UDK 546.62:620.173
Original scientific article/Izvirni znanstveni članek

ISSN 1580-2949
Mater. Tehnol.

THERMOMECHANICAL RESPONSE OF AS-CAST, HOMOGENISED AND EXTRUDED FORGING-GRADE 7075 ALLOY

TERMOMEHANSKI ODZIV ZLITINE 7075 V LITEM, HOMOGENIZIRANEM IN IZTISKANEM STANJU

Matija Arzenšek[1,2*], David Bombač[1]

[1]University of Ljubljana, Faculty of Natural Science and Engineering, Department of Materials and Metallurgy, Aškerčeva cesta 12, 1000 Ljubljana, Slovenia
[2]Impol Aluminium Industry, Partizanska 38, 2310 Slovenska Bistrica, Slovenia

Prejem rokopisa – received: 2026-01-19; sprejem za objavo – accepted for publication: 2026-05-12

doi:10.17222/mit.2026.1649

The hot deformation behaviour of aluminium alloy EN AW-7075 was investigated in three material states: as-cast, homogenised and forging-grade, over a temperature range of 300–500 °C and strain rates of 0.01–10 s^{-1}. Compression tests were performed on cylindrical specimens using a Gleeble 3500P thermomechanical simulator. Using correction methods, the results were curated for modelling applications, providing simulation-ready data. As stationary conditions were observed at $\varepsilon = 0.4$ and $\varepsilon = 0.8$, further analysis was conducted on state variables such as strain-rate sensitivity (m), temperature sensitivity (s), activation energy (Q) and instability (n), for which maps were constructed. The analysis of metallurgical state variables provides insight into the optimal processing domains for the EN AW-7075 wrought aluminium alloy.

Keywords: aluminium alloys, compression test, processing maps

V članku avtorji predstavljajo raziskovalno delo in analizo mehanskega odziva izbrane aluminijeve zlitine EN AW-7075 v litem, homogeniziranem in iztiskanem stanju v temperaturnem območju med 300 °C in 500 °C ter pri hitrosti deformacije 0,01-10 s^{-1}. Tlačni preizkusi na preizkušancih (valjčkih) so bili izvedeni na termomehanskem simulatorju stanj Gleeble 3500P. Z namenom uporabe podatkov za izgradnjo numeričnih modelov so avtorji podatke obdelali preko postopkov korekcij. Glede na opaženo nespremenljivo stanje pri stopnji deformacijah $\varepsilon = 0{,}4$ in 0,8 so pripravili analizo spremenljivk stanj, kot so občutljivost na hitrost deformacije m, temperaturna občutljivost s, aktivacijska energija Q in nestabilnost n, s pomočjo katerih so izdelali procesne mape. Analiza metalurških stanj je dala vpogled v ustrezne procesne pogoje pri katerih je mogoče uspešno preoblikovati aluminijevo zlitino EN AW-7075.

Ključne besede: aluminijeve zlitine, tlačni preizkus, procesne mape

1 INTRODUCTION

Aluminium alloy EN AW-7075 is a common, high-strength lightweight material used in aerospace, high-performance applications.[1,2] The high alloying element content of the 7075 alloy makes it more difficult to produce than other 7xxx series of aluminium alloys, especially the Al-Zn-Mg-Cu subfamily, which are among the most difficult aluminium alloys to produce.[3–5] The most critical step in preventing alloy failure during bulk forming is the identification of appropriate thermo-mechanical parameters. The high alloying element content induces solid-solution hardening, which, in combination with precipitation hardening and strain hardening, gives the 7075 alloy superior mechanical properties, yet processing and production procedures tend to promote microstructural instabilities. One approach to identifying suitable thermo-mechanical parameters is the use of processing maps, defining stable material processing domains. Similar research on as-cast material was published by Guo et al.[6] and on extruded material by Xia et al.,[7] where the authors considered the materials in terms of the Dynamic Material Model, as proposed by Prasad and other authors.[8–12] Their research delves into instability criteria and their evolution through different process conditions, supported with extensive microstructural analysis. Park and Kim[13] compared the effects of the homogenisation heat treatment of an as-cast material on compression test results. Similar research was published on comparison of the as-cast and as-extruded forging-grade of the aluminium alloy EN AW-7075 carried out by Jeong and Kim.[14] The multistep forging behaviour of alloy 7075 was researched by Ben Naser and Krallics.[15] Neural network was used by Jenab et al.[16] to model the low-strain rate behaviour. El-Shenawy et al.[17] investigated flow behaviour throughout the multi-pass thermomechanical processing of 7075 aluminium alloy and industrial application of such a process.

The aim of this research is to define the stable material processing domains for hot deformation in various material states. The analysis of material processing domains is conducted in the as-cast, homogenised, and extruded forging-grade material states, covering all condi-

*Corresponding author's e-mail:
matija.arzensek@impol.si (Matija Arzenšek)

© 2026 The Author(s). Except when otherwise noted, articles in this journal are published under the terms and conditions of the Creative Commons Attribution 4.0 International License (CC BY 4.0).

tions, in which forgings may be found throughout the production chain.

2 EXPERIMENTAL METHODS

Thermodynamic modelling of the material was performed using JMatPro v14.3, considering solidification and equilibrium calculations. The chemical composition of the researched alloy, presented in **Table 1**, was provided by Impol Group. The real solidus temperature of each state was determined via differential scanning calorimetry using a Netzsch DSC 404 F3 Pegasus. The samples in each state were heated up to 720 °C, with a ramp rate of 10 K/min in argon atmosphere. Since the method remelts the material, resetting its thermal history, the cooling effects were not considered in this research. Determination of the solidus temperature provided the upper bound of the deformation processing temperature for each alloy state. One must consider the possibility of temperature rise at high strain rates, taking into account the initial temperature of each compression test, to avoid possible melting onset.

Table 1: Chemical composition of researched aluminium alloy EN AW-7075

	Zn	Mg	Cu	Si	Fe	Mn	Cr	Ti	Al
mass %	5.33	2.27	1.32	0.07	0.17	0.06	0.20	0.02	*bal.*

The rheological response of the EN AW-7075 alloy in various states was investigated using single-hit hot compression tests performed on a Gleeble 3500P thermomechanical simulator. Cylindrical specimens, with a diameter of 10 mm and a length of 15 mm, were machined from the material provided by Impol Group in different states. The as-cast state was obtained from a cast aluminium billet with a diameter of 282 mm and a length of 7 m. Hot compression samples were machined in the radial direction relative to the axial direction of the as-cast billet, where an equiaxed microstructure is expected. Samples in the homogenised state were machined from a heat-treated billet in the same way as used for the as-cast material. Homogenised billets were extruded into rods with a diameter of 46 mm using a 35 MN SMS Hasenclever indirect extrusion press. Hot compression samples in the extruded forging-grade state were machined radially to the extrusion direction to simulate forging conditions, where the forging direction is often radial to the extrusion direction. True stress versus true strain curves were obtained from experiments conducted at strain rates of 0.01 s^{-1}, 0.1 s^{-1}, 1 s^{-1} and 10 s^{-1}, and at temperatures between 300 °C and 450 °C in 50 K intervals for the as-cast material, and at temperatures between 300 °C and 500 °C in 50 K intervals for homogenised and extruded forging-grade 7075 alloy. The maximal initial temperature of the compression test was determined based upon thermodynamical modelling and differential scanning calorimetry results for all material states. Samples were heated to the deformation temperature at a rate of 3 K s^{-1}, held at the deformation temperature for 180 s, and then compressed to a true strain of 1. To reduce friction and avoid inhomogeneous deformation, 0.05 mm thick tantalum foils and graphite foils were inserted between the cylindrical specimen and the compression tool. After deformation, samples were quenched by argon gas, at an approximate cooling rate of 7.5 K/s, to preserve the microstructure of the hot-compressed samples. Due to strain-rate instability at an end strain of $\varepsilon = 0.8$ for a strain rate of $\dot{\varepsilon} = 10\ s^{-1}$, all data were limited to $\varepsilon = 0.8$. Considering stationary stress conditions where $\sigma \neq f(\varepsilon)$, the system states at $\varepsilon = 0.4$ and $\varepsilon = 0.8$ are regarded as stationary states and are a subject of further modelling.

