STUDY OF IMPROVING STATIC RIGIDITY ON MACHINE TOOL STRUCTURE USING CONCRETE COMPONENTS

Mihai SIMON¹¹, Lucian GRAMA²², Macedon GANEA³³

¹¹Industrial Engineering and Management Department, Petru Maior University
Nicolaie Iorga Street, No. 1, Targu Mures, Romania
¹¹mihai_simon@yahoo.com
²²lgrama46@yahoo.com
³³Engineering and Management Department, University of Oradea
Universitatii Street, No. 1, Oradea, Romania
³³macedonganea@yahoo.com

ABSTRACT

In this paper is studied and experimented a cheap method to improve static rigidity on CNC machine tool beds or supporting structures, using poured concrete components. The study is applicable on tubular steel frames constructions or other hollow type structures made from steel or cast iron. The experimental prototype is a 3 axes CNC milling machine tool center custom made from welded rectangular steel tubes. The test confirms that were the weight is not an issue, the increased mass and rigidity improvement, reduces vibrations considerably with the benefit of a very small investment.

Keywords: concrete filled structure, machine tool improved rigidity, vibration suppression.

1. Introduction

The construction of machine tools structures should be economical [1] however, the characteristics of strength, stiffness and vibration dampening must satisfy the machining demands.

In recent years increasing interest has been shown in the use of concrete as an alternative composite structure to mild steel or cast iron for the structural components of machine tools [2].

Several machine tool manufacturers supplied the necessary parts to assemble complete machines on concrete structures and thus made possible direct comparison with corresponding machines having cast-iron structures [3].

Concrete-filled steel tube columns combine the advantages of ductility, generally associated with steel structures [4], with the stiffness of a concrete structural system. The advantages of the concrete-filled steel tube column over other composite systems include: The steel tube provides formwork for the concrete [5], the concrete prolongs local buckling of the steel tube wall, the tube prohibits excessive concrete spelling, and composite columns add significant stiffness to a frame compared to more traditional frame construction [6].

Indirect cost reductions such as the reduced amount of surface dressing and filling on the concrete base by comparison with such costs on the metal base may well increase overall cost savings significantly; additionally [7], studies show that the cost of producing concrete components prior to final machining should be 30 to 50 percent below that of the conventional cast iron components [8].

Fig. 1 - Example of concrete filled machine tool structure [2]

Apart from strength and ductility, adequate bond between steel and concrete at the interface is important in concrete filled steel tubes columns to ensure a composite action [9].
2. Method used

The paper studies the design and construction of a milling machine structure (Fig.2.), using alternative methods for static rigidity improvement.

Experiments try a cheap method to improve static rigidity on CNC machine tools supporting static structure, using poured concrete components. The study is applicable on tubular steel frames constructions, or other hollow type structures made from steel or cast iron.

The idea comes from 60’ development of America’s several institutes, to make machine tools beds directly from concrete [10]. Also hi span modern bridges use this technique with good result.

Experimental prototype is a CNC milling machine tool center custom designed (Fig.2.) and constructed (Fig.4.) from welded steel tubes.

The material used for construction was tubular steel with the following characteristics (Table 1):

<table>
<thead>
<tr>
<th>Size</th>
<th>100 x 100</th>
<th>80 x 80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>EN 10 210</td>
<td>EN 10 210</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>5 mm</td>
<td>4 mm</td>
</tr>
<tr>
<td>Mass/length</td>
<td>14.41 kg/m</td>
<td>9.22 kg/m</td>
</tr>
</tbody>
</table>

The concrete was a quality B 300 standard C18/22.5 type [11]. Because of the small quantity used, approx. 1/2 cubic meter, even a quality type of concrete was not expensive compared to the metal [12].
using CAD software in such way that the concrete can communicate between the vertical and horizontal tubular structure for a good bond (Fig. 5);

- Constructing the structure from tubular section steel by welded joints (Fig. 3); Length of tubes was catted (Fig. 3.a.) and assembled (Fig. 3.b.) according to design by MIG and MMA welding. Perpendicularity, parallelism and metal deformation from welds, were the problems to take care with proper known techniques.

- Assembly of other component that can influence the results (Fig. 4);
- Filling the empty structure (Fig. 6);
  The hallow structure must be prepared for concrete pouring in such way that the pour was made in one step for beater results.

- Concrete setting and drying period when no actions were made to machine.
- Custom made test installation using swing impact hammer and vibration sensors (Fig. 7);
- Comparative rigidity and vibration dampening tests between hallow and filed structure;
- Processing and interpretation of the results.

3. Experimental

The hallow structure was impact tested using a swing arm with mounted soft tip impact hammer.

Fig. 5 - The empty structure before poring

Fig. 6 - Structure with poured concrete

Fig. 7 - Structure with poured concrete

Fig. 8 - Data processing path of the test method

The height of the suspended hammer was kept during all tests (Fig. 7) for comparative same conditions results.
After data acquisition of the hollow type structure, the comparative tests were made with concrete filled structure. The observed frequencies were low frequencies, between 20 and 120 Hz. In this low frequency field, the machine tool has more amplitude and chatter and can influence the machined surface in use. A diagram was obtained in each test. Overlapped, the differences can be seen in (Fig. 8.)

4. Results and conclusions

The test confirms that were the weight is not an issue, the increased mass, reduces vibrations considerably with the benefit of a small investment.

Regard of performance, differences was detected between the concrete filled structures and the tubular hollow steel structure (Fig.8).

Noise characteristics of the machine, deformation affecting the distance between the tool and the work piece were lower. Overall vibration characteristics of the concrete filled structure were heavily damped than those for only metal based structure. In low frequency modes of vibration, the stiffness was greater in the structure with concrete. No limitation on material removal rate shod accrues in use by using this method.

In this particular chaise the study shows that the designed machine has improved performances by use of concrete. Tests can be done concern the effects of thermal inertia and the long-term stability.

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Fig. 7 - Structure testing method

Fig. 8 - Low frequency response