

# GUI APPLICATION ON THE BALLOONING YARN

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## Abstract

This paper deals with the graphical user interface (GUI) built in environment MATLAB. It serves to simulation of the processes happening by the yarn ballooning and to displaying of the graphical outputs from the mathematical model. The application of user interface is for instance in education, in practices by new production implementing, in current production optimisation or in research.

## 1 Introduction

High-speed winding system ranks among systems where friction shear forces and resistance of air play an important role. The process of yarn formation is related with the rotation of yarn round a fixed axis, generating a phenomenon which is called yarn ballooning (see Fig. 1). The results presented up to now demonstrate non-linear character of the physical phenomenon of yarn ballooning. The compiled mathematical model is employed for simulation of the complete process of yarn winding under determined boundary conditions [3]. Attention is paid to the solution of movement of the yarn on the yarn carrier (separator). The compiled mathematical model serves for analysis and optimisation of boundary conditions of the examined winding process.

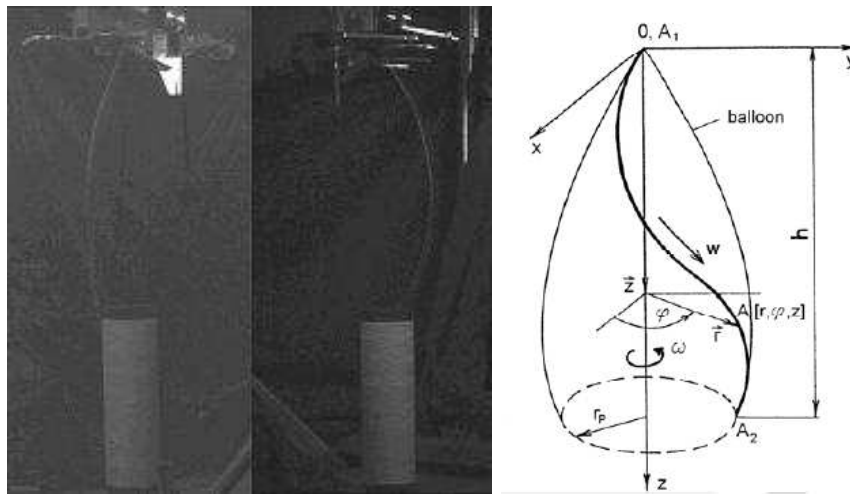


Figure 1: Ballooning yarn

A graphical user interface (GUI) is a graphical display that contains devices, or components, that enable a user to perform interactive tasks [5]. To perform these tasks, the user of the GUI does not have to create a script or type commands at the command line. Often, the user does not have to know the details of the task at hand. The GUI components can be menus, toolbars, push buttons, radio buttons, list boxes, and sliders—just to name a few. In MATLAB software, a GUI can also display data in tabular form or as plots, and can group related components.

## 2 Spinning system description

The twisting of yarn is provided by means of a rotating hollow body (carrier), through the hollow of which the produced yarn is passing, lying on its inner wall (see Fig. 2). The rotating inner wall carries the yarn, and at the same time, it functions as separator of the yarn balloon, which would

be generated by the rotating yarn. The angular velocity of the carrying rotational movement of the yarn with respect to the carrier changes in dependence upon the winding diameter, and the yarn is dragged along the inner wall of the carrier. After leaving the hollow of the carrier, the yarn passes upon a fixed ring, serving for a reduction of outer diameter of the rotating loop. From the ring, the yarn passes into a loose balloon, it creates a loop and it is wound upon a bobbin. The loop of ballooning yarn participates considerably in the magnitude of the tensile force in the winding process. The loop spinning ranks among the systems of yarn formation with a constant balloon height.

