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Impact Metal Forming

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1 Introduction

IMF is a new forming method, working on the well known local forming principle: An impact body impinges the surface of a component. The impact energy produces a local elongation of the material. Dependent of mass, form and velocity of the impact body as well as the conditions of the component, e.g. material, part thickness, the local elongation causes a shape change. That principle follows different techniques, for example forging or peen forming [1].

In general these techniques can be distinguished whether a holder-up, e.g. an anvil for forging, is necessary or not. The anvil is not necessary, if the mass of the impact body in comparison to the component is very low and the speed of the impact body is very high.

This principle is used for peen forming, when balls or similar elements are shot on the surface of the component. To reach a forming effect, the conditions of the peening process (type of grain, velocity, size, material) have to be optimised.

The same idea is realized in IMF: An impact body with low mass (> 0.2 g) is accelerated by a motor driven spring on a closed guideway and impinges with high velocity (> 10 m/sec) on the component surface. **Figure 1.** shows some principle spring designs.

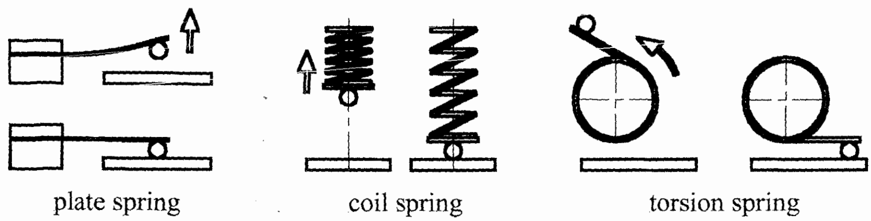

Figure 1. Spring designs

2 Tool Design

The IMF — tool is based on three elements:

1. Impact body with guideway
2. Spring
3. Spring tension system

2.1 Impact Body

The impact body penetrating the surface of the component, is formed according to the designed shape. This shape change may be a concave or convex, uni- or multi-axially curved. Furthermore an elongation without any shape change is possible [2]. The layout of the impact area is only limited by the production feasibility of the tool, for example grinding or spark erosion. Using suitable surface coatings, the flow reduction between impact body and component can be reduced as well as a chemical or thermal reaction can be prevented.

The impact body can not be lost and is exactly guided, so the position and the working force can be chosen repeatable. The shape change can be predicted and executed with high precision, because every punch causes only a small action. **Figure 2.** shows the comparison of two different pattern. Both number of impacts generate the same part radius. The reason for this behavior is the material between the impacts. This material is not formed and prevents a stronger bending of the part.

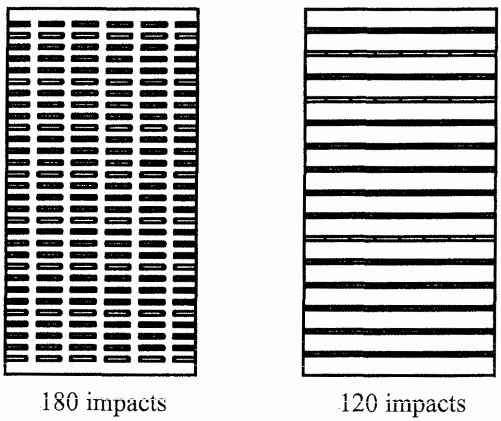

Figure 2. Different pattern, single impacts and line impacts

The impact tool can be equipped with one or more different or equal impact bodies. The design of the tool depends on the requirement. In any case, the construction of the tool allows a rapid change of the impact bodies.

2.2 Spring

A spring is seen to be the smallest and most lightweight energy storage with the highest efficiency and greatest acceleration force. There is a great variety of forms and a lot of knowledge on the design rules. The dynamic performance of a spring is constant over a lot of stress cycles. Therefore it is predestined for the use in a repeatable production process.

The form of the spring, i.e. coil spring, helical torsion spring or leaf spring, depends on the special application (working stroke, acceleration way, ease of access) and has influence on the spring tension system.

2.3 Spring Tension System

The tool IT 200-LP , shown in **Figure 3.** , uses a pneumatic cylinder to compress a coil spring. The regulation of impact power is done by changing the compression way of the spring. Theoretically 2 to 3 rounds per second are possible.

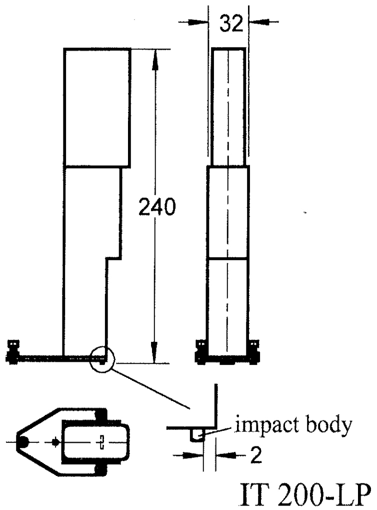

Figure 3. Impact tool IT 200 LP

Another way of actuation is the usage of an electric drive. A higher frequency of hits is expected for that kind of actuation. By using an accumulator the impact tool becomes mobile and can be used in difficult accessible areas too. **Figure 4.** shows an example with a rotating plate spring.

