Hydraulic Sequence Design for Automated Turning Machine

Cylinder Force Requirements & Pressure Calculations

For each cylinder, we calculate the pressure required to produce the specified force using **Force = Pressure × Piston Area**. All cylinders share a bore of 40 mm and rod of 22 mm, so their piston areas are identical on the cap end (extension side):

- **Bore (cap-end) area:**
  $A_{cap}=\pi(d_{bore}/2)^2=\pi(40\text{ mm}/2)^2\approx1256.6\text{ mm}^2=1.2566\times10^{-3}\text{ m}^2.$A_{\text{cap}} = \pi (d_{\text{bore}}/2)^2 = \pi (40\text{ mm}/2)^2 \approx 1256.6~\text{mm}^2 = 1.2566\times10^{-3}~\text{m}^2.
- **Rod (annulus) side area:**
  $A_{rod}=A_{cap}-\pi(d_{rod}/2)^2=1256.6-380.1\approx876.5\text{ mm}^2=0.8765\times10^{-3}\text{ m}^2.$A_{\text{rod}} = A_{\text{cap}} - \pi (d_{\text{rod}}/2)^2 = 1256.6 - 380.1 \approx 876.5~\text{mm}^2 = 0.8765\times10^{-3}~\text{m}^2.

Using these areas:

- **Clamp Cylinder:** Required clamp force = 400 N. Assuming the clamp applies force on its cap end (pushing a clamp pad), the pressure needed is:
  $P_{clamp}=\frac{400\text{ N}}{1.2566\times10^{-3}\text{ m}^2}\approx318{,}300\text{ Pa}=318\text{ kPa}.$P_{\text{clamp}} = \frac{400~\text{N}}{1.2566\times10^{-3}~\text{m}^2} \approx 318,300~\text{Pa} = 318~\text{kPa}.
  This aligns with the given 318 kPa. In practice, some margin is wise (to overcome friction and ensure full clamping). For example, designing for ~350–400 kPa would provide a slight safety factor (~10–25% above the ideal 318 kPa). That corresponds to ~440–500 N clamp force, ensuring the clamp securely holds the workpiece.
- **Cutter Cylinder:** Required cutting force = 800 N, presumably on the cap end (pushing the cutting tool). The pressure required:
  $P_{cutter}=\frac{800\text{ N}}{1.2566\times10^{-3}\text{ m}^2}\approx636{,}600\text{ Pa}=637\text{ kPa}.$P_{\text{cutter}} = \frac{800~\text{N}}{1.2566\times10^{-3}~\text{m}^2} \approx 636,600~\text{Pa} = 637~\text{kPa}.
  This matches the given ~637 kPa. Again, a safety margin is prudent. We might design for ~700–800 kPa available to the cutter to avoid stalling if the cutting resistance is a bit higher than expected. (For example, 800 kPa would produce ~1005 N on the tool.)
- **Feeder Cylinder:** No force was specified, so we must estimate it. **Best practice** is to consider the task of the feeder: it pushes the workpiece into position. The feeder must overcome friction of the stock in guides, and possibly push the stock against a hard stop (to position it for cutting). We also ensure the feeder's force **does not exceed the clamp's holding capacity**, to avoid pushing the part out of the clamp or causing slip. A reasonable assumption is to require the feeder force to be somewhat less than the clamp force. For example, if we assume ~300 N required to feed the workpiece (to overcome

friction/inertia), the required pressure is:

$$P_{\text{feeder}} \approx \frac{300~\text{N}}{1.2566\times10^{-3}~\text{m}^2} \approx 239~\text{kPa}.$$

This is lower than the clamp's 318 kPa, ensuring the clamp can hold against any feeding force. If the feeder needed as much as 400 N (similar to the clamp), that would be 318 kPa; but to maintain an interlock (clamp stronger than feeder), designing the feeder for a slightly lower force is wise. In summary, we estimate **feeder pressure ~200–300 kPa** (to deliver a few hundred Newtons of feed force). We will use this estimate when setting sequence valves for the feeder.

