has improvement and in Figure 5.b is represented final shape which has analyse with finite elements and result lower resistance force in mixing process.

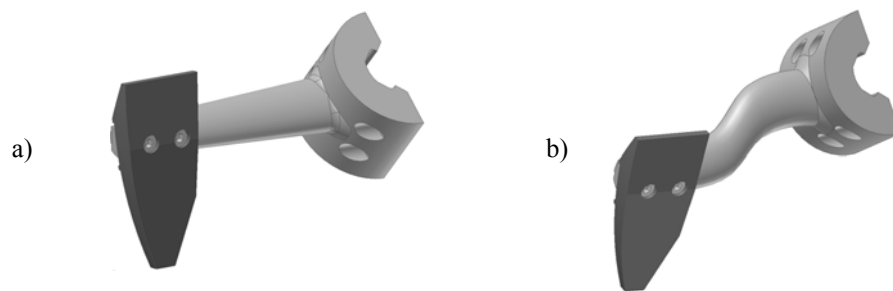


Fig. 5 Arm-palette ensemble:  
a) initial shape; b) final shape.

The best solution obtained in the course of optimization displays lower average stiffness in relation to the initial model, as can be see in Table 1 (for the same type of concrete blended).

Table 1. Optimisation results.

Parameters	Working tool shape	
	Case from fig. 5a	Case from fig. 5b
mass, in kg	9	8
$\sigma_{echiv}$ , in MPa	81.51	75.30
$\varepsilon$ , in mm	0.674	0.690

#### 4. CONCLUSIONS

The result of optimization process of geometrical parameters of the working tool mixer is a compromise between high stiffness and low weight. This study demonstrates that inclination of the arm face to axle and the inclination of the palette face to arm have influence about tensions state and deformations of the palette-arm ensemble during mixing process. The optimization process resulted in the reduction of the tools (palette and arm) weight, as compared to the initial variant, at the level of 11 %. In situ tests will be the ones, which enable the proposed solution because it is the only way to test the homogeneous degree of mixing, after changing the tools shape.

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