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APPLICATION OF RADAR CHART IN THE SELECTION OF MATERIAL FOR CLUTCH PLATES

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Abstract

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Article deals with the choice of material used for manufacturing of clutch plates using graphical analysis. For analysis of used materials and specified parameters were chosen method of radar chart. Radar chart shows visually and quantitatively individually parameters used for the selection of material. The correct selection of the material has effect on the effectiveness and efficiency of manufacturing of clutch plate.

Keywords: radar chart, clutch, yield strength, ultimate strength, elongation, hardness

INTRODUCTION

Clutch disc is a part of clutch kits, whose function is the transfer of mechanical driving forces between the engine and other components. Clutch plates and clutch are used in automotive, engineering and aviation industries.

Clutch Disc is an element which is an integral part of every manual and automatic transmission. Without this component, the car does not move easily. Probably neither needless to say how important it is to have the clutch and all its components in good, driving satisfactory condition. In short, the clutch is designed to carry all the power produced by the engine to the front, rear or both axles (FWD, RWD, AWD), ie. for the needs of propulsion (Matisková, 2012, 2013a).

The materials used in the manufacture of clutch components must be long-lasting, high-quality, since the coupling is one part of the whole machinery rental, which is loaded and used the most. Therefore, it is important to address this important innovation component connector's particular material from which it is produced. One of the ways to restore the activity Sprocket is its renovation (Fig. 1), but it is easier to avoid this method of saving this element, finding better quality and longer-lasting material (Matisková, 2013b).

Verification state of organizations in the field of business economics can be understand like safety audit. Results of the verification are recorded by different methods. Manufacturing process and procedures can be assessed not only on the basis of the audit, but also by indicators of process capability C_p (characterizes the variance of process) and C_{pk} (characterizes the position of process in tolerance field. The manufacturing process shall be considered as qualified if the prescribed values of capability indexes are abided (Hrubec, 2001; Kredatusová *et al.*, 2010; Lestyánszka, 2009; Konstanciak, 2012).

Graphical methods are widespread in statistics, because they are transparent and easily interpretable. Graphic display is especially important for transparent data analysis and understanding the relationship between individual variables (Tague, 2005).

A radar chart is a graphical method of displaying multivariate data in the form of a two-dimensional chart of three or more quantitative variables represented on axes starting from the same point. The relative position and angle of the axes is typically uninformative (Nenadál, 2004).

The aim of this study is comparison properties of the supplied material that are used in the manufacture of the clutch plate with ideal properties of material. Subsequently, we choose the most suitable material for use in the manufacture, thus leading to a reduction the number of disagreements of final product, pressing machine downtime and tool wear. Using worn cutting tools in the production process causes higher surface roughness R_a of the machined part, which results in lowering production accuracy (Votava, 2013a). Surface quality R_a likewise influences not only further production technologies and but also an anchoring profile of an anticorrosion coating (Votava, 2013b). With the proposed solution, we increase efficiency and effectiveness of pressing clutch plates.

MATERIALS AND METODS

Radar chart was applied to manufactured component (clutch plate Fig. 1) which is currently manufactured from materials with different parameters specified in the Tab. I. Component is manufactured in the organization Miba Steeltec Ltd.

In the analysis can be used the quantity of parameters, however the radar charts are effective when using a limited number (no more than 8) (Plura, 2001).

Procedure of designing radar chart:

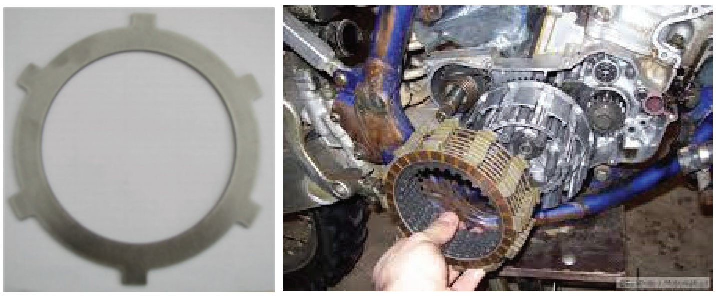
1. To determine variables that will be plotted and compared in the radar chart in the selection of the material. For determining variables can be used brainstorming, affinity diagram or Pareto analysis which is normally used for examine possible causes of disagreements.
2. To define intervals of values for each criterion. For each criterion, determine the indication of value intervals from 1 to 5, in ascending order of selected intervals.
3. To draw chart, 360 degrees divided by the number of criteria that determine angles between rays. To draw individual indications (1–5) belonging to interval of values on rays, and to connect the dots with lines.
4. To plot graphs separately for each material and ideal (the most suitable) material (i.e. 8 graphs).
5. To record the obtained values of indications and ideal (the most suitable) value of indications for each ray (to plot 2 points on each ray). Connect individual points according to the relevant materials.

Interpretation of the Radar Chart

The difference between values marked of individual materials and required values on each ray is a gap between the ideal and the actual. Parameter with the largest gap (deviation) usually requires an immediate attention. When using the charts is needed to avoid display that can potentially distort visual perception. Simple charts are the best.

RESULTS AND DISCUSSION

After the execution of brainstorming, we selected and set intervals of physical variables for used materials, i.e.: yield strength, ultimate strength, elongation and hardness. We prepared a table of intervals for the individual parameters of the material (Tab. II).



1: *Clutch plate*

I: *Parameters of used materials in the manufacture of clutch plates*

Parameters	Material No. 1	Material No. 2	Material No. 3	Material No. 4	Material No. 5	Material No. 6	Material No. 7
Yield strength R_{eH}	511	452	496	428	402	444	401
Ultimate strength R_m	688	693	688	666	717	687	701
Elongation A_5	28.4	32.4	30.6	31.6	35.2	32.2	37.3
Elongation A_{80}	19	20.7	19.8	20.8	22.7	20.8	23.5
Hardness *HB*	217	216	217	196	216	214	214

II: *Required physical properties of clutch plate material*

Parameters	Range
Yield strength R_{eH}, N.mm^{-2}	424–446
Ultimate strength R_m, N.mm^{-2}	688–699
Elongation A_5, %	32–33.8
Elongation A_{80}, %	20.8–21.7
Hardness *HB*	209–214

We made a table of intervals for individual values of physical variables (Tab. III) with the respective markings (1 to 5). The table contains the following columns:

The first column indicates *marking of variable*. Marking range of variables was determined in the range from 1 to 5 (dimensionless number), where 1 represents the lowest value of individual variables and 5 represents the highest value of variables.

The following columns represent the different intervals according to selected parameters.

According to the Tab. III we transferred the individual parameter values of used materials with appropriate markings from 1 to 5. The same markings we applied for required (ideal) material from Tab. II. As follows, obtained data were written down into Tab. IV, from which data were used for the construction of radar chart Fig. 2 to 8.

Evaluation of Radar Chart

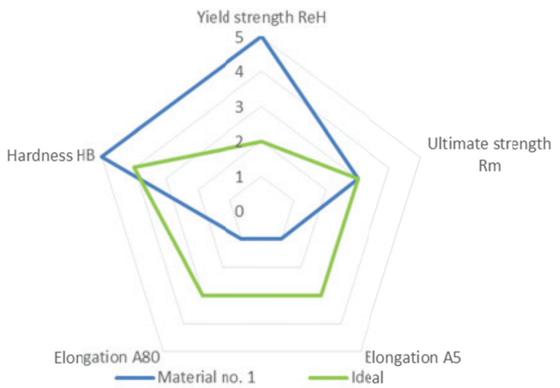
In the evaluation of radar chart, we concluded that delivered material has different physical parameters. Materials No. 1, 3 and 7 are similar only in one of required parameters with ideal (required) characteristics that are defined in the Tab. II. In two cases, it is ultimate strength R_m and in one case, it is hardness *HB*. Material No. 5 does not coincide in any of required parameters, and the manufacture of clutch plate causes the greatest probability of disagreement occurrence. Material No. 2 coincides in two required parameters i.e. R_m ultimate strength and elongation A_5. Material No. 4 coincides in two required parameters i.e. yield strength R_{eH} and elongation A_{80}. Delivered material No. 6 coincides in four of five required parameters, i.e. yield strength R_{eH}, elongation A_5 and A_{80} and hardness *HB*. According to the results from this analysis, Material No. 6 has proved to be the most suitable

