Communication scientifique, écrite et orale, en langue anglaise

Fifth session

How to publish a paper – Part V.

1. Question period

In which section of the paper you

- describe how you obtained the data you want to publish,

- describe the results obtained,

- discuss what the results mean.

What changes can be done in experimental data?

What did Ptolemy do when he compared the predictions of his theory to his observations?

2. An example for main sections in a theoretical paper

Here we follow the example already introduced in the Introduction part. The text written below in blue contains mistakes. Please rewrite it correctly. The corrected text is also presented below.

2. Basic hypotheses

A composite consisting of two phases considered. Phase no. 1 is made up from inclusion while phase no. 2 is matrix. The behavior of the phases can described by usual viscous power laws given by eqs. (2-3). Both phases and the composite itself is considered to be isotropic and obeys von Mises type viscoplastic creep flow. The mechanical behavior of the inclusions and

the matrix are described with eqs. (2) and (3) respectively while that of the composite is given with eq. (1). In order to simplify the equations the stresses and strains, will not used as tensorial quantities in this work. Only one component of stress and the corresponding component of strain rate is considered (the major ones). This is permitted because isotropy. The law of mixture for the strain rates can be employed :

$$\dot{\varepsilon} = f_1\dot{\varepsilon}_1 + f_2\dot{\varepsilon}_2 \quad (6)$$

The strains are not necessarily to be the same in the phases as the strain applied on the composite. Nevertheless they have to be proportional to each other, because isotropy. Thus the strain localization in phase 1, can be described by:

$$\dot{\varepsilon}_1 = r\dot{\varepsilon} \quad . \quad (7)$$

Here *r* is strain localization factor. From (6) and (7), the strain localization in phase 2 is obtained as:

$$\dot{\varepsilon}_2 = \frac{1 - f_1 r}{f_2}\dot{\varepsilon} \quad . \quad (8)$$

The law of mixtures for the stresses also can be used:

$$\sigma = f_1\sigma_1 + f_2\sigma_2 \quad . \quad (9)$$

Similarly to strain localization, the stresses in the phases, can also be different from the stress that applied on composite. To describe this, a stress localization factor *t* is introduced for phase 1:

$$\sigma_1 = t\sigma \quad . \quad (10)$$

Using (9) and (10) the stress localization factor for phase 2 can be express as:

$$\sigma_2 = \frac{1 - f_1 t}{f_2}\sigma \quad . \quad (11)$$

3. Effective strain rate sensitivity in strain controlled case.

I can identify the conditions of testing as *strain controlled* if the test is conducted by prescribing the strain rate. That is, when, the boundary conditions formulated in terms of strains. In such a case, the rule of mixtures for the stresses can a starting point (eq. (9)). Using eqs. (1)-(3) in eq. (9) one obtains:

$$k\left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}\right)^m = f_1 k_1 \left(\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_0}\right)^{m_1} + f_2 k_2 \left(\frac{\dot{\varepsilon}_2}{\dot{\varepsilon}_0}\right)^{m_2} . \qquad (12)$$

In order determine the strain rate sensitivity parameter of a materials, the experimentalist will apply a jump in the strain rate. Let's change the applied strain rate on the composite by a factor α:

$$\dot{\varepsilon} \to \alpha\dot{\varepsilon} \quad . \qquad (13)$$

As we have strain-controlled case we can assume that, the strain rates are multiplied by the same factor in the two phases:

$$\dot{\varepsilon}_1 \to \alpha\dot{\varepsilon}_1 \quad , \qquad \dot{\varepsilon}_2 \to \alpha\dot{\varepsilon}_2 \quad . \qquad (14\text{ a-b})$$

Using (13)-(14) in (12) yield:

$$k\alpha^m \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}\right)^m = f_1 k_1 \alpha^{m_1} \left(\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_0}\right)^{m_1} + f_2 k_2 \alpha^{m_2} \left(\frac{\dot{\varepsilon}_2}{\dot{\varepsilon}_0}\right)^{m_2} . \qquad (15)$$