Sequence Valve Pressure Settings and Functional Sequencing

The circuit uses **pressure sequence valves** to ensure the cylinders operate in the required order. A sequence valve stays closed until upstream pressure reaches its set value, then opens to send flow to the next actuator. This allows one cylinder to complete its motion (or build a certain pressure) before the next one begins (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion). We will verify/correct each sequence valve setting against the required pressures:

- **Desired Sequence (Extension): Feed** first, then **Clamp**, then **Cut**. This satisfies: *"No cut until clamp force met"* and positions the work before clamping and cutting.
- **Desired Sequence (Retraction): Cut** retracts first (tool out of the way), then **Clamp** releases, then **Feed** retracts. This ensures: *"No feed (new cycle) unless clamp & cutter are fully retracted."* The clamp stays engaged until the tool is clear, so the part is secure if the cut piece hasn't separated fully. After clamp opens, the feeder can safely retract and prepare for the next part.

Below are the recommended sequence valve settings for each stage, with rationale:

Extension Sequence (Feed → Clamp → Cut)

- **SV1 – Feeder to Clamp Sequence:** *No clamp extension until feeder is finished.* In the circuit, the clamp's advance line is controlled by a sequence valve that remains closed until the feeder builds sufficient pressure (indicating it has reached end-of-stroke or seated the workpiece). The current design showed a sequence valve at **318 kPa**, but that is **too low** – 318 kPa is just the clamp's own requirement and could be reached before the feeder is actually done. We recommend setting SV1 to **~350–400 kPa** (e.g. 350 kPa if feeder needs ~240 kPa, or up to 400 kPa if feeder force was higher). This is **above the feeder's normal working pressure** (~240 kPa), so that as long as the feeder is moving freely, pressure stays below the setpoint and the clamp doesn't move. Once the feeder cylinder fully extends (e.g. hits its stop or pushes the workpiece firmly), pressure will rise. When it exceeds ~350 kPa, SV1 opens and allows oil to the clamp cylinder. This guarantees *no clamping begins until the feed stroke is complete*. (If the initial design had SV1 at 318 kPa, it should be increased – for example, one could use the next available setting like 0.5 MPa (500 kPa) to be safely above the feeder's requirements. 318 kPa likely came from clamp force, but as a sequence setting it's inadequate to enforce order.)

- **SV2 – Clamp to Cutter Sequence:** *No cutter advance until clamp force is achieved.* This sequence valve monitors the clamp's pressure and stays closed until the clamp builds up the needed clamping force. In the current schematic, one sequence valve was set to **684 kPa**, which is well above the ~318 kPa needed for 400 N – that would overclamp the part (684 kPa on the clamp gives ~860 N force, more than double required). Overshoot can risk damaging the workpiece, so we correct this. SV2 should be set just **above the clamp's required pressure** to account for friction and ensure the clamp is tight. **~350 kPa** (if not already used for SV1) or about **0.4 MPa (400 kPa)** is a reasonable setting. In practice, a small margin (e.g. 10% above 318 kPa) is enough because we also plan to **hold the clamp pressure** (see safety features below). For example, setting SV2 to 350 kPa means the clamp must reach ~350 kPa (≈440 N force) before the cutter cylinder's line opens. This satisfies the requirement that the cutting tool only advances after clamping force is met. The **original 318 kPa setting** (if that was intended for this sequence) is basically the exact clamp force – it might allow the cutter to start moving the instant 400 N is reached, with no safety margin. Conversely, **684 kPa is too high**. We suspect 684 kPa was an initial guess to "guarantee" clamping, but it's excessive. **Correct SV2 to ~350–400 kPa** so that the clamp is firmly engaged but not wildly over-pressurized before the cutting stroke begins.
- **Cutter Cylinder Advance:** Once SV2 opens, the **cutter cylinder extends** to perform the cut. As it extends, the clamp's pressure will remain at least at the sequence setting so SV2 stays open (in fact, a pilot-operated sequence valve will hold upstream pressure at the set point while flow goes to the cutter (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion)). The cutter now sees full pump flow and will build pressure up to whatever is needed for cutting (≈637 kPa). If cutting requires the full 800 N, system pressure will rise to ~637 kPa during the cut. Our sequence valve setting (350–400 kPa) is lower, but that's fine – once opened, the sequence valve will allow pressure to climb further as needed for the operation (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion). The clamp remains clamped throughout (pressure might increase slightly above the initial 350 kPa as the whole circuit pressure goes up for cutting, but the clamp won't unclamp). *Thus, the cutting cylinder will not advance at all until the clamp has reached the preset clamping pressure.* This meets requirement (4).