Experimental data were modelled with an in-house Python script, using the NumPy library and visualized with an in-house Octave script. Data were processed with a binning technique, where data frequency is reduced in order to decrease the size of data vectors, as well as reduce the noise. Each data matrix (M) consisting of raw data vectors (v) is transformed into a reduced matrix (N), whose vectors (w) contain a binned number of elements. The main objective with such data manipulation is to construct 3rd order matrices in order to present data evolution in (ε, $\dot{\varepsilon}$, T) dimensions. Therefore, 200 × 200 × 200 matrices were generated for each state of the material: as-cast, homogenised and extruded forging-grade. Inter-vector values were interpolated via cubic interpolation. With data represented as $\sigma(\varepsilon, \dot{\varepsilon}, T)$ there is a further possibility to produce derivatives such as strain-rate sensitivity (m), as presented in Equation (1), and thermal sensitivity (s), as presented in Equation (2). With values of $s < 1$ the instability condition is met.[6,18]

$$m(\dot{\varepsilon}) = \left.\frac{\partial \ln \sigma}{\partial \ln \dot{\varepsilon}}\right|_{\varepsilon,T} \tag{1}$$

$$s(T) = \frac{1}{T} \cdot \left[\frac{\partial \ln \sigma}{\partial\left(\frac{1}{T}\right)}\right]_{\varepsilon,\dot{\varepsilon}} \tag{2}$$

Activation energy maps[18,19] (Q-maps) were constructed by calculating activation energy (Q), as shown in Equation (3), at a given strain level (ε) in the ($\dot{\varepsilon}$, T) space.

$$Q(\varepsilon, \dot{\varepsilon}, T) = R\left[\frac{\partial \ln \dot{\varepsilon}}{\partial \ln[\sinh(\alpha\sigma)]}\right]_T \left[\frac{\partial \ln[\sinh(\alpha\sigma)]}{\partial\left(\frac{1}{T}\right)}\right]_{\dot{\varepsilon}} \tag{3}$$

Instability conditions, as proposed by Kim & Jeong,[20] were calculated with Equation (4). The proposed criterion is based upon the power-law breakdown.

$$n(\dot{\varepsilon}) = \left.\frac{\partial \ln \dot{\varepsilon}}{\partial \ln \sigma}\right|_{\varepsilon,T} = \left.\frac{1}{m}\right|_{\varepsilon,T} \tag{4}$$

All compression test data were friction corrected, as proposed by Ebrahimi & Najafizadeh,[21] as well as thermal corrected, as suggested by Goetz & Semiatin.[22]

3 RESULTS

Thermodynamical characterisation via differential scanning calorimetry provided a solidus temperature of 479.2 °C for the as-cast material, 551.3 °C for the homogenised material and 545.5 °C for the extruded forging-grade state. The modelling of solidification process, using JMatPro v14.3 software, determined an equilibrium solidus temperature of 542.3 °C and a non-equilibrium solidus temperature of 475.0 °C.

The flow curves $\sigma(\varepsilon)$ obtained from hot compression tests of the as-cast, homogenised and extruded forging-grade 7075 alloy are shown in **Figures 1–3**, respectively, in the raw, unredacted form. Due to the elasto-viscoplastic response of the material, the stress-strain $\sigma(\varepsilon)$ decreases with increasing temperature (T) in all cases. As observed, $\sigma(\varepsilon)$ increases with the evolution of strain (ε). This effect is not due to the hardening mechanisms within the material itself, but rather results from the barrelling effect of the specimens, where the top and maximal diameters of the sample differ. This is caused by the friction between the die and the specimen, as thoroughly discussed by Ebrahimi & Najafizadeh,[21] who also proposed a correction method. Adiabatic heating also affects the results at strain rates of 1 and 10 s^{-1}, with the effect being more pronounced at the strain rate of 10 s^{-1}. The material heats up, and subsequently softens, since the temperature rise ($\uparrow T$) leads to a decrease in stress. The impact of adiabatic heating on hot compression test results was well discussed in the study by Goetz & Semiatin.[22] Both effects were considered in data correction, and the corrected results are presented in **Figures 4–6**. A significant contribution to stress was observed in all test results, while the temperature contribution due to adiabatic heating had a minor, yet noticeable, softening effect. The data from **Figures 4–6** were also curated to reduce noise, achieved through data binning. As seen from the hot compression test results in **Figure 5**, the homogenisation heat treatment has a significant effect on $\sigma(\varepsilon)$ evolution compared to the as-cast state, presented in **Figure 4**. This effect is particularly desireable for aluminium extrusion processing, as it may reduce the required extrusion pressure in many applications. However, the homogenisation heat treatment also increases $\sigma(\varepsilon)$ at higher temperatures, such as 450 °C, compared to the as-cast material state. Since the as-cast material is near its solidus[23] at a temperature of 450 °C, a drop in $\sigma(\varepsilon)$ is commonly observed. The data presented in **Figures 4–6** are simualtion-ready since they may be used for further finite-element and mechanical simulations.

Thermomechanical response may be interpreted as strain-rate sensitivity maps, presented as maps in **Fig-**

