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| **Research programme:**   1. **Research, development and practical application of methods and devices for the measurements of the technical parameters of machinery** |
| **Prvním cílem** projektu je další rozvoj teorie měření, zpracování dat a hloubkových analýz pro oblast točivých strojů, např. vačkových mechanismů, převodovek, řemenových převodů, torzních kmitů a v poslední době i řízených servopohonů. **The first goal** of the project is to further develop the theory of measurement, data processing and in-depth analyses of rotating machines, such as cam mechanisms, gears, belt transmissions, torsional oscillations and recently also controlled servo drives/actuators. Lze přitom navázat na vlastní vyvinuté, ověřené a používané postupy a metody dynamického měření úhlů, úhlových rychlostí a zrychlení, včetně přesných diferenciálních měření, s možností synchronního zápisu s dalšími fyzikálními veličinami pro komplexní analýzy. At the same time, it can be continued in our own developed, validated and applied procedures and methods of dynamic measurement of angles, angular velocities and accelerations, including the precise differential measurements, with the possibility of synchronous registration with the other physical quantities for complex analyses. Rozvíjený systém umožní řádově vyšší přesnost měření než je obvyklé. The developed system will enable a higher-order accuracy of measurements than it is usual. Využívá recipročních metod a neekvidistantního vzorkování. It uses the reciprocal methods and non-equidistant sampling. K uvedenému přístupu nelze použít klasické teorie zpracování diskrétních signálů a musí být odvozeny nové teoretické závěry. To the above mentioned approach, conventional theories of discrete signal processing cannot be used and new theoretical results must be derived.  **Druhým cílem** je vytvoření pracoviště pro měření a analýzu strojů s vysokou dynamikou a přesností. **The second goal** is to create a facility for the measurement and analysis of machines with high dynamics and precision. Pracoviště vyžaduje řadu upínacích stendů s velkou základovou hmotou pro definované uložení strojů. The workplace requires a number of clamping stands with great base material to a defined storage of machines. K dispozici bude řada rotačních řízených dynamometrů pro pohon a brzdění strojů a sada řízených vibrátorů. It will be available a series of rotating controlled dynamometers for driving and braking machines and a set of controlled vibrators. Zatěžovací zkoušky bude možné provádět i při definovaných klimatických podmínkách. Rozsáhlé přístrojové vybavení umožní přesná měření kinematických veličin, deformací a teplot. It will be possible to carry out load tests even when defined climatic conditions. Extensive instrumentation will allow accurate measurements of kinematic variables, deformations and temperatures. Ve vybavení budou i potřebné metrologicky navázané kalibrační prostředky. In the equipment there will be also metrologically traceable calibration means. Předpokládá se také vybavení pro zkoušky mechanických vlastností materiálů. It is also assumed facilities for testing the mechanical properties of materials.  **Třetím cílem** bude vybudování specializovaného pracoviště pro měření a snižování hluku a vibrací, technickou diagnostiku a zákaznické poradenství v těchto oblastech. **The third goal** will be to build a special workplace for measuring and reducing noise and vibrations, technical diagnostics and customer technical advice in these areas. V rámci pracoviště budou vytvořeny a aplikovány postupy pro identifikaci a popis dílčích zdrojů hluku a vibrací, pro analýzu vzájemné souvislosti šíření hluku a vibrací a pro analýzu jejich vztahu k modálním a dynamickým vlastnostem strojních soustav. Within the workplace, there will be developed and applied procedures for the identification and description of partial sources of noise and vibrations, the analysis of mutual connections of the spread of noise and vibrations and for the analysis of their relationship to the modal and dynamic properties of mechanical systems. Základem bude bezodrazová a dozvuková laboratoř pro definovaná měření hluku a vibrací vybavená moderní přístrojovou technikou. Na základě měření a analýz budou navrhovány a realizovány tradiční i netradiční opatření vedoucí k potlačení emisí hluku a vibrací. Nedílnou součástí bude výzkum a vývoj netradičních autonomních zákaznických řešení technické diagnostiky strojů. An anechoic and echo laboratory chamber for defined measurements of noise and vibrations equipped with up to date instrumentation will be a base. Based on the measurement and analyses, there will be designed and implemented both traditional and non-traditional measures to suppress noise emission and vibration. An integral part, there will be the research and development of innovative autonomous customer solutions of the technical diagnostics of machines.  **Čtvrtým cílem** je vytvoření unifikovaných modulárních systémů pro verifikaci matematických modelů strojů a zařízení měřením. **The fourth goal** is to create unified modular systems for the verification of mathematical models of machines and equipment by measurements. Matematické modely a výpočetní systémy (FEM, CAE a další vznikající a rozvíjející se výpočetní a modelovací systémy) jsou ve vědě a technice nenahraditelné. Výsledky výpočtů se však u složitých systémů často významně liší od skutečnosti. Mathematical models and computer systems (FEM, CAE and other emerging and developing computational and modeling systems) are in science and technology irreplaceable. The results of the calculations, however, are often significantly different from reality for complex systems. Důvodem je, že se nedaří správně zadat všechny výpočetní parametry a okrajové podmínky modelu a často se použije i jejich nevhodné zjednodušení. The reason is that one can fail to correctly enter all the parameters of the computational model and boundary conditions, and often their inappropriate simplification will be used. Proto se modely ověřují a ladí podle výsledků měření na skutečných nebo vhodně zjednodušených mechanických modelech. Therefore, the models are verifying and debugged as to the results of the measurements on real or suitably simplified mechanical models. Další významnou možností ke zpřesnění a zjednodušení výpočetních systémů a modelů je nahrazení části modelu změřenou veličinou, např. průběhem úhlové rychlosti hnacího hřídele stroje, průběhem působící síly a pod. Another important opportunity to precising and simplifying computing systems and models is replacing a part of the model by a measured variable, such as the course of the machine drive shaft angular velocity, the course of the applied force. To obvykle vede vedle zkvalitnění a zrychlení výpočtu i ke snížení nákladů na tvorbu software. This usually results in improving and accelerating the calculation, in addition to reducing the cost of creating software.  **Pátým cílem** bude výzkum a realizace speciálních snímačů a měřicích zařízení a jejich komponent. **The fifth goal** will be the research and realization of special sensors and measuring devices and their components. Vznikne modulární systém, pomocí kterého bude možné rychlé sestavení potřebných speciálních měřicích zařízení včetně jejich jednotného SW vybavení. This will provide a modular system by means of which it will be possible to rapidly build the required special measurement devices, including their unified SW equipment. Uživatelům z řad vývojových i výrobních podniků bude možné dodávat snímače a měřicí zařízení, které se pro požadované specifické vlastnosti na trhu nevyskytují nebo svými parametry nevyhovují. To the users from development and manufacture companies, it will be possible to supply sensors and measuring devices which are not available on the market for the required specific properties or which do not comply with their parameters.  **Šestým cílem** bude výzkum měřicích metod a postupů zaměřených na kvalitativní parametry textilních produktů a na vzájemné působení textilních materiálů a výrobních orgánů textilních strojů. **The sixth goal** it will be the research of measurement methods and procedures aimed at the qualitative parameters of textile products and the interactions between textile materials and textile machinery manufacturing organs. Se zvyšujícími se výkony strojů bude nutné inovovat vlastní řadu speciálních textilních snímačů, které jsou již řadu let vyráběny. With the increasing performances of machines, there will be a need to innovate the own series of special textile sensors that are manufactured for many years. Většina speciálních snímačů a měřicích postupů je patentově chráněna. Hlavní pozornost bude zaměřena na výzkum a aplikace nové unikátní metody pro kontinuální měření poměrného prodloužení přízí, která poskytuje cenné informace o strukturách přízí. Most of the special sensors and measurement techniques are patent protected. The main attention will be focused on the research and application of a new and unique method for continuous measurement of the relative extension of yarns which provides valuable information about the structures of yarns. **Výstup 1.** Souprava pro vícekanálová precizní měření na točivých strojích s vysokou dynamikou – do 2015. |

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| **Research programme:**  **2. Research and application of mechatronical systems for controlling and driving the working links of mechanisms and machines** |