Note: The pump flow is 9.95 GPM (~37.6 L/min), which is quite high relative to the cutter's desired speed of 500 mm/min. In fact, to move the Ø40 mm cutter cylinder at 500 mm/min, only ~0.63 L/min is needed. Without control, the cutter would extend much faster than required. In a real design, a **flow control valve** (meter-in or meter-out) should be added in the cutter's line to limit its speed to 500 mm/min. (When using flow controls with sequence valves, we would take the sequence's pilot signal downstream of the flow control so that the sequence valve sees the actual load pressure (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion).) For simplicity, we assume a flow control is implemented so the cutter's speed is regulated as specified.

Retraction Sequence (Cut → Clamp → Feed)

After the cut, the cylinders must retract in a safe order. Typically the tool should retract before the clamp opens (so the tool doesn't snag the part), and the clamp should open before the feeder brings in a new part. The sequencing can be achieved with another sequence valve and pilot checks:

- **SV3 – Clamp Retract Sequence:** *Hold clamp closed until cutter is fully retracted.* We introduce a sequence valve on the **clamp's retract (unclamp) line** that prevents it from retracting until the cutter cylinder has retracted. How is this triggered? When we command all cylinders to retract, the cutter will start moving back first (since the clamp's retract path is initially blocked by SV3). Once the **cutter cylinder fully retracts**, it will hit its end-of-stroke and pressure in the cutter's retract line will spike (the pump is still supplying flow until all cylinders retract). That pressure can be used to pilot-open SV3. We recommend setting SV3 to a modest value that the cutter's retract line will reach at end-of-stroke – for example, around **450–500 kPa**. (The original design had values **456 kPa and 500 kPa** in the sequence valves list, which likely correspond to this function. ~0.45 MPa is reasonable as it's higher than any backpressure during free retraction but will be attained when the cutter bottoms out.) When cutter retraction pressure exceeds the SV3 setting, SV3 opens and allows the clamp cylinder to retract (releasing the workpiece). This sequencing ensures the clamp does **not unclamp until the cutting tool is safely retracted** (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion). We thus satisfy the latter part of requirement (3).
- **Feeder Retract:** The feeder cylinder retracts to its home position to grab the next workpiece (or get behind the next stock segment). In many cases, the feeder can retract concurrently without issue once the clamp is open. We must ensure, however, that the feeder **does not try to retract the stock while it's still clamped**. In our sequence, the feeder's retract motion will naturally wait if the bar is still clamped – either the feeder's retract flow will divert to the easier-moving cutter (since clamp is locked) or the feeder will pull a vacuum if it tries (unlikely if the part is fixed by clamp). Once the clamp opens, the feeder is free to retract. In an all-hydraulic logic circuit, we could also enforce this with a sequence valve on the feeder's retract line triggered by clamp opening. However, this may not be necessary if the clamp physically prevents any retraction movement until released.
- **No Feed Until Others Retracted (Interlock for Next Cycle):** This requirement is essentially met by the above sequence: at the end of a full cycle, both the cutter and clamp are retracted (home position) before the feeder advances again. If the machine cycles automatically, we need to ensure the **feeder's next advance does not occur until the clamp and cutter are fully retracted**. This can be achieved by an **interlock** in the control system or via additional hydraulic checks. A common hydraulic solution is to use **pilot-to-open check valves** that act like an "AND" logic: for example, place check valves in the feeder's advance line that only open when pilot pressure signals from both the clamp **and** cutter retract positions are present (i.e. both cylinders are retracted). In practice, one might attach pilot lines from the retract ends of the clamp and cutter cylinders to a dual-pilot check on the feeder line. Only when both pilot signals are high (which would happen when both cylinders hit their retracted end stops and build pressure) will the feeder line open. This kind of **mechanical/hydraulic interlock** can enforce *"no feed unless clamp & cutter retracted"*. Alternatively, limit switches or

sensors on the clamp and cutter could be used in an electrical control system to prevent the feeder's solenoid valve from energizing until those conditions are met. In summary, by sequencing the retractions and/or adding an interlock, we guarantee the feeder will not advance a new part until the previous clamp and cut cylinders have fully returned (satisfying requirement 3).

