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THE INFLUENCE OF CUTTING ENVIRONMENT UPON PRODUCTION MACHINE SHIELDS

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Abstract: Paper deals with the role and importance of scratch parts of telescopic covers of manufacturing plant in the total management of sliding machine solution. Telescopic covers design of machine elements are exposed to more adverse factor in the cutting process and material handling operations in the operating area of the machine. Telescopic covers represent a traditional form of cover edge guides, spindles, shafts, columns and other sensitive parts of the machine. Their main function is to protect against guides chips and cutting fluid, to prevent mechanical damage of the guiding surfaces of the machine, increase the lifetime of the machinery, visually improve the overall look of the machine and prevent injuries.

1. INTRODUCTION

Telescopic shields are machine design elements subject to the influence of several adverse factors of material cutting and handling in the machine operation area. Telescopic shields represent a traditional cover form for guide edges, spindles, shafts, columns and other sensitive machine tool parts. Thus, their main function is to protect guide gibs against chips and cutting compound, to avoid mechanical damage of machine guide surfaces, to improve service life and overall appearance of machines, and to avoid injuries caused by moving parts of the dynamic system. Functional output components of telescopic shields – their contact surfaces are represented by wiper profiles; they are high-load protective shield components because during operation, both when idle and moving, they are in direct contact with high temperatures of the technological process and with aggressive substances contained in cutting compound. Dynamic load occurring during cutting process realisation and during tool and work piece handling is also significant. Variable telescopic shields are manufactured and the choice is upon the customer, and the design is always tailored to dimensions of the machine in question. The only component used in all types is the guide gib whose design and material affects functioning ability and reliability of the shield guidance and of entire production machine significantly.