| **The first goal** will be research in the field of electronic cam dynamics  The electronic cam dynamics has been understood as *kinematic* (position, velocity, acceleration)and *dynamic* (driving accelerating moment) magnitudes being provided by a servomotor, i.e. power member of the electronic cam, on its output shaft. There is an intention to maximize these magnitudes. At present, it is given by a conception of driving systems of given manufacturer (e.g. Yaskawa, Siemens etc.). The dynamics is a function of available algorithms being realized in the development environment of the electronic cam; or in other words, it is possible to be realized by means of software aids in the control program. This is the principal topic of goal 2. The principal topic of this point is, however, the research of dynamics as a function of *the* *control structure* of the electronic cam or servomotor respectively. The control structures are usually of the cascade type with positional, velocity and current coupling. The possibility to interfere with control structure and parameters has been specified by the producer, who generally prefers his own business aims. However, the principal aim of the dynamics research there is the research of the servomotor control to reach the maximum dynamics. For this purpose, there is necessary to build special stands and to use one-purpose electronics with special software aids (e.g. Matlab) where it is possible to study the dynamics problem. The result is then higher dynamic parameters that affect the manufacturer of the electronic cams. We contact the field of the basic research in this direction.  This field of dynamics includes the questions how to eliminate residual vibrations, which are caused by the flexible links in electronic cam mechanism.  *The defined aims* in this research field there are also special stands, hardware and software modules which enable the higher dynamics of electronic cams in connection with positional accuracy of motion functions being generated by the electronic cams. These results will be used for creation of new algorithms and their verification in the control system of the electronic cam and for the design of new control structures in the servomotor control.  **The second goal** will be research in the field of electronic cam control systems in connection with control systems of machines  The electronic cam control system has been realized in the controller which has the *PLC* (Programmable Logic Controller) and *continuous motion* fields. The electronic cam has been realised in the PLC field. The time passages (scans) of the PLC are always shorter, and storage and software possibilities broaden. There are two directions of the research in this field. In *the first direction*, there is to realize the knowledge in accordance with point 1 or to realize the algorithms which increase the electronic cam dynamics and minimize the residual vibrations respectively. T*he latter direction* concerns the development and realization of the entire electronic cam control system in connection with the control system of the whole processing machine or processing systems respectively. The control system of the machine or the electronic cam must be built in such a way to enable an efficient enlargement in accordance with realized motion axis number. All of it relates to the mutual connection of the electronic cam system and the processing machine system as well. Another research field in this software field there is the realization of the *motion working function* of the electronic cam. The motion function is defined by its first three *derivatives* and the handling these derivatives results in a lot of influence, e.g. on the positional accuracy of the motion function.  *The defined aims* in this research field there is the conception and realization of the electronic cam control systems based on a chosen hardware platform (e.g. Yaskawa, Siemens, etc.). The developed control systems will contain possible algorithms in accordance with point 1 and solve the realization way of the motion function of the servomotor shaft with maximum dynamic including the solution disturbing residual vibrations. Another aim is the conception and realization of communication of the electronic cam system with other subsystems of the processing machine including solution of integration of the electronic cam and the communication to the higher-level control system of this machine or processing system respectively.  **The third goal** will be research in the field of mechatronic drives of working links  Research aim based on characteristic properties of the conventional cam and electronic cam systems there is to propose a method and solution for a brand new high quality differential drive, which would unite the favourable properties of both cam systems in the optimum way. This *mechatronic drive method* of the working links is expected to bring the synergic effect at that point that there will be possible, in special cases, to realize such applications being complicated from the dynamics point of view, which are not possible to be realized by means of the cam-joint mechanisms or electronic cams alone. The solution results from our own (patented) mechatronic method of drive of the working links of mechanisms. It is the principal of a differential, the one power input of which is the motion function being generated by a conventional cam or joint mechanism and the latter input is the reprogrammable function of the electronic cam. The output is the desired motion. This parallel configuration of combinations of electronic and conventional mechanisms brings new possibilities. Another of possibilities there is a serial combination of mechanisms with conventional and electronic components. It is a conception of the drive of the input link of a conventional mechanism by means of the electronic cam.  