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QKK 50 MANIPULATOR TONGS CALCULATION

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Abstract: *This paper deals with the strength and deformation check of designed tongs assembly, tongs assembly with extensions and tongs axle for the QKK 50 manipulator according to the spatial image and drawings.*

Keywords: ***QKK 50 manipulator, strength check.***

1. Introduction

ŽĎAS forging manipulators are designed to handle a forging in the press working space. QKK rail manipulators (Figs. 1 and 2) represent the basic series and have a carrying capacity of 3, 5, 8, 12, 20 and 35 t. Manipulators with higher carrying capacities are designed and made individually according to the customer's specific requirements. The biggest manipulator manufactured up to now has a carrying capacity of 100 t.

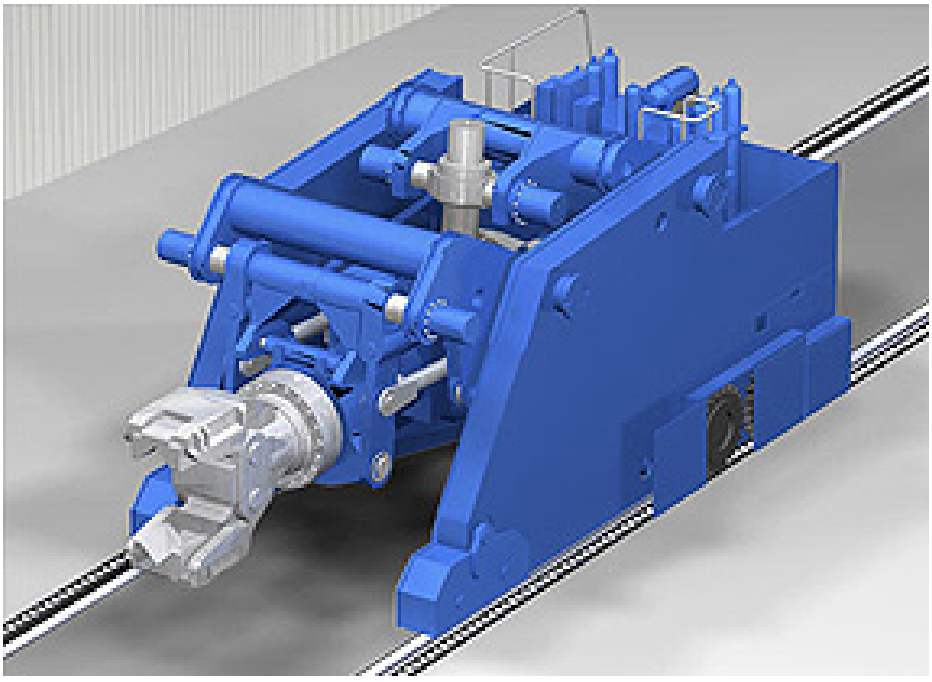

Fig. 1: QKK 50 Manipulator (Mrkos, 2010).

2. Computational model

Set parameters for calculation:

Material:	material and heat-treatment values have been set for individual parts.
Working temperature:	-5°C to +60°C, -5°C to +200°C

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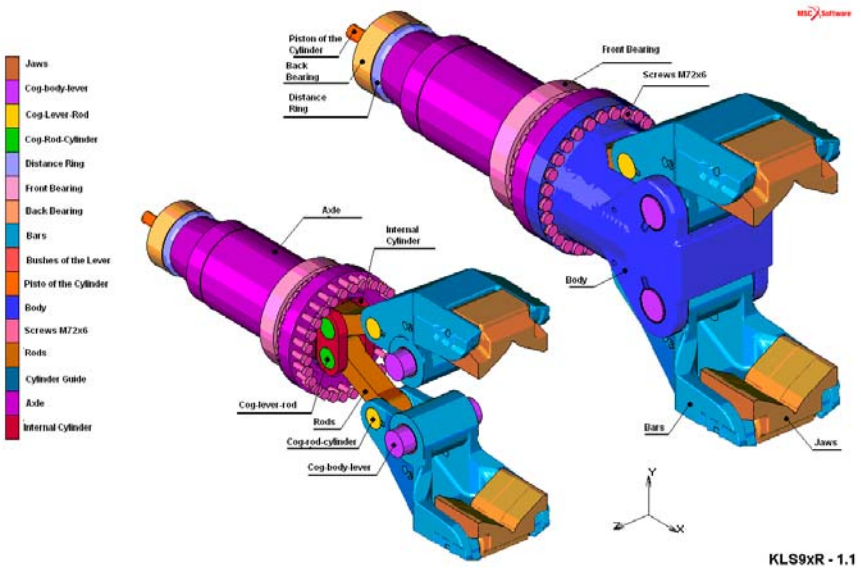

Fig. 2: Tongs of the QKK 50 Manipulator.

