

DESIGN OF A PROGRAM FOR CHECK AND CALCULATION OF BELT GEARS

LUBA BICEJOVA

Technical University of Kosice
Faculty of Manufacturing Technologies with a seat in Presov,
Department of Technical Systems Design and Monitoring,
Presov, Slovak Republic

DOI : 10.17973/MMSJ.2017_11_201726

e-mail: luba.bicejova@tuke.sk

The paper deals with the design of a program for calculation of belt gears. The aim of the presented paper is to create the program for check and calculation of belt gears and consequent comparison of the results of the newly created program with the existing ones. The introductory part of the paper analyses the issue of belt gears, their categorization as well as the design and calculation of the belt gears. The core of the paper focuses on the most frequently used software applied in the design and calculation of belt gears. The summary describes the design regarding the calculation of the belt gears and final comparison of calculations.

KEYWORDS

belt gear, design, calculation, program

1 INTRODUCTION

The drives represent the most significant parts of machines transferring kinematic and force effects from a driving motor to a working tool. It usually consists of several components which are interconnected and exposed to considerable stress. The components are frequently overloaded and thus the machine is extensively worn and damaged. Consequently, such machine is put out of operation. Therefore selection of appropriate layout of drive and correct design of its individual components represent a principal precondition to achieve reliable, safe, and economic machine operation [Mascenik 2011].

One of the aims of the paper is to clarify the issue of belt gears and analyse some of the available softwares for the design and check of the belt gears. The main aim is to design the program for the calculation of parameters inevitable for the belt gear design [Bicejova 2016a]. The market offers wide assortment of belts and therefore correct specification of conditions of machine operation under which the gears shall be used is rather important. Currently, V-belts and toothed belts are quite often employed.

The introduction of the presented paper explains the issue of the design and check of the mechanical belt gears by means of the available softwares. The following programs were selected: MechSoft, Autodesk Inventor, MITCalc and ContiTech Suite. The main aim of the paper is to present a newly designed program for the design and control of mechanical gears, particularly of belt gears along with the new program design. The designed program was developed in the programming language C# by means of the programming tool Visual Studio Community which is the most commonly employed in creation of database programs. The chapter also contains information on selected programming tool and on properties of language C#, on starting the designed program, on selection of calculation method and on displaying of the calculation results in the designed program.

2 ANALYSIS OF AVAILABLE SOFTWARES FOR DESIGN OF BELT GEARS

MechSoft Program

MechSoft containing over fifty detailed engineering calculations. For instance, the calculation of gears of front and conical toothing, calculation of gears by means of the V-belt, by means of the toothed belt or chain, calculation of a fold joint, calculation of a joint by a key, check of a joint by welding, calculation of springs, calculation of bearings, check and design and calculation of shafts, design and calculation of cams, check and calculation of supports, etc. [Bicejova 2016b] The calculation outputs can be represented by parametric models and all calculated objects occurring in the drawings contain complete information on calculation thus anytime the object can be altered and functional bonds among objects could be formed. MechSoft comprises a detailed engineering manual in electronic form with further structural information and basic data.

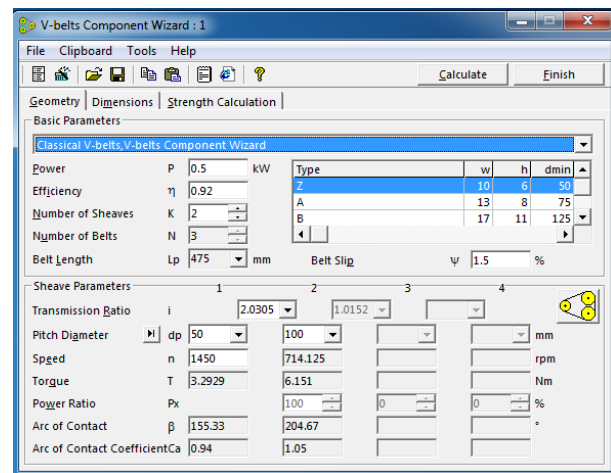


Figure 1. Program MechSoft

Calculation of Gear with the V-belts and with the Toothed Belts

One of the program modules is intended for calculation of transfer by the V-belts with standard sections as well as by the V-belts of narrow sections. The program allows complete designing and calculation of the belt gear. In fact, two types of calculation can be performed as follows:

- design - it designs the belt type meeting required properties of the gear.
- strength - it calculates strength check of the selected belt type [Mascenik 2012].

