AUTOMATION IN A FIELD OF DIE CASTING

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Abstrakt

Obor tlakového lití se v dnešní době neobejde bez automatizace nejen u samotných strojů tlakového lití , ale hlavně u technologických pracovišť obsahujících čím dál více periferních zařízení. Evidentní je pokrok automatizace u bezobslužných systémů, navrhovaných pro třísměnný provoz tak, aby obsluha obstarávala pouze dozor. Řízení celého pracoviště je provedeno centrálním řídícím systémem, který je součástí řídicího systému tlakového licího stroje.

Další inovací v oboru tlakového lití je využití nejmodernějších progresivních metod TL (rheocasting a elektrotroskové odlévání) a využívání virtuálních prototypů pro návrh i testování. Virtuální prototyping je rychlá, jednoduchá a levná cesta k vývoji výrobků a procesů výroby. Modely se po návrhu mohou testovat za různých podmínek. Tím se významně ušetří, nejen z hlediska financí, ale i náročnosti a pracnosti zkoušek. Nedostatky navrhnutých řešení jsou rychle nalezeny a opraveny. To vše probíhá ještě před vyrobením prvního fyzického modelu, čímž se značně zlevní a urychlí realizace výroby.

Klíčová slova

Tlakové lití, technologické pracoviště, bezobslužné pracoviště, řídicí systém, virtual prototyping, progresivní metody, rheocasting.

1. Introduction

Die casting automation is the only competitive edge in today's competitive environment. There are many changes of projecting producing machines nowadays. Traditional ways (project of a machine, knot, subgroup and individual components) are subsiding and concepts with an application of ready components (subgroups) are used. Virtual prototyping is used more and more. Simulations of possible work regimes (with the aim of understanding a behavior before the first physical model is bulit) are used frequently. Tools that are able to simulate and optimize the behavior of a producing machine with CAD/CAE systems are utilized much more than they used to be.

2. Targets of my work

There are few aims I am supposed to fulfill in my thesis. There are targets I should compute and finis recently, that are:

- Develop method for designing the whole forming machine's cells and machines with a similar design
- Verify created method on a given machine type and create the virtual parametric model
- Verify created model with all product type group.
- Integrate a machine to a robotics technological workplace for automated production

At present I am ready with my critical exploration of a field of technological workstations and computing of cutting press and die casting machine.

3. Die Casting - advantages and disadvantages

Die casting is a process that is characterized by high speed forcing of molten metal under high pressure (20 - 100 MPa) into a mould cavity. The mold cavity is created by hardened steel dies. Most die castings are made from non-ferrous metals such as zinc, copper, aluminium, lead, magnesium, tin and their alloys. Depending on the cast metal, the type of a machine is used. There are two possibilities a hot- or cold-chamber machine.

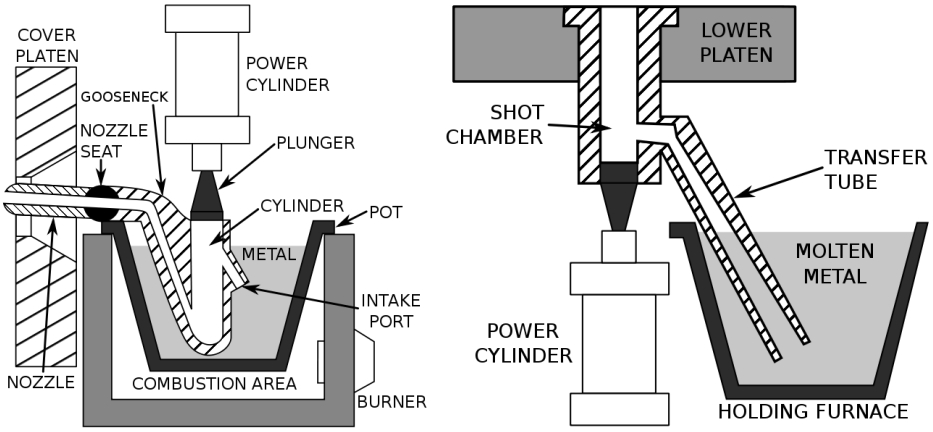


Figure 1. *Hot and cold chamber machine*

Die casting is characterized by a very good state of surface and dimensional consistency. Gas porosity is well eliminated, so the structural quality is high. On the other hand casting machines and the metal dies are quite costly, that´s why this technology is limits the process

to high volume production. The main aim of manufacturers is to keep the incremental cost per item low. It is suited for a large quantity of small and medium sized castings.

4. Projecting of technological workstation of die casting

Recent trend of die casting leads us to use fully automatized workstation. That means mostly investments for buying peripheral equipment. The aim of a foundry is to assembler a workstation in as short time as possible to ensure effective use of all peripheral machines and equipment. The higher degree of automation, the higher the cost and productivity.
The fully automatized unattended workstation by Bugler is perfectly constructed to pay back expenses in a short time if used around the clock (3 shifts a day) producing great series of dies.

