Project No. I

Due March 13/15th, 2018

Your company has agreed to design, build, test and deliver a set of four (4) machines that are used for cutting, punching, blanking, bending and light stretching work of sheet metal parts. These types of machines – a mechanical punch press – handle stock sheet metal that is feed automatically to the press. The feeding mechanism exists already and does not need to be included in the design. The press generates its power mechanically, by using an electric motor that is connected to a crankshaft, which cycles the ram of each operation. The cycle action is facilitated by the use of a flywheel and a gear box. The objective of the flywheel is to build up pressure which is released at the initiation of the press function. This pressure transfers energy to the primary side of the punch process. For this press, the customer requires only a single action, i.e. one ram is used. A general depiction of a mechanical press, see Figure 1.

Figure 1: Example of a mechanical punch press with controls, a straight sided frame (*ref: Komatsu America Industries, Wood Dale, Illinois*).

As stated above, the to be designed press is powered by an electric motor that drives a large flywheel. The flywheel stores kinetic energy, which is released through a specific drive type (explained below). For each 360-degree cycle of the press, or stroke, energy in the flywheel is consumed as the part is made in the die. During this process the flywheel slows down, usually between 10 and 15 percent. The electric motor is responsible to restore this lost energy back into the flywheel on the upstroke of the press. The process is repeated again as the press is ready for the next cycle.

The customer intends to process high strength steel as its main material for producing the parts with the press. An assumed SPM (strokes per minute) of less than 29 is requested by the customer (for your design, please consult the detailed specification sheet at the end of this document for the exact SPM you are designing for as well as other information). Since a relative low SPM and a relatively high strength of the processed material is specified, the mechanical press drive train needs to be a double geared system. A schematic of a single geared end drive system is shown in Figure 2:

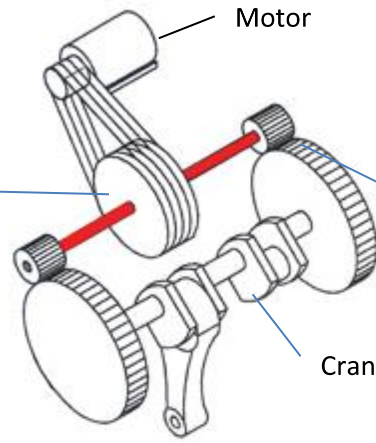

Figure 2: Schematic of a geared end drive system (reference: https://www.thefabricator.com/article/stamping/get-the-most-out-of-your-press)

In Figure 2, the motor sits on top and drives the flywheel that includes the clutch and break. The shaft of the flywheel drives a gear reduction system. In Figure 2, there is just one stage shown, hence it is a single geared end drive system. For achieving less than 29 SPM, the required design will include one more stage of gears, which are placed between the flywheel shaft and the crankshaft. Usually, a set of two opposing helical gears are used for such an additional gear stage.

For stopping and starting the mechanical press, the customer requests to use an electronic control to a clutch and a brake, which in turn disengages the flywheel to the press drive. The clutch and the brake are spring-applied and have a hydraulic release. The stopping time of the clutch and brake is critical in determining both the speed that the press can be run and the safety of the operator and die.

In the design, considerations have to be made for limiting the vibration that is induced by the operation of the press. In particular, it is requested by the customer to include a dynamic balancing of the upper die and press slide (ram) weight using an opposing force.

The frame of the mechanical punch press is straight sided, i.e. there are two sides and four to eight guideways for the slide. This is in contrast to C-type frames, where a single column is present and an overhead to accommodate the press mechanism. As relative large forces are specified by the customer, C-type frames cause too much in-accuracy as the frame deflects. Straight sided frames do not have this problem, as they are balancing the forces. An example of a C-type frame mechanical punch press with flywheel is shown in Figure 3.

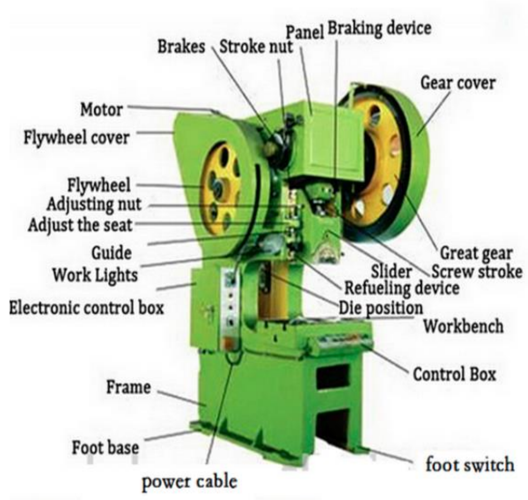

Figure 3: C-Frame for a mechanical punch press with flywheel.

As the company has agreed to produce such a system, the head engineer assigns you to be responsible for the complete gear box design as well as the housing of the gear box, the lubrication, and the mount for the gearbox itself to the frame, the dynamic balancing of the upper die and press slide and the selection of the motor. Specifications are given to you in a separate document with regard to the design. Specifications for such a press may entail the following information:

Table 1: Possible specification parameters and their units.

Parameters	Unit
Nominal Pressure	KN/Ton
Nominal Pressure Stroke	mm
Ram Stroke	mm
Stroke Number	min-1
Max. Die Height	mm
Die Height Adjustment	mm
Distance Betwwen Ram Centre to Frame	mm
Table Board Thickness	mm
Distance Betwwen Columns	mm
Table Size	mm
Table Hole Size	mm
Slide Block Bottom Size	mm
Shank Hole Size	mm

The In order to perform the engineering work, you will do a number of tasks based on a given timeline, which is given below:

Tasks and Timeline:

1. Familiarize yourself with this type of mechanical punch press. Research books and other references to gather information on the terminology of the parts, the functionality, and the different designs. Develop a glossary of terms and an associated description (preferably with diagrams and figures). Turn in a professionally generated document with this list on **January 18th**, prior to class time as well as in an email (to schomarc@isu.edu). Research all information you may need. You may have questions for the design: write down your questions and bring them to class on January 18.