Pressure Relief Valves (PRVs) and Safety Considerations

Two pressure relief valves were noted: **800 kPa (upper)** and **1000 kPa (lower)**. We interpret the **lower PRV (1000 kPa)** as the main system relief (likely located near the pump). The **upper PRV (800 kPa)** appears to be a secondary relief – likely installed on the clamp branch or as a safeguard for clamping pressure. We will verify these settings:

- **Main Relief (1000 kPa):** This is equal to 1.0 MPa (≈145 psi), which is above all the sequence setpoints and required pressures. It's about 57% higher than the highest normal working pressure (637 kPa for cutting). This is acceptable; it provides headroom so that if the cutter encounters a sudden load spike, pressure can increase up to 1000 kPa before relieving. **1000 kPa is reasonable as the main PRV setting** – it never actually opens during normal operation (since cutting needs ~637 kPa, clamping ~318 kPa). It would only lift if something abnormal happens (like a cylinder stalls before completing its stroke). We do not see a need to change the 1000 kPa main relief; it protects the pump and system from over-pressure.
- **Clamp Branch Relief (800 kPa):** Having a dedicated relief at 0.8 MPa for the clamp circuit is a safety measure to **limit clamp pressure**. If for some reason the sequence valve were mis-adjusted or the clamp bottomed out, this PRV would crack at 800 kPa to prevent excessive force on the workpiece. 800 kPa on the clamp's bore yields ~1005 N, which is about 2.5× the required clamp force – still within a safe range for the cylinder, but hopefully not damaging to the part or fixture. We could consider lowering this closer to the needed pressure plus some margin; for example, setting it around 600–650 kPa would cap the clamp force around ~750–820 N. However, we must ensure it's *above the clamp's sequence trigger*. Since we recommended the cutter sequence (SV2) at ~350–400 kPa, even a 600 kPa clamp relief would not interfere with sequencing (clamp never needs to exceed ~400 kPa normally). Setting it to 800 kPa is conservative and fine – it stays out of the way during normal operation but provides a **fail-safe** if the clamp were accidentally over-pressurized. We advise keeping **800 kPa** as is (or slightly lower if one is confident in the sequence tuning), to protect the workpiece.

Pump Power Loss Protection: A crucial safety requirement (5) is to protect against loss of pump power. If the pump shuts off or a power failure occurs, we don't want the system to suddenly depressurize in a way that could release the clamp or drop a load. Two measures are recommended:

- **Pilot-Operated Check Valve on the Clamp Cylinder:** This is a **load-holding valve** that locks fluid in the clamp cylinder when the directional valve is neutral or if supply pressure is lost. Essentially, a pilot-operated check on the clamp's cap-end line will let oil **into** the cylinder normally (to clamp), but will **not allow it to flow back out** unless a pilot pressure is applied (from the clamp's rod side, when actively unclamping). In the event of pump loss, this check valve traps pressure in the clamp cylinder, so the clamp jaw stays firmly closed (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion) (Pilot Operated Check Valves for Cylinder Position Holding). Even if the main directional valve springs to center (potentially connecting lines to tank), the clamp won't open because the check valve prevents backflow. This guarantees the workpiece remains clamped and safe. Pilot-operated checks are widely used for safety and holding position – they "trap pressure in order to hold a cylinder in place" (27 Series Pilot Operated Check Valves Safety Category. 1 PL c ...). We **strongly recommend** adding a pilot-to-open check valve on the clamp cylinder. (The original preliminary circuit may not have shown this explicitly, but it's an essential addition for a clamping device.)

- **Check Valve on the Pump Line:** To further guard against pump shutdown, a one-way check valve can be placed right after the pump outlet. This prevents pressurized fluid in the system from bleeding back through the pump case to tank if the pump loses torque. In normal operation, the pump's check allows flow out; if the pump stops, the check closes, isolating the system. This, combined with the pilot check on the clamp, means the clamp will hold pressure for an extended time even with no pump (there's minimal volume for oil to expand). It's effectively an inexpensive way to meet the requirement (5). (If ultra-safe operation is needed, a small accumulator could be added to maintain pressure on the clamp during an outage, but for a 0.4 MPa clamp, the cylinder itself and check valve are usually sufficient.)
- **Other Safety Notes:** The cutter and feeder cylinders are less critical in a power-loss scenario. The feeder would simply stop (and due to check at pump, it won't drift forward). The cutter would also stop; if it's mid-cut, the clamp check holds the part so the tool isn't kicked back by the work. If any cylinder is holding a vertical load (not the case here, presumably all horizontal), pilot check or counterbalance valves would be needed there as well. In our turning machine, the primary concern is the clamp. We also ensure all sequence valve drains are properly connected to tank (sequence valves must have an external drain at 0 pressure, or their setpoints get offset). In addition, once power is restored, the pilot check on the clamp will require intentional pilot pressure (by activating the clamp's retract) to release – this is a good safety feature (prevents inadvertent unclamping).