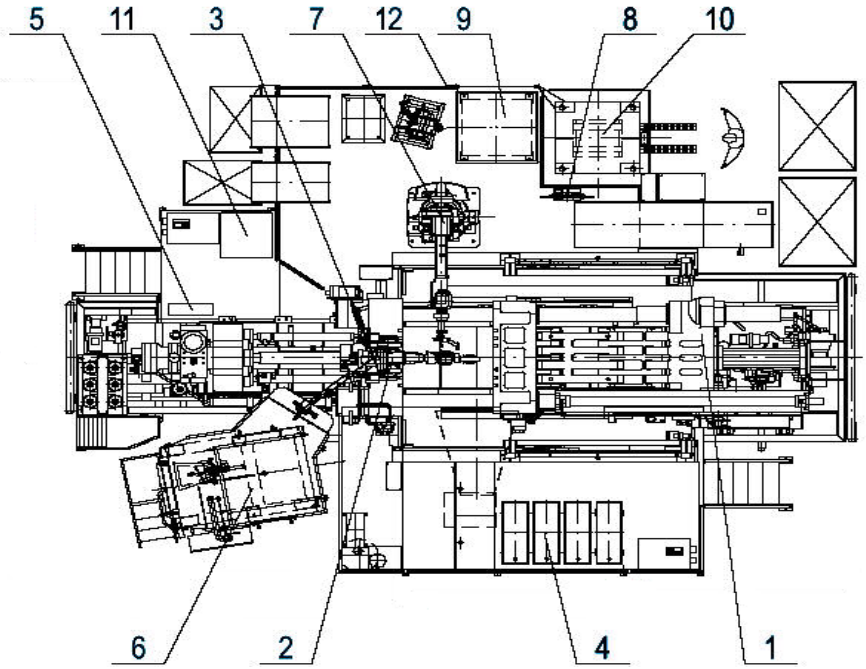


Figure 2. *Buhler fully automated unattended workstation*

1 Die Casting machine
2 Treatment of die forms by a robot (Spraying machines)
3 Lubrication of a pressing piston
4 Equilibration of die forms
5 Examination of a die cooling
6 Furnace
7 Manipulation robot (Removal unit)
8 Examination of integrity
9 Cooling of a die
10 Trimming press
11 Communication with IS
12 Completation parts

There are two most common compositions of technological workstations, with portal manipulators and with robots with serial kinematic structure. Portal workstations are used with bigger machines (bigger force than 4 000 kN). To increase effectiveness of robots (manipulators) these can be used for a couple of identical die casting machines (see fig.5)

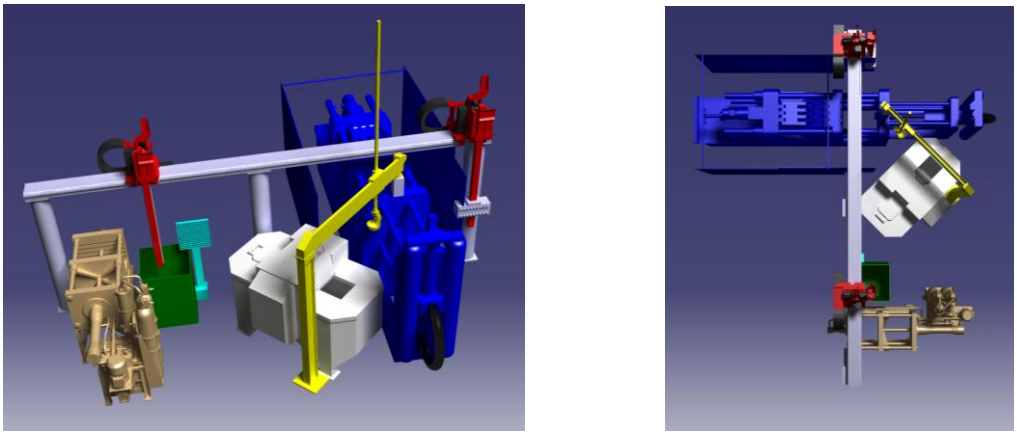


Figure 3. *Workstation composition with portal manipulators in isometric view and plan view*

