Design of Machines and Structures, Vol. 4, No. 1 (2014), pp. 25–32.
https://doi.org/10.32972/dms.2014.002

DESIGNING A PORTABLE FORGE

DÁNIEL HERBST–ÁGNES TAKÁCS
University of Miskolc, Institute of Machine and Product Design
3515, Miskolc-Egyetemváros
herbstdaniel12@gmail.com; takacs.agnes@uni-miskolc.hu

The open die forging like ancient profession accompanied the path of humanity to both technical and aesthetic aspects. So this way it will be industrial technology and art of fancy metalwork at the same time that has forges as a chief assistant.

1. Open die forging is technology and art

Since ancient times people were stimulated towards development by their complex minds. Tools and weapons initially were made of non-metallic materials, than later more durable metals. Application of iron meant one of the significant, if not the most significant step in the evolution of mankind. *„In the human history the iron production achievements within the acquis, a kind of discovery, which has no parallel in, a performance equivalent to not know, and besides that, everything else was insignificant inventions and discoveries, or at least seems subordinate significance. We owe the discovery of iron smelting the metal hammer and the anvil, the forged iron sword, axe and chisel, the iron slippers plow, briefly the basic tools of civilization. The lack of iron tools hampered the development of humanity." [1]*

Production and processing of iron has become increasingly sophisticated in the storms of ages. The forging from the unique hand-made pieces reached die forging that is economical in large quantity.

However considering any ages of forging open die forging has not been lost because some aesthetic surplus belonged to it. This surplus enabled the development of artistic forging, the raison d'etre of fancy smiths. Their work is flanked our history with ages spanning, lasting creations. There is no age style in which artistic fancy metalwork-pieces would not have made. As the opposite of the impermanence of human life and the fragility of human being objects, which was made of metals express the longing for eternity and the invulnerability. Thus, for example, may witness a forged rose of eternal love, even if we are aware of the impermanence of metals. So the target audience of the designed machine are those users, who wish to deal with fancy forging.

2. The motivation of designing a portable forge

A smithery for the large majority of people is highly rooted at regional level with a conventional fire brick oven fanned by leather bellows. Experienced may have come across portable forges, or whole portable workshops, or even recognize their right to exist. You cannot even find a fair, in which would not be at least one ornamental blacksmith, who proclaims the beauty of his profession in a noble way, with his portable workshop, whose heart and soul is a portable forge.

Today, the need of the deviation from the average is formulated by many, social norms refract their creativity, but confronting with the grey twilight of averageness, they begin to create their own. The branch of ornamental metalwork art is not obvious to the average, since the above-mentioned image of a stationary workshop is really alive for them. One of the main aims is to make the heating device for the forgeable feedstock portable. The installation process is easy to carry out it takes just a few seconds. After a short fixing capture process, the user can start working.

3. The energy needs of forging

The most important sector of forging is hot forging, which is based on heating the work piece to a more favourable temperature for forming. Required heat energy can provide on several different ways. Nowadays three main possibilities can be recovered on the basis of the available technologies for heat transfer medium or physical interactions.

- With burning or heating of solid fuels work pieces can be heated with low efficiency by continuous supplementation of its favourable carbon content. Such solid fuels could be black coal, brown coal, coke, charcoal.
- In case of aero form fuel, the fuel is injected through focused burners into the heating chamber, where during combustion it heats the work piece to optimal temperature. However, in this case carbon loss occurs, thus the use of additives proposed.
- The most energy intensive process that is mainly applied in the industry is heating by induction coils. Fast and effective process with good efficiency but high electricity and safety claim.

In terms of the forging pieces the best of these three methods is to use solid fuel. Its advantages include simplicity resulting of traditional sophistication and its safer and more economical operation.

4. The most important considerations in combustion technology

In combustion technology approach the quantity of required air for combustion of the fuel used in the heating has to be known, which from the required amount of air to annealing follows. The professional literature, which deals with forging does not provide specific calculations for heating with solid fuels, it only recommend air intake limits for industrial furnace chamber design. The air necessity values of a small portable forge are determined in speculative way and can be refined with preparation of subsequent iteration prototypes.

Considering the raw materials of the work pieces and the dimensions of the blanks a base volume is assumed, in which the heating will be carried out. Taking the perfect combustion of fuel as a basis and taking the possible contamination of fuels, the efficiency of combustion and that the aim is only annealing into account the approximate value of the required air volume arisen. So the suitable fan unit can be selected that will provide the airflow.

