Claims

1. Method for the determination of workpiece transport trajectories in a multiple station press, comprising the steps of

   a) providing a set of constraints for the workpiece transport trajectories, the constraints comprising at least pickup and deposit positions for a workpiece in a plurality of stations of the multiple station press;

   b) providing machine properties of the plurality of stations and of at least one transfer device for transporting the workpiece from a first of the plurality of stations to a second of the plurality of stations;

   c) providing information on a candidate workpiece transport trajectory;

   d) simulating the plurality of stations and the at least one transfer device based on the provided information for determining whether the candidate workpiece transport trajectory conforms with the provided machine parameters;

   e) displaying the result of the determination; wherein

   f) the workpiece transport trajectories and the candidate workpiece transport trajectory are parameterized by a plurality of positions of a plurality of axes as a function of an angle parameter;

   g) the workpiece transport trajectories and the candidate workpiece transport trajectory are partitioned into a plurality of segments, each of the segments including the axes positions for a continuous range of values of the angle parameter; and wherein

   ~~e)~~h) the information on the candidate workpiece transport trajectory comprises a set of motional information and values of angle parameters relating to transitions between neighbouring segments of a set of segments of a trajectory template, the motional information at least comprising velocity information.~~,~~

2. Method as recited in claim 1, characterized by the step of providing information on a press tool geometry of the plurality of stations and/or a workpiece geometry, wherein the simulation step includes a determination whether the candidate workpiece transport trajectory conforms with the provided press tool and/or workpiece geometry.

~~3. Method as recited in claim 1 or 2, characterized in that the workpiece transport trajectories and the candidate workpiece transport trajectory are parameterized by a plurality of positions of a plurality of axes as a function of an angle parameter.~~

~~4. Method as recited in claim 3, characterized in that the workpiece transport trajectories and the candidate workpiece transport trajectory are partitioned into a plurality of segments, each of the segments including the axes positions for a continuous range of values of the angle parameter.~~

~~5.~~3. Method as recited in claim 41 or 2, characterized in that a first of the segments relates to unloading a workpiece from a pickup position and that a second of the segments relates to loading a workpiece in a deposition position.

~~6.~~4. Method as recited in claim ~~5~~3, characterized in that at least a third segment connects an end of the first segment to a start of the second segment and in that at least a fourth segment connects an end of the second segment to a start of the first segment.

~~7.~~5. Method as recited in one of claims ~~4~~1 to ~~4~~6, characterized in that the information on the candidate workpiece transport trajectory comprises at least one shift parameter, wherein the shift parameter relates to a temporal offset of at least one segment of the candidate workpiece transport trajectory.

~~8.~~6. Method as recited in claim ~~7~~5, characterized in that the at least one shift parameter comprises an unloading shift parameter and a loading shift parameter for delaying or forwarding a running through an unloading or a loading segment, respectively.

~~9.~~7. Method as recited in claim ~~7~~ 5 or ~~8~~6, characterized in that the at least one shift parameter comprises a general motion shift parameter for delaying or forwarding a running through a complete succession of segments constituting the candidate workpiece transport trajectory.

~~10.~~8. Method as recited in one of claims ~~4~~1 to ~~9~~7, characterized in that the plurality of segments comprise at least one velocity-to-velocity segment, the velocities at a beginning and at an end of the segment being predetermined and non-zero.

~~11.~~9. Method as recited in one of claims ~~4~~1 to ~~10~~8, characterized in that the information on the candidate workpiece transport trajectory comprises a motion scaling parameter, wherein the motion scaling parameter is a scaling factor for proportionally scaling a start and stop of segments in angle parameters.

~~12. Method as recited in one of claims 4 to 11, characterized in that the information on the candidate workpiece transport trajectory comprises a set of motional information and values of angle parameters relating to transitions between neighbouring segments of a set of segments of a trajectory template, the motional information at least comprising velocity information.~~

~~13.~~10. Method as recited in one of claims ~~4~~1 to ~~12~~9, characterized in that the trajectory template comprises a plurality of segments chosen from the following types of segments:

a) standstill-to-standstill;

b) standstill-to-velocity;

c) velocity-to-standstill;

d) velocity-to-velocity;

e) standstill-to-standstill with limited velocity.