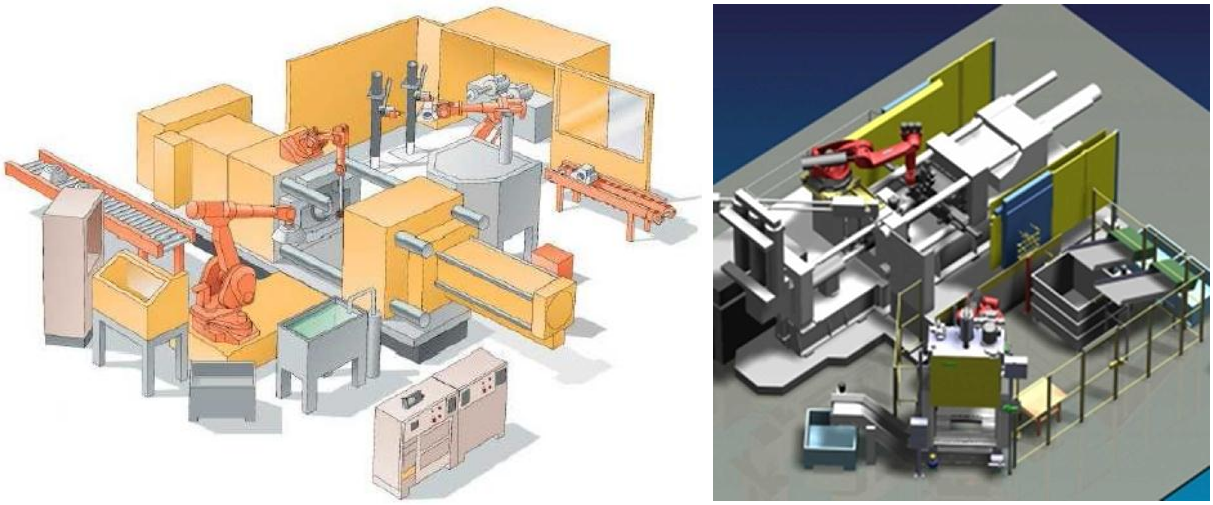
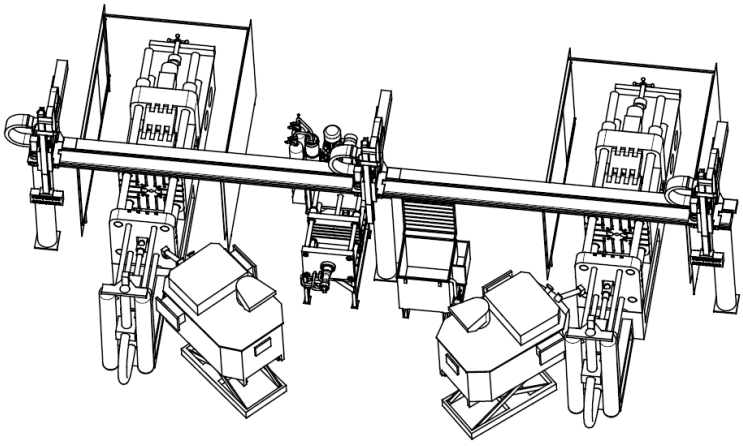


Figure 4. *Workstation composition with robots in isometric view*



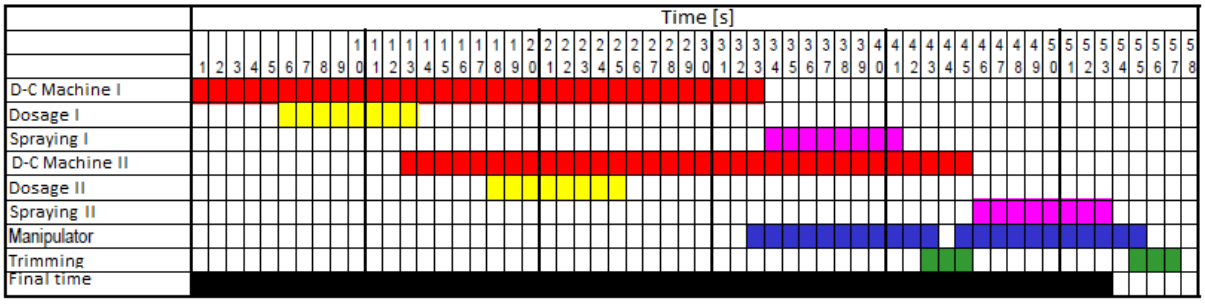


Figure 5. *Workstation composition with 2 robots with time diagram*

5. Peripheral equipment

In this chapter I would like to describe peripheral machines of the fully automated workstation.

5.1 Die Casting machines

The target of manufacturers of die casting machines is to ensure fully automatic operation and shortened cycle time to boost productivity, while lowering production cost.
Machines are supposed to be equipped with various peripheral equipment, allowing the machine to achieve highly automated die casting operations