Finally, it's worth noting that relying purely on pressure sequence valves has some limitations. If an actuator stalls or a false pressure builds, a sequence valve could be triggered incorrectly (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion). In critical applications or where human safety is involved, mechanical/electrical interlocks (like limit switches or sensors confirming position) are preferred (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion) (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion). In our design, we assume the sequence valves are properly set and the process forces behave as expected, which is acceptable for an automated machine with known loads.

Operation Summary: How the Circuit Achieves Sequencing

To illustrate the functional sequencing, here's a step-by-step description of one cycle of operation, incorporating the above valve settings and modifications:

1. **Initial State:** All cylinders are retracted – feeder is back (no workpiece in the cutting area), clamp is open (retracted), and cutter is withdrawn. The feeder is ready with a new workpiece (or connected to a bar stock). The sequence valves SV1 (to clamp) and SV2 (to cutter) are closed because pressures are zero. The pilot check on the clamp holds nothing at this point (clamp is open, no pressure).
2. **Feeder Advance:** The main directional valve (or the feeder's valve) is shifted to extend the cylinders. Since the clamp's and cutter's paths are blocked by SV1 and SV2, **the feeder cylinder (Feed)** has the path of least resistance and extends first (BOOK 2, CHAPTER 20: Sequence valves - Power & Motion). It pushes the workpiece forward the full 200 mm stroke into the machining position. During this motion, system pressure stays low (just enough to move the feeder and overcome friction, on the order of 100–200 kPa). SV1 is set ~350 kPa, so it remains closed while the feeder is in motion. *Thus, clamp and cutter stay put until feeding is done.*
3. **Feeder Completion -> Clamp Engage:** When the feeder reaches its end of stroke (e.g. the workpiece contacts a positive stop or the cylinder bottoms out), resistance suddenly increases. The pump flow now builds pressure in the feeder line. As soon as pressure rises above SV1's setting (say 350 kPa), **Sequence Valve 1 opens**, diverting flow into the **clamp cylinder** cap-end. The clamp cylinder now extends. It moves a clamp arm or jaw onto the workpiece. Initially, it may move quickly until it touches the part, then as it begins to apply force, pressure in the clamp line rises. The feeder is now static at its end position (it stays extended, holding the stock against the stop). The **clamp cylinder builds pressure up to the clamping requirement** (~318 kPa or slightly above). We set SV2 ~380 kPa (for example), so the clamp will continue to be fed with oil until around that pressure. At that point, **the clamp has attained ~400 N or more of force on the part**, securing it. (The pilot-operated check valve on the clamp is open during this clamping phase because the pressure from the pump unseats it in the forward direction; once clamped, the check will trap this pressure.) The condition for the next sequence is now met: clamp pressure has reached the SV2 threshold.
4. **Clamp Force Achieved -> Cutter Advance:** When clamp line pressure exceeds SV2's setpoint (~0.38–0.4 MPa), **Sequence Valve 2 opens**, allowing flow to the **cutter cylinder**. Now the cutter cylinder begins to extend. It drives the cutting tool (carbide cutter) into the workpiece. Throughout the cutting stroke, the clamp stays pressurized. In fact, the **pilot check valve on the clamp closes** once the pump flow re-routes to the cutter, locking the clamp cylinder so it can't lose pressure if there's a dip. The sequence valve SV2 also ensures the upstream pressure (clamp side) doesn't fall below its setting while the cutter is moving (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion). As the cutter engages the material, pressure in the cutter line builds to whatever is required (let's say ~637 kPa for the 800 N cutting force). The main relief (1000 kPa) is high enough not to interfere – the cutter can reach the needed pressure without any fluid dumping. The feeder remains extended, holding position, and the clamp remains clamped with full force. The cutter advances at the controlled feed rate (500 mm/min) and completes the cutting operation (which could be a parting-off or a turning cut).
5. **End of Cut:** Once the cutter finishes its 250 mm stroke (or the cut is complete), the **cutter cylinder reaches the end** of its travel. At this point, the operator or automatic control will shift the main directional valve to retract all cylinders (or separate valves for

each are actuated for retraction, depending on the control scheme). Just before retraction, if the cutter was, for example, parting off the workpiece, the piece may separate. The clamp is still holding the cut piece (preventing it from dropping or spinning off). Now we initiate the return sequence.