These parallel and serial combinations bring new possibilities in applications of electronic cams and the drive shows the synergic properties. There belongs to this research field the permanent development of computing aids, which are the bases for modelling of mechanical properties and determination of kinetostatic parameters that are necessary for dimensioning and choice of servomotors.  This third research cycle unites the research of dynamics of the electronic cams with the solution of problems of control systems in applications of the mechatronic drives with new properties.  *The defined aims* in this research field is development, design and building of prototypes of mechatronic driving systems in parallel and serial combination of conventional and electronic mechanisms. *Another aim* there is computation software for the kinetostatic analysis of these problems. The result of the analysis there is dimensioning of servomotors, which are used in appropriate mechatronic combinations. |

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| **Research programme:**  **3. Development and application of methods and procedures of calculations and mathematical modeling of the properties and behavior of machine complexes including their interactions with the environment.** |
| **Prvním cílem** výzkumného programu budou analýzy a optimalizace součástí strojů i rozsáhlých sestav metodou konečných prvků (FEM), a to jak v oblasti statiky, tak i dynamiky. **The first goal** of the research program will be the analyses and optimization of machine parts and large assemblies by the finite element method (FEM), both in statics and dynamics. V oblasti statiky budou prováděny deformační a napěťové analýzy a optimalizace součástí i rozsáhlých sestav, a to jak v lineární oblasti, tak s uvažováním materiálových, kontaktních a geometrických nelinearit. Within the statics, there will be carried out deformation and stress analyses and optimization of components and large assemblies, both in the linear region and with the consideration of material, contact and geometric nonlinearities. V oblasti dynamiky budou rozvíjeny poznatky, které budou následně aplikovány při výpočtech modální analýzy součástí a sestav, výpočtech vybuzených kmitů strojů a jejich rámů. In the field of dynamics, there will be developed pieces of knowledge that will subsequently be applied in the calculations of modal analyses of components and assemblies, the calculations of excited vibrations of machines and their frames.  Poznatky budou využity při predikci dynamického chování strojů v provozních podmínkách a budou sloužit zejména k vyloučení nežádoucích provozních stavů strojů (např. samobuzených kmitů obráběcích stroThe findings will be used to predict the dynamic behavior of machines in operating conditions and they will serve mainly to avoid undesirable operating conditions of machines (e.g. self-excited vibrations of machine tools).  Metodou konečných prvků budou připravovány též superelementy poddajných těles pro použití ve výpočetních modelech mechanismů. By the finite element method, there will also be prepared the superelements of elastic bodies for the use in the computational models of mechanisms. Pro verifikaci FEM modelů budou používány výsledky měření na reálných strojích. For verification of FEM models, there will be used the results of measurements on real machines.  **Druhým cílem** bude experimentální zjišťování (metoda jednoosé tahové zkoušky při zatěžování tahem, tlakem nebo cyklickým namáháním) vlastností materiálů s nelineárním chováním při mechanickém namáhání, typickým např. u plastů či vláknových kompozitů, a to při různých teplotách (-70C **The second goal** will be the experimental testing (uniaxial tensile test method at tensile, pressure loading, or cyclic strain) of the properties of materials with nonlinear behavior at mechanical stress, which is typical for example at plastics or fiber reinforced composites, at different temperatures (-70 C0 o až +250 C o ). up to +250 CoDále bude vytvářena databáze těchto materiálů obsahující jejich detailní popis (pracovní diagramy).). Moreover, a database of these materials with their detailed description (working diagrams) will be created.  **Třetím cílem** bude přiřazení vhodného fyzikálního materiálového modelu k daným materiálům z vytvořené databáze. **The third goal** will be to assign an appropriate physical material model for the given materials from the created database. Materiálový model, sloužící k simulaci vlastností daného materiálu ve FEM modelu, bude verifikován pomocí FEM analýzy odpovídající příslušnému experimentu.The material model used to simulate the properties of the given material in the FEM model will be verified by a FEM analysis corresponding to the appropriate experiment.  **Čtvrtým cílem** bude optimální nahrazení mechanicky exponovaných těžkých kovových součástí novými díly vyrobenými na bázi vláknových kompozitů s termoplastickými a termosetovými matricemi. **The fourth goal** will be the optimal replacement of mechanically exposed heavy metal parts with new parts made on the basis of fiber composites with thermoplastic and termoset matrices.  **Pátým cílem** budou simulace a optimalizace mechanismů vedoucí ke snižování nežádoucích dynamických účinků (včetně hlukové zátěže) a ke zvyšování pracovních otáček a produktivity strojů. **The fifth goal** will be the simulation and optimization of mechanisms leading to the reduction of adverse dynamic effects (including noise pollution) and to an increase of the working speed and productivity of machines. Mechanismy budou uvažovány jako „multi-body“ systém při respektování tuhých i poddajných členů, kontaktů a kinematických vazeb s vůlemi a třením. Mechanisms will be considered as "multi-body" systems in compliance with rigid and compliance members, contacts and kinematic linkages with clearances and friction.  **Šestým cílem** bude verifikace matematických modelů strojů na základě experimentálně-výpočetních metod měřením na reálném stroji - vlastní frekvence a tvary kmitů, frekvenční dynamické poddajnosti, okrajové podmínky, hodnoty tuhosti a tlumení, momenty setrvačnosti apod. **The sixth goal** will be the verification of mathematical models of machines based on experimental-computational methods by measuring on a real machine - natural frequencies and wave shapes, frequency dynamic compliance, boundary conditions, stiffness and damping values, moments of inertia, etc.  **Sedmým cílem** bude aplikace a rozvoj numerických simulací obecných proudových polí (rychlostních, teplotových atd.) v rozmanitých teoretických i technických aplikacích proudění, především při výzkumu a vývoji pneumatických a hydraulických součástí a systémů, tepelně technikých zařízení apod. Numerická simulace umožní na jedné straně modelovat výchozí hypotézy nových řešení, zjistit jejich reálnost a případně navrhnout úpravy. **The seventh goal** will be the application and development of numerical simulations of general flow fields (velocity, temperature fields etc.) in a variety of theoretical and technical applications of flow, especially in the research and development of pneumatic and hydraulic components and systems, thermally technical equipment etc. The numerical simulation will enable to model, on the one hand, the initial hypotheses of new solutions, to identify their feasibility and to propose appropriate modifications, as the case may be. Na druhé straně, u stávajících zařízení lze např. odkrýt příčinu nesprávné či nehospodárné funkce systému a navrhnout úpravy, vedoucí ke zvýšení spolehlivosti, účinnosti apod. Výsledky numerické simulace proudění lze aplikovat nejen ve strojírenství a tepelné technice, ale i v jiných oborech (stavebnictví, textil, životní prostředí,...). On the other hand, with the existing equipment, e.g., it can be possible to uncover the cause of an improper or inefficient operation of the system and to propose adjustments to increase the reliability, efficiency, etc. The results of numerical simulation of flow can be applied not only in mechanical and thermal technology, but also in other sectors (building, textiles, environment ,...). **Výstup 1.** Databáze materiálů s nelineárním chováním (plastů, vláknových kompozitů) - několik základních materiálů matrice s různými hodnotami objemového podílu vyztužující složky - 2017. |

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| **Research programme:**  **4. Development and application of up-to-date methods and procedures in designing machines and devices for processing industry.** |
| **The first goal** will be the development of up-to-date methods of proposals, development and design of machines and devices.  These are characterized by a considerable measure of sophistication under which we realize the mutual coordination of all necessary work in linear time sequence leading to the most effective implementation of a machine or device design, i.e. from the problem setting to implementing and validating the prototype. Parallel coordination represents work sequence then when at the beginning (in a time period of designing a machine) all the fields and their intersections on one level are examined and the result is an ideal model of processing machine with securing and with a clear idea of implementation, i.e. setting the basic concept, implementation costs, computation analysis examination, choosing the drive conception, the control system with machine simulation environment, effective design (as far as the conditions enable it, applications of unified design elements then) and the preparation of securing a prototype manufacture. This trend, i.e. parallel synergism, is very often regarding shortening product innovative cycles and it requires a complex and coordinative procedure. All the phases are to be involved in this chain.  **The second goal** wil be implementation of analyses and conceptual designs of machines and devices.  