Tipps&Tricks with G^raf^Compounder

H-J G Consulting

Part IV
Compound Libary: Dynamic Application

Introduction:

Car manufacturers have ask for a series of engine mounts with a stepwise increase of a property, the static stiffness for example, to tune the NVH behavior of a car. Normally the engineer would go in the warehouse and collect some parts, which may fit into the customers project. This has caused discussions about a **compound libary**, which enables to serve the customer any time. Nobody had to search and collect anymore.

Specifically a compound libary would make sense, if the static stiffness is varies, but the dynamic hardening is kept constant, beside other properties, like compression set, tensile for example.

This challenge is almost ideal to evaluate with AI based software like G^raf^Compounder, without a lot of trials and effort in the laboratory.

Procedure:

For this demonstration, I selected a compound file based on EPDM. The file consists of some DoE (Design of Experiment), screenings and few Trial&Error data sets. The original purpose of the development was to investigate the service life of a round mount for vibration decoupling between the body and chassis. The main components of this data sets are as follows:

- EPDM C2 – 58 %, ENB – 5 %,
  VH Mooney grade
- Carbon Black range
  CB N550: 30 phr – 60 phr
  Perkasil KS 207 0 phr – 75 phr
  Paraffinic Oil 20 phr – 85 phr
- Accelerator System
  Sulfur / TMTD / CBS identicall for almost all data sets.

Evaluation of Data in the 2 D Diagram starts with the correlation analysis and discharge of data not fitting an estimated trendline to yield a correlation coefficient greater than 0,9. We have a good correlation between hardness and C_{stat} (**Figure 1**) and we accept this data sets for further evaluation. (Remark: The value in the upper right corner is confirmed)

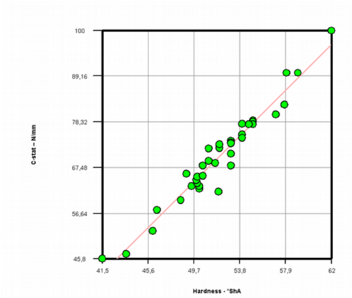

Figure 1: Hardenss over C_{stat}: Correlation coefficient 0,97.

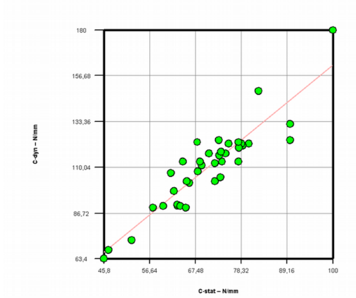

Figure 2: C_{dyn} over C_{stat}: correlation coefficient 0,91.

Criteria:

Name	Min	Max	From	To	Weight	Trdoff
Loss Angle 23°C -	*3,7*	*7,5*				
Loss Angle -25°C	*16*	*22,3*				
C-dyn – N/mm	*63,4*	*180*	92	92	50	
C-stat – N/mm	*45,8*	*100*	68	68		
Verhärtungsfaktor	*1,37*	*1,81*	1,42	1,42	50	

Table 1: Section of criteria window with targets and weights

In the criteria window the values are set for

- Hardening Factor (VHF):
  1,72 – in the first run
  1,42 – in the second run
  always with a weight of 50 (See **table 1** as an example)
- The C_{stat} / C_{dyn} pairs I selected using the Cdyn over Cstat Diagram (**Figure 2**).
  - Choose a C_{stat} value on the x-Axis and identify a C_{dyn} value on the y-axis.
    Just to be sure put a weight of 50 on the C_{dyn} value.
  - The results reported in **table 2**.
- Append the experimetal mixture columns into the <Input data> window to visualize their location in the diagram (**Figure 3**).
  Finally we discard all original data sets and show the excperimental G[raf]Compounder data point alone, which are unconfirmed yet.

What should be done before we perform a confirmation experiment: Proove, whether results are logic and in line with experience.
For this we check the physicals of the compounds (**table 3**).

VHF	C_{stat}	H-°ShA	TS-MPa	EB-%	C-Set-% 125°C/72h	Σ-Filler - phr	Oil - phr
1,72	98	61	15	480	40	58	36,2
1,72	90	58	16	535	45	60	43
1,72	80	56	14	525	43	58	47
1,72	68	52,5	13	551	45	59	58
1,72	62,5	51,2	12	585	47	72	62
1,42	90	58,4	11	455	47	51	22
1,42	80	55	9	430	43	42,5	30,8
1,42	62	50	7	405	44	47	43

Conclusion:

- Data suggest, that Dynamic Hardening [VHF] is mainly dependend on filler content comparing both compound series.
- C-Set is almost uneffected
- tan-δ is 6° for the 1,72 VHF and 4° for the 1,42 VHF
- Regarding other basic physicals there is some room to meet specification targets, specifically the Hardness follow C_{stat}.
- G[raf]Compounder allows to provide parts designed as a compound libary for NVH tuning of cars or any other machine

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C_{stat} [N/mm]	C_{dyn} [N/mm]	VHF
98	169	1,72
90	157	1,72
80	137	1,72
68	118	1,72
62,5	108	1,72
90	129	1,42
80	115	1,42
62	108	1,42

Table 2: C_{stat}, C_{dyn} and VHF values of G[raf]Compounder output data.

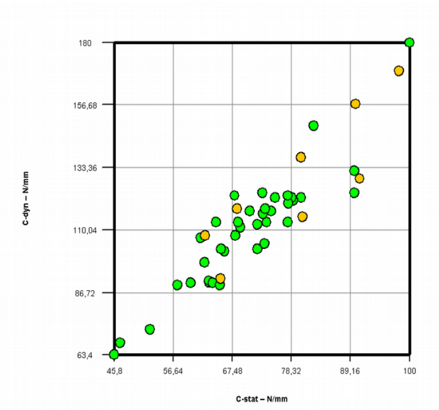

Figure 3: C_{dyn} over C_{stat}: original plus experimental data point (darker yellow).

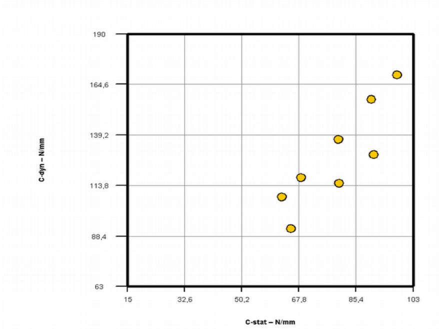

Figure 4: C_{dyn} over C_{stat}: experimental values at constant dynamic hardening factor [VHF] at two levels.