Autodesk Inventor Program

The program of Autodesk Inventor contains complex tools for generation of exact structural and manufacturing documentation directly off the 3D model. It includes the tools for design on the basis of rules and automation of standard tasks which facilitate the work and allow the users to concentrate on the structural aim instead of manual modelling of geometry. Autodesk Inventor captures functional requirements of the design and employs them in automatic creation of intelligent components and acceleration of the individual design phases. It helps:

- define complex configurations of products,
- increase development productivity,
- optimize designs [Balazikova 2016].

The program allows creation and analysis of the entire product prior to its production. At the same time the program enables to make use of advantages of the digital prototyping by the integration of the 2D drawings from application of Autodesk AutoCAD and 3D data into a single digital model [Bicejova

2016c]. The digital model creates virtual illustration of the final product and assists the companies with better designing, visualisation and simulation of the product. Relying on costly physical prototypes is thus avoided. It also helps launch the products more quickly and reinforces their competitive advantage [Salokyoiva 2016a].

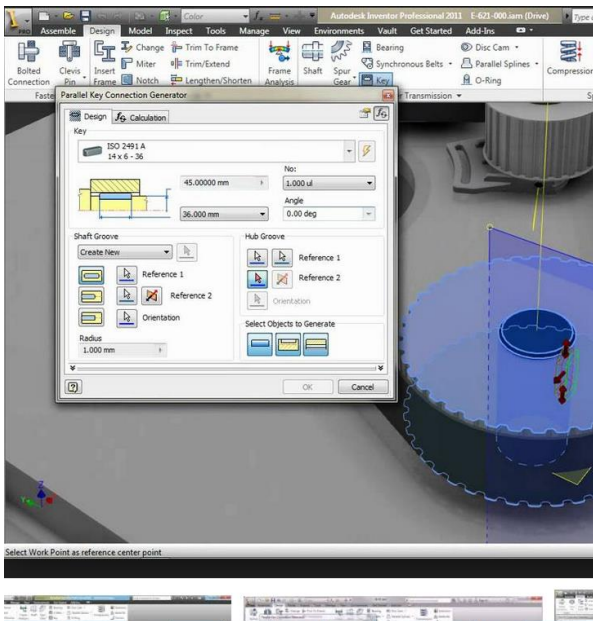


Figure 2. Calculation of the V-belt by the Autodesk Inventor program

MITCalc Program

MITCalc represents a system designed in Microsoft Excel. It is a set of engineering, industrial and technical calculations for everyday practice which provides a reliable, exact and fast overview of the design of the component, solution of technical issue or calculation of engineering and mechanical tasks. MITCalc contains design and check calculations such as following: front toothing (inner and outer), conical toothing, planetary gear, V-belts, toothed belts, chain gears, bearings, supports, plates, shells, shafts, springs, screwed joint, shaft connection, tolerances, pressed joint, pins, tolerance analysis, welded joints, technical formulae, and many others. A number of material, comparing and decision tables is at disposal including a system for administration of the solved tasks.

Belt transmissions - V-belts [mm]			
i Calculation without errors.			
ii Project information			
V-Belts, 3 Pulleys			
1.0 Manner of loading, operational parameters			
2.0 Design of geometry and number of belts			
3.0 Results, coefficients			
4.0 Pulley and belts dimensions			
V-Belts, 2 Pulleys			
5.0 Manner of loading, operational parameters			
5.1	Transferred power / power distributed to pulleys	P	15 14,37 [kW]
5.2	Speed of pulleys	n	1500,0 800,0 [1/min]
5.3	Transmission ratio	i	1,875
5.4	Torque	Mk	95,50 171,54 [Nm]
5.5	Type of driving units (loading)	B. Moderate shocks	
5.6	Types of driven machine (loading)	A. Light duty	
5.7	Daily loading of the transmission	B. Over 8 - less than 16 hours	
5.8	Belt slip coefficient	0,94	0,94 [%]
5.9	Transmission efficiency	95,8	95,8 [%]
5.10	Automatic design - press the button	Automatic design	<input checked="" type="checkbox"/>
6.0 Design of geometry and number of belts			
7.0 Results, coefficients			
8.0 Pulley and belts dimensions			
9.0 Graphic output, CAD systems			
9.1	Output of 2D drawing to:	DXF File	
9.2	Scale of 2D drawing	Automatic	
9.3	Use the data from calculation of:	Of two pulleys	
9.4	Detail:	Pulley 1	α 20 [°]

Figure 3. MITCalc in environment of MS Excel

One of the modules of the MitCalc program is also a module for the V-belts. The calculation is intended for both geometrical

and strength design of the belt gears by V-belts. The program solves the following tasks:

- calculation of 2 or 3 belt pulleys,
- automatic design of gears with minimal number of inputs,
- design and calculation of geometrical parameters (diameters of belt pulleys, axial distances, belt length, weight of gear),
- calculation of strength parameters (performance transferred by the belt, number of belts),
- calculation of force ratios (pre-stress, axial loading of belt pulleys),
- support of the 2D and 3D CAD systems [Bicejova 2013a].