2. Develop a PDS. The PDS will need to be done in a professional manner. Turn in the PDS on **January 25th** prior to the start of class via email (also submit a hard copy at the beginning of class).

3. Generate assumptions about quantities you do not have and document how you arrive at your assumptions (simple calculations, references, extrapolations, etc.). Research any standards and codes (i.e. ASME XXX, OSHA XXX, ANSI XXX, etc.) Summarize any applicable and pertinent information from the standards you find that have a direct impact on the design of the drive train of this press. Submit a document detailing the assumptions and standard findings by email on **January 25** and bring a hard copy to class on the same day.

4. Compute the power requirements for your system and define the motor specifications. For this, you will need to use your assumptions from step 3 as well as specifications of the flywheel-clutch-break system. The flywheel-clutch-break system is a system that is available from other manufacturer. Specify the clutch/flywheel/break and a motor and get quotations for both. In order to specify a motor, you will need to find out what type of motor and what rating this motor should have. Present the quotation (received from a motor company) along with all your computation for specifying the motor in a short memo on **February 1th** prior to class. In your memo, specify the person and his/her contact information of the motor company you conversed with.

5. Develop concept designs for the system. At minimum, develop two (2) different concepts, each satisfying the design specifications given and presented in the PDS. Sketch or draw each design concept and present them in a 5 minute professional presentation to the class. List each concept designs advantages and disadvantages, present your selection criteria and evaluation chart as well as which design you choose. Submit your PowerPoint presentation prior to class via email. The presentations will occur **February 6th and 8th**.

6. Engineer you design using machine design principles. You will bring your calculations to each class for one-on-one meetings with the instructors. Summarize your progress and achievements in your design from the last class/one-on-one meetings in a brief technical memo to the instructors.

7. Generate drawing files with all technical information (dimensions, tolerances, surface conditions). Include all details and consider the manufacturing process when making the drawings.

8. Generate a BOM. List supplier and any other pertinent information.

9. Generate a manufacturing plan (which part is manufactured how)

10. Do a detailed cost estimates (document your references for each estimation, do not guess!)

11. Present your design to class and submit a design report including all material developed during the progress of the project. Presentations will be held **March 13th and 15th**. Reports are due on alternating date of not presenting (if you present on a Tuesday, your report is due on Thursday, and vice versa).

Specification for Individual design:

Product No.	Nominal Pressure [kN]	Nominal Pressure Stroke [mm]	SPM	Distance b. Ram and Frame [mm]	Distance b. Columns [mm]	Max Die Height [mm]
A1	800	8.5	28	295	650	400
A2	778	9.0	28	295	650	400
A3	819	7.875	28	295	650	400
A4	749	9.125	28	295	650	400
A5	900	7.125	28	295	650	400
B1	800	6.975	27	295	650	400
B2	778	7.25	27	295	650	400
B3	819	6.75	27	295	650	400
B4	749	7.5	27	295	650	400
B5	900	6.65	27	295	650	400
C1	800	8.125	26	295	650	400
C2	778	8.55	26	295	650	400
C3	819	8.01	26	295	650	400
C4	749	8.95	26	295	650	400
D1	900	8.25	25	295	650	400
D2	880	8.125	25	295	650	400
D3	865	8.0	25	295	650	400
E1	1600	8.5	18	295	650	400
E2	1556	9.0	18	295	650	400
E3	1525	7.875	18	295	650	400
E4	1475	9.125	18	295	650	400
E5	1575	7.125	18	295	650	400
F1	1600	6.975	17	325	710	440
F2	1545	7.25	17	325	710	440
F3	1520	6.75	17	325	710	440
F4	1475	7.5	17	325	710	440
G5	1540	6.65	17	325	710	440
G1	1590	8.125	16	325	710	440
G2	1485	8.55	16	325	710	440

G3	1575	8.01	16	325	710	440
G4	1500	8.95	16	325	710	440
H1	1600	8.25	15	325	710	440
H2	1585	8.125	15	325	710	440
H3	1565	8.0	15	325	710	440

Common Stamping Terminology

- Blanking—the shearing or cutting of the complete parameter of any shape, called a blank, out of coil or strip material.
- Bottom dead center (BDC)—the lowest point of crankshaft (eccentric shaft) and press slide (ram) travel in a 360-degree press cycle.
- Die—an upper and lower tool set configured to cut, bend, form, draw, or coin metal that is placed between it. The press guides the tool set together under pressure.
- Drawing—a metal forming process in which a product is made by controlling sheet metal flow into a cavity with force from a punch. Forming of deep, recessed parts from sheet material by means of a plastic flow of the material worked in presses and dies.
- Piercing—the penetration of material that is placed between a punch and die and force is applied by a press. A precise hole is generated in the material to a required tolerance.
- Reverse load—the resultant force on the press when snap-through occurs.
- RPM—Revolutions per minute.
- Slide—also called the ram, the slide is connected to the upper half of the tool set and moves up and down in the press frame. It is powered by the crankshaft. It also delivers the force (tonnage); hence the word ram in some countries.
- Snap-through—the point at which shear occurs when blanking or piercing metal.
- Stretching—elongation and reduction of metal thickness (not to be confused with drawing, in which the material thickness is maintained. Drawing requires metal flow, while stretching does not).
- SPM—strokes per minute.