

## BIMETALLIC VALVE

The invention relates to a bimetal valve for a combustion engine with a valve body made from a ferrous base alloy and a body casing close to the valve plate made from a cobalt or nickel base alloy, wherein the thermal expansion of the valve body is significantly greater than that of the body casing; it also relates to a method of producing a bimetal valve of this type.

In the case of a bimetal valve known from EP 0901565 B1, the valve body is made from a ferrous base alloy; its seat area is made from a nickel base alloy. When producing the known bimetal valve, thermo-mechanical treatment below the recrystallisation temperature is essential; the aim of this is to raise the yield point to over 1000 MPa in the nickel base alloy forming the seat area. In this way, the corrosion resistance of the bimetal valve, particularly its resistance to plastic deformation and wear in the seat area, is improved. The formation of indents in the seat material and its burning off should thereby be avoided.

In contrast, the problem addressed by the present invention is that of creating a valve of the sort mentioned above, the fatigue strength of which is significantly greater than that of the known bimetal valve and in which the composite body made up of a valve body and body casing is characterised by a particularly high corrosion resistance. This problem is solved according to the invention by a bimetal valve of the type mentioned above, in accordance with the characterising clause of claim 1.

The fact that according to claim 1 the difference in thermal expansion between the valve body and the body casing exceeds a minimum value of  $2 \mu\text{m/mK}$  ensures that when the bimetal valve is heated, the yield point of the body casing, which exhibits the smaller thermal expansion, is exceeded, so that an internal compressive stress is generated in the body casing upon subsequent cooling to ambient temperature. This internal compressive stress is the prerequisite for the valve being loaded under operating conditions in the fatigue strength range between the yield

point to the upper temperature range, on the one hand, and the offset yield strength to the lower temperature, on the other. The fact that the body casing is under internal compressive stress within a temperature range of between roughly 100 and 300 °C means that at higher operating temperatures the valve is loaded under residual tensile stress only in the fatigue strength range below the yield point.

The internal compressive stress present in this case in the body casing when loading begins is therefore only reduced as the temperature rises, before the residual tensile strength phase begins. The bimetal valve according to the invention is therefore characterised by a considerably increased stability under load.

In the simplest case, the body casing may be essentially designed as a peripheral ring, i.e. a peripheral ring with a seat area. There is a loading of the peripheral ring in this embodiment too, within the meaning of the present invention, i.e. in the lower temperature range between 100 and 300 °C internal compressive stress prevails in the peripheral ring. However, the person skilled in the art knows that if the body casing is reduced to a peripheral ring, it is not possible to create such a comprehensive corrosion-proof solution for a bimetal valve as in the case of a body casing that envelops the valve plate, in such a manner that it encloses the latter close to the valve floor, the valve circumference and the valve seat.

In relation to the material composition of the ferrous base alloy, the nickel base alloy and the cobalt base alloy, reference is made to the dependent claims. The materials described there are available on the market under the names indicated; other comparable materials can also be used for the body casing, however, which exhibit a breaking elongation (A5) and a contraction at fracture (Z) of at least 35 % in each case.

In order to prevent cracking, it is advisable for the body casing not to be oversized. In the area of the valve floor,

values of up to 12 mm are recommended for the thickness of the body casing; in other areas of the body casing, thicknesses of less than 5 mm are appropriate.

In an embodiment of a body casing made from a nickel base alloy with a seat area made from a cobalt base alloy, it is advantageous to endeavour to ensure that the seat area and not only the peripheral area are subject to internal compressive stress, as defined by the teaching of the present invention.

Internal compressive stress is generated as a result of the production method according to the invention, both in a qualitative and quantitative respect. In this case, a composite body made up of a valve body and a body casing is heated to over 450 °C until the yield point of the body casing is reached and thereafter further heated to a temperature at least 100 °C higher before being cooled back down to the ambient temperature. The higher temperature reached after further heating, which represents the starting temperature for the following cooling phase, is advantageously between 600 and 800 °C. During this heating of the composite body made up of a valve body and body casing, it is advisable to ensure that the yield point is reached, but not exceeded in practice. In this way, the hot cracking susceptibility of the nickel base alloy used to form the body casing is taken into account.