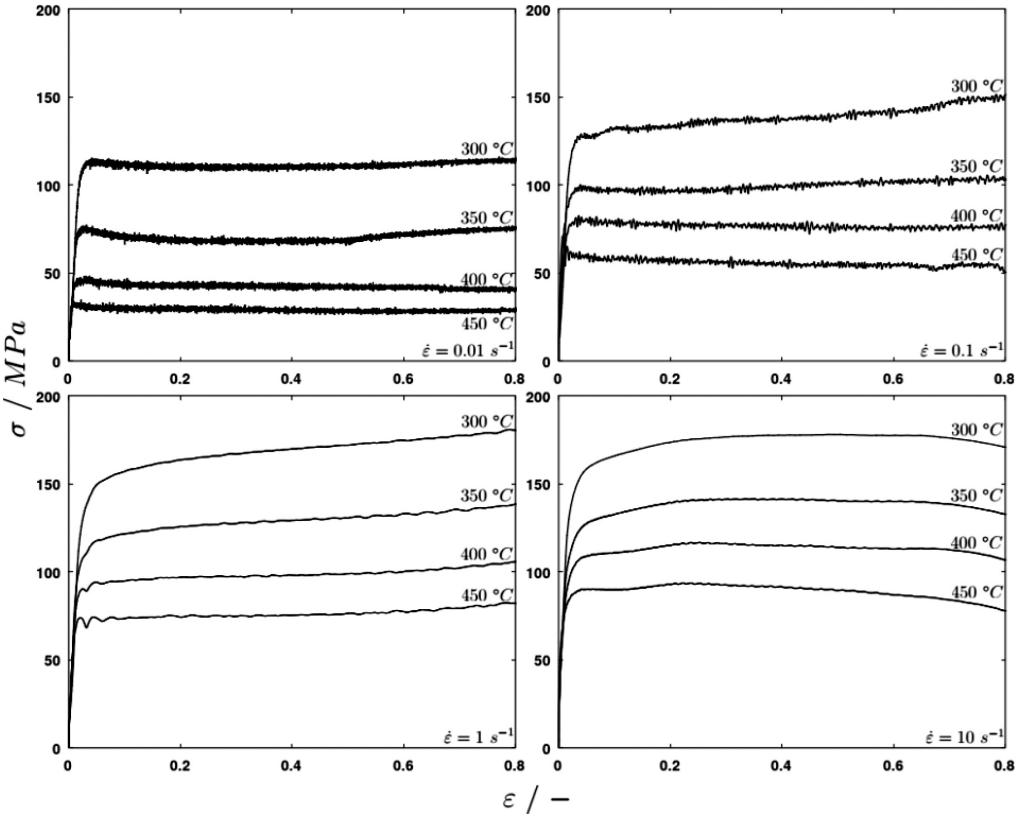

Figure 1: Stress-strain curves $\sigma(\varepsilon)$ obtained from hot compression tests of aluminium alloy EN AW-7075 in the as-cast state

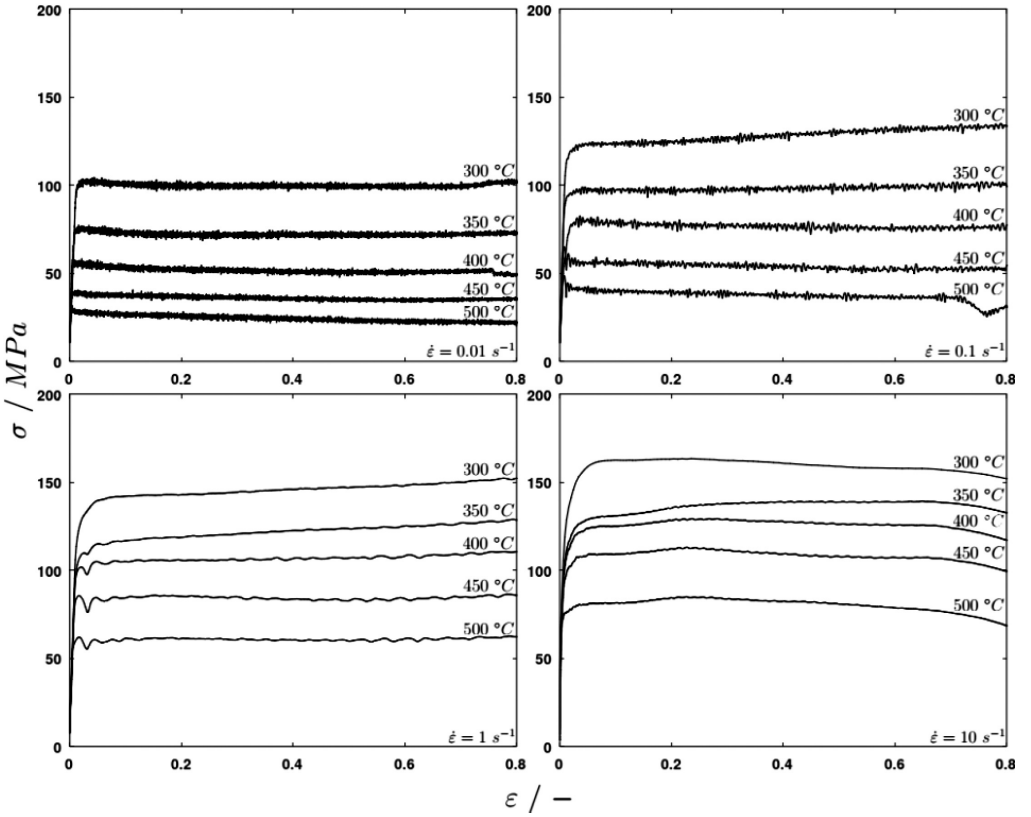

Figure 2: Stress-strain curves $\sigma(\varepsilon)$ obtained from hot compression tests of aluminium alloy EN AW-7075 in the homogenised state

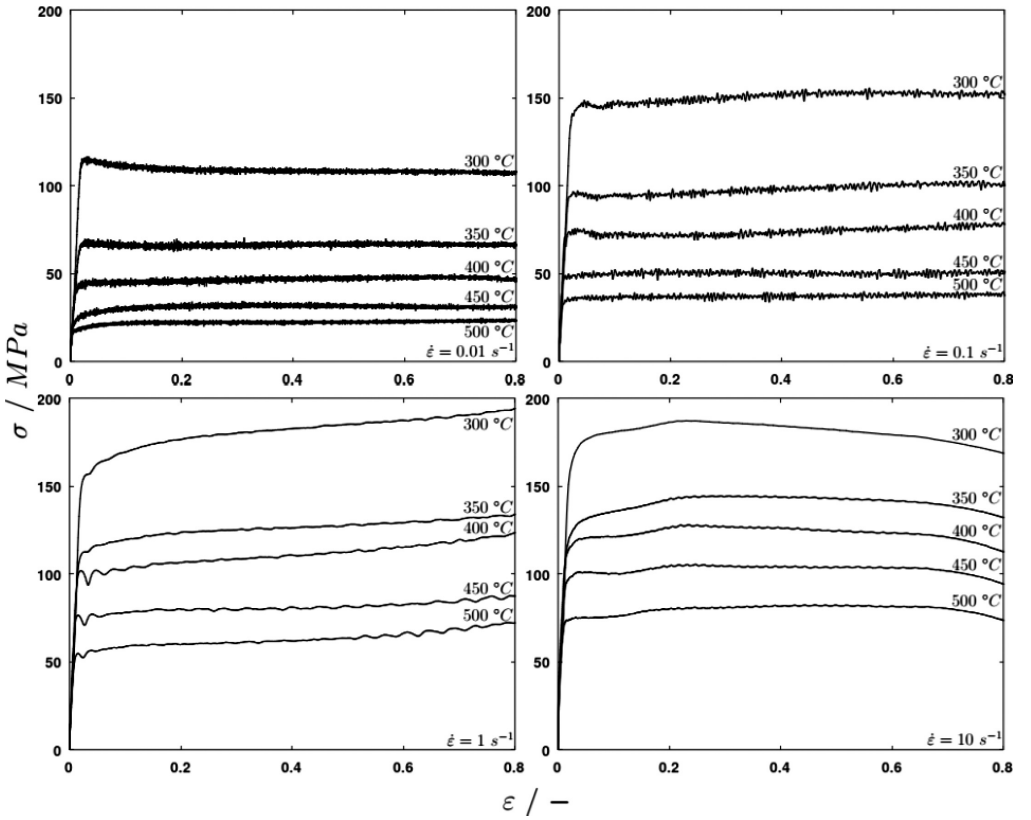

Figure 3: Stress-strain curves $\sigma(\varepsilon)$ obtained from hot compression tests of aluminium alloy EN AW-7075 in the extruded forging-grade state