III: *Table of intervals and ranges according to individual parameters*

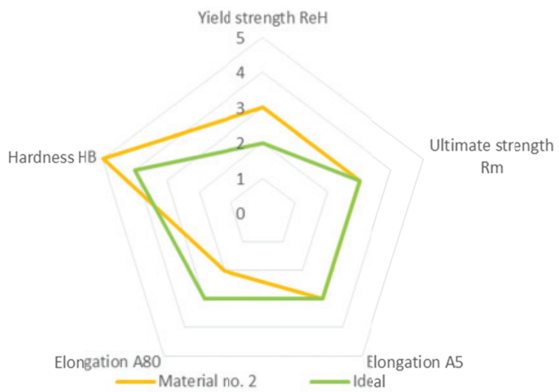
Markings	Yield strength R_{eH}, N.mm^{-2}	Ultimate strength R_m, N.mm^{-2}	Elongation A_5, %	Elongation A_{80}, %	Hardness *HB*
1	401–423	664–675	28.2–30	18.8–19.7	194–198
2	424–446	676–687	30.1–31.9	19.8–20.7	199–203
3	447–469	688–699	32–33.8	20.8–21.7	204–208
4	470–492	700–711	33.9–35.8	21.8–22.7	209–214
5	493–515	712–723	35.9–37.8	22.8–23.7	215–220

IV: *Marking of parameters for individual materials based on their values*

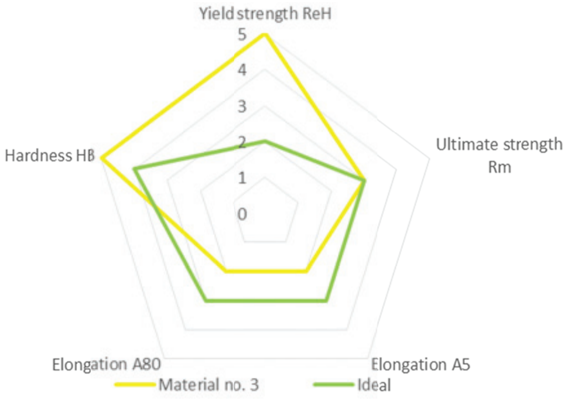
Parameters	Material No. 1	Material No. 2	Material No. 3	Material No. 4	Material No. 5	Material No. 6	Material No. 7	Ideal
Yield strength R_{eH}	5	3	5	2	1	2	1	**2**
Ultimate strength R_m	3	3	3	1	5	2	4	**3**
Elongation A_5	1	3	2	2	4	3	5	**3**
Elongation A_{80}	1	2	2	3	4	3	5	**3**
Hardness *HB*	5	5	5	1	5	4	4	**4**



