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(54) **LOW ALLOY STEEL PLASTIC INJECTION MOLD BASE PLATE, METHOD OF MANUFACTURE AND USE THEREOF**

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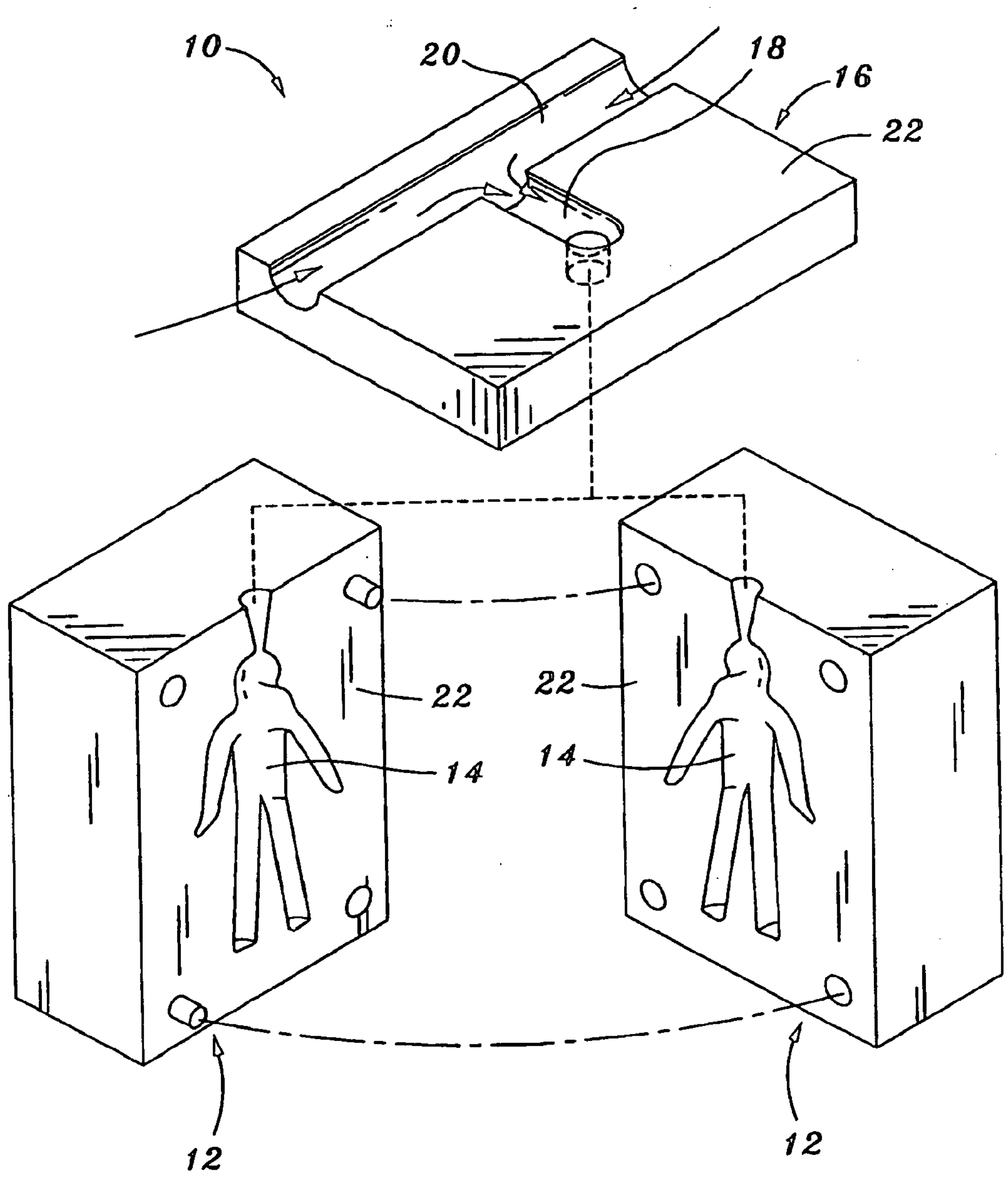
(57) **ABSTRACT**

A hot worked low alloy tool steel plate can be machined into mold base parts useful for holding tooling used in plastic injection molding. The tool steel alloy preferably exhibits desired strength, toughness, ductility, weldability, uniform hardness and dimensional stability. A process for manufacture of the steel plate includes hot working, hot roller leveling, air cooling and tempering to desired hardness.