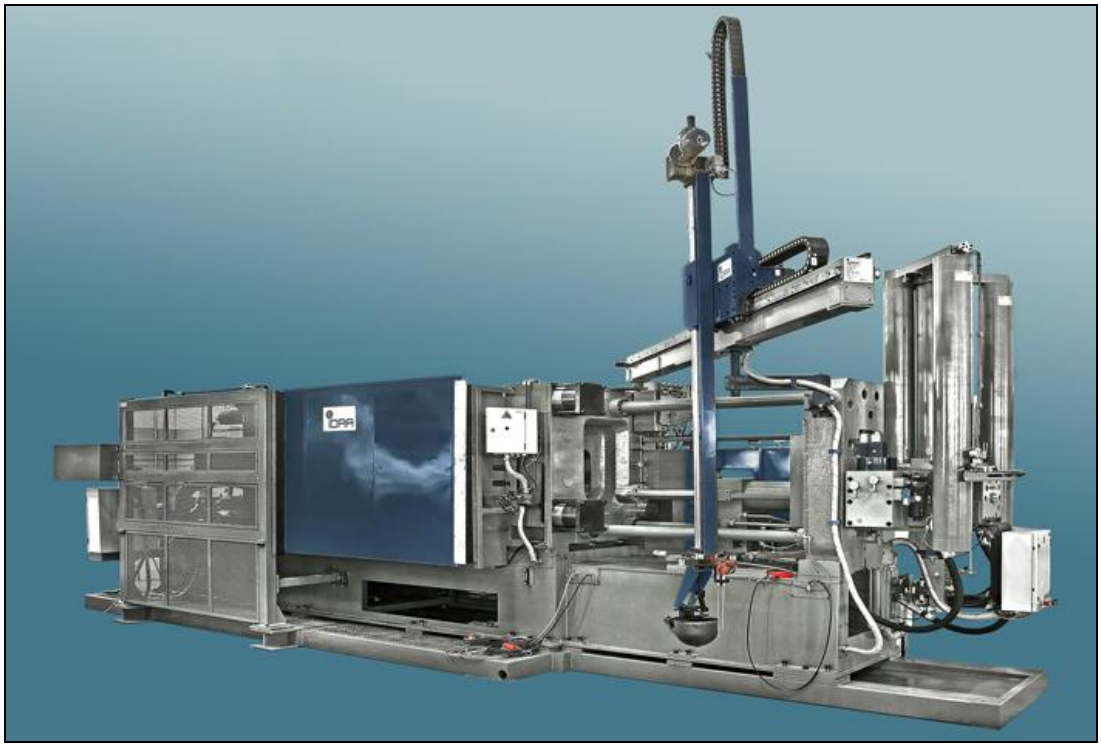


Figure 6. *IDRA Die casting machine with a manipulator*

5.2 Ladling units

The fully automatic, motorised dosing units are supposed to offer high dosing precision in a robust arm design. The speed, user-friendly control system and the flexibility are the biggest aims of manufacturers of ladling units

Figure 7. *Various ladling units*

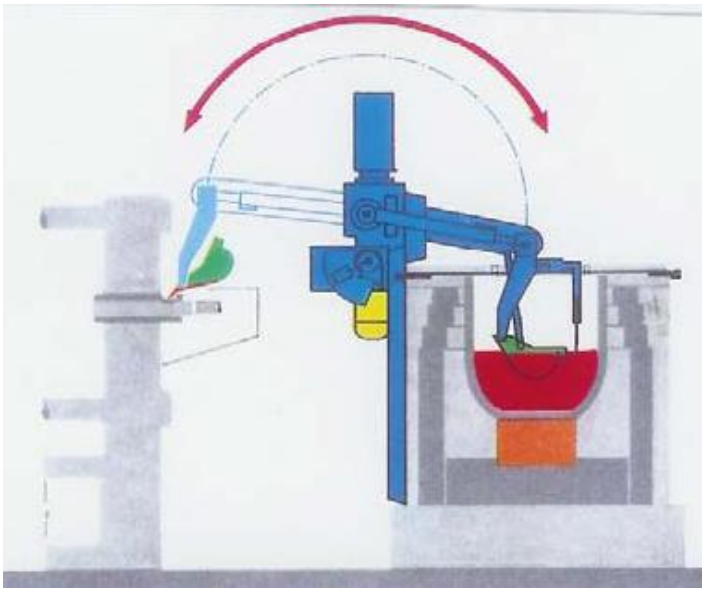


Figure 8. *Principle of ladling units*

5.3 Spraying systems

Spraying systems are used to prevent from contact of molten material and a die form and to enssure better release of a die from a form
The requirements for the most sophisticated die spraying technology are:

- Highly accurate positioning and reproducibility
- High dynamics and high velocity driving speeds
- Powerful spraying tools for the most complicated geometries
- Optimised liquid preparation and feeding

Figure 9. *Examples of spraying peripheral machines*

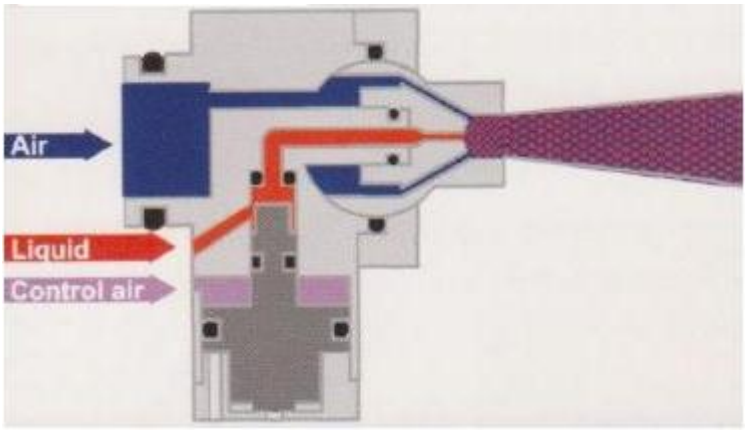


***Figure 10**. Principal of a spraying system*

***Figure 11**. Noozle of a spraying system*

5.4 Removal Units

Die protection requires precision. That´s why precise movements with a secure, positive gripping action are supposed to be provided by removal units.
Advantages of these units are:
- Easy setting
- Fast, precise gripping and checking of the shot
- Robust construction

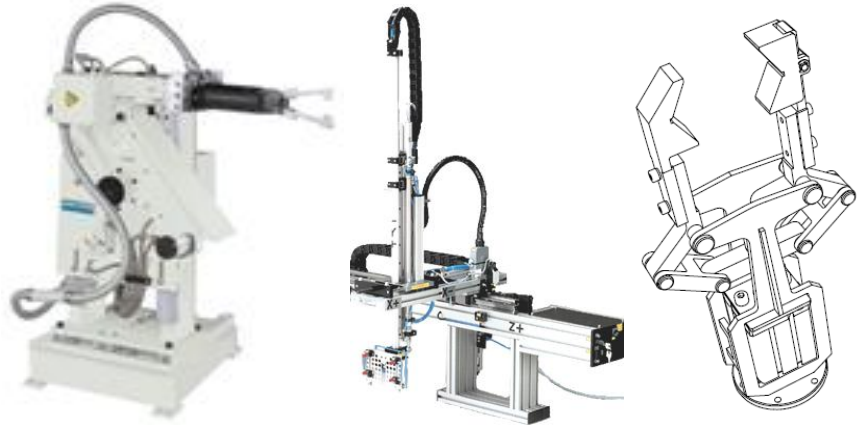


***Figure 12**. Means of removal units with a gripper for removing casts*

5.5 Weight sensing device

Weight sensing device secures a reliable weight comparison and communicates with the diecasting machina. It guarantees die- protection and quality control for castin weights.

