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Abstract

Sustainability in Forging

INTERNAL HEATING SYSTEM FOR HOT FORGING DIES

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The pre-heating of dies is a common practice in hot forging. Improper pre-heating results in a variety of problems due to thermal fatigue. In hot forging, gas flame torches are generally used for die heating while the forging equipment is kept idle. Problems commonly encountered with the flame torch heating method are mainly long heating time and uncontrollable temperature distribution. The current practice of torch heating of the hot forging dies has been firstly experimentally observed to examine the temperature distribution and common encountered problems.

In this study, a novel internal heating system for hot forging dies has been developed and patented to provide the required temperature distributions on the forging dies during pre-heating and forging process. Due to the stresses developed during the process and high temperature effects in the heating channels, a thermo-mechanical analysis of the dies and the workpiece has been performed for the die heating system. The proposed system has also been experimentally verified in an industrial environment and implimented in AKSAN Steel Forging Company, Ankara, Turkey. As a case study, the die temperature has been regulated throughout forging of a particular product batch experimentally. The die life and early failure due to thermal fatigue have been observed and the results have been compared with the computer simulation results. It is seen that die life increases when the internal heating system is used. The proposed method has also been applied to other industrial forgings, therefore the patended method is found to be successfully applicable. Main contributions of the internal die heating system can be stated as follows:

- The system eliminates/reduces thermal fatigue, forging die surface wear, operational time losses, combustion gasses and pollution, decarburization on forging die surfaces, scale formation on forging dies.
- The system provides operational ease and convenience, short preheating time, uniformity of the temperature distribution on the forging dies, increasing of the die life, increasing of the

number of parts to be forged before rework of the forging dies, the uniformity of high impact toughness on the forging die.

- In this system, heating energy is directly applied to the forging dies, and energy efficiency is increased.
- In this system, forging die cooling during the forging process is prevented.

Prof. Dr. Haluk Darendeliler

Prof. Dr. Haluk Darendeliler is a professor at the Mechanical Engineering Department of Middle East Technical University. His research field focuses on continuum theory of plasticity, solid mechanics and computational mechanics. He has been working on simulation of metal forming operations; especially sheet metal forming and forging. Additionally, he is studying constitutive relations and ductile failure criteria for metal forming processes. Currently his research is on micro-structure-based crystal plasticity, strain gradient plasticity, dislocations and grain size effects.

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Prof. Dr. Mustafa İlhan Gökler received his Ph.D. degree from University of Birmingham, UK with thesis study on forging process in 1983. He has started his academic carrier at the Mechanical Engineering Dept. of METU, Ankara, Turkey. He has been Professor since 1998. He has served for around 40 years at the Faculty. His research interests are Forging and Metal Forming, Digital Transformation, Automotive, Vehicle Safety, Manufacturing, He has supervised more than 90 graduate studies. More than 1/3 of them are on forging process. He was the director of METU-BILTIR Center between 1999 and 2023. He founded METU-BILTIR Center Forging Research and Application laboratory in 2006. He has realised several R&D industrial projects, especially in the forging industry and in the automotive. He is a founding member of DÖVSADER Turkey Forgers' Association. He has been the chair of OTEP Automotive Technology Platform Digital Transformation Working Group since 2017.