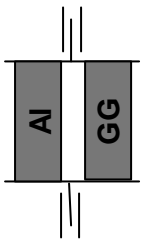




Casting Crankcases with Gray Iron Sleeves



$T_{0GG} = 400^{\circ}\text{C}$ $T_{0Al} = 400^{\circ}\text{C}$
 $a_{GG} = 10 \cdot 10^{-6} \text{ K}^{-1}$ $a_{Al} = 21 \cdot 10^{-6} \text{ K}^{-1}$
 $E_{GG} = 160 \text{ kN/mm}^2$ $E_{Al} = 75 \text{ kN/mm}^2$

Aluminum and gray iron have very different thermal expansion coefficients. Therefore we will get residual stresses in the range of the yield stress of Aluminum. We are using two connected bars as an theoretical example (fig.: 1). The stress can be calculated by:

Figure 1:
Cooling two connected bars from 400 °C to 0 °C will induce stresses of 225 N/mm²

$$F = s A$$

with

$$s = Ee = E\left(\frac{\Delta l}{l} - e_{\Theta}\right),$$

$$e_{\Theta} = (T_0 - 0)a,$$

and

$$F_{Al} + F_{GG} = 0$$

we get

$$\frac{\Delta l}{l} = \frac{E_{Al} e_{\Theta Al} + E_{GG} e_{\Theta GG}}{E_{Al} + E_{GG}}$$

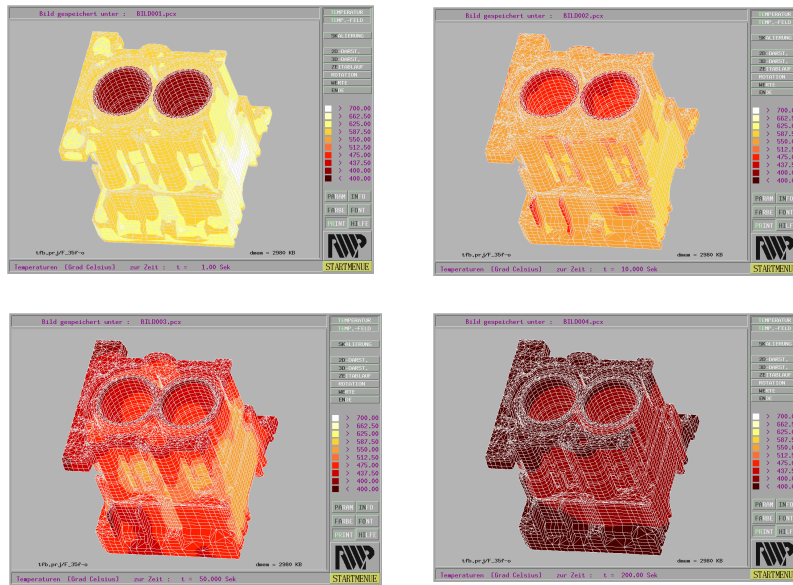


Figure 2:
Different time frames of the solidification of a crankcase with GG - sleeves.

putting all values to the equation the residual stress can be calculated.

$$s_{Al} = -s_{GG} = 224.7 \text{ N/mm}^2$$

This simple example shows that the residual stress will be in the range of the Yield stress!

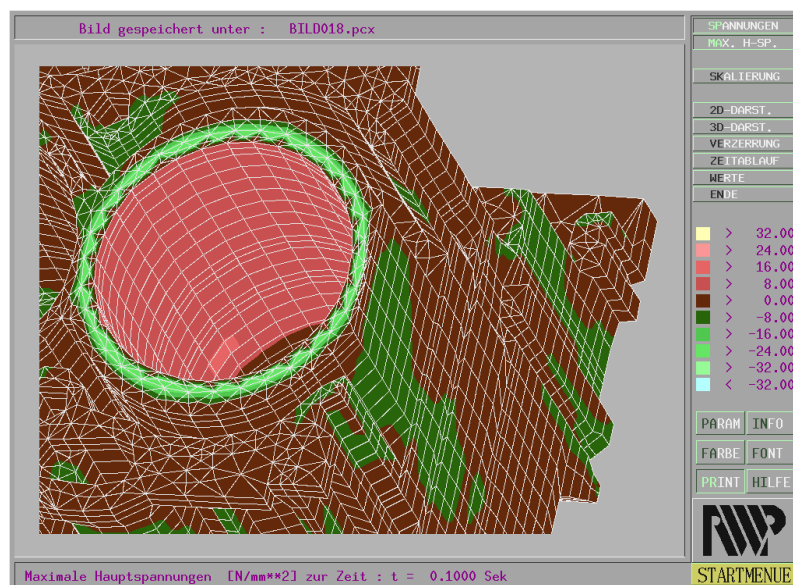
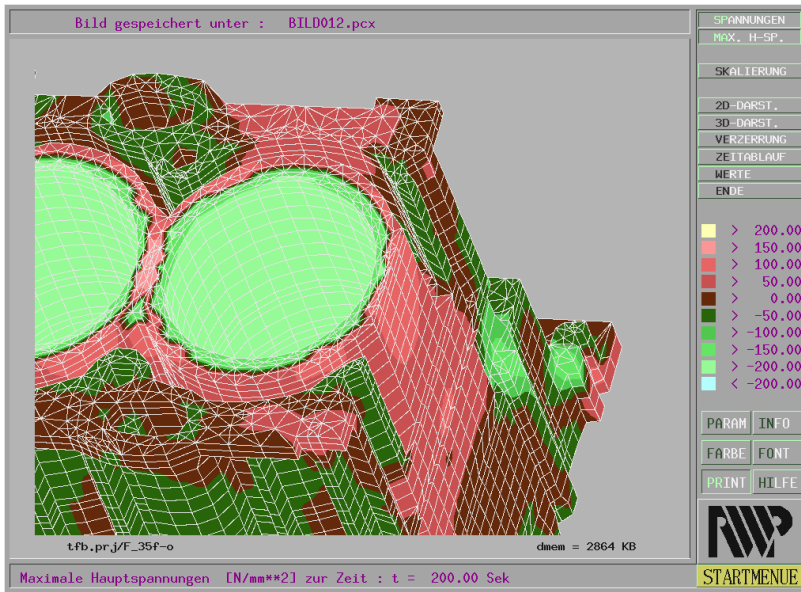