~~14.~~11. Method as recited in one of claims ~~4~~1 to ~~13~~10, characterized in that the trajectory template comprises a first segment type, the trajectory of which being parameterized by a polynomial of a first order, and a second segment type, the trajectory of which being parameterized by a polynomial of a second order, the first order being different from the second order.

~~15.~~12. Method as recited in one of claims 1 to ~~14~~11, characterized in that the information on the candidate workpiece transport trajectory comprises a move in and/or a move out stroke of an unloading and/or a loading path.

~~16.~~13. Method as recited in one of claims 1 to ~~15~~12, characterized in that at least one of the plurality of stations is a servo press, wherein the machine properties of the plurality of stations comprise information on a maximum velocity, acceleration and/or maximum force allowed on the servo press and preferably information on a maximum power consumption allowed for the servo press.

~~17.~~14. Method as recited in claim ~~16~~13, characterized by the step of providing information on a candidate servo press trajectory, wherein the simulation of the plurality of stations and the at least one transfer device includes a simulation of the servo press operated according to the provided candidate servo press trajectory.

~~18.~~15. Method as recited in claim ~~17~~14, characterized in that the information on the candidate servo press trajectory comprises at least one of the following:

a) a deep draw height;

b) a deep draw velocity profile;

c) a deep draw energy profile.

~~19.~~16. Method as recited in one of claims ~~16~~ 13 to ~~18~~15, characterized in that the simulation of the plurality of stations and the at least one transfer device includes a simulation of a dynamical model of the servo press, taking into account moving masses and corresponding inertia and a maximum slide velocity.

~~20.~~17. Method as recited in one of claims ~~16~~ 13 to ~~19~~16, characterized in that the simulation of the plurality of stations and the at least one transfer device includes a simulation of an

electrical model of the servo press, taking into account a maximum motor velocity, a maximum torque, a maximum current and/or power consumption.

~~21.~~18. Method as recited in one of claims ~~16~~13 to ~~20~~17, characterized in that the information on the candidate servo press trajectory comprises at least one parameter for adjusting the candidate servo press trajectory, wherein the parameter affects the trajectory in such a way that a deep draw velocity profile is unchanged.

~~22.~~19. Method as recited in one of claims ~~16~~13 to ~~21~~18, characterized in that the simulation of the plurality of stations and the at least one transfer device comprises a simulation of energy management involving the plurality of stations and/or the at least one transfer device.

~~23.~~20. Method as recited in claim ~~22~~19, characterized in that the multiple station press comprises a plurality of servo presses and in that the simulation of energy management involves the plurality of servo presses.

~~24.~~21. Method as recited in claim ~~23~~20, characterized by the step of generating a progression of current values for controlling operation of the servo press, based on the simulation of the servo press and preferably the at least one transfer device.

~~25.~~22. Method as recited in one of claims 1 to ~~24~~21; characterized by the step of performing an optimisation process for determination of a workpiece transport trajectory minimising a total stress on the plurality of stations and the at least one transfer device.

~~26.~~23. Software for the determination of workpiece transport trajectories, comprising software code portions for implementing a method according to any one of claims 1 to ~~25~~22.

~~27.~~24. Arrangement comprising

a) a multiple station press,

b) at least one transfer device for transporting the workpiece from a first of the plurality of stations to a second of the plurality of stations

c) a controller for the transfer device, wherein the controller

- accepts and stores a set of constraints for the workpiece transport trajectories, the constraints comprising at least pickup and deposit positions for the workpiece in a plurality of stations of the multiple station press,

- accepts and stores machine properties of the plurality of stations and of the at least one transfer device,

- accepts and stores information on a candidate workpiece transport trajectory,

wherein

- the controller is adapted to simulate the plurality of stations and the at least one transfer device based on the stored information for determining whether the candidate workpiece transport trajectory conforms with the stored machine parameters; ~~and~~

~~wherein~~ - the arrangement further comprises means for displaying the result of the determination; ~~.~~

- the workpiece transport trajectories and the candidate workpiece transport trajectory are parameterized by a plurality of positions of a plurality of axes as a function of an angle parameter;

- the workpiece transport trajectories and the candidate workpiece transport trajectory are partitioned into a plurality of segments, each of the segments including the axes positions for a continuous range of values of the angle parameter; and wherein

- the information on the candidate workpiece transport trajectory comprises a set of motional information and values of angle parameters relating to transitions between neighbouring segments of a set of segments of a trajectory template, the motional information at least comprising velocity information.