Following the cooling phase according to the process, an internal compressive stress is created in the body casing, which is advantageously up to 200 MPa. An internal compressive stress range that can preferably be adjusted by the process according to the invention lies between 50 and 150 MPa, i.e. it is therefore significantly higher than the offset yield strength to be observed.

The invention is described in greater detail below using a drawing with Figures 1 - 4. These show

Fig. 1: in a bimetal valve, a view of the valve plate

Fig. 2: a partial axial section, in accordance with section II in Fig. 1

Fig. 3: a schematic cross-section through a bimetal disc  
made up of a basic body and peripheral ring and  
Fig. 4: a residual stress diagram relating to Fig. 3

Fig.1 shows a view of the valve plate 1 with the valve shaft detached with its axis 2 extended. A central valve body 3 of the valve plate 1 is surrounded by a body casing 4 close to its greatest periphery, which comprises a floor area 5, a peripheral area 6 and a seat area 7, according to Fig. 2. Within the seat area 7, a seat ring 8 made from a material other than that used for the rest of the body casing may be welded on, as shown in Fig. 2.

The valve body 3 is made from a ferrous base alloy, the body casing from a cobalt or nickel base alloy. The valve materials used are selected in such a way that the thermal expansion of the valve body is at least  $2 \mu\text{m/mK}$  above that of the body casing. An austenitic valve steel, under the name SNCRW, for example, may be advantageously used as the material for the ferrous base alloy. Suitable body casing materials include, for example, Nimonic80A as a nickel base alloy and Stellite6 as a cobalt base alloy. In the case of a body casing made from a nickel base alloy, a cobalt base alloy is a possible suitable material for the seat ring 8, due to its particular hardness and corrosion resistance.

Fig. 3 shows a disc-shaped base body 11 with a peripheral ring 12 in half-section. This is a model of a bimetal disc, which ideally represents a valve plate, in which the base body 11 corresponds to the valve body 3 in Fig. 1 and the peripheral ring 12 corresponds to the peripheral area 6 or else the body casing 4 in Fig. 1.

The model in accordance with Fig. 3 is based on the internal stress diagram in Fig. 4. Fig. 4 shows the temperature-dependent comparative stress  $\text{SigVT}$  plotted against the temperature  $T$  for the outer diameter of the base body 11 or the inner diameter of the peripheral ring 12. This diameter  $D_i$  is 290 mm for the exemplary model; the outer diameter of the peripheral ring  $D_a$  is 300 mm. The

materials selected for the base body 11 were the ferrous base alloy X26CrNiW2010, for the peripheral ring 12 the nickel base alloy IN625.

The comparative internal stress values  $\text{SigVT}$  represent tensile strength values on the positive side of the base line and compressive strength values on its negative side. The upper limit curve  $\text{Sig1 Rp0.2}$  represents the course of the yield point, the lower threshold curve  $\text{Sig2 Rp0.2}$  represents the course of the offset yield strength. Between the two limit curves is the working range of the bimetal disc model, i.e. as the temperature rises, the internal stress is reduced until it reaches the base line and the stress in the diameter  $D_i$  then continues as the tensile strength until the yield point  $\text{Sig1}$  is reached. Three specific working curves  $S_1$ ,  $S_2$  and  $S_3$  are given as an example; these can be selected depending on the development of the internal compressive stress during production of the bimetal disc or transfer to the object of the invention of the bimetal valve.

The production process according to the invention envisages that the valve body 3 and the body casing 4 create a composite blank (represented in the model by the bimetal disc 11, 12), which is heated to roughly 450 °C until the yield point of the body casing 4 is reached, and that after further heating to a temperature at least 100 °C higher, the cooling phase follows.

