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Denis Chemezov
Vladimir Industrial College
M.Sc.Eng., Corresponding Member of International Academy of Theoretical and Applied Sciences, Lecturer, Russian Federation
https://orcid.org/0000-0002-2747-552X
chemezov-da@yandex.ru

Valeriy Shchetnikov
Vladimir Industrial College
Master of Industrial Training, Russian Federation

Vladimir Goremykin
Vladimir Industrial College
Master of Industrial Training, Russian Federation

Leonid Khripkov
Vladimir Industrial College
Student, Russian Federation

Oksana Dubova
Vladimir Industrial College
Student, Russian Federation

Kirill Filatov
Vladimir Industrial College
Student, Russian Federation

Ivan Moiseev
Vladimir Industrial College
Student, Russian Federation

VOLUMETRIC AND GRAPHICAL PRESENTATION OF STRESS-STRAIN STATE OF THE ALUMINIUM BILLET AT REALIZATION OF THE FORGING PROCESS

***Abstract**: Modeling of plastic strain of the aluminium billet by forging was performed in the article. Contours of stress and effective plastic strain of the billet material over the entire time range of the forging process were obtained. Dependencies of stress from effective plastic strain and strain velocity from the billet height at realization of the forging process were built.*

***Key words**: forging, a billet, effective plastic strain, stress, a forged piece.*

***Language**: English*

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Introduction

Forging is the process of plastic strain of metal billets to give them the necessary geometric shapes and properties. Metals are heated to the certain temperature to facilitate the strain process when forging, but in special cases, materials are processed in cold state. Massive forged pieces are manufactured in large quantities on hydraulic presses.

The forging process in the die is similar to the casting process. Metal in solid state is deformed and begins to flow, filling the die cavities [1-10]. In this case, strain velocity will vary over the entire time range of the forging process in the entire volume of metal. These strains lead to the decrease of strength characteristics of the forged piece in the conditions of cold forging.

The calculation and the subsequent analysis of the forged piece state after machine cold forging will allow to draw the conclusion about the influence of emerging stresses in plastic material on strain.

Materials and methods

The process of cold forging of the aluminium billet with the height of 110 mm and the outer diameter of 150 mm was simulated. The following parameters units were selected for this purpose: lbf/in^2, s, lbf, and psi.

Processed material was elastic-plastic with the arbitrary dependence between stress and strain. Mass density of material was 2.5×10^{-4}, the Young's modulus was 10×10^6, and the Poisson's ratio was 0.33. The values of effective plastic strain varied in the range from 0 to 4, the values of yield strength varied in the range from 4.785×10^3 to 3.081×10^4. The punch was accepted as the perfectly rigid body.

The punch progressively moved along the Z-axis. The loading curve described the dependencies of motion from time.

Contact of the punch with the billet was carried out on the end surfaces. The coefficients of static and dynamic friction between the contact surfaces were accepted 0.1; the coefficient of viscous friction was accepted 2.055×10^3.

The strength calculation was performed with the solution step of the mass recalculation of elements of 1.2×10^{-7}. Energy was calculated into the total balance.

Results and discussion

The billet height after plastic strain was 40 mm. The stress contours of the billet material when forging are presented in the Fig. 1.

The billet model was displayed as the segment for more detailed presentation of stress state of material. The surface layer of the outer diameter in contact with the punch is subjected to maximum stress when reducing the billet height by 0.3 times. The inner layers of the billet are subjected to stress in the less degree. Stresses arise from the surface layer to the center of the billet at the angle of 45 degrees in these volumes. The forged piece has stress state in the surface layer and in the center. The percentage of stresses of the forged piece material in the center and in the surface layer was 67%.

The contours of effective plastic strain of the billet material when forging are presented in the Fig. 2.

Intensity of effective plastic strain of the billet material is identical to stress. The difference is that the most deformed volume of the forged piece material has the shape of the ring located slightly below the surface layers in contact with the end surface of the punch. The maximum value of the coefficient of effective plastic strain of the forged piece material was 1.3.

The dependencies of stress from effective plastic strain of the billet material over the entire time range of the forging process are presented in the Fig. 3.