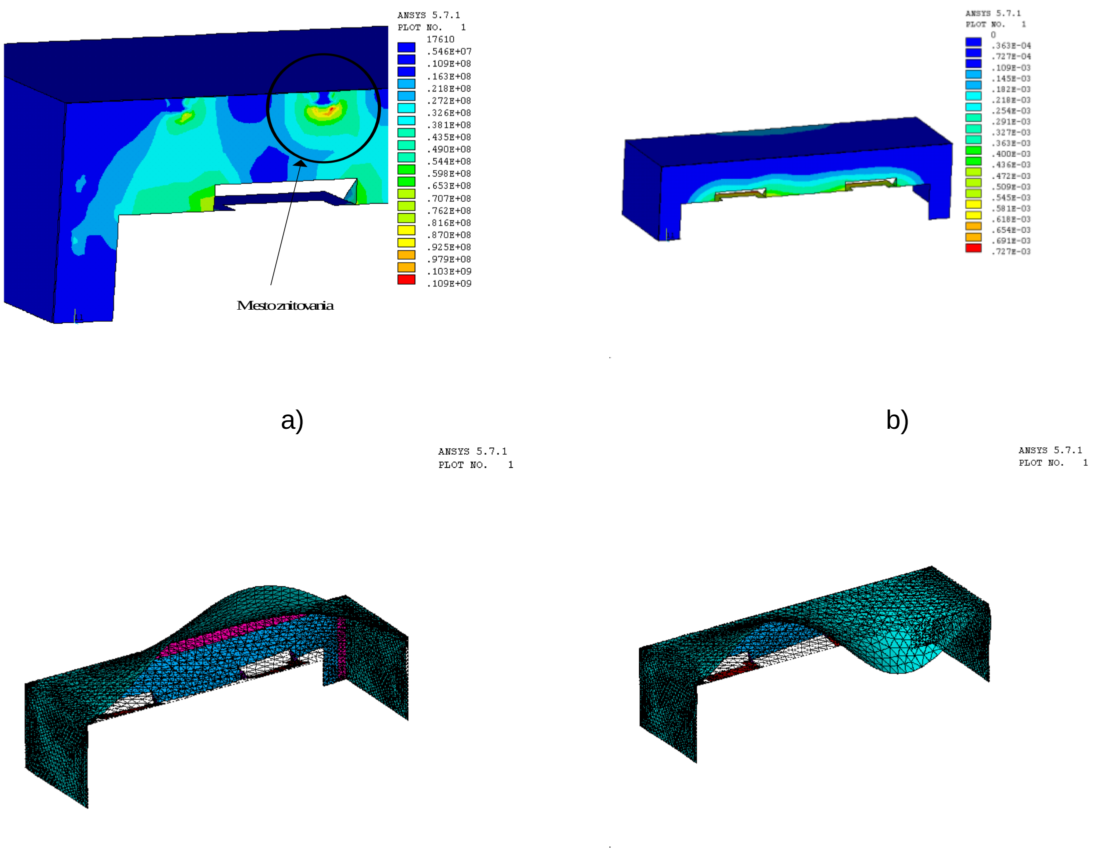
1.1. CHARACTERIZATION OF TELESCOPIC SHIELD DESIGN

Telescopic shields are box structures made from class 11 305 or 17 241 metal sheets. New generation shields are made from zinc plated, zinc-nickel plated or tin-lead plated sheets.

The design variety offers flat or V-roof-shaped symmetric or asymmetric shields, as well as shields with unilateral inclination, flat telescopic shields with vertical orientation, gravitation type shutter shields, transverse shields, circular ring shaped shields, multi-angle shape shields, etc. The options for shield manufacture by the manufacturer are limited; for instance, Kábelschlepp Slovakia, s. r. o. has the following limits: travel length up to 40.103 mm, guide surface width up to 5.103 mm. Travel rate increase from 15 m.min-1 to current rates up to 60 m.min-1 required a significant change in shield design. With respect to the occurrence of high noise level at bumps and high mechanical load of individual shield sections, designers had to find out new solutions. Massive application of differential drives resulted in smooth movements and elimination of noise at bump. The use of damping components depends upon travelling speed and the mass of moving shield parts. Telescopic shield with shear-type mechanism ensuring smooth movement with relatively low differential speed during operation movement of the shield became popular. With this shield design, travelling speed up to 200 m.min-1 are known, and force maximums occurring normally during mutual bumps of individual shield sections do not occur. It should be noted that on the basis of the research described in [1], the cracks resulting in shield destruction were initiated by such bumps

a) b)

Figura 1. Telescopic shield with shear-type opening mechanism: a – closed, b – opened



a) b)

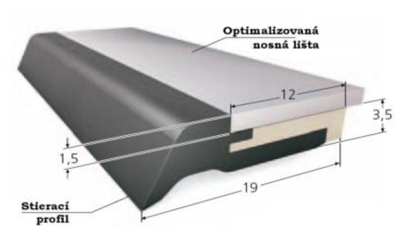
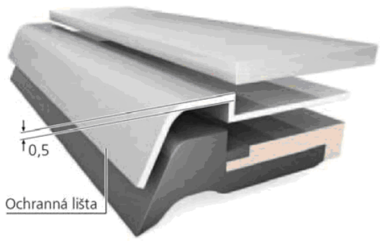
c) d)

Figura 2. Presentation of selected numerical results of MKP telescopic shield simulation according to the authors of [1], a – maximum stress for shield tension case (shield riveting detail), b - maximum deformation during shield tension, c – proper frequencies of shield 1, d – proper frequencies of shield

1.2. CHARACTERIZATION OF SHIELD WIPERS

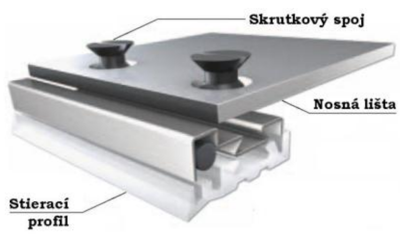
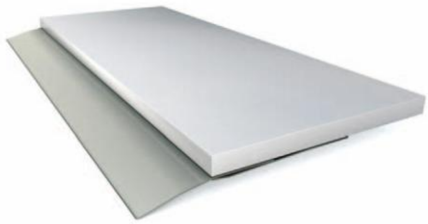
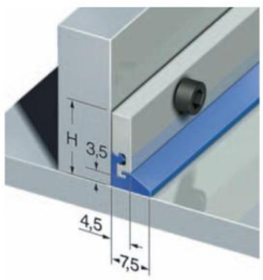
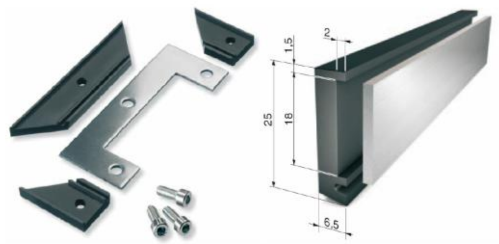
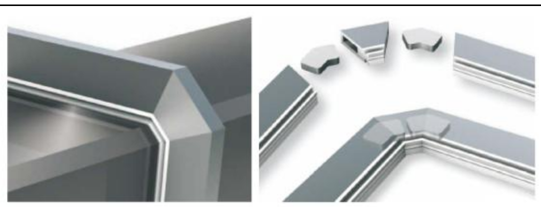
Like telescopic shields, their wipers must also have design variability. The first group includes the components resistance spot-welded or riveted to shield section. The shape and design of such wipers are given in Table 1.