Figure 3:
Thermal stress in the initial phase of the solidification.

Looking at an actual example (figure 2) we see that approximately at 400 °C the Al – crankcase and the GG – sleeve have the same temperature. Therefore we can expect residual stresses of more than 200 N/mm². Figure 3 shows the thermal stresses in the initial phase of the solidification.



The GG-sleeve is heated from the outside. The outer layers would expand, but they are restricted by the inner layers. Therefore we get compressive stresses in the outer layers (green color scale) and tensile stresses in the inner layers (red color scale). After a short time both materials have the same temperature in the range of 400°C. At that time we have relatively the same cooling conditions. Depending on the different heat expansion coefficient we now get high tensile stresses in the Al housing and compressive stresses in the GG sleeve at the end phase of the solidification (figure 4).

Figure 4: Depending on the different heat expansion coefficient we get high tensile stresses in the Al housing and compressive stresses in the GG sleeve at the end phase of the solidification.

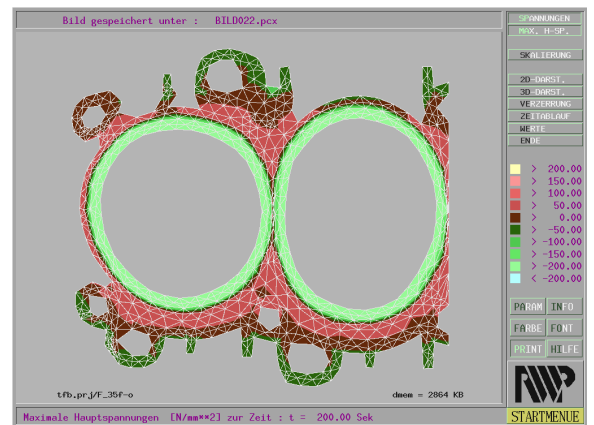


Figure 6: Section through the cylinders

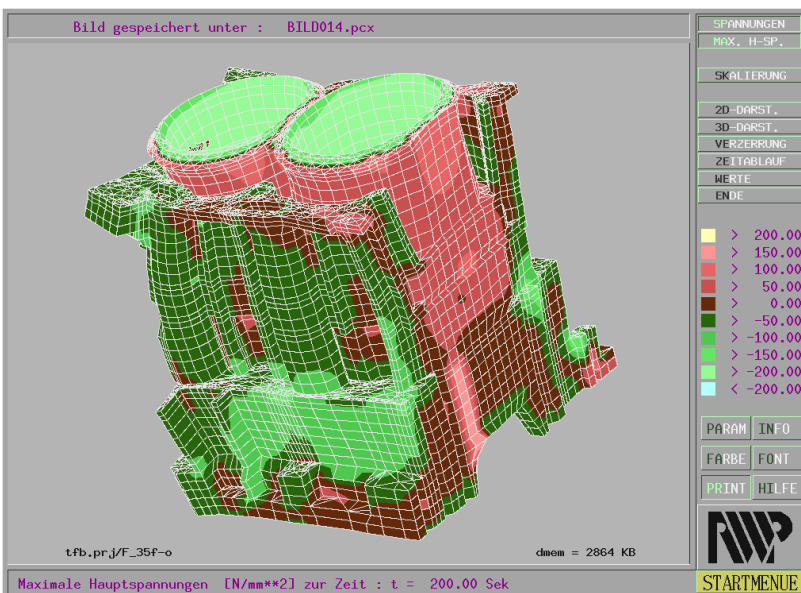


Figure 5: The large bearing blocks are the parts of latest solidification. Due to the shrinkage they will bend the upper Part of the housing.

Due to the same mechanism distortion will occur in the housing. The large bearing blocks are bending the upper parts of the housing. The circular sleeves are deformed to an elliptical shape (figure 5+6).