***Figure 13**. Weight sensing devise*

5.6 Lubrication unit of a pressing piston

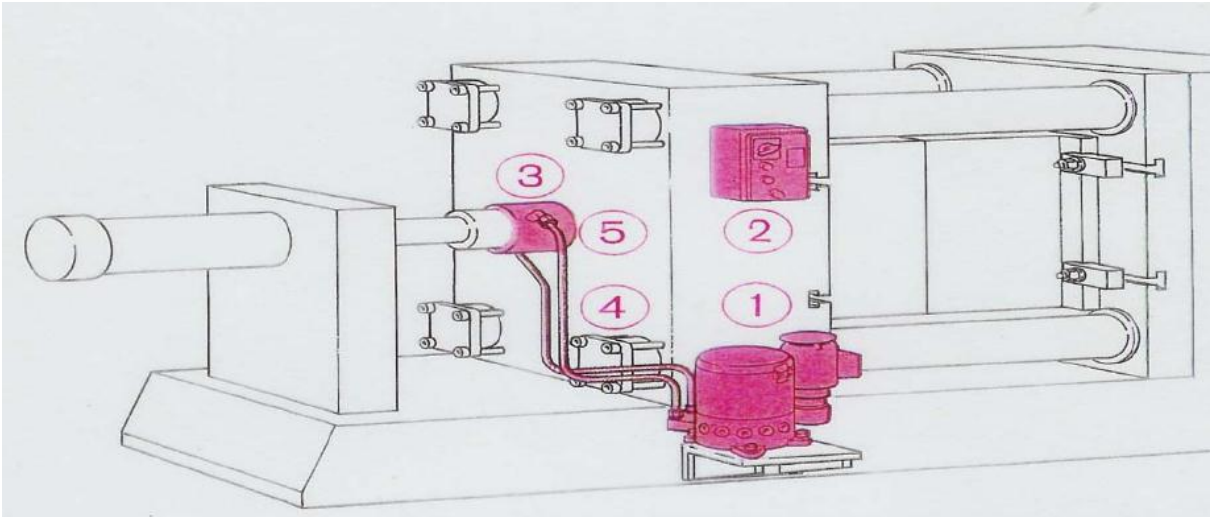


Figure 14*. Lubrication unit of a pressing piston*

5.7 Trimming presses

Trimming hydraulic presses are designed for removing of frays on pressure mouldings or complete sets with sprues. Removing should be made with help of cutting, perforating in combination with cushioned parts.

Figure 15*. Trimming press from TOS Rakovník OL28 (280 kN)*

5.8 Industrial Robot

The most utilised robot in a field of die casting automation is an agular robot ABB IRB 2400 with a serial kinematic structure. Reach of this Robot is 1,55 m and its working area is shown in figure 16. Common 3-dimensional motion manipulator is developed by REIS ROBOTICS (see Figure 18). To enlarge the working area and shorten time necessary for manipulation, a track can be used.