2.1. Example of the load

KLS91R - tongs-and-jaws assembly with use of contact between the interacting parts, including the simulation of the weight of transferred load, tongs opened - Z1 load (Fig. 3).

KLS92R - dtto KLS91R - Z2 load

KLS92R-1 - dtto KLS91R - Z2-1 load

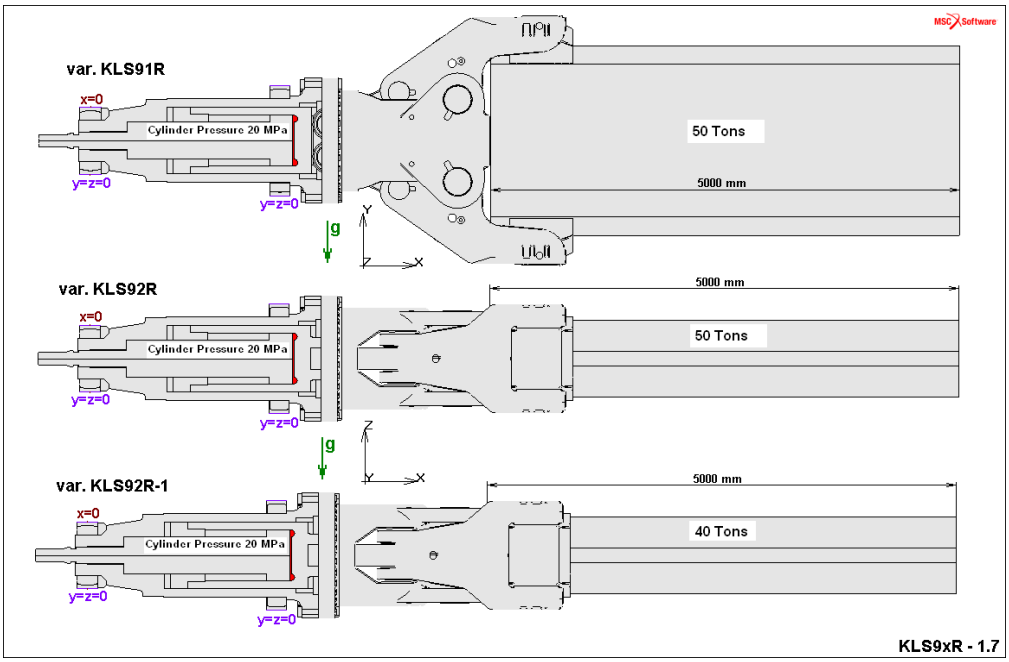

Fig. 3: Loads for KLS91R, KLS92R and KLS92R-1.

3. Methods

Elasticity calculation

Computing system: MARC – elastic field, spatial elements

Optimization: not performed

Calculation variants: description of the calculation-model geometry is shown in Figures KLS9xR-1.1 and for Tongs with Extensions.

Load Z1: Loading with hydraulic-cylinder force F_x = 4 567 kN (20 MPa).
Loading with hydraulic-cylinder-piston force F_x = 4 567 kN (20 MPa).
Prestressing of bolts M72.
Simulation of the weight of transferred forging (50 tons) with tilting moment of 1250 kNm.
Dead tongs weight included.
Effects of gravitation are in the direction of the Y-axis of the system of coordinates.

Load Z2: Loading with hydraulic-cylinder force F_x = 4 567 kN (20 MPa).
Loading with hydraulic-cylinder-piston force F_x = 4 567 kN (20 MPa).
Prestressing of bolts M72.
Simulation of the weight of transferred forging (50 tons) with tilting moment of 1250 kNm.
Dead tongs weight included.
Effects of gravity are in the direction of the Z-axis of the system of coordinates.

Load Z2.1: Loading with hydraulic-cylinder force F_x = 4 567 kN (20 MPa).
Loading with hydraulic-cylinder-piston force F_x = 4 567 kN (20 MPa).
Prestressing of bolts M72.
Simulation of the weight of a forging being transferred (40tons) with tilting moment of 1000 kNm.
Dead tongs weight included.
Effects of gravitation are in the direction of the Z-axis of the system of coordinates.

The calculation has been performed for various load combinations.

For all loads, numerical, computational stability is ensured by introduction of homogenous edge conditions into some nodes.

Working load spectrum: The above-mentioned stationary loads have been evaluated for various spectra.

Number of loading cycles: Not specified

Required life: $N_D > 1.0E7$ cycles (permanent)

Design assumptions:

- load is considered to be static,
- dead weight taken into account,
- geometrical non-linearity used,
- it is a non-linear calculation.

4. Example of the outputs

Elasticity calculation results

Graphic outputs - deformations v_x, v_z in the direction of global X-, Z-axes [mm], principal stress S1 (Fig. 4), design (reduced) stress SV acc. to HMH – [MPa].

Strength evaluation:

Ultimate state evaluation: Program system SKALA

Strength evaluation consists in the analysis of assumed critical sections and points in light of the possibility of occurrence of ductile, fatigue and sudden brittle fracture, including crack propagation.