The average values of stress and effective plastic strain calculated along the Z-axis were accepted for building the dependencies. Gradual compression of the billet is characterized by the decrease of stress in the most deformed volumes of material. These volumes are located in the upper part of the billet (from the pressure side of the punch). Small strain and the increase of stress in material are observed in the lower layers of the billet. Maximum effective plastic strain of material was determined in the upper part of the forged piece after processing.

The dependencies of velocity of plastic strain of material from the billet height over the entire time range of the forging process are presented in the Fig. 4.

Strain velocity of the billet material is constantly increasing. Strain velocities of material can be changed up to 4 times on the accepted length of the billet. The billet material is deformed when maximum velocity at the beginning of the forging process. Strain velocity is reduced by 1.5 times when maximum compression of the forged piece material.

Conclusion

The forged piece after processing has the most deformed volumes in the center and in the surface layer from the pressure side of the punch. The decrease of material stress at the increase of effective plastic strain on the some time ranges of the process is characteristic feature of the billet forging. The most deformed material of the forged piece is supposed to be removed by the mechanical methods during formation of the hole.

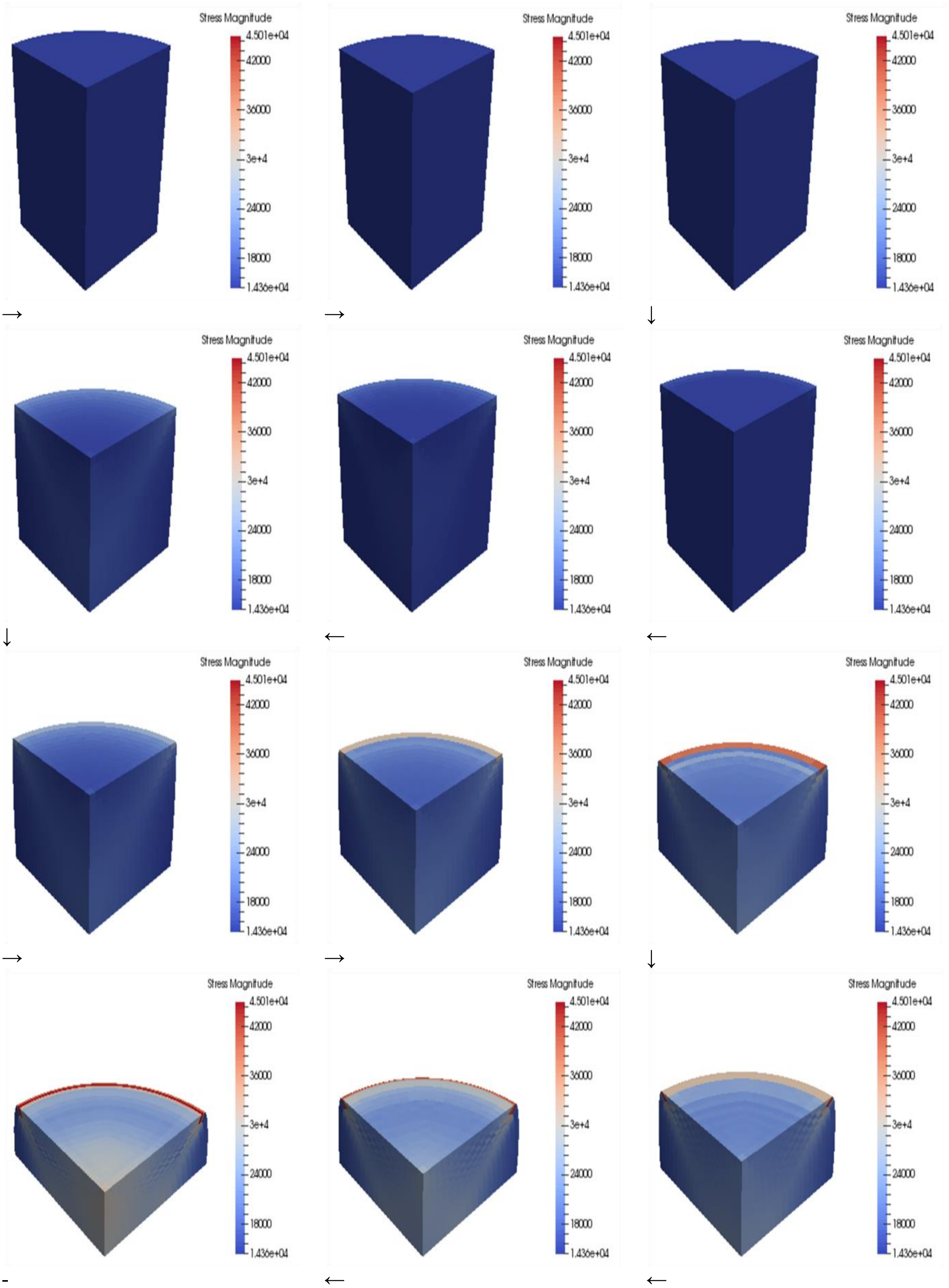

Figure 1 – The stress contours of the billet material.

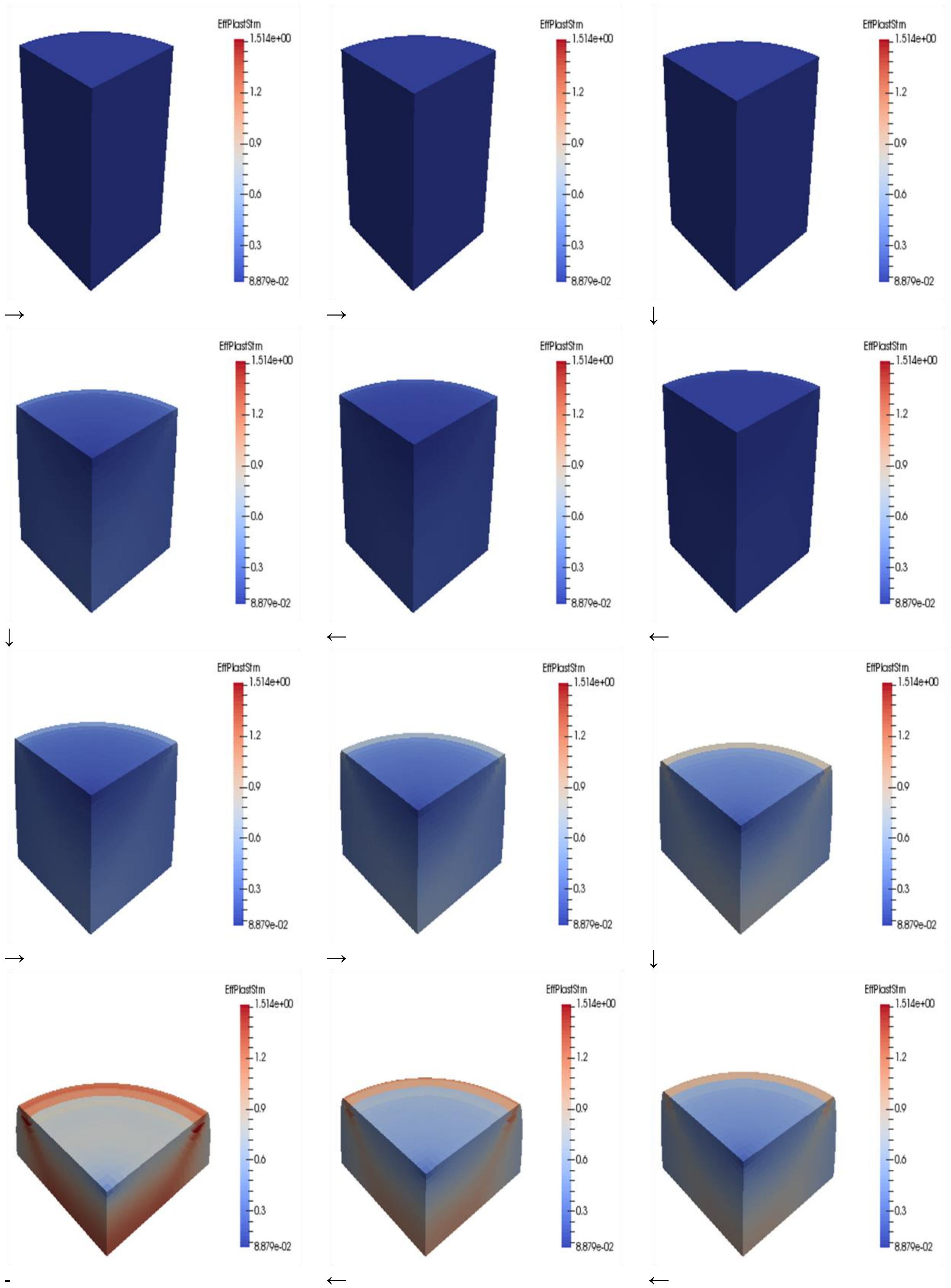

Figure 2 – The contours of effective plastic strain of the billet material.