Table 1. Legend: optimalizovaná nosná lišta – optimized bearing bar, stierací profil – wiper profile, ochranná lišta – protective profile

Item	Design	Description
1		Simple design wiper profile, made from steel bar profile with NBR (acrylo-nitrile-butadiene dry rubber) wiper profile vulcanised to it
2		Group 1 wipers with modified design, with protective cover from high-grade steel to protect the wiper operative part from hot chips.
3		Rolled wiper bar profile welded to shield box. The wiper profile is made from PUR (polyuretane mixture, green, grey and black) inserted in the bearing profile.
4		Spring steel wipers: using a special method, approx. 0,4 mm thick and 25 mm wide austenitic steel strip is spot welded to the cover plate; this wiper is recommended for dry machining.

The second group includes components with replaceable wiper profiles. The design of these new generation wipers is shown in Table 2.

Table 2. Legend: skrutkový spoj – screwed joint, stierací profil – wiping profile, ochranná lišta – protective areip

Item	Design:	Description:
1		Replaceable wiper with PU wiping profile can be replaced on the machine directly, without dismantling the telescopic shield. The wiper consists of four parts. The steel bearing profile is used to mount the PUR wiping profile and the thrust profile made from simple thrust rubber of corresponding hardness. The wiper is fixed to the cover plate by revolving locks. The wiping system can be locked or released by turning the lock by 90°. The necessary distance is 5 to 5,5 mm.
2		Replaceable steel plate wiper allows replacing the preceding type (wiper with resilient mounting). Bearing plate of special shape is spot welded to the shield box. Then the wiper is slided on, held firmly by flexible force of the bearing plate. The necessary distance of the cover plates is 1 mm.
3		This type of wipers is supplied as finished product of various shapes which can be assembled as required, as PU profiles 500 or 1000 mm long. Aluminium wiping profile is replaceable, and the bearing profile remains functional. They guarantee high shape stability and high mechanical load. Assembly pre-stressing is 2 mm, temperature range between - 40 oC and +100 oC.
4		Component-type wipers with good price. NBR (neoprene dry rubber) layer is applied on the bearing profile. The profiles where wipers are mounted are pre-fabricated. Short-time resistance up to 140 oC. Wiping plate pre-stressing max. 1 mm, resistance against bacteria.
5		This design is suitable for hydrostatic guide surfaces with round edges. The wiper profile works in both directions. It is applied on the bearing profile by plastic injection. The straight parts are joined precisely to make a firm joint using corresponding edge and angle parts.

1.3. CHARACTERIZATION OF CUTTING COMPOUNDS

Cutting compounds influence the productivity and economy of manufacture considerably. Their cooling, lubrication, corrosion resistance and cleaning effects influence cutting edge life positively, improve the machined surface quality, facilitate the removal of chips and decrease energy demand.

On the basis of the cutting operation, the cutting tools used the cutting conditions and of quality of water used, suitable cutting compound is selected. All the above parameters influence the choice of the product to be supplied considerably, depending upon the knowledge of the formulation used and of the chemical process taking place.

Types and characterization of cutting compounds are given in Table 3.

Table 3.