Depending on the fuel the amount of combustion products has to be considered this will appear as ash and fuel gas in case of the selected form. Calculations carried out on the ash content it can be concluded that how big amount of ash will be generated during the operation of the equipment, so what specifications (recommendations) can be made to the users for smooth operation due to the removal of combustion products.

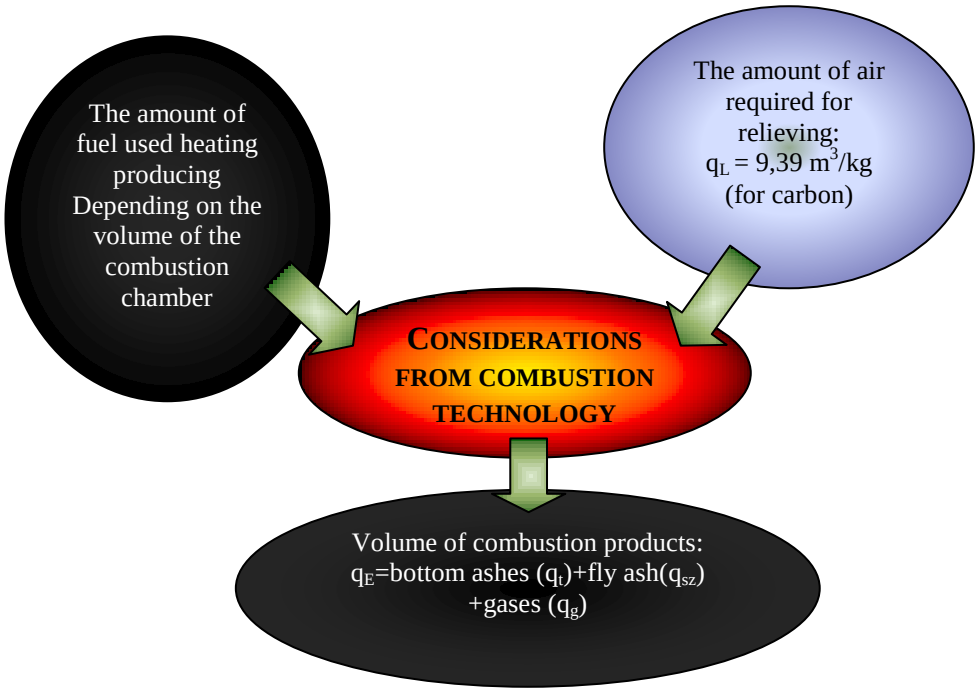


Figure 1: Combustion considerations

5. The design process broadly in line

The first step of the whole design process is the conceptual design phase, when the opportunities in patents and potential rivals in the market, and the resulting operational features are discussed. Solution variants can be built up from the simplest level to create a portable forge. Analysing the variants the optimal solution can be defined that can be carried out in the construction design phase.

The construction design relies on the functions identified during the conceptual design. The application of a countervailing space for ensuring constant pressure of the air stream before the furnace can be mentioned as an example.

When creating the construction, it is important to take the statutory provisions and specifications into consideration in order to let the product be merchandized. These provisions mainly defined for preserving the user's safety and comfort during the use of the product. The currently in force regulation in our country has been published in the 127th issue of the Hungarian Bulletin (Magyar Közlöny), which is the regulation of the National Development and Economy Ministry 16/2008 (VIII. 30.) that is about the certification of machines safety requirements and conformity. Another aspect is the compliance of the

human body's anthropometric parameters, which helps the long-lasting, comfortable and thereby pleasant work, the adequacy of comfort [4]. Ultimately during design of a unique product it is worth taking the command of specific engineering ideas and guidelines into account.

The design of the construction can happen in accordance with the foregoing written, and bearing in mind the logical edification of the parts on each other, their hierarchy. The selected equipment for air flow and the sum of the heating- and the necessary control components enter the final dimensions of the workspace. On this basis the construction of the structure can be continued, the position and construction of mechanisms for movement and for security.

Embedded in the design process every opportunity can be captured to improve the structure from the mechanical model all the way in the conduct of finite element investigations. Using finite element software the distribution of the heat load resulting from the furnace and the analysis of its effects had been recorded. (For example: the furnace must be fixed flexible, otherwise it is arousing large deformation in the basic structure).