The program cooperates with the CAD systems and contains the respective models of belt pulleys and belts. The calculations employ the procedures, algorithms and data of the ANSI, RMA (Rubber Manufacturers Association), ISO, DIN, BS documents and standards and of the basic documents from the catalogues of the company CONTITECH R [Mascenik 2014a,b].

ContiTech Suite Program

The CONTITECH SUITE calculation program represents a professional tool for the design of belt gears. The basic advantages are as follows:

- provides tabular user environment,
- allows design of drives within short period of time,
- allows complete solution of the design including the protocol on results and graphical representation.

The program allows fast and reliable solving of the calculations of any of the common types and kinds of belts such as:

- toothed belts,
- V-belts,
- grooved belts,
- multiple V-belts [Mascenik 2014].

The calculation results with all details can be saved, printed and sent in the PDF format by via e-mail.



Figure 4. Program ContiTech Suite

3 DESIGN OF THE PROGRAM FOR BELT GEAR CALCULATION

The program was designed in the programming language C# by means of the programming tool Visual Studio Community. In this development environment the design of the desktop application with the application of WPF technology was employed. In case of such design type the XAML language was applied in a high degree [Halko 2013].

Programming Language C#

C# represents an object oriented programming language developed by the Microsoft Company with the NET Framework platform. C# is based on the languages C++ and Java. It can be referred to as “an indirect descendant of the C language which syntax is drawn from”. Contrary to other programming languages the C# assures correct memory release. The operation is provided by a garbage collector. At the same time the errors can be processed by means of exceptions and it should behave accordingly [Gaspar 2013].

The C# is the most frequently employed in generation of database programs, form applications, web applications and pages, web service as well as in software development for mobile devices [Mascenik 2016a].

Properties of the C#:

- each category can be a descendant of a single category only and multiple inheritance is absent,
- global variables are absent, functions as well as methods must declared within the category at all times. Yet static variables and methods can be used instead which are implemented into a public category,
- declaration order of methods is not significant in the C# language,
 - the C# language distinguishes between small and capital letters and is “case sensitive” [Krenicky 2011, Murcinkova 2013].

The user interface is designed to be tabular and intuitive. The emphasis is put especially on balanced ratio between interactivity and simple control. The main application window is divided into six basic parts. Each of the parts contains several control or display elements. In the part “Calculation Method” the unpack menu offers three loading methods which influence the steps of individual calculations. Other part “Belt” contains two unpack elements by means of which the belt type and properties can be selected. Apart from the two elements a button “Help” can be found through the activation of which the window with graphs is opened. The graphs help to select the belt parameters [Bicejova 2013b].

The most important part of the main application window is the part “Parameters”. The part contains the fields for entering the input data. According to program logic only few of the fields are active that must be filled and in the course of calculation the other are gradually activated. A few more “Help” buttons can be found here as well. To display the basic results the part “Results” is at disposal which shows the individual values during calculation. All fields in this part are inactive and thus they cannot be rewritten. The entire part with results is filled when the calculations have been completed. The bottom part of the window contains buttons by which the calculation is controlled or the results can be displayed continuously in a separate window. The upper left corner of the application contains the unpack menu for work with data and with the program window itself. In this part a new window can be opened for a separate calculation as well as actual calculation can be reset or saved in the .pdf or .xlsx format. The menu also offers possibility to display the information on application.

Program Start-up

The application is started by clicking on the icon of the generated program. When the program has been started, the main window appears with some of the pre-set values. It is the case of initial setting of the values for selection of the loading method in calculation and for selection of the V-belt type. In the initial setting the rolling buttons are active and thus their values can be changed during this stage of calculation. In part of application for the value entering there are three text fields active after start-up. Number and type of active fields is

changed according to the setting of loading method. Due to emphasizing of the necessity of entering or modification of data the text fields are highlighted. [Mascenik 2016b]



Figure 5. Application window after start-up of the developed program

Selection of Calculation Method

According to the type of task it is inevitable to opt for the loading method of the designed gear. Three possible loading types can be opted from the following:

- entered performance and revolutions and torque shall be calculated,
- entered torque and revolutions and performance shall be calculated,
- entered torque and performance and revolutions shall be calculated [Puskar 2013].

