# ANALYSIS OF POSSIBLE BRAID CONFIGURATIONS ON A 4x4 HORN GEAR BRAIDING MACHINE

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## ABSTRACT

*The braiding machines with 4x4 set of horn gears and computer controlled switches can be arranged for production of braided structures with different cross sections. The objective of this work is to analyse the possible basic configurations on such machine. These basic configurations can be used in the future as main building elements for more complex structures with bifurcations. The analysis is performed using numerical simulation of the braiding process with the software TexMind Braiding Machine Configurator.*

**Key Words:** *Braiding machine, 3D braiding, horn gear arrangement, Braiding Machine Configurator*

## 1. INTRODUCTION

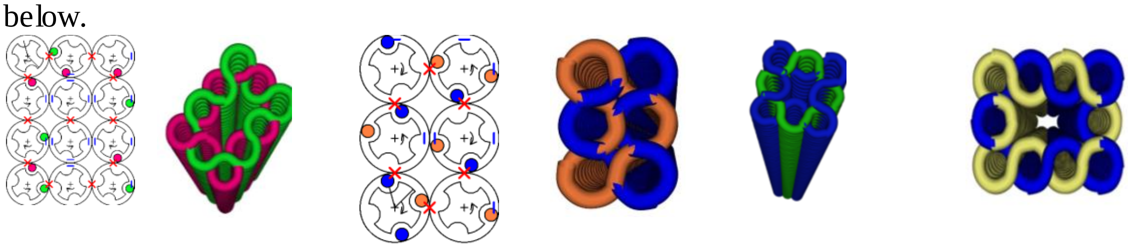
Braided products have wide applications in medical, transportation, industrial and other various areas [1,2]. The classical tubular and flat braiding machines have limitation, that they can be used for production of only one type of structure. The Vario braider VF with a set of 4x4 horn gears is available on the marked since 2009 and overcome this limitation, because the state of its switches can be changed manually or with computer control, depending on the machine version. In some of the literature sources are given some possible configurations for this machine [1, 3]. This paper has a goal to make systematic analysis and listing of the possible arrangements and the resulting braids for this machine, if the switches are not changing their state during the braiding. These arrangements can be used as main building blocks for production of more complex structures with bifurcations or other changes of the cross section.

## 2. NUMERICAL EXPERIMENTS

For the investigation, TexMind Braiding Machine Configurator software is used [4]. It performs numerical simulation of the carrier motion and generated virtual twin of the new product[5]. By selecting different arrangements of the gears, different number of carriers and configurations (1Full 1Empty, 2Full 2Empty or 1Full 3Empty), the possible tubular, flat, solid and, core & sheath structures can be created.

### 2.1.Tubular braids

For the production of tubular structures suitable selection of the switches on the machine is required. Tubular braid configurations with 4, 6, 8, 10, 16, 20 up to 32 carriers are possible. Some configurations for tubular braids with the generated simulations are given in figures below.

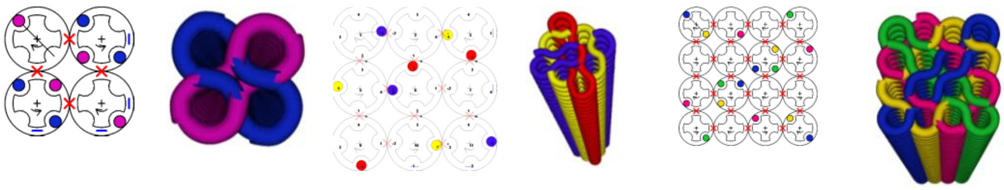


*a. 10 carriers* 1F3E *b. 12 carriers 1F1E* *c. 16 carriers 1F 1E* *e. 20 carriers 2F2E*

Fig.1: Some configurations of tubular braids on 4x4 horn gear braiding machine

### *2.2.Solid braids*

Solid braids are known by the term diagonal braids, too (2D, 3D, 4D, where D means Diagonal). Technically the diagonal represents one separated track followed by set of carriers. An arrangement of N tracks has N diagonals. For even number of tracks half of the diagonals will be parallel to one main diagonal and half parallel to the other main diagonal. But if the arrangement has odd number N tracks, it will have $\frac{N-1}{2}$ diagonals parallel to each track and one diagonal symmetric to both which connects the midpoints of the square sides [1]. In the case of 4x4 braiding machine only configurations of 2D, 3D and 4D arrangements are possible.