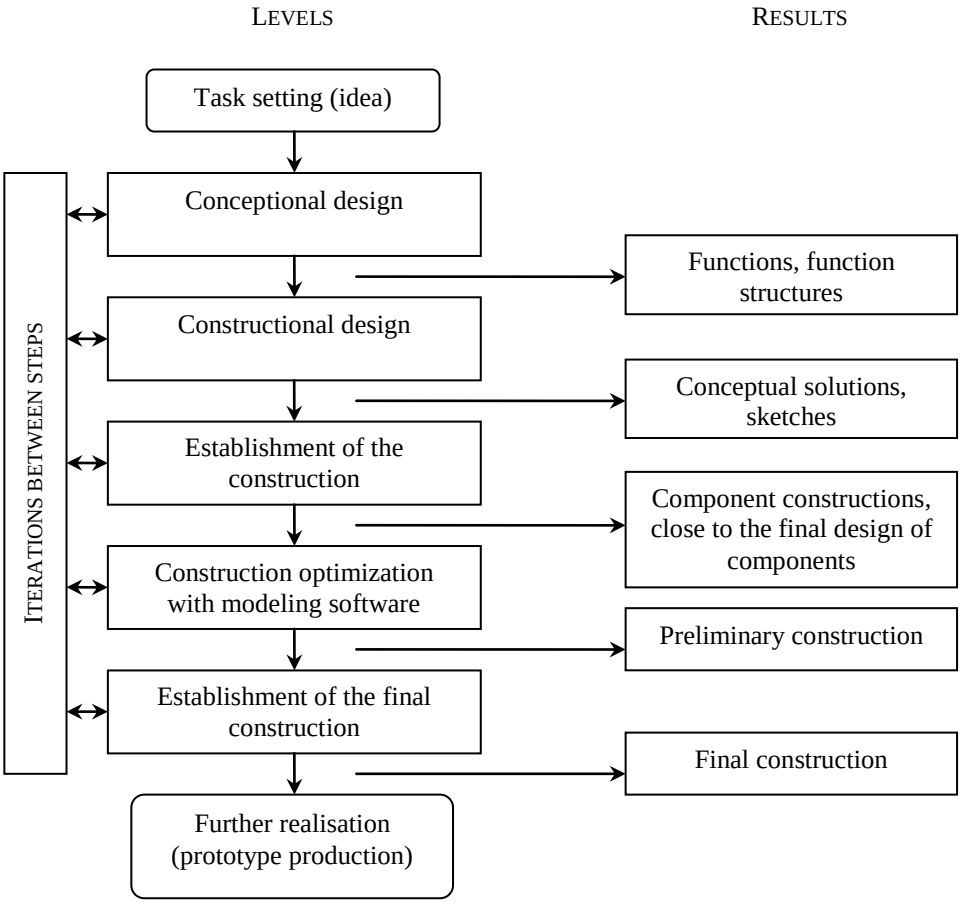


Figure 2: Design process in case of individual design

The portable machine received by the end of the design process, although it pulls through in principle, it is strongly recommended to implement an iterative repair on a prototype and to improve the cost efficiency before putting on the market, consequence of which it can be further improved, personalized.

6. Introducing the construction

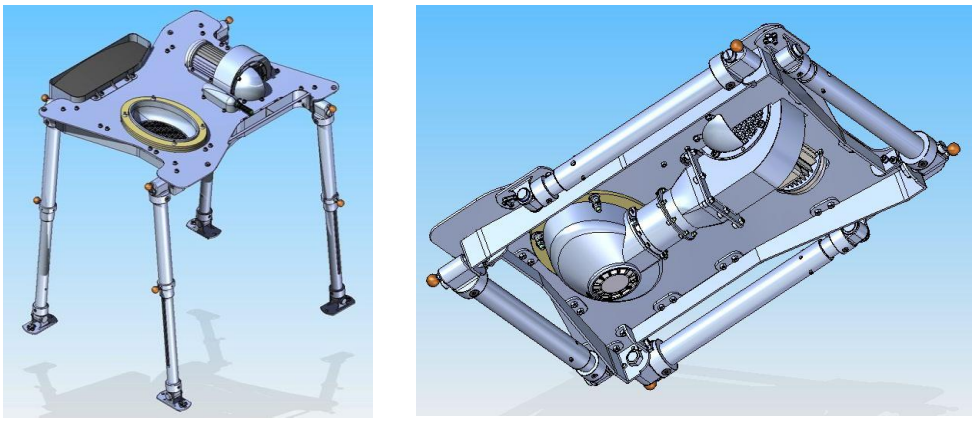


Figure 3: Completed construction in 3D

The in principle finished construction can be seen in the pictures of Figure 3. The image on the left shows standing condition, while on the right the packed base condition of the fully assembled construction can be seen.