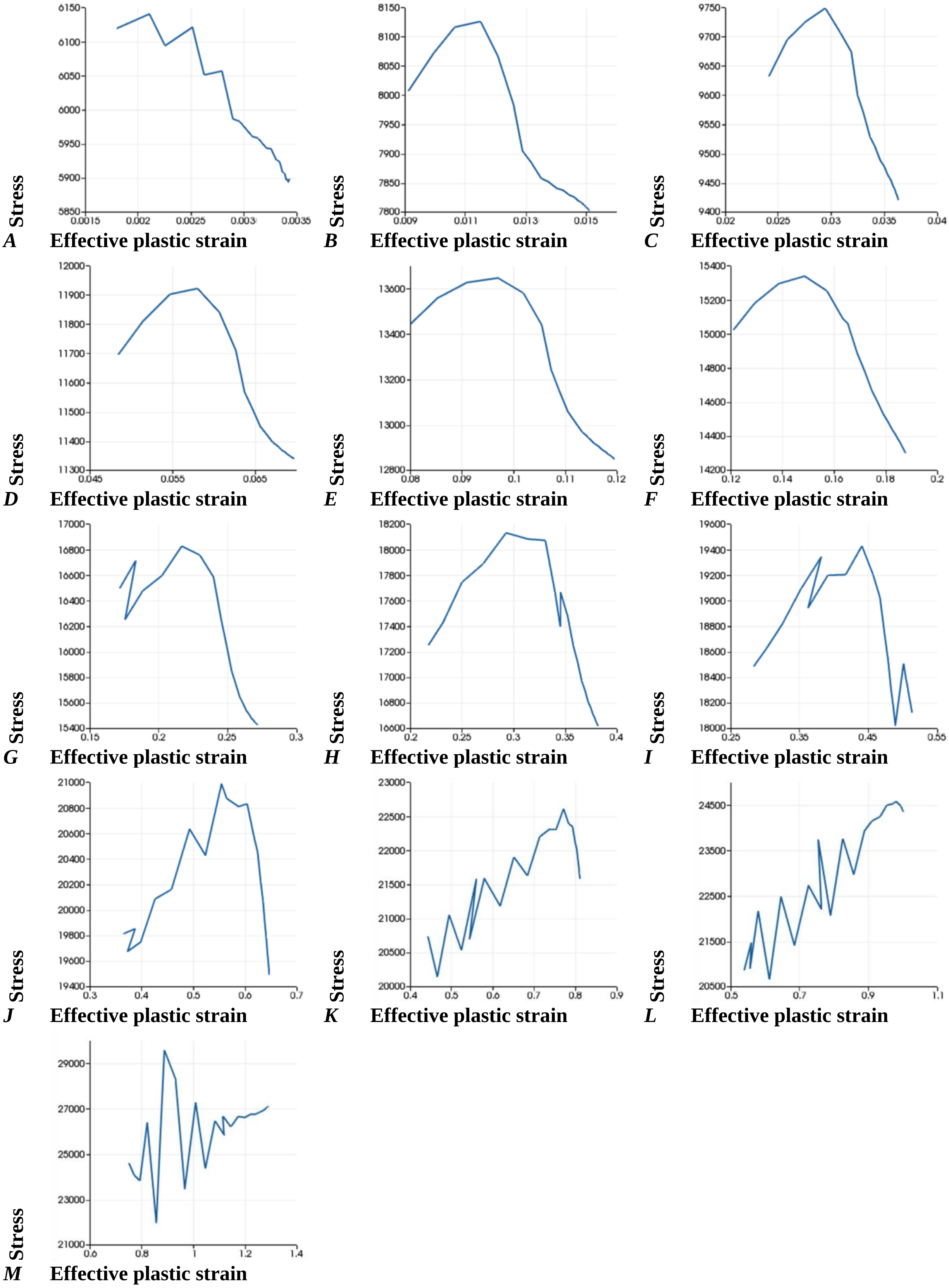

Figure 3 – The dependencies of stress from effective plastic strain of the billet material over the entire time range of the forging process.