Based on the example shown in Fig. 4, the heating curve A ends when the yield point  $\text{Sig1}$  is reached at roughly  $T_1 = 450$  °C. By further heating, one of the cooling curves  $S_1$ ,  $S_2$  or  $S_3$  is reached on the graph by moving to the right along the limit curve for the yield point  $\text{Sig1}$ . Taking cooling curve  $S_2$  as an example, a temperature  $T_2 = 700$  °C is obtained as the starting point for cooling. Cooling takes place under elastic deformation with residual tensile stress until the base line is reached at approx. 160 °C and below as internal compressive stress up to the ambient temperature at around  $-90 \text{ N/mm}^2$  internal compressive

stress. The values obtained then apply according to the pretreatment of the bimetal disc or, in a correspondingly treated bimetal disc, according to the chosen course of the cooling curve S1, S2, S3. This is chosen depending on the course of the material-dependent heating curve A, which reaches the yield point  $\sigma_{gl}$  at  $T_1$  (450 °C), after which the limit curve  $\sigma_{gl}$  is followed during further heating until a maximum temperature, e.g.  $T_2$  (700 °C) is reached on the cooling curve S2.

It is self-evident that the comparison between the trajectories of the curves for internal stresses according to Fig. 4 will exhibit differences compared with corresponding curve trajectories for a bimetal valve, e.g. depending on which materials are used and how the bimetal valve is individually sized and designed, e.g. whether a closed body casing is provided or a body casing only extends over a section of the central valve body 3. Moreover, the internal stress values achieved depend on the thickness of the body casing and, as demonstrated above, the heat or cooling treatment parameters during production of the bimetal valve. It can be assumed, however, that the qualitative course of the internal stress curves according to Fig. 4 can be applied to specific bimetal valves.

## CLAIMS

1. A bimetal valve for a combustion engine with a valve body (3) made from a ferrous base alloy and a body casing (4) close to the valve plate (1) made from a cobalt or nickel base alloy, wherein the thermal expansion of the valve body is significantly greater than that of the body casing (4), characterised in that  
the difference in thermal expansion  $\alpha(20^\circ - T)$  between the valve body (3) and the body casing (4) is at least  $2\mu\text{m/mK}$  according to the formula  $(\alpha_{VK} - \alpha_{HK}) > 2$ ,  
the valve body (3) and the body casing (4) are welded to one another and an internal compressive stress prevails in the body casing (4) at ambient temperature, which is generated by the valve body (3) and the body casing (4) being heated after welding above the yield point of the body casing (4) with plastic deformation of the same and then cooled.
2. The bimetal valve according to claim 1, characterised in that  
the body casing (4) is essentially designed as a peripheral ring (6).
3. The bimetal valve according to claim 1, characterised in that  
at ambient temperature and within a temperature range above this between 100 and 300 °C internal compressive stress exists in the body casing (4).
4. The bimetal valve according to claim 3, characterised in that  
the internal compressive stress is up to 200 MPa.
5. The bimetal valve according to claim 4,

characterised in that  
the internal compressive stress is between 50 and 150  
MPa.

6. The bimetal valve according to claim 1,  
characterised in that  
X26CrNiW2010, X45CrNiW 18.9 or SNCRW is provided as  
the ferrous base alloy.
7. The bimetal valve according to claim 1,  
characterised in that  
Nimonic80A, IN625 or IN718 is provided as the nickel  
base alloy.
8. The bimetal valve according to claim 1,  
characterised in that  
Stellite6 or Stellite12 is provided as the cobalt base  
alloy.
9. The bimetal valve according to claim 1,  
characterised in that  
the material for the body casing (4) exhibits a  
breaking elongation (A5) and a contraction at fracture  
(Z) of at least 35 % in each case.
10. The bimetal valve according to claim 1,  
characterised in that  
the thickness of the body casing (4) is less than 8  
mm.
11. The bimetal valve according to claim 9,  
characterised in that  
the thickness of the body casing (4) is less than 5  
mm.
12. The bimetal valve according to claim 1,  
characterised in that

the body casing (4) includes a seat area (8) made from a cobalt base alloy, is in addition made from a nickel base alloy, and that the seat area (8) is subject to internal compressive stress following plastic deformation.

13. A method of producing a bimetal valve in accordance with one or more of the claims 1 - 12, characterised in that the valve body (3) and the body casing (4) create a composite blank, which is heated to over 450 °C until the yield point of the body casing (4) is reached, and that after further heating to a temperature at least 100 °C higher, the cooling phase follows.
14. The bimetal valve according to claim 13, characterised in that the cooling phase starting from the yield point  $\text{Sigl Rp0.2}$  takes place in the temperature range between 600 and 800 °C.