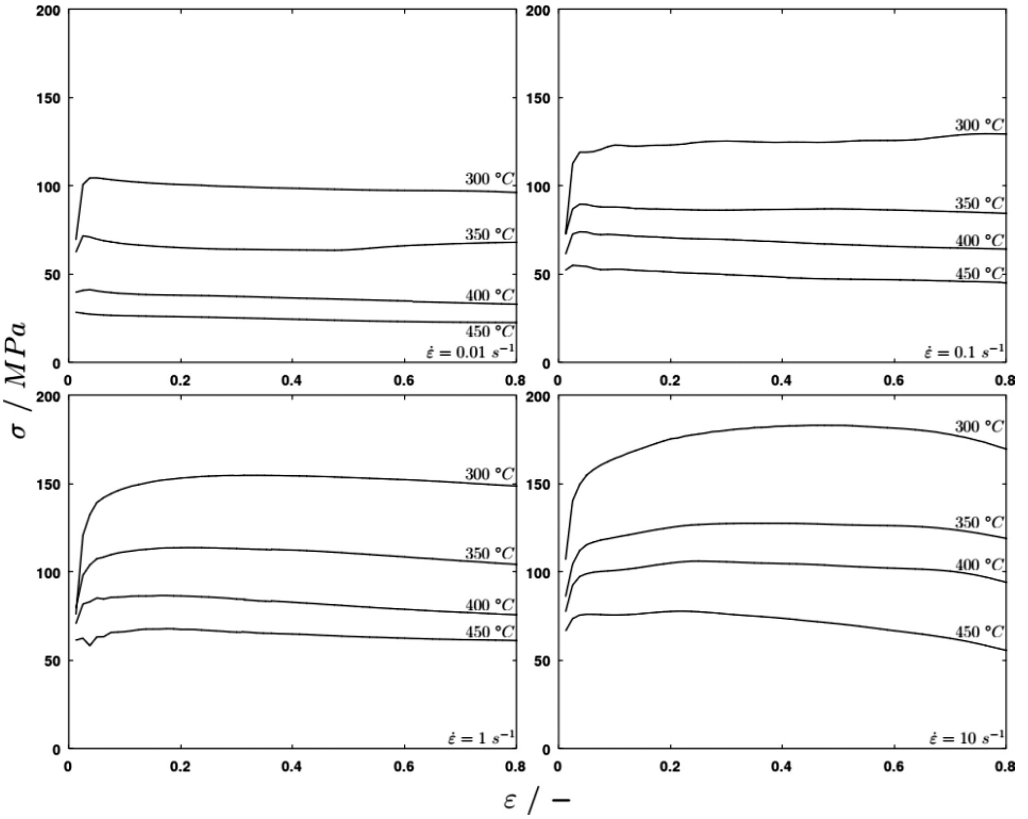

Figure 4: Friction- and temperature-corrected stress-strain curves $\sigma(\varepsilon)$ of the as-cast aluminium alloy EN AW-7075 obtained from compression tests

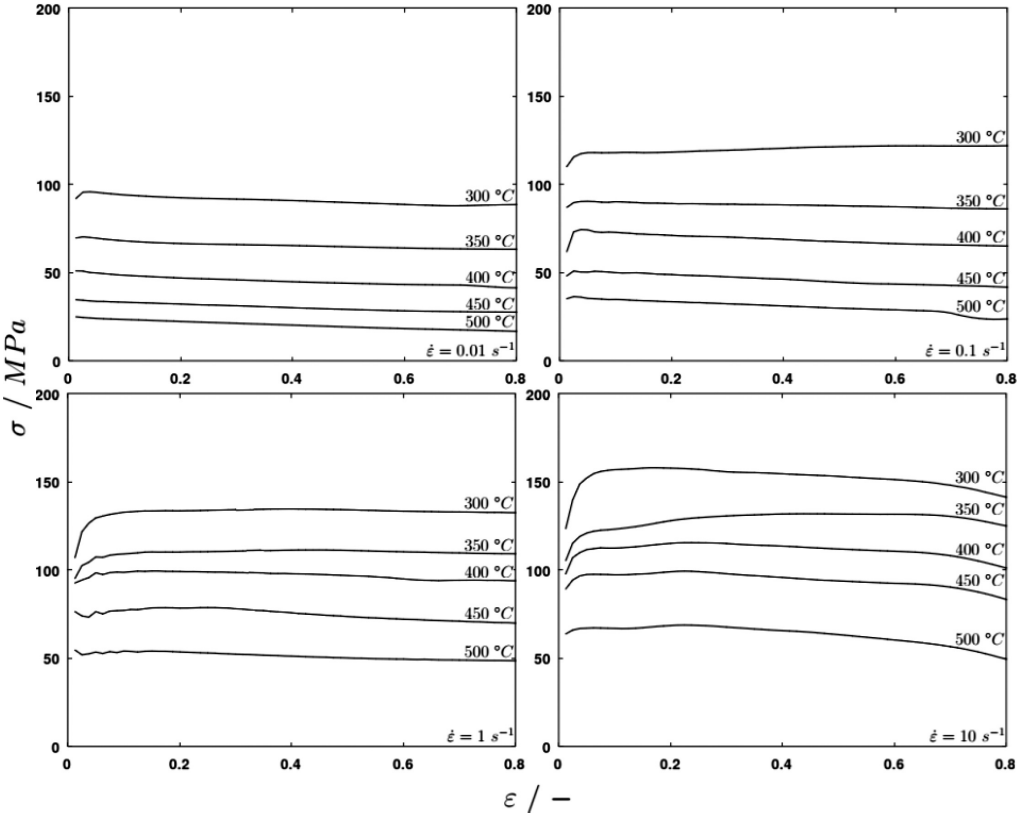

Figure 5: Friction- and temperature-corrected stress-strain curves $\sigma(\varepsilon)$ of the homogenised aluminium alloy EN AW-7075 obtained from compression tests