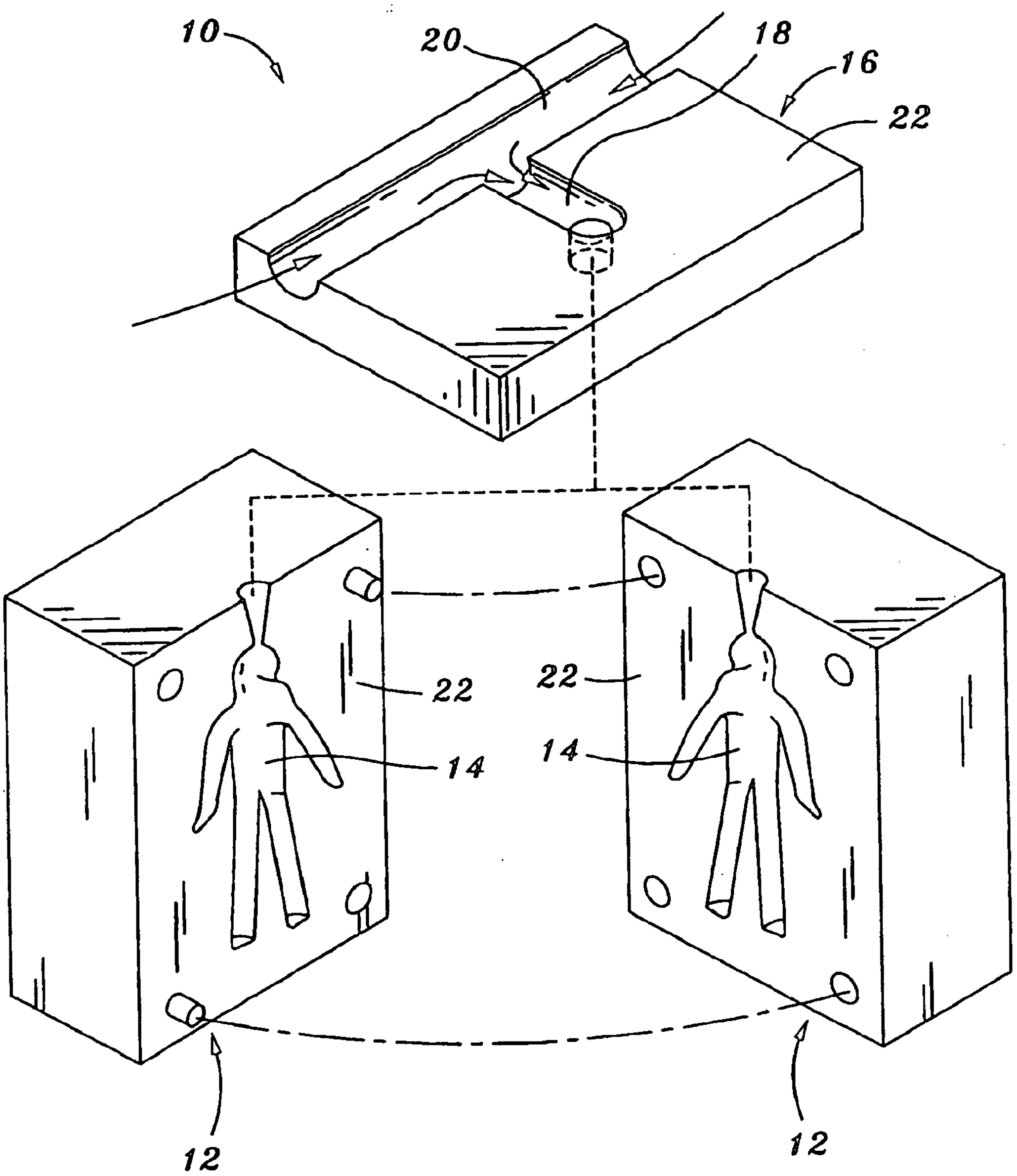


Fig. 1

LOW ALLOY STEEL PLASTIC INJECTION MOLD BASE PLATE, METHOD OF MANUFACTURE AND USE THEREOF

BACKGROUND

[0001] This invention relates to a low alloy steel plate used for a plastic injection mold base, method of its manufacture and method of using the mold base.