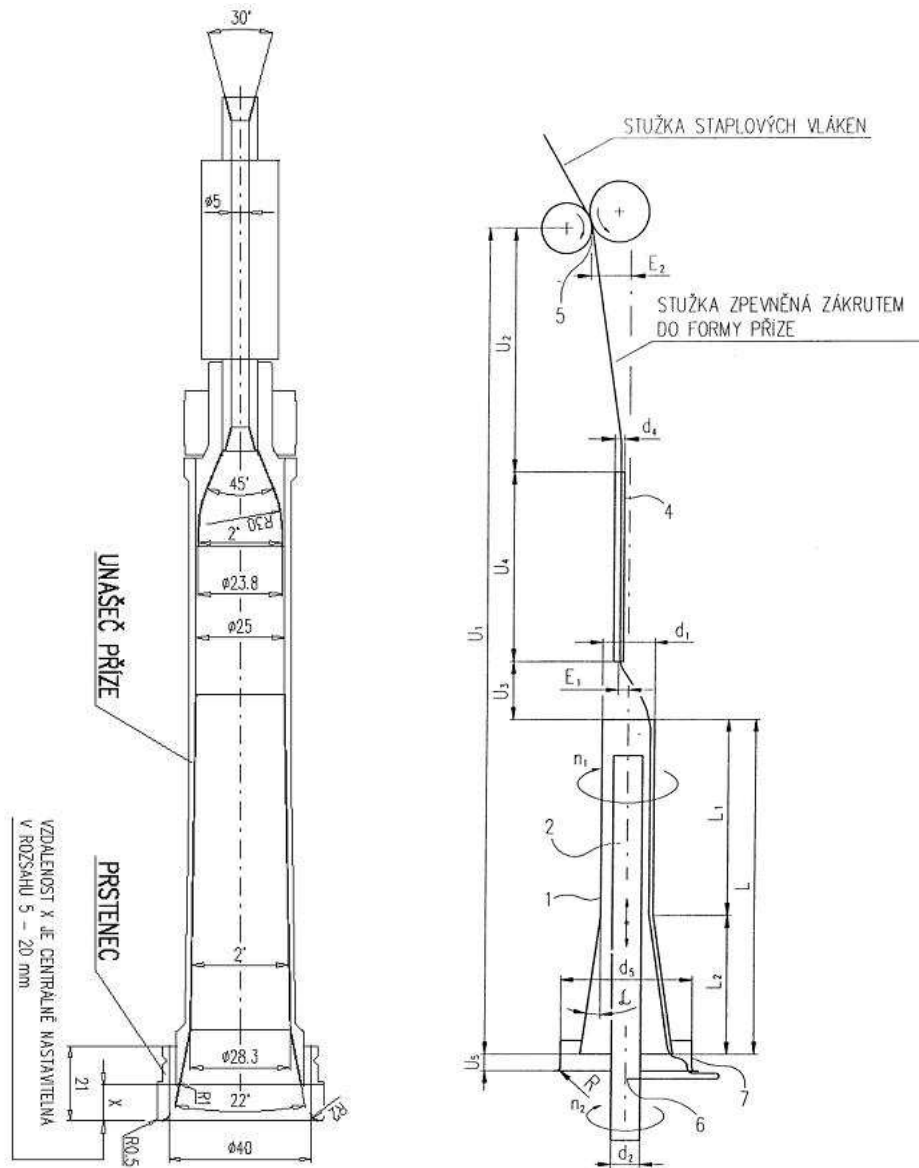


Figure 2: Diagram of loop spinning and alternate diagram of loop spinning [3]  
(In the left figure: yarn carrier// ring// the distance  $x$  is adjustable centrally in the range 5-20 mm; In the right figure: band of staple fibres// band strenghtened by twisting to the yarn form)

The simplified chart in Fig. 2 consists of the following components: carrier 1, rotating peg of the spindle 2, tube of the carrier 4, gripping line of output rollers of the drafting motion 5, place of winding 6, support ring 7, guide eye (not shown).

### 3 Model of the loop spinning system

An exact solution of the shape of the yarn curve in general three-dimensional case results very difficult. It is practically impossible to get to a simple analytic expression of the shape of this curve. On certain simplifying assumptions, it is possible to establish the curve of the moving yarn by numerical solution of the given boundary problem.

#### **Assumptions defining a simplified model of the ballooning yarn:**

- the yarn is elastic ideally,
- the yarn is uniform in mass,
- the deformation of the yarn is not influenced either by relaxation or by creeping phenomena, and it does not depend upon the temperature,
- the dragging angular velocity of the yarn is constant,
- the relative velocity of the yarn feeding is constant,
- the boundary conditions are independent upon the time,
- the high-frequency phenomena, bringing about the vibration of yarn round the quasi-stationary position, are not considered in the model,
- the effect of air resistance in the direction of the tangent to the curve of ballooning yarn is disregarded.

From the point of view of acting forces, the curve of the twisting yarn in the spinning system can be divided into several sections, depending whether in the concerned section the yarn balloons loosely or the yarn balloon is limited in some manner. Furthermore, particular attention is paid to that section of the spinning system that is characterised by yarn ballooning, both with loose and with limited balloon. The proposed mathematical model simulates the process of yarn formation in the section between the guide eye 4 and the winding of the yarn upon the tube of rotating spindle 6 (see Fig. 2). The part of the system between the output of fibre band from the drafting motion 5 and the guide eye 4 is not included in the model directly, because the change of forces acting upon the yarn in this section is not significant.