7. FEM analysis of the equipment

During the presentation of the construction it is important to take the hierarchical relations among the components into account. It was already mentioned that the heating assisting elements are the primary components. The furnace is a heat-resistant cast steel, which is embedded a socket framed of aluminium-silicate ceramic insulator rings and it has dimensions that make it suitable for full heating of smaller work pieces or partial heating for larger work pieces.

Using FEM software the propagation of heat and the appearance of adverse effects of heat stress in the structure may be assessed. It is important to know how much heat the isolation of the furnace loads it's surrounding, possibly in contact parts.

In the left picture of Figure 4 the heat propagation in the contact zone at the furnace, the insulator rings and the table top can be seen. It can be observed that the insulator rings absorb much of the heat protecting the nearest elements of the structure from the 1100 °C heat loading. In the picture the hottest area (I) is shown in red, while the coldest (III) is signed by dark blue. The second darkest blue shades zone (II) start from that part of the table top, where it is contacted with the insulator rings. The local temperature is about 110 °C.

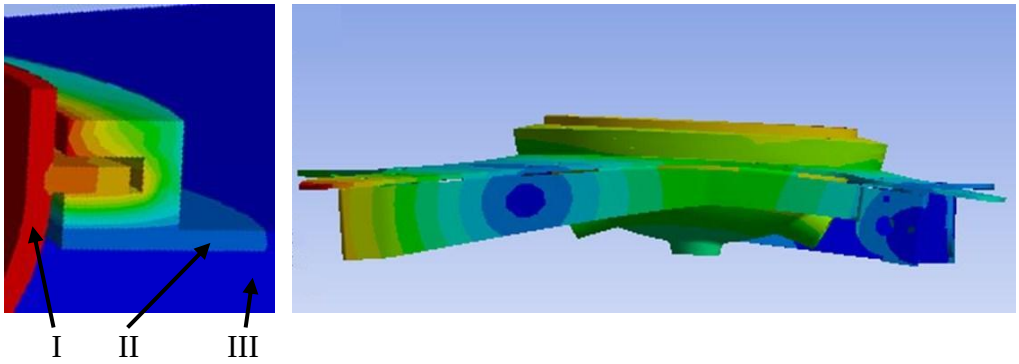


Figure 4: Heat loading and deformation

Components with different materials produce different thermal expansion due to the heat loading, which would result in case of solid anchoring of the components impermissible deformations and inherent fatal tensions.

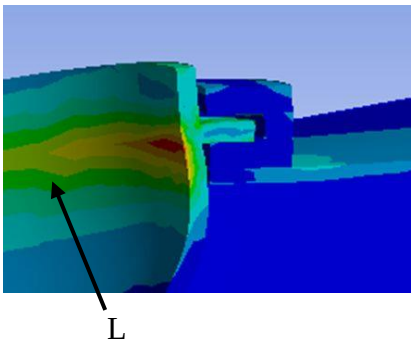


Figure 5: Equivalent stress

According to the above written in Figure 5 an emphasized detail the deformation caused by the stress distribution can be seen. Green zone (L) shown in the figure already exceeds the allowable stress of the furnace material, thus leads to immediate failure. Cross the yellow all the way to the red zone the model shows even higher stress, so it can be said that, the combustion chamber and it's insulation should be flexibly fixed to the other elements of the structure to minimize stresses and deformations caused by heat.

8. The structure of the device

From below the combustion chamber is closed by a pressure countervailing chamber its bottom is possible to open by a bayonet type lid to remove combustion products. The countervailing chamber and the insulator rings are flexible fixed to the table top.

The air gets access to the combustion chamber through three holes, while to the countervailing chamber cross in a larger inlet. Between the countervailing chamber and the fan a dilations-yielding pipe section and the air flow control laminar gate valve are located. The air flow control can be provided by an interrupt can crank, which is derecognised from the gate valve to the user interface. The scrolling transfer mechanisms are protected from the heat and soiling by a sheet formed part.

The fan unit is selected on the basis of combustion calculations and it is a commercially available item, which is applied with some minor modifications. It will be underpinned fixed with half rings by the drive motor. On the suction side a grind and a split quarter spherical baffle plate protect users from potential damage and the ingress of impurities to the impeller.