[0002] A mold base used for plastic injection molds is a group of steel plates and blocks which retain, align and support the molding insert components and optional auxiliary equipment. Such parts are machined out of a six sided plate with precise dimensions and surface finish. A problem with some steel plate material used for this purpose is dimensional stability. In particular, due to waviness or unevenness of the plate it may need to be roller leveled at low temperature, tempered to relieve bending stresses and machined to the required dimensions. In spite of such measures, after further machining to accommodate mold tooling inserts including mold cavities, runners, gating and the like, heavy machining of the mold base can result in distortion of the mold base requiring further six sided machining to restore the required dimensions and possibly welding to build up areas affected by the warping/distortion caused by built up stresses in the plate material.

SUMMARY

[0003] Provided is a low alloy steel mold base plate useful for holding tooling used in plastic injection molding. The steel alloy preferably exhibits desired strength, toughness, ductility, weldability, uniform hardness and dimensional stability. Also provided is a process for manufacture of the mold base plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** is an illustration of plastic injection tooling including a mold base.

DETAILED DESCRIPTION

[0005] In plastic injection molding, a mold base is used to hold other plastic mold tooling in a precise mating engagement to allow mass production of one of more plastic injection molded articles. The mold base is typically a group of 4 to 15 thin plates for small molded articles but a group of thicker plates is required for larger molded articles to accommodate the larger sized molds. Manufacture of mold base parts involves machining a six sided plate having parallel major surfaces, parallel top and bottom sides and parallel left and right sides. In order to minimize waste of material, it is desirable to make the mold base parts from plate material requiring the least amount of machining of the six sides. It is also desirable to make the mold base parts from material that exhibits dimensional stability after heavy machining of the major surfaces to accommodate other plastic injection mold tooling parts. Such heavy machining can result it warping of the mold base material due to built up stresses in the plate. Removal of such warpage requires extensive machining and grinding to provide the plate with the required six sided dimensions.

[0006] A manufacturing mold having a portion thereof including a mold base and manifold **16** is shown in FIG. **1**. The manifold **16** may include sprues **18** or runners **20** such that the manifold **16** may be used in plastic injection mold **10**. The mold base is of a low alloy steel. The steel alloy can be electric furnace melted, ladle refined, vacuum degassed and argon shield poured in a manner as will be described in greater detail below. The composition range of elements of exemplary tool steel alloys is given in ranges of percent weight in Tables I and II and the general alloy composition is set forth in Tables III and IV below wherein "LAP" means low as possible. Table IV sets forth preferred maximums for additional elements. The values are preferred, and variations in one or more elements are permissible which do not alter the suitability of the alloy for use as mold bases in plastic injection molds.

TABLE I

Slab Cast Analysis - Plates to 3.125 Inch Rolled Gauge

	Element								
	C	Mn	P	S	Si	Cr	Ni	Mo	Al
Minimum	0.21	0.6	0	0.02	0.25	1.8	0.15	0.15	.015
Maximum	0.26	0.9	0.02	0.04	0.5	2.2	0.35	0.2	.05
Typical	0.23	0.75	LAP	0.03	0.35	2.0	0.17	0.17	.025

TABLE II

Ingot Cast Analysis - Plates Over 3.125 Inch Rolled Gauge

	Element								
	C	Mn	P	S	Si	Cr	Ni	Mo	Al
Minimum	0.23	0.6	0	0.02	0.25	1.8	0.15	0.15	.015
Maximum	0.28	0.9	0.02	0.04	0.5	2.2	0.35	0.2	.05
Typical	0.25	0.75	LAP	0.03	0.35	2.0	0.17	0.17	.025

TABLE III

Total Production Chemistry range - All Gauges

	Element								
	C	Mn	P	S	Si	Cr	Ni	Mo	Al
Minimum	0.21	0.6	0	0.02	0.25	1.7	0	0	0.015
Maximum	0.28	0.9	0.02	0.1	0.5	2.2	0.35	0.2	0.05