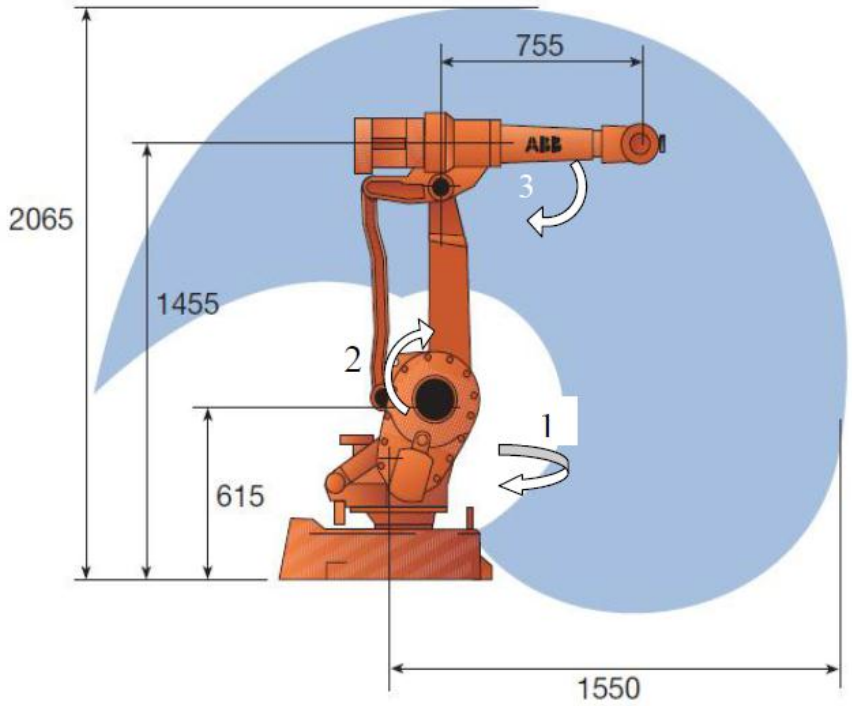


Figure 16*. Industrial robot ABB IRB 2400 L*

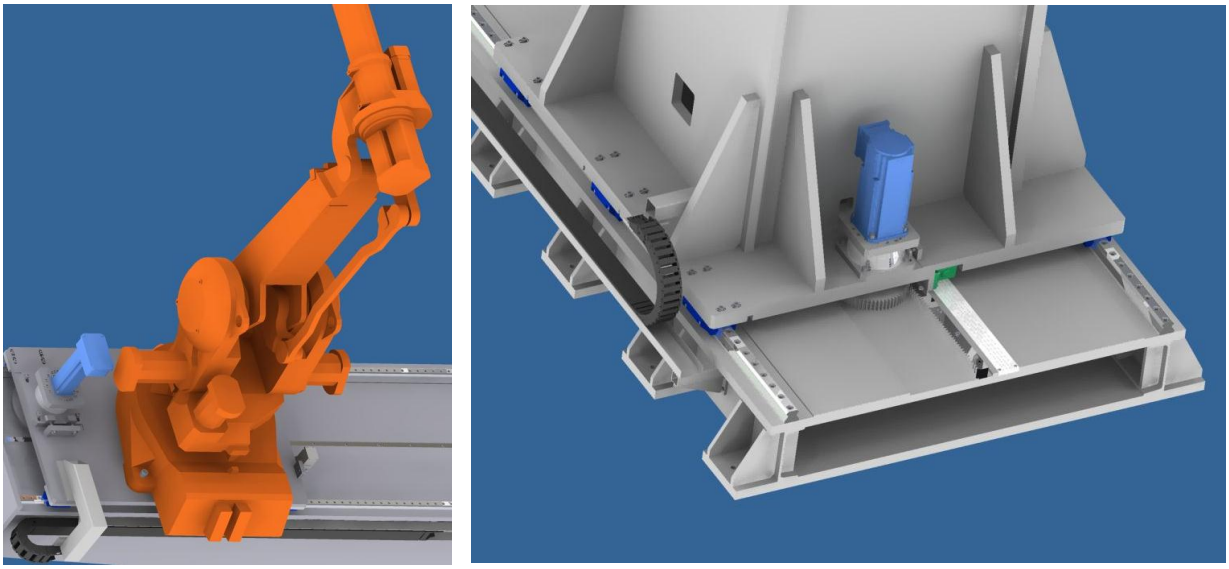


Figure 17*. Robot on a track to enlarge a range of reach and working are, base station for 3-axis track*