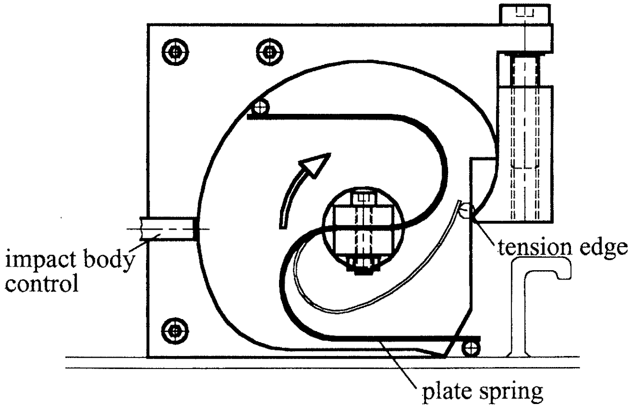

Figure 4. Rotating plate spring

If necessary several impact tools can be coupled. This allows forming of bigger components in a very short time, and compared with other methods, with a very low energy consumption. The spring tension system can easily be connected with a measurement system, e.g. for automatic production.

3 Applications

In general all components, treated by similar processes, for example peen forming, are suitable for forming or straightening. The spectrum of components can be even enlarged, since the possibility of repeatable production can be realised now. This refers to the exact impact point of any impact form, a defined impact pattern and the prevention of uncontrolled coverage concentration.

Formability of components depends on various factors. In general a suitability can be expected, if the rate of forming or straightening is relatively low. Examples may be the panels for aircraft wings or fuselage. In many cases the deviation after heat treatment, welding or milling can be corrected.

A real new application is the straightening of assembled components. The low mass of the impact body causes no side effects on the riveted or screwed structure. An important requirement for this application is, that the impact tool can not be lost. Therefore it can be used e.g. inside an aircraft. The small geometrical dimensions and the wide field of tool design permits the work on a great variety of structure elements.

Another field of application is the straightening of welding distortion in aircraft and shipbuilding industries. **Figure 5.** shows a typical situation of those structures.

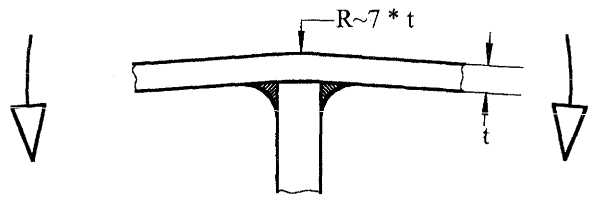

Figure 5. Distortion by welded stiffener

To have success in straightening, a lot of energy must be concentrated on a very small part area, for the bending radius is very small. That means high impact speed, small tool radius and enough mass of the impact body.

Figure 6. shows the two forming possibilities: on the left hand side the concave forming in the middle of the welding seam, on the right hand side the convex forming beside the welding seam.

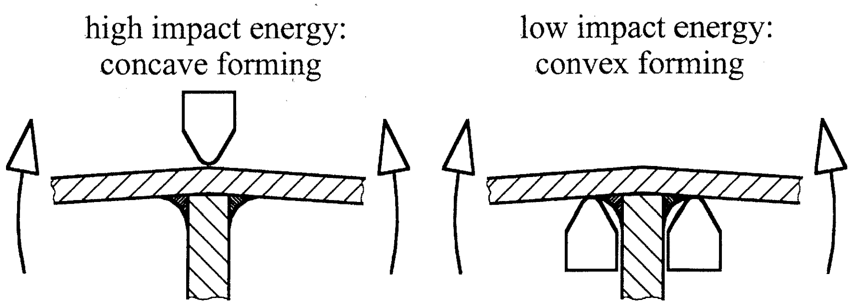

Figure 6. Forming techniques

In **table 1.** IMF is compared with shot peen forming [3,4]. Although both systems are similar in the process, there are some differences in tooling and forming.

forming process	Shot Peen Forming	Impact Metal Forming
power system	open, no holder up	open, no holder up
impact tool	free flying ball	guided flying punch
impact position	scattered	exact
impact radius	dependent of mass	independent of mass
		girder (1 axis forming)
mould form	calotte	ellipse (2 axis forming)
		callote (spherical forming)
tool material	steel	any hard material
tool acceleration	compressed air, bladded wheel	spring
work station	closed	open
process control	ball diameter ball velocity flow motion coverage	mould form punch velocity punch weight impact position impact direction coverage

IMF is not only a competition to peen forming, but also new possibility of combination, because both methods produce similar internal stress. Especially for the forming of integral parts with changing part thickness IMF can be an useful help.

4 References

[1] Hornauer, K.-P., Untersuchungen zur Umformung von Bauteilen durch Kugelstrahlen, Dr.-Ing. Dissertation, RWTH Aachen 1982

[2] H. Reccius, D. Endemann, K.-P. Hornauer, Sheet forming by producing the coverage with a simultaneous working system of balls, ICSP5, Oxford University 1993

[3] R. Kopp, F. Wüstefeld, W. Linnemann, High precision shot peen forming, ICSP5, Oxford University 1993

[4] Guy Levasseuer, Peen forming feature possibility for wing skin fabrication, Metal Finishing News, Vol. 3, May issue 2002