This domain must result from the long-term experience with proposals and designs and it can be stated that there exists no direct supporting means, e.g. SW, which would entirely replace this human activity. With all other activities, technical means can be used with larger or less intensity. When creating conceptual proposals it is necessary to go out from the requirements laid on the given machine or device and to take into account the pieces of knowledge about available components and parts within an optimum choice simultaneously. E.g. in servo-drives, electronic cams, mechatronic drive systems, manipulation systems, clamping systems, controlling and monitoring elements, inspection systems etc.  **The third goal** wil be development of sophisticated methods of pre-production analysis.  These are calculations and virtual simulations namely. When designing the device as a whole, CAD design parametric methods are used with success mostly. The proper model can be then subjected to various analyses already, such as are determining of deformations, stress and natural vibrations. Studying the influence of dynamic effects in processing mechanisms onto the deformations of proper links and force dynamic effects into the machine frame falls into this category of computations. In this field, collaboration with the CRSV group is expected, aimed at „The development and application of methods and calculation procedures and mathematical modelling of the properties and behaviour of machine units inclusive their interaction with the environment“.  **The fourth goal** will be virtual (computerized) simulations.  Within the field of designing mechanical flexible systems, these methods are well-known. A processing machine, on which its working motions are carried out with various mechanisms, cannot be, however, divided into the appropriate models of particular mechanical, electrical, hydraulic and other subsystems in a simple way because they are mutually each other influenced in the final phase. In such a way, a complicated mechatronic system of a processing machine is generated, which is to be virtually simulated. Then, a virtual simulation of the mechatronic system of a processing machine may enable to assess, evaluate and test all the possible states of running of a generated machine and in such a way to avoid unpredictable situations that considerably slow down and raise the price of the research and development without using simulation. Thus, remarkable time and fund savings can be attained. This demanding activity requires a close collaboration of a team of people which possess knowledge in the field of technical mechanics and designing, control and regulation, programming, electronics, electrotechnics and measurements. For this sphere, collaboration with CRSV groups engaged in the activity „Research and application of mechatronic systems for controlling and driving the working links of mechanisms and machines” and the activity „Research, development and practical application of methods and devices for measuring the technical parameters of machines and devices“is expected.  From the viewpoint of user spectrum of all the outputs of this activity, it is possible to speak about all the academic workplaces demanding development and design work as well as about all the user from the field of application, companies in the field of the processing industry, i.e. machine tools, glass, polygraphic, packing and food processing machines, one-purpose and other machines, except textile machines that will be investigated separately. |

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| **Research programme:**  **5. Sophisticated proposals and designs of machines for special textile applications** |
| **The first goal** will be technology for weaving technical fabrics.  Further development of the new conception of jet weaving machine is assumed which was verified in the operation of CAMEL machines, it will continue in implementing concepts for the combined weaving of conventional and leno weaves and jet weaving machine with hydraulic picking.  On unique patents of our owns, also further research of a weaving machine with a new conception of shed formation, i.e. two-zone shed and warp thread control via special drives which can replace complicated and expensive dobbies and jacquard machines will be established.  In addition, research and development work will be aimed at technologies for weaving very demanding yarns from glass, basalt, carbon and other fibres.  **The second goal** will be technologies for textile finishing.  With viewing to environmental aspects and searching for energy savings, new conceptual solutions will be sought, e. g., microwave drying machines for movable textiles, drying line with a combination of microwave and impact drying etc.  **The third goal** wil be technologies for special nonwoven textiles.  The work in this field will be directed to machine designs for nonwovens in continuation to the „Laid Scrim“ technology and to searching for new technologies of the formation of nonwoven textiles. New opportunities of non-conventional application of bio-fibre (nettles, some kinds of grass) in the textile production will be sought. |