After the previous outlined steps arises the ‘heart’ of the structure, which determines the additional dimensions. The next step is the development of a table frame, which consists of general-purpose structural steel curved plate parts. It is composed exactly four pieces, endeavouring a flexible yet strong construction. The table frame is made up table top perpendicular sections, thus increasing the resistance to bending stress. In its four corners suitable pins for receiving the foot wrists will be placed.

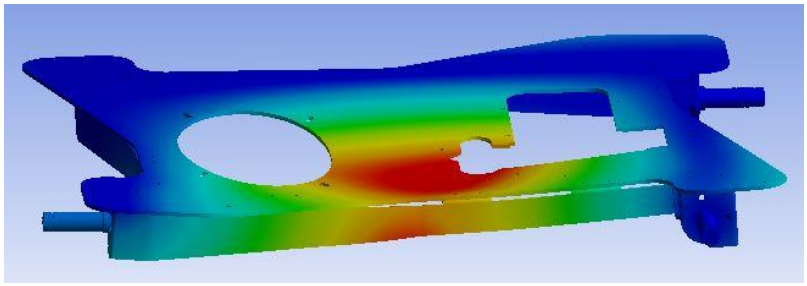


Figure 6: Table frame deformation

The sizes of the table frame sections are determined by calculation. Figure 6 shows an example for the examination of overload and the case of inappropriate use, assuming a mass of 100 kg user sitting on the edge of the table structure and exerts on a differentiated load. The maximum displacement in this case is 0.7 mm, which is not a permanent deformation, so the structure suffers no damage.

Four spiral-opening, two-stage, double-secured telescopic legs intended to perform the holding task of the table work space. In closed state legs are recorded to the lower surface of the table top and the frame. At the junction of the articulated foot and the table top works a mechanism for ensuring a kingpin associated with a sliding, while at the frame a single spring-pin ensuring mechanism.

To open a third mechanism also have to be released, which is a pin-type spring mechanism, located between the two pipe sections of the legs. When the legs are completely set free, grabbing the table top and lifting the equipment the legs because of their own weight swinging and the spring-loaded safety-pinned mechanisms click into their position. On the wrists and on the frame formed abutment surfaces meeting subdue the momentum of the legs.

Once the legs have been extended position, it is possible to rotate the soles into required position, around their pivot axis and around the axis of the leg up to ninety degrees. The

fixing of the table can be enhanced with nails placed through the holes of soles slider mechanism into the ground.

Finally got the table top its shape and it is fixed to the so far listed items with screws as the rest of the structure. It is designed to follow the spiral motion of the legs. As well as providing an optimum location, when the legs are closed to gripping them for the easier transport.

Acknowledgement

The research work presented in this study based on the results achieved within the TÁMOP-4.2.1.B-10/2/KONV-2010-0001 project and carried out as part of the TÁMOP-4.1.1.C-12/1/KONV-2012-0002 „Cooperation between higher education, research institutes and automotive industry" project in the framework of the New Széchenyi Plan. The realization of this project is supported by the Hungarian Government, by the European Union, and co-financed by the European Social Fund.

References

[1] Morgan, L. H.: The ancient society, Transaction Publishers, 1877.
[2] Kamondi L.–Sarka F.–Takács, Á.: Fejlesztés-módszertani ismeretek. Elektronikus jegyzet. Készült: „Korszerű anyag-, nano- és gépészeti technológiákhoz kapcsolódó műszaki képzési területeken kompetencia alapú, komplex digitális tananyag modulok létrehozása és online hozzáférésük megvalósítása" TÁMOP-4.1.2-08/1/a-2009-0001, http://web.alt.uni-miskolc.hu/tananyag/index.html, Miskolc, 2011.
[3] Kamondi L.–Takács Á.: Környezettudatos tervezés. Útmutató és segédlet az előadáshoz és a gyakorlathoz BSc. szakos Ipari termék- és Formatervező hallgatók részére. Elektronikus jegyzet. Készült a TÁMOP-4.2.1.B-10/2/KONV-2010-0001 jelű projekt részeként az Európai Unió támogatásával, az Európai Szociális Alap társfinanszírozásával, Miskolc, 2012.
[4] Woodson, W. E.–Conover, D. W.: Human Engineering Guide for Equipment Designers. University of California Press, 1964.