As has been stated already, during its formation in the spinning system the yarn passes through several sections, differing in particular by their geometric shapes and different forces acting upon the yarn. Namely, they are the following ten sections:

- first section of loosely ballooning yarn between the guide eye and the input to the carrier tube, including the transfer of yarn upon its inner wall; the small cone on the input section is not considered,
- the section of yarn movement on the inner wall of the cylindrical part of the carrier tube, including the transfer upon its conical end section, considering the Euler's relation for the increase of tensile force,
- the section of yarn movement on the inner wall of the conical section of the carrier (angle  $45^\circ$ )
- the section of yarn movement on the toric plane including the transfer of the yarn upon the inner cylindrical wall of the carrier (the short cone with angle  $2^\circ$  has been disregarded and substituted with cylindrical plane),
- the section of yarn movement on the inner wall of the cylindrical section of the carrier, including the transfer to its following conical section,

- the section of yarn movement on the inner wall of conical section of the carrier (angle  $2^\circ$ ) including the transfer to its following conical section, considering the Euler's relation for the increase of tensile force,
- the section of yarn movement on the inner wall of the conical section of the carrier (angle  $22^\circ$ ) including the transfer into loose balloon, considering the Euler's relation for the increase of tensile force,
- the section of loosely ballooning yarn between the carrier and the static wall of the cylindrical ring, including the transfer of yarn upon its inner wall,
- the section of yarn movement on the inner wall of the static ring, including the transfer of yarn upon its inner wall, considering the Euler's relation for the increase of tensile force,
- the section of loosely ballooning yarn between the bottom edge of the static ring and the place of winding on the bobbin.

In the last section of loosely ballooning yarn, the compiled model considers the movement of the rotating loop in the plane perpendicular to the spindle axis only, i.e. the distributing motion of the spindle board has been disregarded.

The mathematical model appears from basic equations for loosely balloon [2] complemented with equations of limited balloon [3].

## 4 Mathematical model in MATLAB

Ballooning yarn motion can be described in according to [2] and [1] by means of equations a system of non-linear differential equations of  $2^{nd}$  order. Conditions of relevance, interference and further informations are presented in [2] and [1] too.

The calculation of the yarn curve has been carried out for each section of the spinning system separately, with some sections leading to a boundary problem. The system of differential equations is resolved by the Runge-Kutt method. For determining the approximations of the missing initial values, the iteration method of secants has been employed. As the basis of the calculation, there serves the outer iteration cycle for determination of the initial value of yarn tension, and the iteration is ended if the boundary condition on the wound bobbin is fulfilled. The missing initial values of individual sections are determined by means of inner iteration cycles; for example, for the first section there is resolved the progression of initial problems with various values of the first derivation of the initial radius, and the iteration is ended if the boundary conditions in the place of transfer of loosely ballooning yarn upon the cylindrical plane of the carrier tube on the wound bobbin are fulfilled. For the resolution of the problem, there has been compiled a program in the environment MATLAB, allowing to obtain discrete values of the searched functions, from which it is possible to establish the shape of the curve of rotating yarn and the yarn tension in an arbitrary point of this curve, for all the sections of the spinning system.

Solution of ballooning yarn model leads generally to boundary- value problem for system of linear differential equations of second degree. These equations contain searched functions and their first or second derivation. Length of threadline  $s$  is independent variable. System of assembled equations can be solved with respect to top derivations of searched functions and converted on first degree equations. Boundary- value problem is solved with shooting method, when the boundary conditions character makes possible conversion on initial- value problem. [3]

The largest problem at mentioned program creation was solution of differential equations system by means of Runge- Kutta method. In the MATLAB exist a function ode45 [4], which is based on an explicit Runge-Kutta (4,5) formula, the Dormand-Prince pair. It is a one-step solver in computing  $y(t_n)$ , it needs the solution at the immediately preceding time point,  $y(t_{n-1})$ .

Problem was by stopping of calculation. Because we don't know the value of independent variable  $s$  (length of the yarn in the balloon), but balloon height  $h$  is known, it is necessary to stop the calculation in point, when is reached the required high of the baloon, thus  $z(s) = h$ . However, this procedure is not enabled by MATLAB. Therefore was created subprogram for Runge- Kutta method manually.

An outcome of the mathematical modelling is assembled program, which supports solution of yarn ballooning model by means of described methods.