The SKALA program fully utilizes the results of the strength solution using the system MARC in the linear field. To determine plastic deformation necessary to evaluate the life, generalized Neuber's principle has been applied widely.

Material characteristics: gained from the database SKALA (data acquired from CSN, CSN EN or other standards, from measurements, technical literature or from the expert estimate).

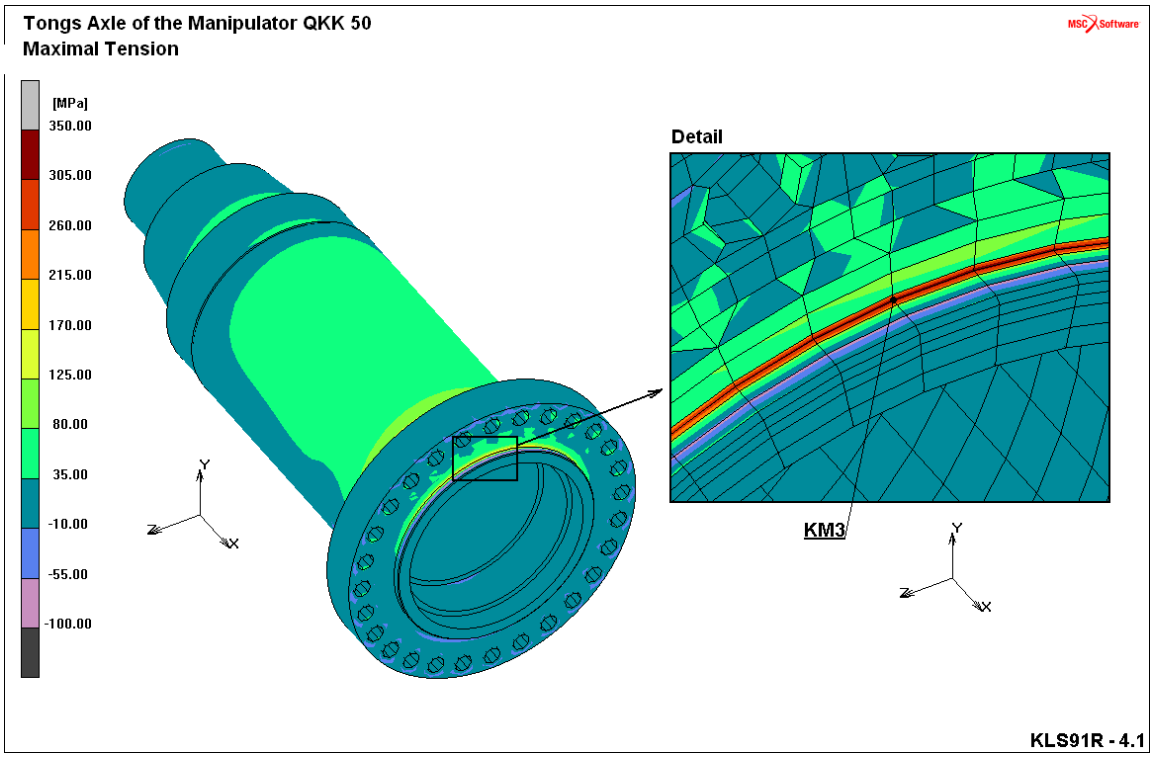

Fig. 4: QKK 50 manipulator tongs axle (load by a 50-t casting) - maximum principal stress S1.

Type of loading: 1. Stationary amplitude of load (maximum operating one)

The ultimate states of ductile and sudden fracture are limited by maximum working or testing or emergency loads (if specified).

5. Conclusions

According to the results of the strength evaluation of the specified and final calculation variants of the tongs of the QKK 50 manipulator, it is possible to state the following:

- For the specified maximum operating load, the above mentioned materials and the working temperature range, the QKK 50 manipulator tongs comply in all critical points in terms of usually required safety both with the limit state of ductile fracture and with the limit state of sudden (brittle) fracture with a small up to a sufficient reserve.
- For the specified stationary maximum repetitive and/or alternating or pulsating operating loads, the above mentioned materials and the working temperature range, the QKK50 manipulator tongs comply in all critical points in terms of usually required safety with the fatigue limit state (N_D > 1.0E7 cycles – permanent life) with a small up to sufficient reserve.
- For the specified non-stationary pulsating, repetitive or alternating working loads (see simulation spectra 1 through 4), the above mentioned materials and the working temperature range, the QKK50 manipulator tongs comply in terms of usually required safety with the required life of 19 years (N_D see point 2) with a sufficient reserve, even in all critical points as mentioned under point 2).
- Deformations of the QKK 50 manipulator tongs have also been analyzed.

References

Mrkos J. (2010) Report V-007/10 QKK 50 Manipulator Tongs Calculation, Žďár nad Sázavou.