As the *m* value - in principle – can depend on the applied strain rate, the value of α will to be kept around unity. This condition permits employing a Taylor series for α:

$$\alpha^m \cong 1 + m(\alpha - 1) . \qquad (16)$$

Using a Taylor series for also α^{m_1} and α^{m_2}, as well relation (12), the effective strain rate sensitivity of the composite can be expressed from (15):

$$m = \frac{f_1 k_1 m_1 \left(\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_0}\right)^{m_1} + f_2 k_2 m_2 \left(\frac{\dot{\varepsilon}_2}{\dot{\varepsilon}_0}\right)^{m_2}}{f_1 k_1 \left(\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_0}\right)^{m_1} + f_2 k_2 \left(\frac{\dot{\varepsilon}_2}{\dot{\varepsilon}_0}\right)^{m_2}} \quad . \tag{17}$$

Employing now the strain localization factor (eqs. (7)-(8)) a general formula for *m* can be obtained :

$$m = \frac{f_1 k_1 m_1 + f_2 k_2 m_2 R}{f_1 k_1 + f_2 k_2 R} \quad , \tag{18}$$

where

$$R = \frac{(1 - f_1 r)^{m_2}}{f_2^{m_2} r^{m_1}} \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}\right)^{m_2 - m_1} \quad . \tag{19}$$

For the special case if the two phases deform identically (model Taylor), the value of *r* equals to 1, thus *m* can be obtained from:

$$m = \frac{f_1 k_1 m_1 + f_2 k_2 m_2 \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}\right)^{m_2 - m_1}}{f_1 k_1 + f_2 k_2 \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}\right)^{m_2 - m_1}} \quad . \tag{20}$$

4. effective strain rate sensitivity in stress controlled case

In contrast by the strain-controlled case, the conditions of testing also can be defined by imposing the stress state. In such a case the boundary conditions are formulated by terms of stresses. Therefore one can start the analysis with the rule for mixtures of the strains (eq. 6). With the help of eqs. (1)-(3) one obtains:

$$\left(\frac{\sigma}{k}\right)^{\frac{1}{m}} = f_1 \left(\frac{\sigma_1}{k_1}\right)^{\frac{1}{m_1}} + f_2 \left(\frac{\sigma_2}{k_2}\right)^{\frac{1}{m_2}} \quad . \tag{21}$$

In order to access the m value, a stress jump necessary:

$$\sigma \rightarrow \alpha\sigma \quad . \tag{22}$$

Because the possible dependence of *m* on stress state, the value of α has to be kept around unit. As we control the boundary conditions in terms of the stress components the same jump of stress can be assumed also in the two phases:

$$\sigma_1 \rightarrow \alpha\sigma_1 \quad , \qquad \sigma_2 \rightarrow \alpha\sigma_2 \quad . \tag{23 a-b}$$

Using (22)-(23) in (21) gets:

$$\alpha^{\frac{1}{m}}\left(\frac{\sigma}{k}\right)^{\frac{1}{m}} = f_1\alpha^{\frac{1}{m_1}}\left(\frac{\sigma_1}{k_1}\right)^{\frac{1}{m_1}} + f_2\alpha^{\frac{1}{m2}}\left(\frac{\sigma_2}{k_2}\right)^{\frac{1}{m_2}} \quad . \tag{24}$$

First order Taylor series can again be employed, for *m* it reads:

$$\alpha^{\frac{1}{m}} \cong 1 + \frac{1}{m}(\alpha - 1) \quad . \tag{25}$$

Using first Taylor order series also for α^{m_1} and α^{m_2} in (24), the m value can be expressed with the help of (21) as:

$$\frac{1}{m} = \frac{\dfrac{f_1}{m_1}\left(\dfrac{\sigma_1}{k_1}\right)^{\frac{1}{m_1}} + \dfrac{f_2}{m_2}\left(\dfrac{\sigma_2}{k_2}\right)^{\frac{1}{m_2}}}{f_1\left(\dfrac{\sigma_1}{k_1}\right)^{\frac{1}{m_1}} + f_2\left(\dfrac{\sigma_2}{k_2}\right)^{\frac{1}{m_2}}} \quad . \tag{26}$$