## 5 Calculation results display

To the display of calculation results is possible to use only graphs, of course. A disadvantage of this process shows itself by simulation with different input parameters and initial conditions. Task can become untransparent and this can lead to mistakes. Hence is created user interface (see Fig. 3), where are well arranged all parameters, which can be dated up before calculation starts.

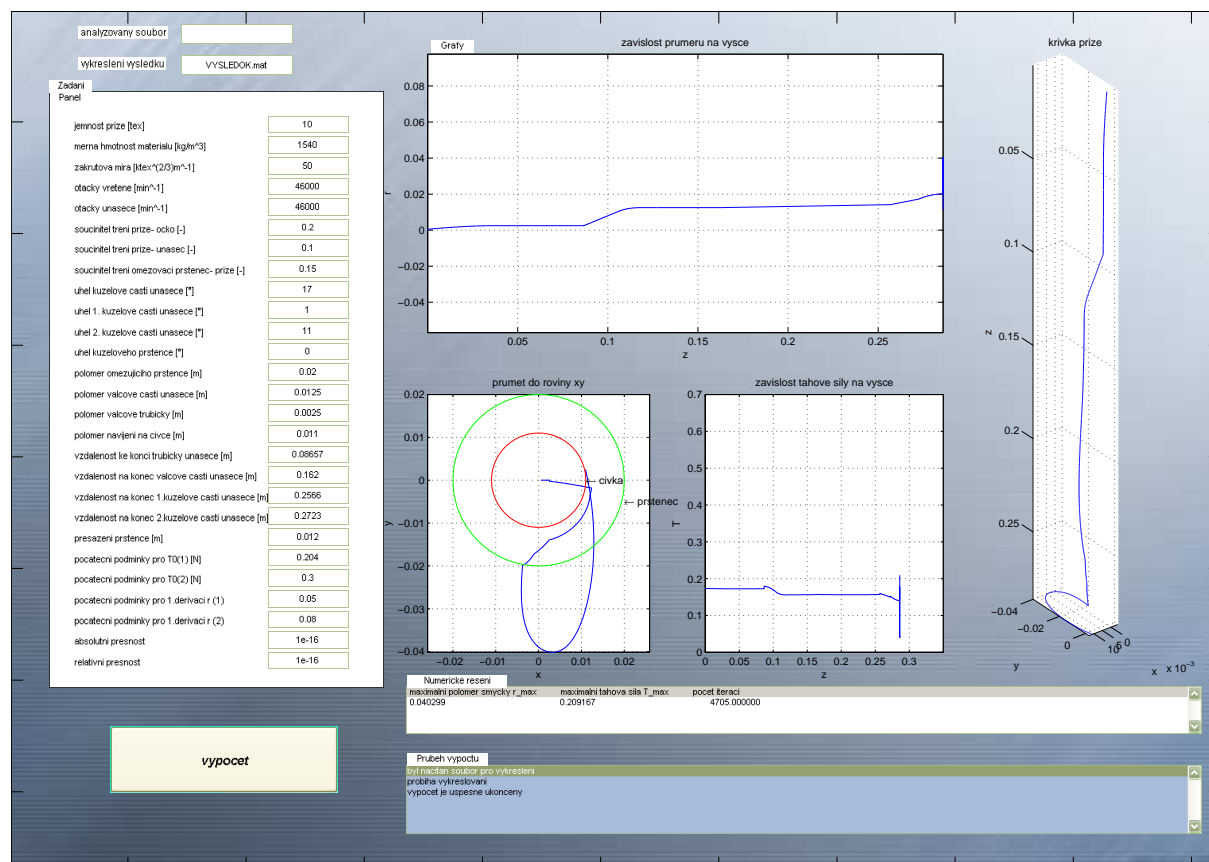


Figure 3: GUI for modelling of the ballooning yarn

GUI can be created through two ways. The first way is creating GUIs programmatically, what is considerably complicated. The second one, preferable, is building of the graphical user interface by means of GUIDE- graphical user interface development environment. According to user manual presented by MathWorks [5] you can use the GUIDE tools to

- *Lay out the GUI.*  
Using the GUIDE Layout Editor, you can lay out a GUI easily by clicking and dragging GUI components such as panels, buttons, text fields, sliders, menus, and so on into the layout area. GUIDE stores the GUI layout in a FIG-file.
- *Program the GUI.*

GUIDE automatically generates an M-file that controls how the GUI operates. The M-file initializes the GUI and contains a framework for the most commonly used callbacks for each component—the commands that execute when a user clicks a GUI component. Using the M-file editor, you can add code to the callbacks to perform the functions you want.