Display of Results

When the calculations have been completed, the results can be displayed as follows:

- display of results in a separate application window – option serves for detailed calculation result preview in the application window. The window with results shall be displayed after clicking on the button “Result Preview”.
- print in the .xlsx format – complete results can be exported to the file in the .xlsx format which can consequently be opened for instance by the Microsoft Excel program.
- print in the .pdf format – final results can also be exported to the .pdf format [Pavlenko 2016].

4 CONCLUSIONS

The main aim of the presented paper is to introduce a newly designed program for calculation of parameters inevitable for design and check of belt gear. The program was designed with the Visual Studio Community tool in the programming language C#. Considerable advantage of Visual Studio is possibility to employ the project templates the task of which is to assure that a programmer does not need to generate gradually all of the source files necessary for the project. The design of the presented application was generated in this development environment with the application of the WPF technology. In case of such designed type the language XAML is used in a high degree. The user interface is designed to be tabular and intuitive [Mascenik 2016c]. The emphasis is put especially on balanced ratio between interactivity and simple control. Calculation of the belt gears in the designed program is given by the individual steps which must be followed to achieve the most accurate result [Salokyova 2016b]. To verify the calculation results and usability of the designed application in practice, the data acquired from three sources were compared during designing of the program – i.e. through manual

calculation, by the MechSoft program and by the designed application. In the future the program could be extended by calculations of the toothed and of the flat belt gears as well as by calculations with more belt pulleys. Further program improvement could include automatic entering of tabular values into calculations or graphical representation of the designed gear.

ACKNOWLEDGEMENTS

This article has been prepared within the project KEGA O80TUKE-4/2015.

REFERENCES

- [Balazikova 2016] Balazikova, M. Assessment of ergonomic risks of the selected work activity by niosh method, Science. Business. Society. Vol. 1, No. 5, 2016, pp. 42-45. ISSN 2367-8380
- [Bicejova 2013a] Bicejova, L. Water jet technology head vibration generation due to selected technology parameters fluctuation effect during alloy cutting. Applied Mechanics and Materials, Vol. 308, 2013, pp. 81-86. ISSN 1660-9336
- [Bicejova 2013b] Bicejova, L., Pavlenko, S., Mascenik, J. Abrasive Granularity Impact on Water Jet Technology Head Vibrations during Cutting Steel. Applied Mechanics and Materials, 2013, pp. 304-309. ISSN 1660-9336
- [Bicejova 2016a] Bicejova, L., Pavlenko, S., Mascenik, J. Measuring, processing and evaluating of technology head water jet vibration signal. Key Engineering Materials: Operation and Diagnostics of Machines and Production Systems Operational States 3. Vol. 669, 2016, pp. 205-211. ISBN 978-3-03835-629-5, ISSN 1013-9826
- [Bicejova 2016b] Bicejova, L. and Pavlenko, S. Experimental investigation and determination of abrasive granularity change impact to technology head vibration generating during awj technology steel cutting. Key Engineering Materials: Operation and Diagnostics of Machines and Production Systems Operational States 3, Vol. 669, 2016, pp. 220-227. ISBN 978-3-03835-629-5, ISSN 1013-9826
- [Bicejova 2016c] Bicejova, L. and Pavlenko, S. Influence of selected technological parameters on cutting surface roughness in material laser cutting. MM Science Journal, Vol. 2016, No. September, 2016, pp. 973-976. ISSN 1803-1269, DOI: [10.17973/MMSJ.2016_09_201645](https://doi.org/10.17973/MMSJ.2016_09_201645)
- [Gaspar 2013] Gaspar, S. and Pasko, J. Influence of technological factors of die casting on mechanical properties of castings from silumin. Lecture Notes in Electrical Engineering, Vol. 240, 2013, pp. 713-722. ISSN 1876-1100
- [Halko 2013] Halko, J. and Mascenik, J. Differential with an integrated, newly - developed two-stage transfer. Applied Mechanics and Materials: Materials Engineering for Advanced Technologies ICMEAT 2013, Vol. 510, 2014, pp. 215-219. ISSN 1662-7482
- [Krenicky 2011] Krenicky, T. Implementation of Virtual Instrumentation for Machinery Monitoring. In: Scientific Papers: Operation and Diagnostics of Machines and Production Systems Operational States: Vol. 4, RAM-Verlag, Lüdenscheid, 2011, pp. 5-8. ISBN 978-3-942303-10-1
- [Mascenik 2011] Mascenik, J. and Gaspar, S. Experimental Assessment of Roughness Changes in the Cutting Surface and Microhardness Changes of the Material S 355 J2 G3 after Being Cut by Non-Conventional Technologies. Advanced Materials Research, Vol. 314-316, 2011. ISSN 1022-6680
- [Mascenik 2012] Mascenik, J. The evacuation of pressure moulds as progressive developments of die casting process.