Introducing now the stress localization factor defined in (10) and (11) the resultant *m* value given by the following analytical expression:

$$\frac{1}{m} = \frac{\dfrac{f_1}{m_1} + \dfrac{f_2}{m_2}T}{f_1 + f_2 T} \tag{27}$$

where

$$T = \left(\frac{1-f_1 t}{f_2 k_2}\right)^{\frac{1}{m_2}} \left(\frac{t}{k_1}\right)^{-\frac{1}{m_1}} \sigma^{\left(\frac{1}{m_2}-\frac{1}{m_1}\right)} \tag{28}$$

For the special case when the stress state is uniform (model static), the value of *t* is equal to 1 and *m* can written as:

$$\frac{1}{m} = \frac{\frac{f_1}{m_1} + \frac{f_2}{m_2}\frac{k_1^{\frac{1}{m_1}}}{k_2^{\frac{1}{m_2}}}\sigma^{\left(\frac{1}{m_2}-\frac{1}{m_1}\right)}}{f_1 + f_2\frac{k_1^{\frac{1}{m_1}}}{k_2^{\frac{1}{m_2}}}\sigma^{\left(\frac{1}{m_2}-\frac{1}{m_1}\right)}} . \tag{29}$$

5. Effective strain rate sensitivity with the differential scheme.

When the volume fraction of the inclusion phase is high the interaction between inclusions can not be neglected. One way to account this is to use the so-called differential scheme. That model considers the case of small volume fraction, and approaches large concentrations on an incremental way by homogenizing composite and increasing always the volume of second phase with a small fraction only. The homogenization step is simply to take the composite as the matrix in a next increment of the volume fraction. Mathematically, it means the following simply:

$$m_2 = m_{old}$$
$$k_2 = k_{old}$$

Thus, in a subsequent increment during the application of the differential scheme a small quantity of inclusions df_1 is added to the composite. The new *k* value of the composite is obtained from a separate solution of inclusion problem. In the present paper the tangent formulation of the interaction problem is employed for this purpose (Appendix). The procedure is repeated until required volume fraction is reached. Note, that m_2 and k_2 evolves continuously with f_1. At a given increment the following equations can be used:

i. Strain controlled case (eq. (17):

$$m_{new} = \frac{f_1 k_1 m_1 + f_2 k_2 m_{old} R}{f_1 k_1 + f_2 k_{old} R}, \quad (30)$$

with

$$R = \frac{(1 - f_1 r)^{m_{old}}}{f_2^{m_{old}} r^{m_1}} \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0} \right)^{m_{old} - m_1} . \quad (31)$$

ii. Stress controlled case (eq. (26)):

$$\frac{1}{m_{new}} = \frac{\frac{f_1}{m_1} + \frac{f_2}{m_{old}} T}{f_1 + f_2 T} , \quad (32)$$

with

$$T = \left(\frac{1 - f_1 t}{f_2 k_{old}} \right)^{\frac{1}{m_{old}}} \left(\frac{t}{k_1} \right)^{-\frac{1}{m_1}} \sigma^{\left(\frac{1}{m_{old}} - \frac{1}{m_1} \right)} . \quad (33)$$

In the differential scheme the obtained behaviour of composite depends of which phase is considered to be formed by the inclusions. The reason is the difference in interaction between inclusion and matrix when they are exchanged. Results will be presented for each cases in the application part of the present paper, see below.

3. Solution to the exercise

2. Basic hypotheses

A composite consisting of two phases is considered. Phase no. 1 is made up from inclusions while phase no. 2 is the matrix. The behavior of the phases can be described by the usual viscous power laws given by eqs. (2-3). Both phases and the composite itself are considered to be isotropic and obey von Mises type viscoplastic creep flow. The mechanical behaviors of the inclusions and the matrix are described by eqs. (2) and (3), respectively, while that of the composite is given by eq. (1). In order to simplify the equations, the stresses and strains will not be used as tensorial quantities in this work. Only one component of the stress and the

corresponding component of the strain rate are considered (the major ones). This is permitted because of isotropy. The law of mixture for the strain rates can be employed:

$$\dot{\varepsilon} = f_1\dot{\varepsilon}_1 + f_2\dot{\varepsilon}_2 \ . \qquad \textbf{(6)}$$