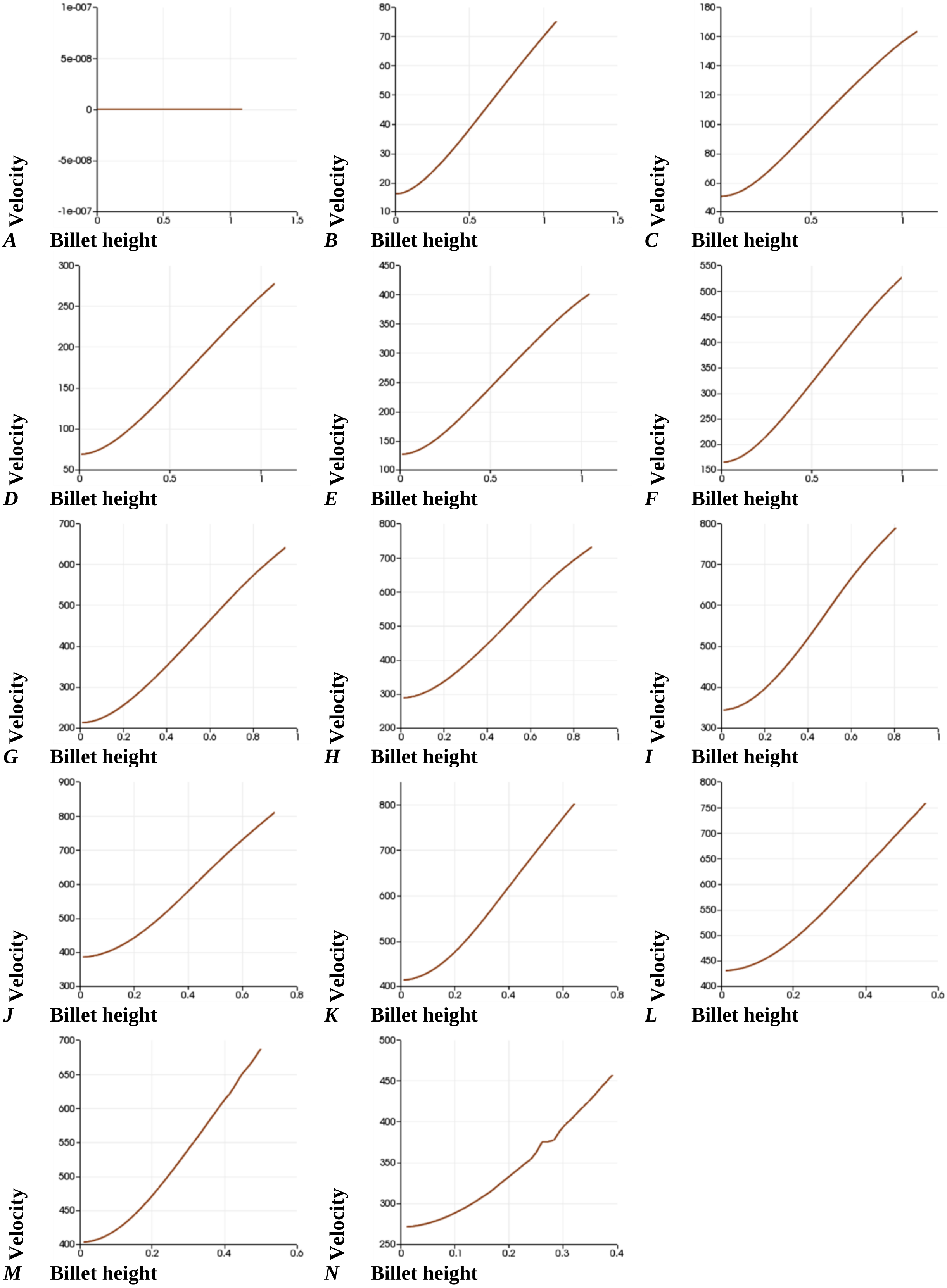

Figure 4 – The dependencies of velocity of plastic strain of material from the billet height over the entire time range of the forging process.

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