TABLE IV

Residual/Unspecified Element Limits

	Element					
	Cu	Ti	Co	Sn	H_2	O
Maximum	0.4	0.05	0.2	0.03	4 ppm	LAP

[0007] In the preferred embodiment, the balance of the composition is iron (Fe) and those impurities and tramp or trace elements that are inevitably included during the melting of a material charge from which the steel alloy may be ultimately produced. Preferably, any additional element in an amount which does not alter the suitability of the alloy for use in plastic injection molds may be considered either an impurity or trace element. The function of each of the intentionally included elements in the composition is as follows:

[0008] Carbon (C): about 0.21 to 0.28%

[0009] Carbon controls the degree of hardness and tensile strength that is attainable in the steel alloy. However, ductility and weldability decrease with increasing levels of carbon. Therefore, the carbon level of the steel alloy advantageously ranges from about 0.21 to about 0.28%, preferably from about 0.21 to 0.25%, and in an example about 0.23% by weight. With such composition ranges, the desired hardness of the alloy may range from about 270 to about 320, preferably about 277 to about 311 Brinell Hardness Number (BHN) after tempering.

[0010] Manganese (Mn): about 0.6 to about 0.9%

[0011] Manganese acts as a strengthening agent and as a de-oxidizer. In addition, manganese acts as an austenite stabilizer and prevents the formation of ferrite phase in the steel alloy. Furthermore, manganese is generally beneficial to surface quality of parts made of the steel alloy. The upper limit of 0.9% manganese is specified to control otherwise embrittling effects of excess manganese. The manganese level of the steel alloy advantageously ranges from about 0.6 to about 0.9%, preferably from about 0.7 to 0.8%, and in an example about 0.75% by weight. The preferred range of 0.6 to 0.9% manganese produces all the desired effects with no negative impact on mechanical properties of the steel alloy.

[0012] Phosphorus (P): Up to a Maximum of about 0.02%

[0013] Phosphorous adds to the strength and hardenability of the steel alloy. However, the phosphorous in the steel alloy is typically reduced to the lowest level possible to avoid brittleness in the steel alloy. However, the phosphorus need not be reduced to extremely low levels. An upper limit of about 0.02% phosphorous provides positive effects on machinability. The level of phosphorous may preferably be specified in an example at about 0.01% as a balance between its enhancement of machinability and its inducement of brittleness in the steel alloy.

[0014] Sulfur (S): About 0.02 to about 0.1%

[0015] For purposes of providing machinability, sulfur is preferably present in an amount up to about 0.1%. Weldability typically decreases with increasing sulfur content. For these reasons, sulfur at the specified upper limit of 0.1% is effective in producing the steel alloy with a relatively high level of weldability. At the same time, the level of sulfur in the steel alloy remains in balance with the rest of the elements in the composition to the extent that hot working properties, toughness and ductility remain acceptable. Toward this end, the level of sulfur in the steel alloy may preferably be specified at about 0.02 to about 0.04%.

[0016] Silicon (Si): about 0.25 to 0.5%

[0017] Silicon acts as a primary de-oxidizer in the metal although silicon is less effective than manganese in increasing strength and hardness. Deoxidizing action occurs with silicon present in the composition of the steel alloy. However, increasing levels of silicon may produce ferrite. Therefore, the silicon level of the steel alloy preferably ranges from about 0.25 to about 0.5%, more preferably from about 0.3 to about 0.4%, and in an example about 0.35% by weight.

[0018] Chromium (Cr): about 1.7 to 2.2%

[0019] Chromium acts to enhance hardenability and high-temperature strength in the steel alloy making possible a material that will readily transform to the desired microstructure in relatively thick cross sections with air cooling. Chromium content of 1.7% minimum achieves these goals. Increasing levels of chromium may promote the formation of the undesirable ferrite phase in the steel alloy. Therefore, the chromium level of the steel alloy preferably ranges from about 1.7 to about 2.2%, more preferably from about 1.8 to 2.2%, and in an example about 2.0% by weight.

[0020] Nickel (Ni): Up to a Maximum of about 0.35%

[0021] Nickel is a ferrite strengthener in the steel alloy. In addition, the nickel may counteract negative effects of hot working that the copper may create. Nickel also increases the hardenability and impact strength of the steel alloy. Therefore, an upper limit of 0.35% of nickel has been specified. However, the upper level of nickel may preferably be specified at about 0.17% in order to limit negative effects of the nickel on overall machinability.