Item	Cutting compound type:	Description:
1	Water solutions	Good cooling properties, but no lubrication property. They are alkaline, unwanted deposit is often formed on the surface. Deposited salts from untreated water cause clogging of pipes and other operating parts of the machine.
2	Soap or oil solutions	Soaps of potassium, sodium and alizarine oil are mostly used; they must be diluted with soft water. Although these fluids are good coolants, their lubrication effect is rather limited.
3	Emulsions	They are oil and water dispersions (sometimes other substances are used), i.e. dispersions of mutually insoluble liquids, one of them forming microscopic drops dispersed in the other liquid. Usually, relative amounts of the emulgation substances are 10 % of soap, 2 to 5 % of alcohol, 7 to 10 % of mineral oil and the rest is water. Because emulsions are good coolants and lubricants, they can avoid deposit effectively, are not toxic, are flammable, have low viscosity and therefore they are most often used as cutting compound.
4	Cutting oils	Mineral, vegetable or animal oils are used. With respect to economic aspects, mineral oils with 2 to 3oE viscosity at 50 oC are used only. When choosing cutting oil it should be remembered that free unstable acids which tend to further decay should be avoided.
5	Environment-friendly cutting compounds	Modern cutting compounds must contain minimum amount of unwanted substances. The properties aimed at ecology and economy with preserved effectivity include better stability against ageing, avoiding unwanted deposits and bacteria (oil service life), minimum evaporation and oil mist (reduced consumption), higher viscosity index allows to use oil with lower viscosity (less oil carried out on chips and workpieces), minimum content of aromatic molecules, low odour, high flash point, absence of heavy metals, zinc and chlorine reduces toxicity and risk at work and makes disposal and recycling easier.

2. EXPERIMENTAL SECTION

The goal of our research and of the partial results described in this contribution is to show the status of operation conditions of telescopic shield, and in particular of their wiping components. On the basis of the analysis performed, to find suitable solutions and to select suitable materials for the fabrication of wiping profiles. The research described in [1,2,3,4] resulted in specifying the "character profile" to be used for analysis as to service life and functioning ability of the wipers. Tensile strength, abrasive wear resistance, cracking and crack propagation resistance should be as high as possible. Suitable material working temperature depends upon thermal demand and character of the machining process. Chemical resistance against the operating substances should also be considered, as well as swelling due to contact with liquid medium that should be as low as possible. Compression set – permanent deformation or compression at certain pressure and a specific temperature is given as percentage – difference of the compression set values at room and operation temperatures, with the minimum values being best. Based upon the above survey and information about possible materials to be used for telescopic shield gaskets a table was developed giving the main properties important for wiper material selection. The values given in Table 4 show the currently used standards for the selection of NBR and PUR materials.

Table 4.

Material	Tensile strength	Abrasive wear resistance	Cracking and crack propagation resistance	Working temperature	Swelling in oil after 70 hrs (100oC)	Compresion set (temperature difference)
NBR	average 7 N/mm2	high	average	+125oC	5% -25%	37% - 47%
PUR	average	high	high	+75oC	40 %	63%

Table 5.

Property:	Ranking:					
	1.	2.	3.	4.	5.	6.
Tensile strength [N/mm2]	CSM high 18	FKM high 12	CM average 10	CO average 6	ECO average 6	ACM low 2
Abrasive wear resistance	CSM average	FKM average	CM average	ACM average	ECO average	CO average
Cracking and crack propagation resistance	CSM high	FKM average	CM average	ACM average	ECO average	CO average
Working temperature	FKM +250°C	ACM +170°C	CSM +150°C	CM +150°C	CO +150°C	ECO +135°C
Swelling in oil after 70h [150°C]	FKM 2%	CO 5%	ECO 10%	ACM 25%	CM 80%	CSM 80%
Compression set*	FKM 2%	ACM 5%	ECO 20%	CO 20%	CM -	CSM -

* *the difference between room temperature and 120°C*

Table 5 shows survey of possible materials for the fabrication of telescopic shield gaskets, namely the main properties important for selection of a suitable wiper material. The list of potential materials starts with elastomere with the best values in the field in question, and ends with that with the worst properties. From the survey, the best telescopic shield wiper material for a specific application can be found easily on the basis of machining process parameters and cutting environment. IN Table 6, the merits of selected innovative materials are summarized systematically on the basis of six most important criteria for telescopic shield wipers.

3. CONCLUSION

The aim of the results published was to analyse suitability of materials for telescopic shield wipers. During the research, operation conditions, design solutions of and the cutting compounds used so far in cutting environments were considered. On the basis of the above analysis, the character profile was established, which was used for the analysis of possible materials and of their properties as to service life and functioning ability of wipers. The resulting solution is the system composed on the basis of six main criteria of application in a specific environment.

References:

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