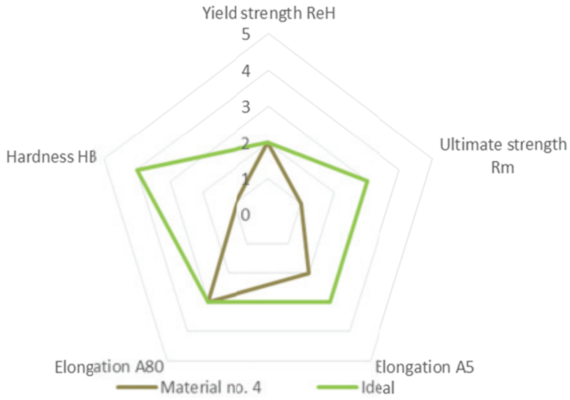
2: *Radar chart No. 1*



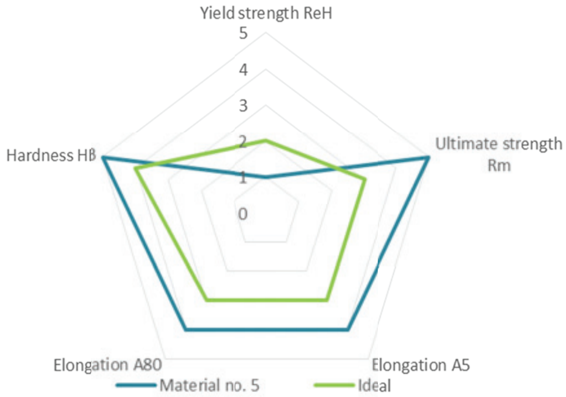
3: *Radar chart No. 2*



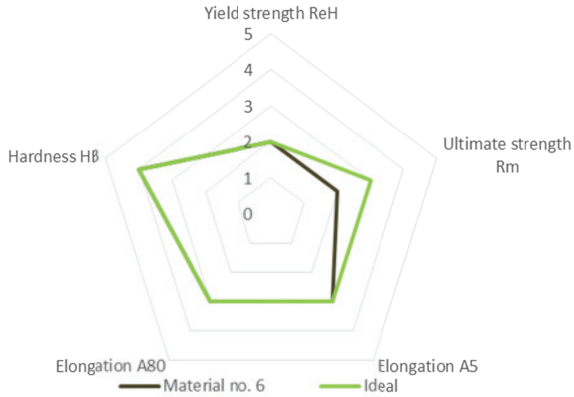
4: *Radar chart No. 3*



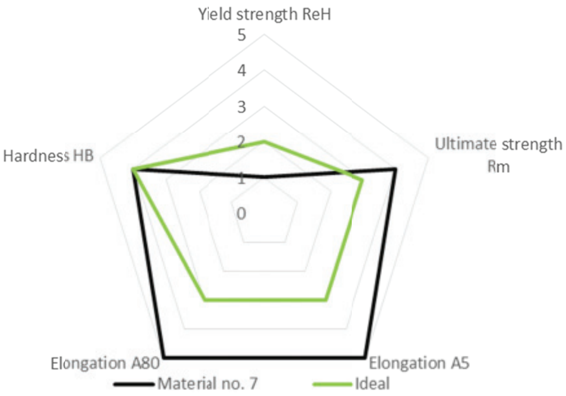
5: *Radar chart No. 4*



6: *Radar chart No. 5*



7: *Radar chart No. 6*



8: *Radar chart No. 7*

for the process of pressing clutch plates, regard to reported parameter values which most closely approximates to ideal set parameters.

Recommended Measures

On the basis of analysis results we have done measures which led to clarify the conditions for supplying material for the manufacturing process of clutch plates. Supplier is obliged to supply the material in required parameters according to Tab. II which represent material No. 6 as the most suited one. Individual parameters will be checked upon delivery of the material, thereby avoiding the possible occurrence of disagreements during the manufacture of clutch plates, respectively higher tool wear.

CONCLUSION

A part of improving process design must include an evaluation of unavoidable hazards and unavoidable risk arising from proposed solutions in determined operating and usage conditions, assessment of the risk when using them and design of protective measures against these hazards (Burda *et al.*, 2010; Hrubec *et al.*, 2009; Lestyánszka, 2012; Ingaldi *et al.*, 2013).

The main aim of this article was to determine parameters of used material in the manufacturing process of clutch plates. On the basis of set (ideal) parameters to evaluate delivered material and to choose from them a material fulfilling the specified intervals in Tab. II. Analyses shows that only one material – material No. 6 fulfils the specified conditions. This knowledge led to an agreement with a supplier about compliance set parameters of incoming material which influences the overall efficiency and effectiveness of the manufacturing process for clutch plates.

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