[0022] Copper (Cu): Up to a Maximum of about 0.4%

[0023] Copper is typically present as a result of contamination of scrap metal that is used to manufacture the steel alloy. High levels of copper can promote hot working problems and can be detrimental to surface quality. Therefore, copper is specified at the upper limit of 0.4%. The upper level of copper in the steel alloy may preferably be specified at about 0.35% in order to improve the mechanical properties for the steel alloy.

[0024] Molybdenum (Mo): up to about 0.2%

[0025] Molybdenum is added in order to provide sufficient resistance to cracking in the steel alloy such as may occur during hot leveling of the steel alloy material. In addition, molybdenum improves creep strength of the steel alloy at elevated temperatures. A preferred lower limit of Mo is about 0.1%. The upper level of molybdenum may preferably be specified at about 0.2% in order to maintain a balance with the rest of the elements in the composition to the extent that hot working properties remain acceptable.

[0026] Aluminum (Al): about 0.015 to 0.05%

[0027] Aluminum may work in concert with silicon to act as a de-oxidizer. In addition, aluminum is one of the most effective elements in inhibiting grain growth in the steel alloy. In this regard, the aluminum is included to provide a relatively fine grain structure in the finished material. Therefore, the aluminum level of the steel alloy preferably ranges from about 0.015 to about 0.05% and more preferably about 0.02% by weight.

[0028] Additional Elements: 0.5% maximum

[0029] Additional elements which may be present in the steel alloy include Ti, Co, Sn etc. and gases such as hydrogen and oxygen may also be present. For example, Ti is preferably no greater than 0.05%, Co is no greater than 0.2%, Sn is no greater than 0.03%, hydrogen is at most 4 ppm and oxygen is as low as possible.

Details of Manufacturing

[0030] A mold base plate for plastic injection mold base parts may be formed from the steel alloy in a process that is initiated with preparation of a material charge. The material charge may be prepared using the elements listed above and in the ranges specified for the chemical composition. The material charge may include additional amounts of certain elements to account for estimated melt losses as a result of oxidation during the production of the tool steel.

[0031] Following its preparation, the material charge is preferably introduced into an electric furnace such as a conventional electric furnace of the type used in manufacturing ferrous and non-ferrous metals. Melting of the material charge may be achieved by supplying energy to a furnace interior. Electrical energy may be supplied to the furnace interior via graphite electrodes. Following melting of the material charge, the melted material may be refined by ladle refining. Such ladle refining acts to remove impurities and homogenize the melted material. In addition, ladle refining allows for relatively tight control over the chemical and mechanical properties of the final product through improved accuracy in the composition of the final product. In addition, ladle refining allows for relatively high levels of cleanliness due to control over inclusion morphology.

[0032] During the ladle refining process, ladles are used to transfer melted or molten material from the electric furnace to a refining or pouring station. Ladle refining involves using ladles with a heating source to heat the melted material that is tapped from the electric furnace to a precise temperature. The ladle refining step provides an opportunity to refine the composition of the steel alloy to a desired chemical composition such that the elements are present in the ranges given above.

[0033] During the ladle refining step, chemicals may be added to the melted material in order to remove impurities. In addition, alloy elements may be added in order to enhance the mechanical properties of the steel alloy. In addition, the ladle refining may include a stirring action that may aid in homogenizing the temperature and composition of the melted material to achieve uniform characteristics or properties of the material. Slag may additionally be removed from the melted material in the ladle refining process.

[0034] The melted material is preferably vacuum degassed in order to remove gases. During vacuum degassing, the melted material is disposed within a degasser vacuum chamber where it is subjected to a vacuum in order to reduce or remove residual levels of nitrogen gas in the melted material. In addition, vacuum degassing causes hydrogen to diffuse and separate from the melted material so as to prevent hydrogen-induced defects in the finished steel alloy. Both hydrogen and nitrogen gases are vented from the vacuum degasser as the steel is continuously circulated through the degasser vacuum chamber so as to improve the mechanical properties of the steel alloy.