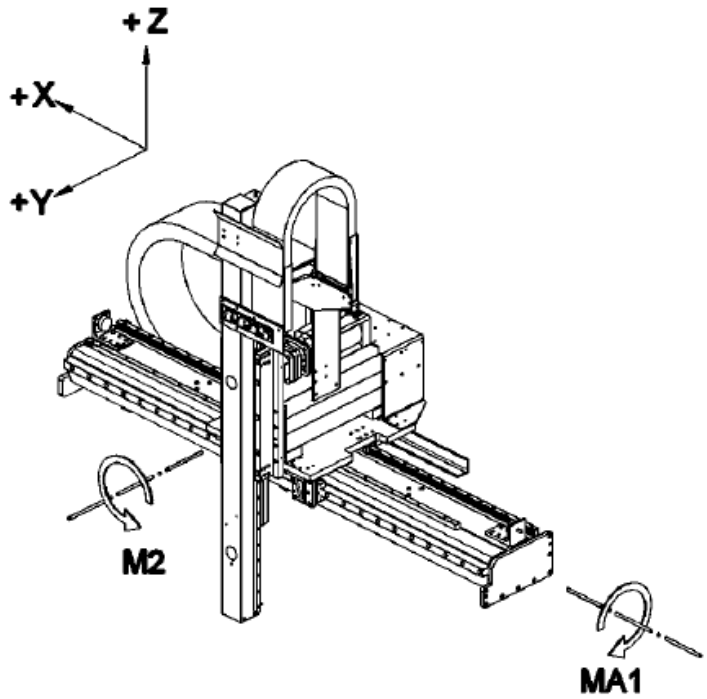


Figure 18. Gantry Portal Manipulator REIS ROBOTICS

5.9 Projecting of a gripper

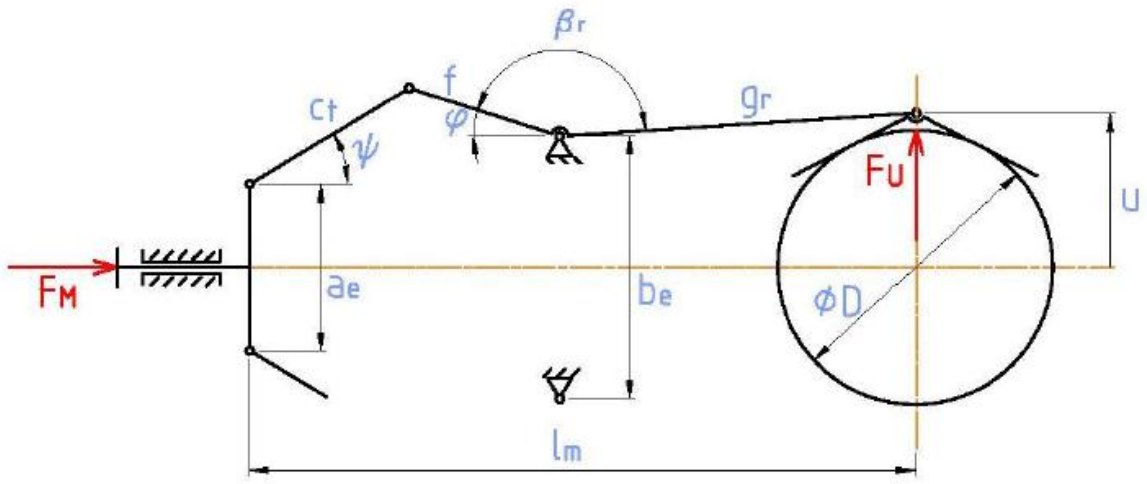


Figure 19. Basic chart of a mechanism for determination of a ratio

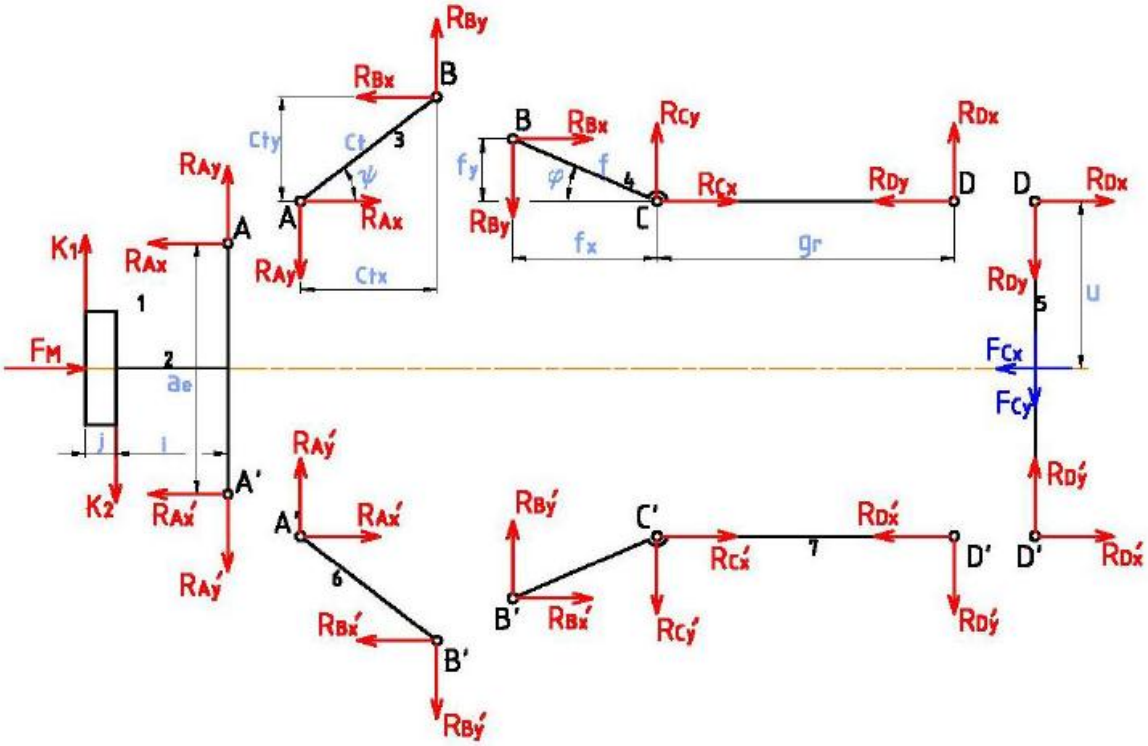


Figure 20. Chart of Forces and Reactions

5.10 Projecting of a Gantry frame:

At first, maximal stress and deflection were computed with an analytic method. Then the initial model of a gantry frame for a manipulator was optimized (thickness of profile, addition of ribs). After the optimized model was created, an ANSYS FEM calculation was carried out (see figure 21 and 22)