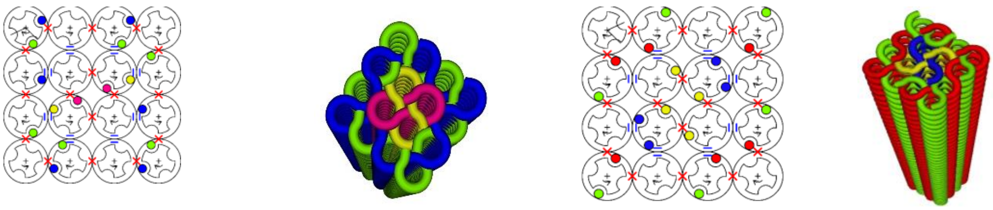


*a. 2x2 with 2 diagonals* *b. 3x3 with 3 diagonals* *c. 4x4 with 4 diagonals*

Fig 2: Configurations for solid braids with 4x4 braiding machine

### *2.3.Core-Mantle braids*

Braided products can be produced as core-mantle [1]. Figure 3 demonstrates two variants of core-mantel braids, where the Fig.3a is a configuration, where the core and the mantle have floating length of one. The core in Fig.3b demonstrates configuration with core with floating length of one, but having two yarns in a group and sheet again with floating length of one. In case of structures with floating length of two both the core and sheet has to be of the same type.

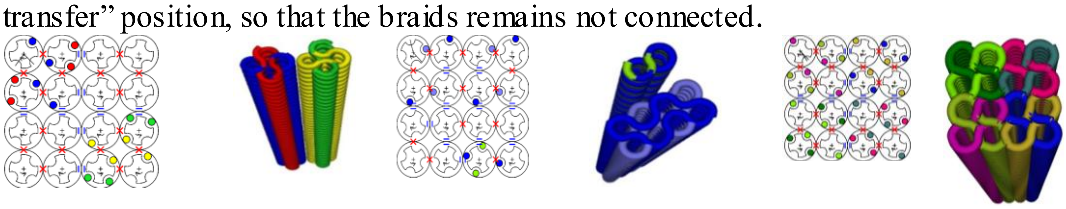


*a.2x2 solid 1F1E core and 1F1E sheath configuration* *b.2x2 solid 2F2E core and 1F3E sheath configuration*

*Fig.3: core-mantle braids configurations with 4x4 braiding machine*

### *2.4.Multiple braids in parallel*

The 4x4 braiding machine allows production of multiple braid structures simultaneously (Fig.4). The switches between the different groups of horn gears have to be set in "not transfer" position, so that the braids remains not connected.

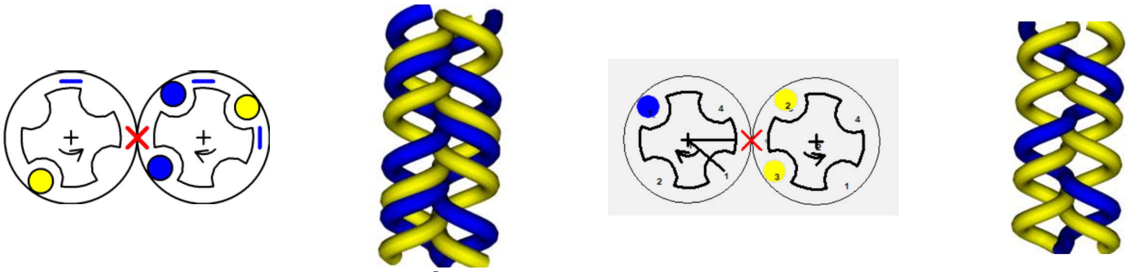


*Two 2x2 braids braided in parallel* *8 carriers tubular and 4carriers flat in parallel* 4 products simultaneously on 4x4 , 1F1E configuration

*Fig.4: configurations of two braids in 4x4 braiding machine in parallel*

### *2.5. Flat braids*

Flat braiding machines usually have one track only and the end horn gears have five or three slots. Such configuration is not possible on the current VF machine. If only two gears are used, small flat braids with three and four yarns can be produced (Fig.5), where this with four yarns will have two yarns working in a group (Fig.5b). Wider flat braids are currently not possible.



A b c D

Fig.5: Flat braids a) and b) with 4 carries and irregular structure, where two of the carriers build one group; c) and d) configuration for classical three yarns braid.

## 3. CONCLUSIONS

The 4x4 gears braiding machine VF allow configurations, where tubular, core-mantle, solid and small flat braids can be produced. These all configurations were checked using simulations and practical tests (not shown here) and can be used as modules for building of more complex braids on the same or larger machines.

## 4. ACKNOWLEDGEMENTS

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