[0035] Following vacuum degassing the melted material can be continuous cast or bottom poured into molds using an argon shield to form solid ingots. During the pouring of the melted material, argon gases are used to shield the melted material from air contamination and create a non-oxidizing environment in which the melted material may be poured into the molds. Continuous casting is an economical process especially useful for lighter gauge plate such as 3 inch thick and thinner plate and in such case the C content in the cast slabs can be lower than in the case of ingot casting. The cast slabs or ingots are later reheated for hot working into a desired shape. Hot rolling and/or forging can be carried out at initial temperatures of 2000 to 2250° F. and finishing temperatures of 1600 to 1800° F. The material may be formed in a plate configuration from which the mold base parts may ultimately be fabricated.

[0036] The material is preferably hot leveled after working in order to flatten the material while still hot. The material is preferably hot leveled while still on the hot rolling mill or hot forging mill. The hot worked plate is preferably maintained above 1500° F. when the hot leveling is performed. The excellent flatness of the material that results from the hot leveling minimizes the amount of material that must be removed from surfaces in order to produce flat and parallel machined surfaces.

[0037] Directly following hot leveling, the material is preferably free air cooled on rigid, level cooling tables such as steel cooling beds to below 600° F. prior to lifting or moving the hot leveled material. The material is air cooled until complete transformation of the microstructure has occurred. Preferably, the air cooled plate material is not mechanically flattened after the air cooling step. The combination of hot leveling and free air cooling produces material that is naturally flat and free of waviness or wrinkles. In addition the hot leveling and air cooling eliminates the creation of residual bending stresses commonly associated with low temperature leveling and flattening operations typically applied to plate products.

[0038] Because the as-hot worked and air cooled material may be slightly harder than required for the tool, the hardness may be adjusted by heat treatment or tempering. Advantageously, such tempering does not require high temperatures (such as normalizing and quenching) that otherwise result in the formation of heavy scaling on the metal surfaces. Furthermore, the tempering step also relaxes or removes residual cooling stresses that may remain in the material from the original hot working process. It is contemplated that the tool steel may be tempered to a hardness in the range of from about 270 to about 320 BHN, preferably about 277 to about 311 BHN such that the tool steel is suitable for use as mold base parts in plastic injection mold tooling. The thermal processing avoids the need for high temperature heating and quenching. The plate in its hot worked state is thus a non-quenched steel which can be provided with a hardness of about 270 to about 320 Brinell with only a stress relief (tempering) heat treatment after hot working (rolling and/or forging).

[0039] The steel alloy preferably has uniform hardness entirely across and through the hot worked plate which does not vary by more than 10%, more preferably the hardness does not vary by more than 5%. For example, if a plate of 30 HRc is desired, all portions of the hot worked and tempered plate will have a hardness of 28 to 32 HRc, preferably 29 to 31 HRc. Such uniform hardness avoids hard and soft spots which are detrimental to use of high tool speeds and/or high tool feeds during machining of the plates

[0040] Referring to FIG. **1**, shown is an exemplary plastic injection mold **10** having mating mold bases **12** connected to the manifold **16**. As can be seen in FIG. **1**, each one of the mold bases **12** includes a cavity half **14**. When mated, the mold bases **12** form a mold cavity in the shape of a plastic product. In preparation for molding the plastic product, the mold bases **12** are mated and the manifold **16** is secured to mated ones of the mold bases **12**. Sprues **18** and runners **20** formed in the manifold **16** allow molten plastic to be injected into the mold cavity. During the mating of the mold bases **12** and securement of the manifold **16** to mated ones of the mold bases **12** as well as during use of the plastic injection mold **10**, it is essential that surfaces **22** do not become warped but remain parallel at all times. Advantageously, the above-described process for producing the tool from the steel alloy results in a tool that exhibits favorable dimensional stability such that warpage or distortion of the material is minimized, even after heavy material removal.

[0041] Such features may be rapidly machined into the mold bases due to the favorable machinability characteristics of the steel alloy. For example, due to the uniform hardness of the steel alloy the mold base parts can be machined at higher tool speeds with increased tool life compared to prior mold base steels. In addition, the improved ductility of the steel alloy prevents breakage around edges of such features. Regardless of technology, equipment and degree of care that may be exercised in machining of the mold bases, machining errors may occur. Such errors may require repairing. Fortunately, the excellent weldability of the steel alloy allows for weld repairs. For example, due to the low C content, with the use of a mild preheat prior to welding and air cooling to ambient after welding the weld area can exhibit similar properties to the surrounding portions of the steel. During welding, it is desirable to use filler metal of the same or similar composition as that of the hot rolled steel plate.