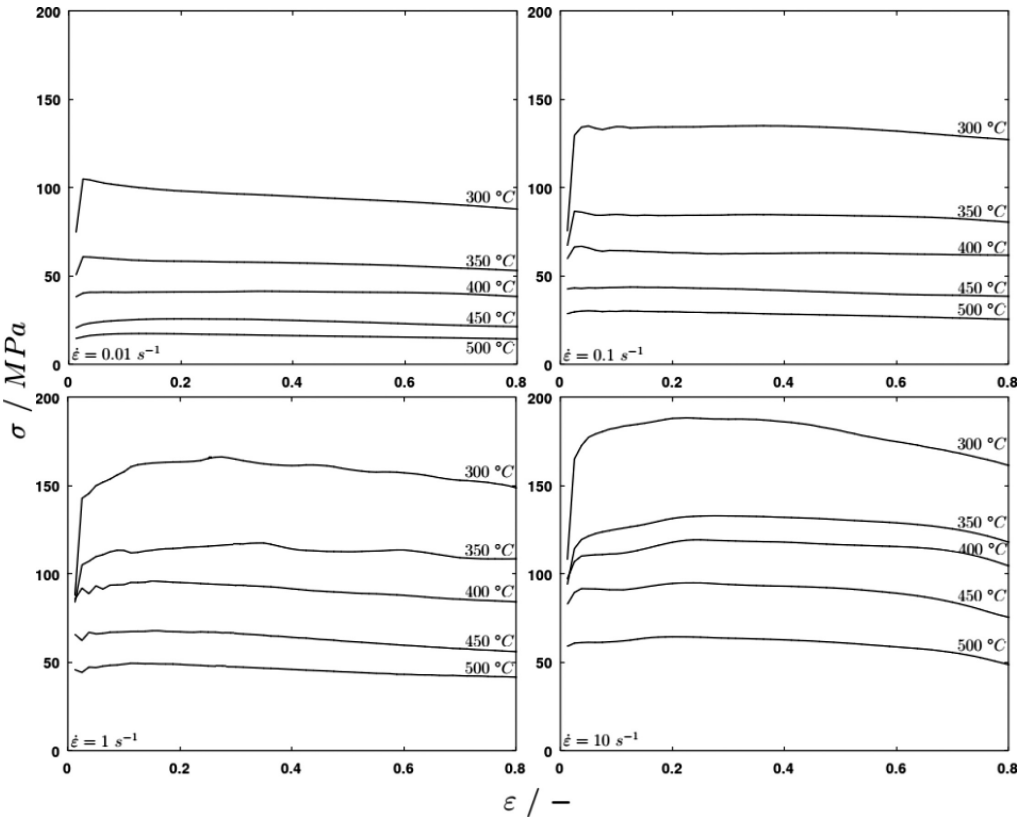

Figure 6: Friction- and temperature-corrected stress-strain curves $\sigma(\varepsilon)$ of the extruded forging-grade aluminium alloy EN AW-7075 obtained from compression tests

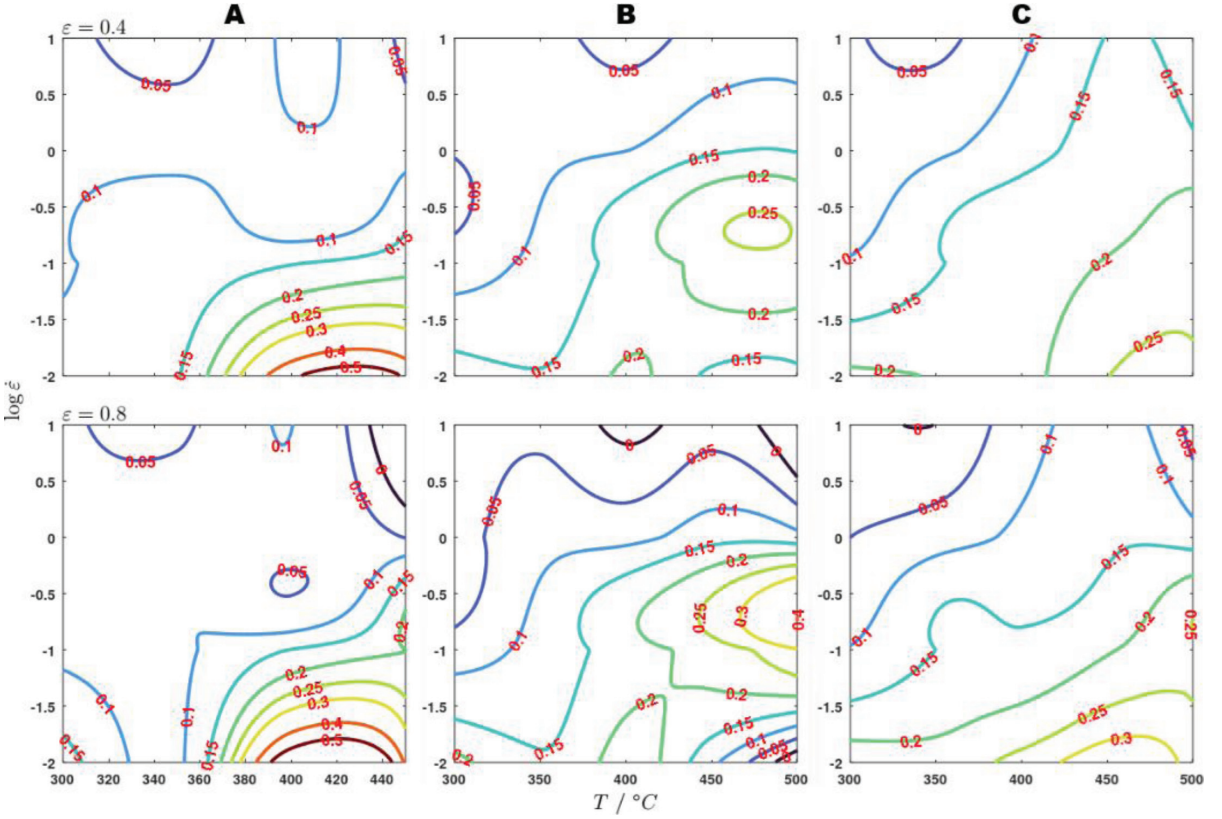

Figure 7: *m*-maps, denoting strain-rate sensitivity, at strain levels of 0.4 (top row) and 0.8 (bottom row) of aluminium alloy EN AW-7075 in the as-cast (A: left), homogenised (B: centre) and extruded forging-grade state (C: right)