The strains are not necessarily the same in the phases as the strain applied on the composite. Nevertheless, they have to be proportional to each other because of isotropy. Thus, the strain localization in phase 1 can be described by:

$$\dot{\varepsilon}_1 = r\dot{\varepsilon} \ . \qquad \textbf{(7)}$$

Here *r* is the strain localization factor. From (6) and (7), the strain localization in phase 2 is obtained as:

$$\dot{\varepsilon}_2 = \frac{1 - f_1 r}{f_2}\dot{\varepsilon} \ . \qquad \textbf{(8)}$$

The law of mixtures for the stresses can also be used:

$$\sigma = f_1\sigma_1 + f_2\sigma_2 \ . \qquad \textbf{(9)}$$

Similarly to strain localization, the stresses in the phases can also be different from the stress that applied on the composite. To describe this, a stress localization factor *t* is introduced for phase 1:

$$\sigma_1 = t\sigma \ . \qquad \textbf{(10)}$$

Using (9) and (10), the stress localization factor for phase 2 can be expressed as:

$$\sigma_2 = \frac{1 - f_1 t}{f_2}\sigma \ . \qquad \textbf{(11)}$$

3. Effective strain rate sensitivity in strain-controlled case

One can identify the conditions of testing as *strain-controlled* if the test is conducted by prescribing the strain rate. That is, when the boundary conditions are formulated in terms of strains. In such a case, the rule of mixtures for the stresses can be a starting point (eq. (9)). Using eqs. (1)-(3) in eq. (9) one obtains:

$$k\left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}\right)^m = f_1 k_1 \left(\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_0}\right)^{m_1} + f_2 k_2 \left(\frac{\dot{\varepsilon}_2}{\dot{\varepsilon}_0}\right)^{m_2} . \qquad \textbf{(12)}$$

In order to determine the strain rate sensitivity parameter of a material, the experimentalist applies a jump in the strain rate. Let us change the applied strain rate on the composite by a factor of α:

$$\dot{\varepsilon} \rightarrow \alpha\dot{\varepsilon} . \qquad \textbf{(13)}$$

As we have strain-controlled case, we can assume that the strain rates are multiplied by the same factor in the two phases:

$$\dot{\varepsilon}_1 \rightarrow \alpha\dot{\varepsilon}_1 \quad , \quad \dot{\varepsilon}_2 \rightarrow \alpha\dot{\varepsilon}_2 . \qquad \textbf{(14 a-b)}$$

Using (13)-(14) in (12) yields:

$$k\alpha^m \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0}\right)^m = f_1 k_1 \alpha^{m_1} \left(\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_0}\right)^{m_1} + f_2 k_2 \alpha^{m_2} \left(\frac{\dot{\varepsilon}_2}{\dot{\varepsilon}_0}\right)^{m_2} . \qquad \textbf{(15)}$$

As the *m* value can - in principle - depend on the applied strain rate, the value of α has to be kept around unity. This condition permits to employ a Taylor series for α:

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Using a Taylor series also for α^{m_1} and α^{m_2}, as well as relation (12), the effective strain rate sensitivity of the composite can be expressed from (15):

$$m = \frac{f_1 k_1 m_1 \left(\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_0}\right)^{m_1} + f_2 k_2 m_2 \left(\frac{\dot{\varepsilon}_2}{\dot{\varepsilon}_0}\right)^{m_2}}{f_1 k_1 \left(\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_0}\right)^{m_1} + f_2 k_2 \left(\frac{\dot{\varepsilon}_2}{\dot{\varepsilon}_0}\right)^{m_2}} . \qquad \textbf{(17)}$$

Employing now the strain localization factor (eqs. (7)-(8)), a general formula for *m* can be obtained :

$$m = \frac{f_1 k_1 m_1 + f_2 k_2 m_2 R}{f_1 k_1 + f_2 k_2 R} , \qquad \textbf{(18)}$$

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For the special case when the two phases deform identically (Taylor model), the value of *r* is equal to 1, thus *m* can be obtained from:

$$m = \frac{f_1 k_1 m_1 + f_2 k_2 m_2 \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0} \right)^{m_2 - m_1}}{f_1 k_1 + f_2 k_2 \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0} \right)^{m_2 - m_1}} \quad . \qquad (20)$$

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In order to access the m value, a stress jump is necessary:

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Using (22)-(23) in (21) yields:

$$\alpha^{\frac{1}{m}}\left(\frac{\sigma}{k}\right)^{\frac{1}{m}} = f_1\alpha^{\frac{1}{m_1}}\left(\frac{\sigma_1}{k_1}\right)^{\frac{1}{m_1}} + f_2\alpha^{\frac{1}{m2}}\left(\frac{\sigma_2}{k_2}\right)^{\frac{1}{m_2}} \quad . \tag{24}$$

First order Taylor series can again be employed, for *m* it reads:

$$\alpha^{\frac{1}{m}} \cong 1+\frac{1}{m}(\alpha-1) \quad . \tag{25}$$

Using first order Taylor series also for α^{m_1} and α^{m_2} in (24), the m value can be expressed with the help of (21) as:

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Introducing now the stress localization factor defined in (10) and (11), the resultant *m* value is given by the following analytical expression:

$$\frac{1}{m} = \frac{\frac{f_1}{m_1}+\frac{f_2}{m_2}T}{f_1 + f_2 T} \quad , \tag{27}$$

where

$$T = \left(\frac{1-f_1 t}{f_2 k_2}\right)^{\frac{1}{m_2}}\left(\frac{t}{k_1}\right)^{-\frac{1}{m_1}}\sigma^{\left(\frac{1}{m_2}-\frac{1}{m_1}\right)} \quad . \tag{28}$$

For the special case when the stress state is uniform (static model), the value of *t* is equal to 1 and *m* can be written as:

$$\frac{1}{m} = \frac{\frac{f_1}{m_1}+\frac{f_2}{m_2}\frac{k_1^{\frac{1}{m_1}}}{k_2^{\frac{1}{m_2}}}\sigma^{\left(\frac{1}{m_2}-\frac{1}{m_1}\right)}}{f_1 + f_2\frac{k_1^{\frac{1}{m_1}}}{k_2^{\frac{1}{m_2}}}\sigma^{\left(\frac{1}{m_2}-\frac{1}{m_1}\right)}} \quad . \tag{29}$$

5. Effective strain rate sensitivity with the differential scheme

When the volume fraction of the inclusion phase is high, the interaction between inclusions cannot be neglected. One way to account for this is to use the so-called differential scheme. That model considers the case of small volume fraction and approaches large concentrations on an incremental way by homogenizing the composite and increasing always the volume of the second phase with a small fraction only. The homogenization step is simply to take the composite as the matrix in a next increment of the volume fraction. Mathematically, it means simply the following:

$$m_2 = m_{old}$$
$$k_2 = k_{old}$$

Thus, in a subsequent increment during the application of the differential scheme, a small quantity of inclusions df_1 is added to the composite. The new *k* value of the composite is obtained from a separate solution of the inclusion problem. In the present paper, the tangent formulation of the interaction problem is employed for this purpose (see Appendix). The procedure is repeated until the required volume fraction is reached. Note that m_2 and k_2 evolves continuously with f_1. At a given increment, the following equations can be used:

iii. **Strain-controlled case (eq. (17):**

$$m_{new} = \frac{f_1 k_1 m_1 + f_2 k_2 m_{old} R}{f_1 k_1 + f_2 k_{old} R} \quad , \tag{30}$$

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$$R = \frac{(1 - f_1 r)^{m_{old}}}{f_2^{m_{old}} r^{m_1}} \left(\frac{\dot{\varepsilon}}{\dot{\varepsilon}_0} \right)^{m_{old} - m_1} \quad . \tag{31}$$

iv. **Stress-controlled case (eq. (26)):**

$$\frac{1}{m_{new}} = \frac{\dfrac{f_1}{m_1} + \dfrac{f_2}{m_{old}} T}{f_1 + f_2 T} \quad , \qquad \textbf{(32)}$$

with

$$T = \left(\frac{1 - f_1 t}{f_2 k_{old}} \right)^{\frac{1}{m_{old}}} \left(\frac{t}{k_1} \right)^{-\frac{1}{m_1}} \sigma^{\left(\frac{1}{m_{old}} - \frac{1}{m_1} \right)} \; . \qquad \textbf{(33)}$$

In the differential scheme, the obtained behavior of the composite depends on which phase is considered to be formed by the inclusions. The reason is the difference in the interaction between inclusion and matrix when they are exchanged. Results will be presented for both cases in the application part of the present paper, see below.