[0042] The chemical composition and method of producing the steel alloy results in a material that is capable of meeting ultrasonic inspection acceptance criteria. Such ultrasonic inspection may be used to detect surface and subsurface flaws in the steel alloy material. Such flaws may include cracks, shrinkage, cavities, flakes, pores, delaminations, and porosity. The steel alloy as described above is substantially capable of meeting ultrasonic inspection acceptance criteria for a {fraction (5/64)}" flat-bottom hole.

[0043] The steel alloy described above includes intentional addition of at least one machinability enhancing element such as S, Se, Pb or the like. For example, S can be added in an amount to promote formation of MnS with a desired size and distribution. The steel alloy material was evaluated according to American Society for Testing and Materials (ASTM) standards (Table V) to determine the extent or severity of nonmetallic inclusion content of the steel alloy.

[0044] The steel alloy was evaluated optically to determine sulfide size and distribution and was found to exhibit the sulfide properties listed in Table V.

TABLE V

Type	A (sulfides)
Thin	1½
Thick	½

[0045] The preferred embodiments are merely illustrative and should not be considered restrictive in any way. The scope of the invention is given by the appended claims, rather than the preceding description, and all variations and equivalents which fall within the range of the claims are intended to be embraced therein.

1. A mold base plate useful as plastic injection mold base parts formed of a hot worked boron-free tool steel alloy plate which has been manufactured by hot working, hot leveling after the hot working, air cooling after the hot leveling until complete transformation of the microstructure occurs, and tempering after the air cooling to lower hardness of the plate to below about 320 BHN, the tool steel alloy comprising: about 0.21 percent to about 0.28 percent by weight carbon; about 0.6 percent to about 0.9 percent by weight manganese; a maximum of 0.02 percent by weight phosphorous; from about 0.02 to about 0.1 percent by weight sulfur; from about 0.25 percent to about 0.5 percent by weight silicon; from about 1.7 percent to about 2.2 percent by weight chromium; a maximum of 0.35 percent by weight nickel; a maximum of 0.4 percent by weight copper; up to about 0.2 percent by weight molybdenum; from about 0.015 percent to about 0.05 percent by weight aluminum; and the balance being iron with up to 0.5 percent by weight total of other elements.

2. The mold base plate of claim **1** wherein the alloy has a hardness within the range of from about 277 to about 311 BHN.

3. A hot worked and tempered mold base plate of a boron-free tool steel alloy, the tool steel alloy being comprised of from about 0.21 percent to about 0.28 percent by weight carbon, from about 0.6 percent to about 0.9 percent by weight manganese, a maximum of 0.02 percent by weight phosphorous, from about 0.02 to about 0.1 percent by weight sulfur, from about 0.25 percent to about 0.45 percent by weight silicon, from about 1.7 percent to about 2.2 percent by weight chromium, a maximum of 0.35 percent by weight nickel, a maximum of 0.4 percent by weight copper, up to about 0.2 percent by weight molybdenum, from about 0.015 percent to about 0.05 percent by weight aluminum and the balance being iron with up to 0.5 percent by weight total of other elements wherein the alloy has a hardness within the range of from about 270 to about 320 BHN.

4. The mold base plate of claim **3** wherein the carbon is in a range of from about 0.21 to about 0.25 percent by weight.

5. The mold base plate of claim **4** wherein the carbon is about 0.22 to 0.24 percent by weight.

6. The mold base plate of claim **3** wherein the manganese is in a range of from about 0.7 to about 0.8 percent by weight.

7. The mold base plate of claim **6** wherein the molybdenum is about 0.1 to 0.2 percent by weight.

8. The mold base plate of claim **3** wherein the silicon is in a range of from about 0.3 to about 0.4 percent by weight.

9. The mold base plate of claim **8** wherein the nickel is about 0.1 to 0.35 percent by weight.

10. The mold base plate of claim **3** wherein the chromium is in a range of from about 1.8 to about 2.2 percent by weight.