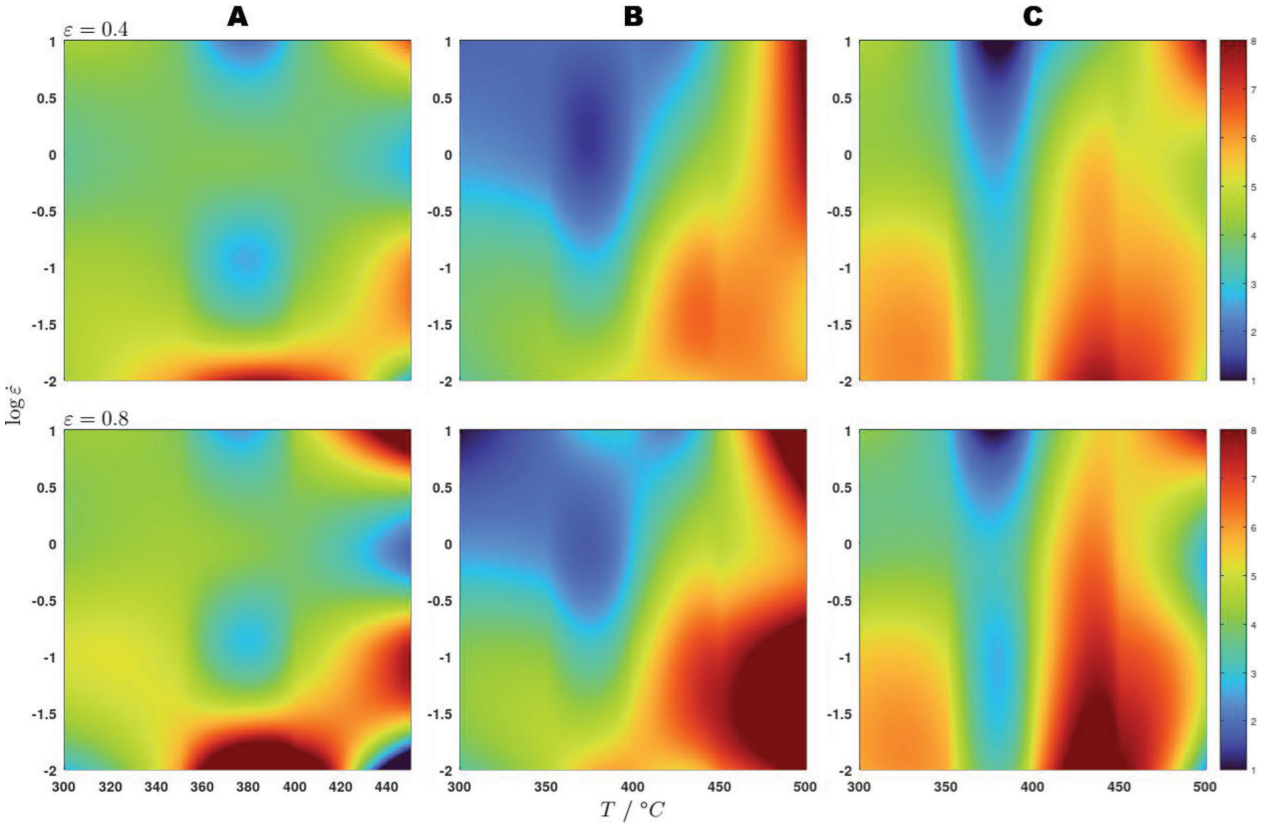

Figure 8: *s*-maps, denoting temperature sensitivity, at strain levels of 0.4 (top row) and 0.8 (bottom row) of aluminium alloy EN AW-7075 in the as-cast (A: left), homogenised (B: center) and extruded forging-grade state (C: right)

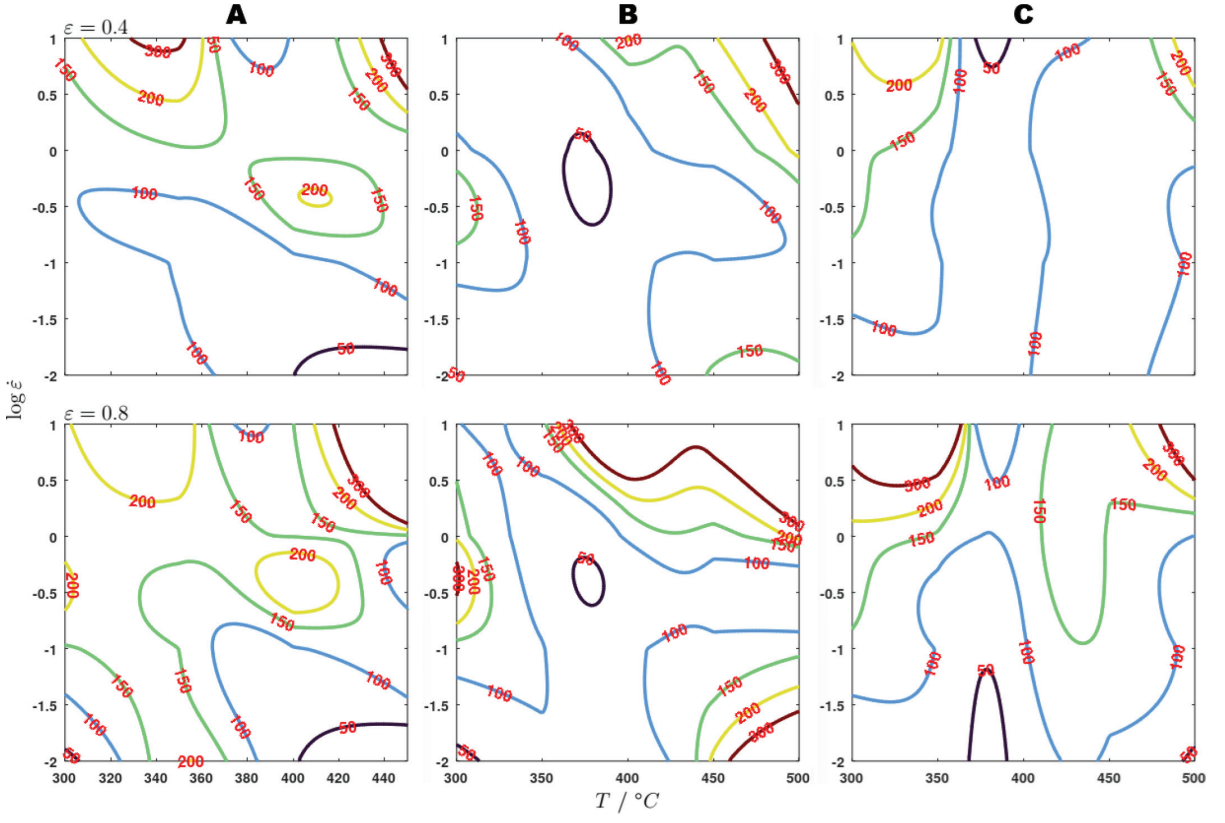

Figure 9: *Q*-maps displaying contours of activation energy levels at given strain levels of 0.4 (top row) and 0.8 (bottom row) of the aluminium alloy EN AW-7075 in the as-cast (A: left), homogenised (B: centre) and extruded forging-grade (C: right) state

ure 7. The material state variable is denoted as column A for the as-cast material, B for homogenised material, and C for the extruded forging-grade material. The top row presents results of *m*-maps at strain level $\varepsilon = 0.4$, and the bottom row at strain level $\varepsilon = 0.8$. Quantitative and qualitative differences may be observed in all material states, yet the tendency to observe higher *m* domains at higher temperatures ($T>$) and lower strain rates ($\dot{e}<<$) is present in all cases. The interpretation of dynamic processes as proposed by Prasad and others[8–12] in terms of the Dynamic Material Model was critically reviewed by Montheillet et al.,[24] who recommend the interpretation of *m*-maps instead of derivatives of as previously proposed.

Additional consideration must be given to the temperature sensitivity of the material response, as presented by *s*-maps in **Figure 8**. Malas[18] defined the stability conditions via Lyapunov stability analysis, in which the boundary value of $s > 1$ is recognised as a stability criterion.[6,18] The condition of $s < 1$ is met only in insignificant regions; thus, no result is presented.

Activation energy maps, or *Q*-maps, were proposed as a modelling tool by Malas,[18] who defines mechanisms that may be attributed to various domains of *Q*-levels. The data from hot compression tests of aluminium alloy EN AW-7075 in various material states, as shown in **Figures 4–6**, were modelled into *Q*-maps, as shown in **Figure 9**. Low-*Q* domains are associated with ease of deformation, indicating that the corresponding deformation mechanism requires less energy to activate.[25,26] The concept of activation energy maps is thus introduced to identify desirable processing domains,[27] as illustrated in **Figure 9**, where the evolution of *Q*-maps for the EN AW-7075 aluminium alloy deformation is presented. As observed, the as-cast material in **Figure 9**, column A, achieves low *Q*-levels in the domain of low $\dot{\varepsilon}$ and high *T*. The homogenised state of the material, shown in **Figure 9,** column B, achieves low-levels at intermediate and intermediate *T*, with a notably extensive low *Q*-domain. The same applies to the extruded forging-grade material activation energy maps shown in **Figure 9**, column C.