Acta Technica Corviniensis : Bulletin of Engineering, Vol. 5, No. 3, 2012, pp. 25-26. ISSN 2067-3809

[Mascenik 2014a] Mascenik, J. and Pavlenko, S. Aspects of alternative dispute creating bolted joint technology flowdrill. Applied Mechanics and Materials: 2nd International Conference on Mechanical Structures and Smart Materials, 2014, Kuala Lumpur, Malaysia. Vol. 680, 2014, pp. 186-189. ISSN 1660-9336

[Mascenik 2014b] Mascenik, J. and Pavlenko, S. Determining the exact value of the shape deviations of the experimental measurements. Applied Mechanics and Materials, Vol. 624, 2014, pp. 339-343. ISSN 1660-9336

[Mascenik 2016a] Mascenik, J., Pavlenko, S., Bicejova, L. A device designed to monitor new belt types with application of diagnostic system. MM Science Journal. Vol. 2016, No. September, pp. 931-934. ISSN 1803-1269, DOI: [10.17973/MMSJ.2016_09_201624](https://doi.org/10.17973/MMSJ.2016_09_201624)

[Mascenik 2016b] Mascenik, J. and Vojtko, I. Experimental monitoring and diagnostics of belt gears in testing device. MM Science Journal, Vol. 2016, No. September, pp. 964-968. ISSN 1803-1269, DOI: [10.17973/MMSJ.2016_09_201641](https://doi.org/10.17973/MMSJ.2016_09_201641)

[Mascenik 2016c] Mascenik, J. Experimental determination of cutting speed influence on cutting surface character in material laser cutting. MM Science Journal, Vol. 2016, No. September, pp. 960-963. ISSN 1803-1269, DOI: [10.17973/MMSJ.2016_09_201639](https://doi.org/10.17973/MMSJ.2016_09_201639)

[Murcinkova 2013] Murcinkova, Z. and Krenicky, T. Implementation of virtual instrumentation for multiparametric technical system monitoring. In: SGEM 2013: 13th international multidisciplinary scientific geoconference: Informatics, geoinformatics and remote sensing, 2013, Bulgaria-Sofia: STEF92 Technology, pp. 139-144. ISSN 1314-2704

[Pavlenko 2016] Pavlenko, S. Determination of relation between influence of laser performance change and cutting surface character in laser cutting technology. MM Science Journal, Vol. 2016, No. September, 2016, pp. 952-955. ISSN 1803-1269, DOI: [10.17973/MMSJ.2016_09_201637](https://doi.org/10.17973/MMSJ.2016_09_201637)

[Puskar 2013] Puskar, M., Bigos, P., Balazikova, M., Petkova, V. The measurement method solving the problems of engine output characteristics caused by change in atmospheric conditions on the principle of the theory of optimal temperature range of exhaust system. Measurement: Journal of the International Measurement Confederation (IMEKO), Vol. 46, No. 1, 2013, pp. 467-475. ISSN 0263-2241

[Salokyova 2016a] Salokyova, S. and Krenicky, T. Analysis of the effects of factors in relation to vibration of technological head during the splitting of construction steels through hydro-abrasive splitting. Key Engineering Materials, Vol. 669, 2016, pp. 216-219. ISSN 1013-9826

[Salokyova 2016b] Salokyova, S. Measurement and analysis of mass flow and feed speed impact on technological head vibrations during cutting abrasion resistant steels with abrasive water jet technology. Key Engineering Materials, Vol. 669, 2016, pp. 243-250. ISSN 1013-9826

CONTACTS

M.Sc. Luba Bicejova, PhD.,
Department of Technical Systems Design and Monitoring,
Faculty of Manufacturing Technologies with a seat in Presov,
Technical University of Kosice, Presov, Slovak Republic
Bayerova 1, Presov, 080 01, Slovak Republic
+421 51 772 6321, luba.bicejova@tuke.sk, www.tuke.sk