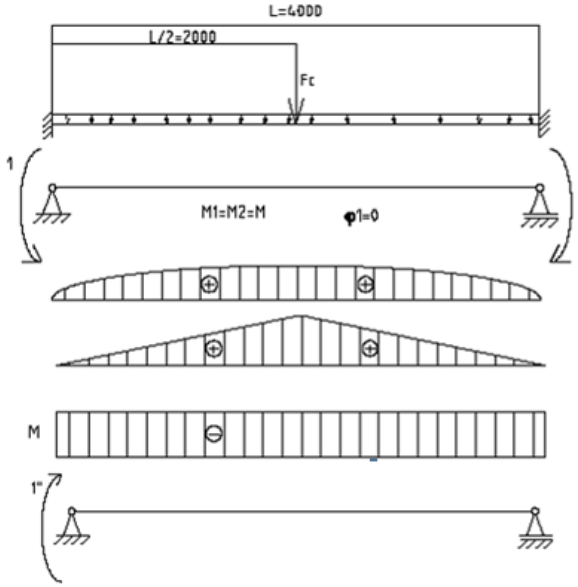


Figure 21. Calculation of torque and stress

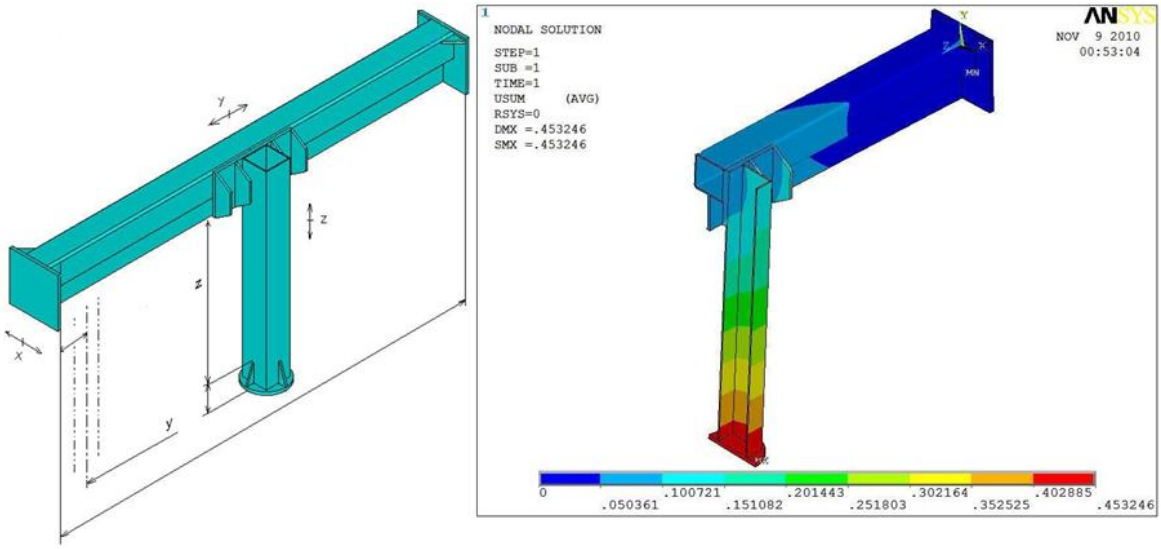


Figure 22. Ansys model, calculation of a maximal displacement

6. Semi solid metal process

Semi solid metal process is carried out to improve features of a final product. Dies are in a semi solid state - tixotropal state. These methods are used for Aluminium alloys such as AlSi7Mg, AlCu4Mg, AlZn6Mg etc. Advantages of semi solid metal process are:

- lower process temperatures
- low content of flowing gases
- lower shrinkage of dies
- lower probability of cracking in a hot state

There are three ways of semi solid metal process

- Thixocasting
- Thixoforming
- Rheocasting

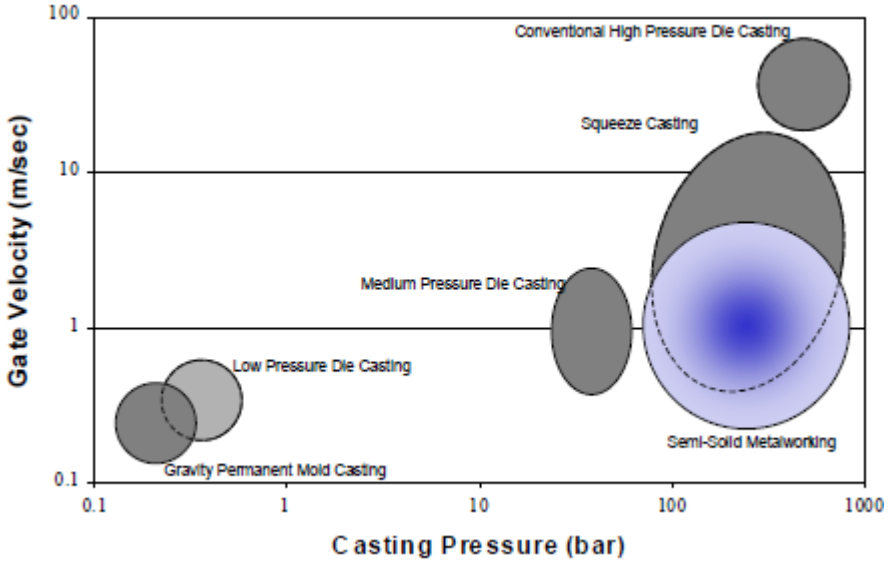


Figure 23. Comparison of technologies

7. Targets of my work

- Develop method for designing the whole forming machine’s cells and machines with a similar design
- Verify created method on a given machine type and create the virtual parametric model
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8. Conclusion

Future state of die-casting is without any doubt given by automation. It provides technical and economical advantages, that ensure competitiveness in steadily harsher conditions. Owing to automation, productivity can be increased by 30 % (see table 1). At the same time, spoilage can be significantly decreased. On the other hand, purchase cost and other investments for functioning and maintenance rise with a degree of automation. To ensure returnability, it is neccessary to produce around the clock (three shifts a day) Great series of production are as well needed for a quick pay-back.

Operation System of DCM	Productivity [%]	Spoilage [%]	Cost of maintanance [%]
Manual control	100	6	100
Fully automated	130	2	109

Table 1. Advantages and disadvantages of automation in a field of die casting

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