Instability maps, as proposed by Kim and Jeong,[20] for aluminium alloy EN AW-7075 are shown in **Figure 10**. Since the Kim and Jeong criterion is based on power-law breakdown, the authors observed results similar to those for the instability criteria proposed by Kumar and Prasad.[8–12] However, the criterion is actually an analysis of *m*-conditions, which, as proposed by Montheillet et al.,[24] is fundamentally sound and may be used for further dynamic process identification, in contrast to the Dynamic Material Model and its fundamentals. As expected, heat treatment broadens the stability domains, as seen in the comparison of columns A, B and C in **Figure 10**. Both as-cast and homogenised material states are relatively strain insensitive, as the strain level has little effect on the stability domain area. In contrast, the extruded forging-grade material in **Figure 10**, column C,

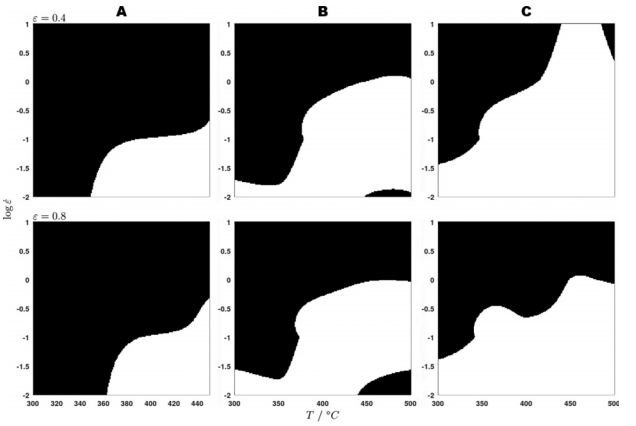

Figure 10: *n*-maps displaying stable (light domains) and unstable (dark domains) domains via power-law breakdown criteria at given strain levels of 0.4 (top row) and 0.8 (bottom row) of aluminium alloy EN AW-7075 in the as-cast (A: left), homogenised (B: centre) and extruded forging-grade state (C: right)

exhibits a strain sensitive response, with the stability domain decreasing as ε increases from 0.4 to 0.8 in the high-temperature range ($T >$).

As observed, the *Q*-maps and *n*-maps share domains of preferable thermomechanical conditions. Therefore, adopting strain-rate and temperature sensitivity for stable domain monitoring may be appropriate, as proposed by Montheillet et al.,[24] in contrast to the Dynamic Material Model[8–12] which provides improper fundamental interpretation of state functions.

4 DISCUSSION

As observed in the results of the experimental section, the heat treatment of the as-cast material produces homogenised and extruded forging-grade aluminium alloy EN AW-7075. Thermodynamic modelling and characterisation showed a substantial increase in the solidus temperature from 479.2 °C of the as-cast state, caused by non-equilibrium conditions leading to the presence of low-melting point phases in the microstructure, up to 551.3 °C of the homogenised state and 545.5 °C of the extruded forging-grade state. Obtained solidus temperatures are comparable to the results obtained by Woźnicki et al.[23]

The material in the homogenised state has lower deformation resistance, in terms of $\sigma(\varepsilon)$, at lower temperatures, e.g. 300 °C, compared to the as-cast material. However, at higher temperatures, the $\sigma(\varepsilon)$ curves are lower for the as-cast material compared to the homogenised material, as close-to-solidus conditions apply. The extruded forging-grade material exhibits higher values of $\sigma(\varepsilon)$ compared to the homogenised material. This may be substantially influenced by the fibrous microstructure, as well as by solute hardening, since quenching from hot forming temperatures is applied.

The as-cast material exhibits large, inadequate domains of strain-rate sensitivity *m* values. This indicates

the difficulty of selecting an adequate processing route to achieve the desired final properties. The homogenised material state, i.e., extrusion-grade material, exhibits larger stability domains in terms of *m*-maps, as presented in **Figure 7**. The upper thermal boundary of material processing, being above 500 °C, provides a much larger domain for consideration in process planning. Consequently, the risk of crack formation is generally lower, since the solidus temperature plays an important role.[3–5] With reference to *m*-maps, the extruded forging-grade material of aluminium alloy EN AW-7075 exhibits a broader domain of suitable strain-rate sensitivity values, as shown in **Figure 7**.

The activation energy maps,[19,25–27] at strain level $\varepsilon = 0.4$, presented in **Figure 9**, show a substantial difference between material states. The as-cast material *Q*-maps, in **Figure 9**, column A, exhibit higher activation energy values compared to the homogenised material, column B, and the extruded forging-grade material, column C, indicating greater difficulty in deformation processes in high-*Q* domains. The homogenised-state *Q*-maps, in **Figure 9**, column B, exhibit high *Q*-levels at a high temperature and high strain rate.

Instability conditions, as defined by Kim and Jeong,[20] where power-law breakdown is considered, are present in most of the domains of the as-cast material, as shown in **Figure 10**, column A. The homogenised and extruded forging-grade states of alloy EN AW-7075 exhibit larger stable domains, where, in all cases, low strain-rate and high-temperature domains are considered stable. The main difference between the homogenised and forging-grade materials, presented in **Figure 10**, columns B and C, respectively, is that the extruded forging-grade material is stable at high strain rates and high temperatures, e.g., close to 500 °C, whereas the homogenised state remains unstable. Instability should be interpreted as plastic instability effects such as shear band formation, cracking, void formation etc.[8–12,18,20]

5 CONCLUSIONS

The hot deformation behaviour of aluminium alloy EN AW-7075 was investigated with regard to the as-cast, homogenised, and forging-grade material states. The aim of the research was to present the differences in behaviour between these material states. The following conclusions can be drawn from the results obtained:

- The as-cast EN AW-7075 alloy has a considerably lower solidus temperature, as observed by some authors[23], which limits the ease of deformation processing. It also exhibits significantly higher $\sigma(\varepsilon)$ values at low temperatures ($T <$) and high strain rates ($\dot{\varepsilon} >$).
- The homogenised and forging-grade states exhibit broader domains of strain rate sensitivity (*m*-domains), within which favourable values are found.
- Temperature stress sensitivity (*s*-instability) conditions are met only to a negligible extent, so this type of instability is not considered relevant for any of the material states.
- Activation energy maps show low *Q*-domains for the homogenised and forging-grade states of EN AW-7075 alloy, whereas the as-cast material exhibits higher activation energy (*Q* values) across the processing domains. The homogenised state exhibits high *Q*-domains at high strain rates ($\dot{\varepsilon} >$) and high temperatures ($T >$). Low *Q*-domains are associated with easier deformation processing. The forging-grade state exhibits high *Q*-domains at high strain rates ($\dot{\varepsilon} >$) and low temperatures ($T >$), which could be caused by the overall high dislocation density and its increase.
- Instability conditions proposed by Kim and Jeong indicate large domains of instability in the as-cast material, whereas the homogenised and forging-grade states exhibit larger stable domains. The forging-grade EN AW-7075 alloy exhibits stability at high strain rates ($\dot{\varepsilon} >$) and high temperatures ($T >$), whereas the homogenised state does not.