6. **Cutter Retract:** On the retract command, pump flow is redirected to the rod sides of the cylinders. The **cutter cylinder retracts first** because it has very little resistance (the tool is no longer under load, just moving back). We intentionally **kept the clamp's retract path closed via SV3**, so the clamp remains locked for now (the pilot check on the clamp's cap holds it closed as well). The feeder's retract may also start, but if the clamp is holding the finished part (and the stock if not parted fully), the feeder might be effectively stalled. In any case, the cutter, having the least resistance, **fully retracts to its home position**.
7. **Clamp Release:** When the cutter hits its **retracted end-stop**, pressure in the cutter's retract line (or the common retract manifold) spikes. Once it exceeds SV3's setting (e.g. ~450 kPa), **Sequence Valve 3 opens**, allowing flow to the **clamp's rod side**. This pilots the clamp's check valve open and drives the clamp cylinder to retract (unclamp). The clamp releases the workpiece. Because we ensured the cutter was already back, the tool is out of the way – safe for the clamp to open. The part (if it was parted off) can now be removed or drops into a collection bin. If it was not fully parted, it's still attached to the bar, but now the clamp opening frees it – the bar stock is typically held on the other end by a chuck, or the cycle would incorporate part removal. (The specifics depend on the machine design, but hydraulically the clamp is now open.)
8. **Feeder Retract:** Now that the clamp is open (and the cutter is retracted), the **feeder cylinder can retract** completely. If the feeder had already started retracting, it might have been limited by the clamped bar; but with the clamp open, it will now slide back, pulling the remaining stock if needed or simply retracting its pusher to pick the next piece. By the end of this step, all three cylinders are back to their **fully retracted positions**: the cutter is home, the clamp is open, and the feeder is back. The system pressure at retract completion might momentarily rise (hitting relief) when all cylinders bottom out in retraction.
9. **Ready for Next Cycle:** The completion of retraction satisfies the interlock condition *"clamp and cutter fully retracted"*. In an automated system, this could trigger the next cycle. The feeder will not advance again until those conditions are met – which we have ensured via the sequence valves and/or would ensure via a logic check. Now the cycle repeats for the next workpiece.

Throughout this process, the **pressure settings of the sequence valves** orchestrate the timing: feeder goes first (lowest resistance until a threshold ~350 kPa triggers the clamp), clamp builds pressure (threshold ~380 kPa triggers the cutter), and clamp stays engaged until a threshold (~450 kPa on retract line) triggers its release after cutter is back. The given initial sequence setpoints (318, 684, 500, 456, 637 kPa) have been adjusted to **match the required forces and proper sequencing**: we use approximately 350, 380, 450 kPa (etc.) as described, instead of those somewhat inconsistent values. The main relief remains at 1000 kPa as a safety limit, and the clamp's local relief at 800 kPa provides backup protection though it never activates in normal operation.

Finally, by adding the **pilot-operated check valve on the clamp**, we have insured that even if the pump were to lose power at any point, the clamp cylinder would hold its position (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion). For example, if power failed mid-cut, the clamp would stay clamped (preventing the part from flying out of the machine) – this addresses requirement (5). Once power is restored, the cycle can be resumed or the clamp deliberately released by applying pilot pressure on the rod side.

In summary, the corrected sequence valve pressures and added safety components ensure that the **hydraulic logic meets all requirements**: the feeder cannot advance out of turn, the clamp always engages before cutting and stays engaged until cutting is finished, and the system will hold the work securely even in the event of power loss. Each component's role has been verified with calculations – clamp and cutter pressures derived from force needs (318 kPa and 637 kPa respectively), feeder force estimated to size its sequence threshold appropriately, and relief valves set to protect the system without interfering with normal operation. This design provides a reliable, safe sequencing of the three cylinders in the automated turning machine.

Sources: Hydraulic sequence valve circuit for clamp and punch (analogous to clamp and cutter) (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion) (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion); pilot-operated check valve for load holding (Pilot Operated Check Valves for Cylinder Position Holding); sequence valve operation and guidelines (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion) (CHAPTER 14: Sequence Valves and Reducing Valves | Power & Motion).