4. The "Discussion" section

This section is the most difficult to write. Many papers get rejected because this part is not written properly, even if the results are interesting and useful. This section is designated for an *interpretation* of the results obtained. In many cases, it is made too long. Especially, when something did not come out as it had been expected. Then the author tries to make such an interpretation of the results, which may still justify the publication of the work.

The main components of the Discussion part are the following:

1. **You describe the new principles found from the Results. You are not supposed here to describe *again* the Results, you have to *discuss* them.**
2. **Do not hide any weakness of your results with respect to the new theory. Discuss the weak points as much as you discuss the positive ones.**
3. **You have to show how your results are situated within the findings of previous works.**
4. **Point out any possible new applications of your results.**

5. The "Conclusions"

In this section you make a list of your main findings. You have to choose properly the real important results of your paper. Be sure you do not put something in the Conclusions that was not discussed at all in the paper. Only *discussed* results can be put into the Conclusions. Also, you should not put any statement into the Conclusions that has already been published already by somebody else. There is usually more than one conclusion in a paper. In such a case, they should be numbered. The main point: only important statements can be listed in the Conclusions.

A story about a Conclusion[1]:

"After training the flea for many months, the biologist was able to get a response to certain commands. The most gratifying of the experiments was the one in which the professor would shout the command "Jump", and the flea would leap into the air each time the command was given. The professor was about to submit this remarkable finding via a scientific journal, but he –in the manner of the true scientist- decided to take his experiment one step further. He sought to determine the location of the receptor organ involved. In one experiment, he removed the legs of the flea, one at a time. The flea obligingly continued to jump upon command, but as each successive leg was removed, its jumps became less spectacular. Finally, with the removal of its last leg, the flea remained motionless. The professor decided that at last he should publish his findings. He set pen to paper and described in meticulous detail the experiments executed over the preceding months."
What was his conclusion? Propose one!

His conclusion was:
"When the legs of a flea are removed, the flea can no longer hear."

Another story[1]:

"A science teacher set up a simple experiment to show her class the danger of alcohol. She set up two glasses, one containing water, and the other containing gin. Into each, she dropped a worm. The worm in the water swam merrily around. The worm in the gin quickly died."
What was her conclusion? Propose one!

Her conclusion was:
"Alcohol is dangerous; it can kill living subjects."

[1] Robert A. Day, „How to Write & Publish a Scientific Paper", Oryx, 5th Edition, 1998.

Another conclusion from somebody in the class:
"The experiment proved that one who drinks gin won't have worms."

It is important to have Conclusions. Actually, it saves digesting the Reader all data and information given in the paper. In the absence of Conclusions, the Reader would certainly make the question: OK, this is nice, and, so what?

There can be cases when there are no major Conclusions to be drawn. In such a case, a Summary can do a similar job. In a Summary, you summarize your work presented in the paper, emphasize its value and locate its place in the field. In contrast to Conclusions, there is no numbering in the Summary.

In any case, a Summary or a Conclusions has to be written in which you have to precise the region of validity of your results. Do not make extrapolations which are out of range of the data presented in the paper.

Example for Conclusions:

"The first objective of this work was to extend the results pertaining to simple shear of polycrystals to the solid torsion problem. As experiments related to large strain shear are invariably carried out on solid round bars in torsion, it is clearly of interest to characterize the effect of the various layers of material in a bar and to correct for the hydrostatic stresses that are induced between them. The second objective was to study the stress response and texture evolution of rate-sensitive FCC polycrystals under conditions of large strain uniform simple shear (within individual layers or shells). Both a full constraint and a relaxed constraint version of the rate-sensitive polycrystal model were used for this purpose. The results of our investigation lead to the following general conclusions.

1. The trends for the stresses which develop in solid bar torsion differ significantly from those of simple shear. The differences are due to the hydrostatic pressure build-up within the solid bar arising from the differential equilibrium conditions which must be satisfied along the bar radius.

2. The simulated textures obtained with the full constraints model at the higher m-value led to the best correlation with experiment for copper. For aluminum, the relaxed constraints model produced a good correlation with experimental results for both the axial stress as well as the texture at high shear deformations."