In principle is the created GUI divided in two areas— area of entering data and area of results display. At the top of left part (see Fig. 3) is field, in which is entering a file given for analysis or file with results of analysis, which we want to display.

Under that is field, in which are entering the parameters determined the model properties. The right part is intended for results display in graphs form, but also for numeric values display, which we require (in this case for comparison of models with different input parameters). Role of the field at the bottom of right part is informing user, in which phase is the calculation momentarily.

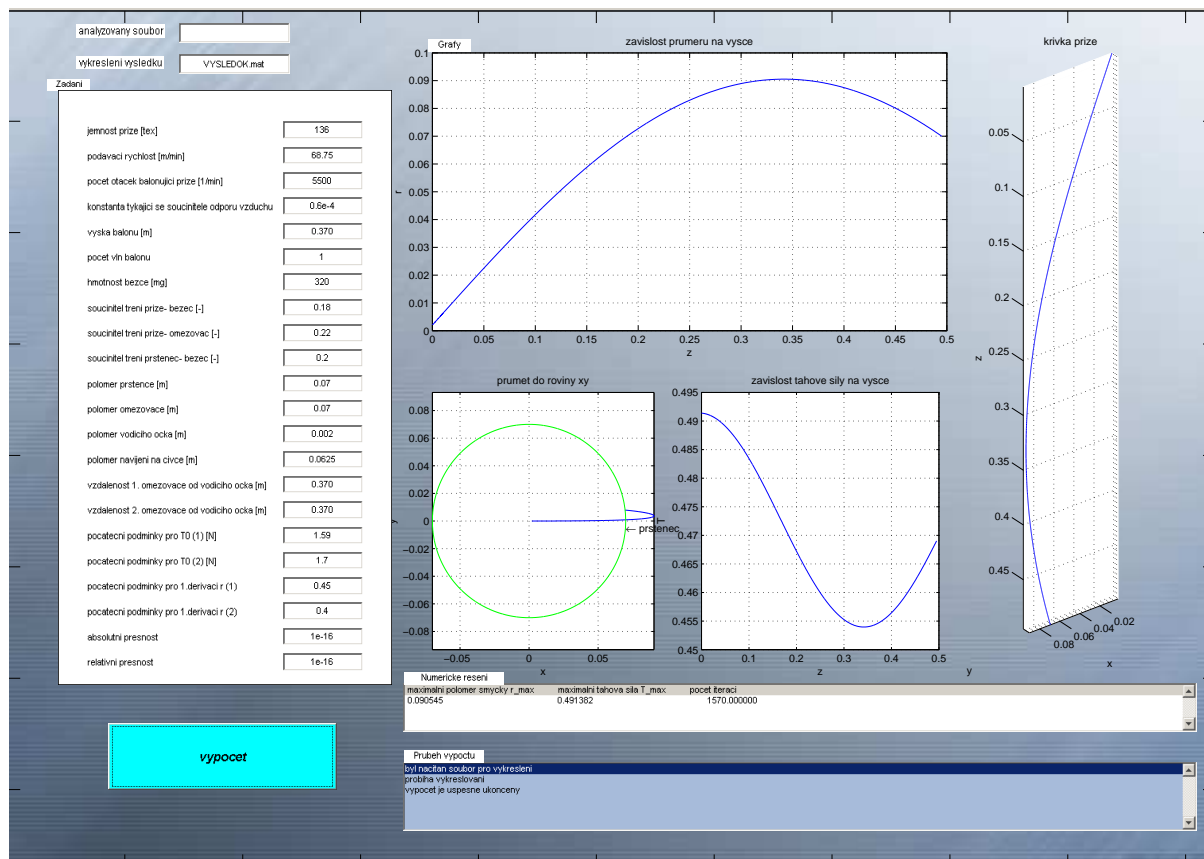


Figure 4: An example of the GUI for modelling of the loosely ballooning yarn

After a small modifications of the GUI is possible to apply an else model, too (Fig. 4).

This way displayed results can be saved in picture format (\*.jpg, \*.bmp or \*.eps), print with selected setting or saved as as numerical results (\*.txt).

## 6 Conclusion

In this article is presented the graphical user interface for modeling of the ballooning yarn. At present it meets the requirements, which are imposed. This interface is possible to improve, of course, e.g. load file with different combinations of the input values with debuged intial conditions. Other possibility is to enable the rotation of the 3D graph and further work with graphic outputs (values taking, insertion of results of another simulations).

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