11. The mold base plate of claim **10** wherein the chromium is about 2.0 percent by weight and the sulfur is about 0.03 percent by weight.

12. A mold base part made from the plate of claim **3**, the mold base part comprising at least one of a top support, bottom support, core plate, cavity block or rail.

13. A hot worked and tempered mold base plate of a boron-free tool steel alloy, the tool steel alloy consisting essentially of from about 0.21 percent to about 0.28 percent by weight carbon, from about 0.6 percent to about 0.9 percent by weight manganese, a maximum of 0.02 percent by weight phosphorous, from about 0.02 to about 0.1 percent by weight sulfur, from about 0.25 percent to about 0.5 percent by weight silicon, from about 1.7 percent to about 2.2 percent by weight chromium, a maximum of 0.35 percent by weight nickel, a maximum of 0.4 percent by weight copper, up to about 0.2 percent by weight molybdenum, from about 0.015 percent to about 0.05 percent by weight aluminum and the balance being iron with up to 0.5 percent by weight total of other elements wherein the alloy has a hardness within the range of from about 270 to about 320 BHN.

14. The mold base plate of claim **13** wherein the carbon in a range of from about 0.21 to about 0.25 percent by weight.

15. The mold base plate of claim **13** wherein the manganese is in a range of from about 0.7 to about 0.8 percent by weight.

16. The mold base plate of claim **13** wherein the silicon is in a range of from about 0.3 to about 0.4 percent by weight.

17. The mold base plate of claim **13** wherein the chromium is in a range of from about 1.8 to about 2.2 percent by weight.

18. The mold base plate of claim **13** wherein the molybdenum is about 0.1 to about 0.2 percent by weight.

19. A process for manufacturing the mold base plate according to claim **1**, the process comprising the steps of: shaping the tool steel alloy by hot rolling or hot forging into a hot worked plate using a hot rolling mill or hot forging mill; hot leveling the hot worked plate while the hot worked plate is still on the hot rolling mill or forging mill; cooling the hot leveled plate by free air cooling to a temperature below about 600° F.; and tempering the air cooled plate to a hardness in the range of from about 270 to about 320 BHN and forming the tempered air cooled plate into a mold base plate.

20. The process of claim **19**, comprising preparing a material charge, melting the material charge in an electric furnace, ladle refining the melted material to remove impurities and homogenize the melted material, removing gases from the melted material by vacuum degassing, argon shield pouring the melted material into a mold and shaping the cast tool steel alloy in a hot rolling or hot forging mill using an argon shield, hot leveling the tool steel alloy after rolling or forging, cooling the tool steel alloy by free air cooling to a temperature below about 600° F., and tempering the tool steel alloy to a hardness in the range of from about 277 to about 311 BHN.

21. The process of claim **19**, wherein the tool steel includes about 0.1 to about 0.2 percent by weight molybdenum.

22. The process of claim **19**, wherein the air cooled plate has a hardness higher than that desired for the mold base part and the tempering lowers the hardness to the desired hardness for a mold base part made from the plate.

23. The process of claim **19**, wherein the tool steel is melted and cast into a mold, cooled and reheated prior to the hot rolling or hot forging step.

24. The process of claim **19**, wherein the tool steel is formed into a plate having parallel top and bottom surfaces, parallel left and right surfaces and parallel front and back surfaces by milling the tempered air cooled plate and the milled plate is formed into a finished mold base plate having pockets, pins and/or alignment holes.

25. The process of claim **19**, wherein the free air cooling comprises cooling the hot leveled plate on a rigid cooling table so as to obtain a flat and wrinkle free plate which is not moved or lifted until the hot leveled plate is cooled below 600° F., the hot leveling and free air cooling thereby producing an air cooled plate free of residual bending stresses associated with low temperature leveling and flattening operations.

26. A method of forming plastic injected parts using plastic mold tooling comprising mold base plates connected to a manifold wherein each of the mold base plates comprise the mold base plate of claim **1**, the method comprising mating the mold base plates to form a mold cavity and injecting molten plastic through the manifold and into the mold cavity.

27. The method of claim **26**, further comprising machining pockets in the mold base plates.

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