6 REFERENCES

[1] J. Sessler, V. Weiss, Materials Data Handbook: Aluminium Alloy 7075, Department of Chemical Engineering and Metallurgy, Syracuse University, Syracuse, New York 1966

[2] R. F. Muraca, J. S. Whittick, Materials Data Handbook, 2nd Edition, Western Applied Research & Development, Inc. 1972

[3] T. Sheppard, Extrusion of Aluminum Alloys, Kluwer Academic Publishers, Norwell 1999, doi:10.1007/978-1-4757-3001-2

[4] P. Korczak, B. Płonka, D. Leśniak, K. Remsak, K. Żyłka, Determining Material Characteristics for Finite Element Simulations of Plastic Forming of the EN AW-7075 Aluminium Alloy, Metals, 16 (**2026**) 2, 219, doi:10.3390/met16020219

[5] D. Leśniak, K. B. Laber, J. Madura, FEM Numerical Calculations and Experimental Verification of Extrusion Welding Process of 7075 Aluminium Alloy Tubes, Metals, 19 (**2025**) 1, 75, doi:10.3390/ma19010075

[6] L. Guo, S. Yang, H. Yang, J. Zhang, Processing map of as-cast 7075 aluminum alloy for hot working, Chin. J. of Aeronaut., 28 (**2015**) 6, 1774–1783, doi:10.1016/j.cja.2015.08.002

[7] E. Xia, T. Ye, S. Qiu, L. Liu, F. Luo, H. Yue, Y. Wu, Deformation Behaviour and Processing Maps of 7075 Aluminium Alloy under Large-Strain Thermal Compression, Materials, 16 (**2023**) 23, 7432, doi:10.3390/ma16237432

[8] Y. V. R. K. Prasad, H. L. Gegel, S. M. Doraivelu, J. C. Malas, J. T. Morgan, K. A. Lark, D. R. Barker, Modeling of dynamic material behavior in hot deformation: Forging of Ti-6242, Metall. Trans. A, 15 (**1984**), 1883–1892, doi:10.1007/BF02664902

[9] Y. V. R. K. Prasad, Author's reply: Dynamic materials model: Basis and principles, Metall. Trans. A, 27 (**1996**), 235–236, doi:10.1007/BF02647765

[10] Y. V. R. K. Prasad, T. Seshacharyulu, Processing maps for hot working of titanium alloys, Mater. Sci. Eng. A, 243 (**1998**) 1–2, 82–88, doi:10.1016/S0921-5093(97)00782-X

[11] S. C Medeiros, Y. V. R. K. Prasad, W. G. Frazier, R. Srinivasan, Microstructural modeling of metadynamic recrystallization in hot working of IN 718 superalloy, Mater. Sci. Eng. A, 293 (**2000**) 1–2, 198–207, doi:10.1016/S0921-5093(00)01053-4

[12] Y. V. R. K. Prasad, Processing maps: A status report, J. Mater. Eng. Perform., 12 (**2003**), 638–645, doi:10.1361/105994903322692420

[13] S. Y. Park, W. J. Kim, Difference in the Hot Compressive Behavior and Processing Maps between the As-cast and Homogenized Al-Zn-Mg-Cu (7075) Alloys, J. Mater. Sci. Technol., 32 (**2016**) 7, 660—670, doi:10.1016/j.jmst.2016.04.006

[14] H. T. Jeong, W. J. Kim, Comparison of Hot Deformation Behavior Characteristics Between As-Cast and Extruded Al-Zn-Mg-Cu (7075) Aluminum Alloys with a Similar Grain Size, Materials, 12 (**2019**) 23, 3807, doi:10.3390/ma12233807

[15] S. Tareg, Ben Naser, G. Krallics, Mechanical Behavior of Multiple-forged Al 7075 Aluminum Alloy, Acta Polytech. Hung., 11 (**2014**) 7, 103–117, doi:10.12700/aph.11.07.2014.07.7

[16] A. Jenab, A. Karimi Taheri, K. Jenab, The Use of ANN to Predict the Hot Deformation Behavior of AA7075 at Low Strain Rates., J. Mater. Eng. Perform., 22 (**2013**), 903–910, doi:10.1007/s11665-012-0332-y

[17] E. El-Shenawy A. I. Z. Farahat, A. E. Ragab, A. Elsayed, R. Reba, Flow Behaviour and Mechanical Properties of Multi-Pass Thermomechanically Processed 7075 Al-Alloy, Metals, 13 (**2023**) 7, 1158, doi:10.3390/13071158

[18] J. C. Malas, III: Methodology for design and control of thermomechanical processes, Ph.D. thesis, Ohio University, Athens, OH 1991

[19] A. Emdadi, H. Michels, M. Tovar, Hot Workability Investigation of an Fe-Al-Ta Alloy Using Deformation Processing Maps, Metals, 13 (**2023**) 7, 1195, doi:10.3390/met13071195

[20] W. J. Kim, H. T. Jeong, Easy construction of processing maps for metallic alloys using a flow instability criterion based on power-law breakdown, J. Mater. Res. Technol., 9 (**2020**) 3, 5134–5143, doi:10.1016/j.jmrt.2020.03.030

[21] R. Ebrahimi, A. Najafizadeh, A new method for evaluation of friction in bulk metal forming, J. Mater. Process. Technol., 152 (**2004**) 2, 136–143, doi:10.1016/j.jmatprotec.2004.03.029

[22] R. L. Goetz, S. L. Semiatin, The adiabatic correction factor for deformation heating during the uniaxial compression test, J. Mater. Eng. Perform., 10 (**2001**), 710–717, doi:10.1361/105994901770344593

[23] A. Woźnicki, B. Leszczyńska-Madej, G. Włoch, J. Grzyb, J. Madura, D. Leśniak, Homogenization of 7075 and 7049 Aluminium Alloys Intended for Extrusion Welding, Metals, 11 (**2021**), 338, doi:10.3390/met11020338

[24] F. Montheillet, J. J. Jonas, K. W. Neale, Modeling of dynamic material behavior: A critical evaluation of the dissipator power co-content approach, Metall. Mater. Trans. A, 27 (**1996**), 232–235, doi:10.1007/BF02647764

[25] P. Zhou, L. Deng, M. Zhang, P. Gong, X.-Y. Wang, Characterization of hot workability of 5052 aluminum alloy based on activation energy-processing map, J. Mater. Eng. Perform., 28 (**2019**), 6209–6218, doi:10.1007/s11665-019-04367-7

[26] J. Kliber, I. Schindler, P. Kawulok, R. Sedláček, Energy dissipation and instability parameter at high temperature forming of middle carbon steel, In: Proceedings of the 26th International Conference on Metallurgy and Materials, Brno, Czech Republic, 24–26 May 2017; Tanger Ltd., Ostrava, Czech Republic, 2018, 370–374

[27] P. Opěla, I. Schindler, P. Kawulok, R. Kawulok, S. Rusz, H. Navrátil, R. Jurča, Correlation among the Power Dissipation Efficiency, Flow Stress Course, and Activation Energy Evolution in Cr-Mo Low-Alloyed Steel, Materials, 13 (**2020**), 3480, doi:10.3390/ma13163480